
# Pole/Zero® Product Catalog

## Advanced Cosite Communication Solutions for your Platform

Microwave Products Group
A DOVER COMPANY

# Table of Contents



Today's crowded communications bands and closely located receivers and transmitters operated simultaneously (SIMOP) require RF system designers to pay increasing attention to their equipment's generation and rejection of signals and noise. The receiver must operate in the presence of large interfering signals on adjacent channels while the transmitter noise and spurious signals can artificially raise the system noise floor for collocated (cosite) receivers with the end result of system desensitization and diminished communications range.

Pole/Zero® offers a full suite of products for these high-interference environments. For the equipment designer, Pole/Zero® offers multiple families of rapidly tunable notch filters, bandpass filters and pre/post-selection filters for incorporation into our customers' equipment. For the system engineer with the challenge of enhancing a modern transceiver's performance in a cosite environment, Pole/Zero® offers our Integrated Cosite Equipment (ICE) which directly interfaces with the transceiver to provide the required cosite interference mitigation – even under fast frequency hopping applications.

Pole/Zero® offers a Cosite Analysis and Integration service to our customers to determine the level of cosite interference mitigation required for a specific communications application. The goal of this analysis is to determine the level of mitigation required to meet the system's concept of operations and ensure full communications range at minimum cost.

# Pole/Zero® History

Pole/Zero® designs and manufactures a comprehensive suite of RF interference mitigation products including tunable filters, Integrated Cosite Equipment (ICE), Low Noise Amplifiers (LNA), cosite power amplifiers and other products that are ideal for solving communication problems caused by various types of RF interference. These interfering sources can include self-interference due to collocation of transmitters and receivers (known as cosite interference), intentional jammers, broadband noise, spectral splatter and spurious transmit signals, rusty bolt effects or any number of other sources. Our approach to business and our ability to cost-effectively solve the most difficult interference problems has made us one of the fastest growing companies in our field.

The company was founded in 1989 with the belief that the military and commercial RF markets were changing Although military budgets were shrinking, the role and the requirements of the military were not. In fact, one may argue that the role of the conventional military was expanding with the global police force and peacekeeping actions being taken. At the same time, real battlefield situations demonstrated that commercial equipment can provide the sophistication and reliability required in a military environment.

Using current state-of-the-art technology we focused on the technological advances of the last couple of decades and applied it to solid-state tunable filters. The result was a leap forward in miniaturization and standardization, permitting a totally self-contained single structure with improved production capability and reduced cost. In addition to these filters, we have developed other building blocks such as low noise amplifiers, cosite power amplifiers, solid-state switches, mixers and synthesizers that now make up a catalog of "off-the-shelf" building blocks. These building block modules are available both as stand-alone modules and also in the systems that we design and manufacture. These products share a common attribute in the support of very high dynamic range communications.

In 1994 Pole/Zero® branched into the Integrated Cosite Equipment (ICE) field with the development of both an airborne and shipboard filter/amplifier cascade product. ICE integrates elements of our standard product line to achieve enhanced performance beyond that achievable with our basic products. Both of these ICE units are still in production. Further, Pole/Zero® has significantly expanded the breadth of ICE products, providing our customers the ability to select optimum cost-effective solutions for their interference mitigation needs. Many of our products are purchased as commercial items, while other customers require modification to the existing products to meet their needs. In both cases, Pole/Zero® provides low risk, cost-effective solutions. Our products can be found in the harshest RF environments on C4ISR (command, control, communications, computers, intelligence, surveillance and reconnaissance) platforms and tactical applications.

Today, Pole/Zero® is delivering hardware to customers around the world for a variety of applications. For the military, our equipment is flying on airborne command posts and jet fighters and is fielded in both ground-fixed and ground-mobile systems. The same hardware is being used in commercial applications from radio telescopes to wireless office communications and from industrial inspection equipment to MRI machines. Applications for our filters range from stand-alone units in a test environment to units embedded in the design of high performance communication equipment.

As we continue to grow in number of employees and yearly sales, we have maintained our focus on supplying readily available, digitally tuned hopping filter modules and components with wide dynamic range performance to provide new flexibility to the RF system designer. Additionally, Pole/Zero® has increased its focus on providing quality products to our customers by instituting the following quality policy: "Pole/Zero® is dedicated to providing defect-free products on time to internal and external customers. Customer satisfaction, quality and continuous improvement are the personal responsibility of each employee." Building on this policy, Pole/Zero® has established and complies with many processes focused on improving performance throughout the company. As a result, Pole/Zero® has maintained third-party certification of our conformance to the ISO9001:2008 standard with AS9100:2009, Revision C, since October 2005.

All products are manufactured and thoroughly tested in our West Chester, Ohio facility, which is fully equipped with modern computer controlled testing and manufacturing equipment.

*Pole/Zero® is dedicated to innovation, quality and absolute customer satisfaction.*

# Selecting the right filter for your application.

## Tuning Components

Changing the resonant frequency of a tuned circuit can be done by varying either its inductance or capacitance. Because of their smaller size and higher Q, capacitors are generally chosen as the tuning element. One way to accomplish this is by allowing the capacitance to be a bank of switched discrete capacitors. Far from ideal, the PIN diode remains the choice RF switching component when medium to high in-band RF power handling, 1 to 100 watts or greater, is required. Once a high cost component, diode manufacturers now offer high performance parts in low cost SMD packages. Some JFETs are available that exhibit usable RF switch characteristics, but RF power handling can only approach the 1 watt level. Varactor diodes remain the choice tuning element for RF power handling to 20 mW.

## Selecting the Right Tunable Filter

Selecting the right filter for the job requires the designer to consider a number of aspects. These relate to technical performance, size/weight, and cost. On the technical side, the filter performance characteristics can be summarized:

- **Insertion Loss**
- **Bandwidth/Selectivity**
- **RF Power Handling**
- **Intercept Point (Third Order Intercept)**
- **Tuning Range**
- **Tuning Speed**
- **Power Consumption**

Additionally, the size and weight of the filter must be considered, especially for portable and airborne equipment. And as always, cost is a major driver in engineering decisions.

## Insertion Loss (IL) & Bandwidth/Selectivity

An unfortunate rule of nature dictates that a filter's insertion loss and bandwidth are inversely related; the narrower the bandwidth of a filter of a given technology, the higher its loss. The bandwidth-loss relationships are measured by a filter designer using the property called "unloaded Q". This property measures the Q of an unloaded resonant circuit. Q is mathematically defined for a resonant circuit by the equation:

$$Q = \omega_0 * R * C \quad \text{or} \quad Q = R/(\omega_0 * L)$$

It is readily obvious that the higher the value of R, which for an unloaded resonator represents the lossy component, the higher the value for Q. The insertion loss of a 2-pole Butterworth filter is given by the equation:

$$IL = 20 * Log[Q/(Q - \sqrt{2}/(BW_{3dB}(\%)))]$$

Again, the only way to improve a filter's IL, for a given technology and bandwidth, is to increase the Q of its resonant circuits. Generally, this means larger size and/or increased DC power consumption, and higher cost, due to higher quality components.

## RF Power Handling

This parameter can be the most important one in selecting a tunable filter. As opposed to fixed tuned filters that consist of passive components, tunable filters contain active components, which have limited linearity. The 1 dB compression point of a filter is the RF signal level where IL increases by 1 dB. For a tunable filter, this occurs when the RF signal's peak voltage imposed across an active tuning component, whether PIN diode or varactor, approaches the DC bias voltage applied. For PIN diodes, power handling can be improved with increased reverse bias. However, care must be taken to ensure the sum of the bias voltage and the peak RF voltage do not exceed the breakdown voltage of the parts. Insufficient forward bias current can also limit power handling but is usually of secondary importance.

## Intercept Point (IP3)

The Third Order intercept point is a figure of merit for linearity and is closely related to the 1 dB compression of the filter. When two large "interfering" signals (F1 and F2) are applied to a filter (input or output), two new signals are generated which appear one on either side of the interferers and spaced from them by F1 - F2. If these interfering signals occur within the filter's passband, the distortion products can be large and easily fall right on top of a desired signal. In a tunable filter, this distortion is caused by the non-linearity of the active components when large RF voltages are imposed on them. In-band Third Order intercept is generally 10 to 15 dB higher than the 1 dB compression level of a filter. The amplitude of the distortion products decreases as the interfering signals are moved out of the passband and on to the filter skirts. Note that even though the filter being specified may not have to handle high RF levels, the requirement for Third Order intercept may drive its size, weight and cost due to the relationship between RF power handling and Third Order intercept.

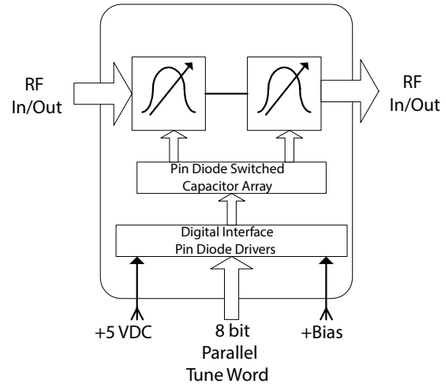
## Tuning Range

Pole/Zero® filter products offer frequency coverage up to a full octave. The narrower the tuning range required of the filter, the higher the performance. If your tuning range can be reduced, or two half-band filters can be utilized, usually at least one other technical parameter can be significantly improved.

## Power Consumption

PIN diodes require DC power when forward biased. Generally, by increasing the forward bias of a diode, unloaded Q is increased and thus IL improved.


**Figure 1**




## Tunable Filter Designs

Pole/Zero®'s NANO-POLE®, MINI-POLE®, MAXI-POLE®, POWER-POLE® and Extended Range bandpass filters (ERFs) are 2-pole, constant Q designs and are aligned to provide a close approximation to a Butterworth response. Filter tuning ranges are available based on popular communication bands covering 1.5 MHz to 3 GHz. Units are available with standard 3 dB bandwidths from 1.8 to 20%. Figure 1 shows a simplified Block Diagram of a filter module.

Tuning is accomplished via a PIN diode switched binary capacitor array placed in parallel with a high Q inductor or resonator. A single +5 VDC input provides the current for diode forward biasing and an additional input voltage between +30 and +100 VDC is required for diode reverse biasing An internal DC-DC converter running off the +5 VDC supply for generating the high bias is an option on the MAXI-POLE®, and is standard on the POWER-POLE®.

The tuning arrays are driven by a decoder/driver that contains all of the necessary circuitry to receive digital tuning commands, translate them to the internal filter tuning codes, and drive the PIN diodes with the proper bias. The entire tuning process is accomplished in under 10 microseconds for most bands. The standard input format is a parallel 8 bit binary word allowing each filter 251 tune positions (the last 5 tune words are reserved for special functions), linearly spaced over its RF tuning range.

These Selection Guides show a comparison of the different standard filter series available by Pole/Zero®. Customized units are always available as well as Tunable Notch Filters and Integrated Cosite Equipment (ICE).

## Tunable Bandpass Filters

| Filter Series: | NANO-POLE® | MINI-POLE® | MINI-SMT™ | MAXI-POLE® | POWER-POLE® | MAXI/3 | MAXI/4R | MEGA-POLE® |
|---|---|---|---|---|---|---|---|---|
| Frequency Range: | 30 MHz to 3 GHz | 1.5 MHz to 700 MHz | 700 MHz to 3 GHz | 1.5 MHz to 1 GHz | 30 MHz to 400 MHz | 300 MHz to 800 MHz | 140 MHz to 400 MHz | 30 MHz to 450 MHz |
| IL X BW Product (Typical): | 24 | 20 | 20 | 10 | 8.5 | 15 | 18 | 4.5 |
| Shape Factor (Typical): (30 dB / 3 dB) | 6.9 | 6 | 7 | 6 | 6 | 3.3 to 3.75 | 3 | 6 to 8 |
| In-band RF Power Handling: | +6 dBm | 1 Watt (Input) | 1 Watt (Input) | 1 Watt (Input) | 20 Watts (Input) | 1 Watt (Input) | 1 Watt (Input) | 50 Watt Avg. |
| Input IP3: | +16 dBm | +40 dBm | +40 dBm | +40 dBm | +50 dBm | +40 dBm | +45 dBm | +63 dBm |
| DC Power Consumption (Static): | +3.3 VDC @ 20 mA (Typical) | +5 VDC @ 10 to 250 mA, +100 VDC @ 2 mA | 100 mA (Typical) | +5 VDC @ 10 to 500 mA, +100 VDC @ 2 mA | +5 VDC @ 400 mA to 1.5 A | +5 VDC (125 to 750 mA) | +5 VDC @ 20 to 1500 mA, +100 VDC @ 2 mA | +28V Standard (< 0.5 A) |
| Tuning Speed (Typical)*: | 15 µS | 10 µS | 4 µS | 10 µS | 15 µS* | < 25 µS | 50 µS | < 25 µS |
| Size (H × W × L) in in.: | .93 × .93 × .21 | 0.6 × 1.4 × 2.3 | 1.50 x 1/50 x 0.25 | 1.5 × 2.5 × 3.3 | 2.6 × 3.0 × 4.0 | 1.5 × 2.5 × 4.3 | 3.1 × 3.5 × 7.0 | 6 × 7.55 × 3.6 |
| Size (H × W × L) in mm: | 23.6 × 23.6 × 5.8 | 15.2 × 35.6 × 58.4 | 38.1 x 38.1 x 6.35 | 38.1 × 63.5 × 82.6 | 66.7 × 76.2 × 101.6 | 38.1 × 63.5 × 108 | 79.4 × 91.4 × 177.8 | 152 × 91 × 190 |
| Weight (Typical) in oz.**: | .18 | 3.2 | 0.6 | 9.2 | 18.7 | 11.2 | 43.2 | < 60 |
| Weight (Typical) in g**: | 5.1 | 90.7 | 18 | 260.8 | 530.1 | 317.5 | 1225 | < 1701 |

* Tuning Speed shown is a typical value for each filter series; the actual tune time can vary significantly based on frequency range and configuration. Please refer to the Switching Characteristics section of each filter series for the maximum tune time.

** Weight varies by configuration, power supply, options, etc.

## Extended Range Tunable Bandpass Filters

The Extended Range Filter (ERF) was developed in support of the new family of radios with extended frequency coverage. These products provide broad tunable filtering while focusing on lower cost and smaller size.

| Filter Series: | HF-ERF™ | NANO-ERF® | MINI-ERF® | MINI-ERF® (S11) | MINI/3-ERF | ERF-5W |
|---|---|---|---|---|---|---|
| Frequency Range: | 1.5 MHz to 30 MHz | 30 MHz to 520 MHz | 30 MHz to 520 MHz | 90 MHz to 520 MHz | 30 MHz to 512 MHz | 30 MHz to 520 MHz |
| IL & BW Product: | 24 (Typical) | 30 (Typical) | 28 (Typical) | 28 (Typical) | 30 (Typical) | 25 (Typical) |
| Shape Factor (30 dB / 3 dB): | 6 ± 0.5 (Typical) | 6 ± 0.5 (Typical) | 6 ± 0.5 (Typical) | 6 ± 0.5 (Typical) | 4 ± 1 (Typical) | 4 ± 1 (Typical) |
| In-band RF Power Handling: | 24 dBm typ. | +6 dBm (Input) | 1 Watt (Input) | 2 Watt (Input) 7%<br>1 Watt (Input) 4% | 1 Watt (Input) | 5 Watts (Input) |
| Input IP3: | 34 dBm typ. (Input) | +16 dBm (Input) | +40 dBm (Input) | +40 dBm (Input) | +40 dBm (Input) | +47 dBm (Input) |
| DC Power Consumption (Static): | +5 V5 @ 400 mA (Max.)<br>+100 VDC @ 3 mA (Max.) | 3.3 V @ 15 mA. Additional 15 mA during tuning interval (15 µsec) | +3.3 VDC @ 200 mA (Max.)<br>+100 VDC @ 2.5 mA (Max.) | +3.3 VDC @ 200 mA (Max.)<br>+100 VDC @ 2 mA (Max.) | +5 VDC @ 250 mA (Max.)<br>+1.65 to +5.5 VDC 18 uA (Max.) | +5 VDC @ 1.5 A (Max.)<br>+1.65 to +5.5 VDC 18 uA (Max.) |
| Tuning Speed (Typical)*: | 85 µsec | 25 µsec | 15 µsec | 12 µsec | 15 µsec | 25 µsec |
| Size (H × W × L) in in.: | 2.0 × 2.78 × 0.6 | 1.10 × 1.10 × 0.216 | 2.40 × 1.75 × .385 | 2.0 × 2.0 × .293 | 0.4 × 2.0 × 2.52 | Single: 4.70 × 6.8 × 1.0<br>Dual: 4.70 × 6.8 × 1.90 |
| Size (H × W × L) in mm: | 50.8 × 70.61 × 15.24 | 28 × 28 × 5.5 | 61 × 44.5 × 9.8 | 50.8 × 50.8 × 7.4 | 10.2 × 50.8 × 64 | Single: 119.4 × 172.7 × 25.4<br>Dual: 119.4 × 172.7 × 48.3 |
| Weight (Typical) in oz.: | 1.51 | 0.2 | 1.05 | 1.05 | 1.34 | Single: 14.08<br>Dual: 24 |
| Weight (Typical) in g: | 43 | 6 | 30 | 30 | 38 | Single: 399<br>Dual: 680 |



## Tunable Notch Filters

| Filter Series: | MINI-POLE® NOTCH | MAXI-POLE® NOTCH | POWER-POLE® NOTCH | MAXI/4R NOTCH |
|---|---|---|---|---|
| Frequency Range: | 1.5 MHz to 425 MHz | 1.5 MHz to 400 MHz | 30 MHz to 90 MHz | 225 MHz to 400 MHz |
| Notch Depth: | 20 dB | 20 dB | 20 dB | 35 dB (Min.) |
| Notch RF Power Handling: | 27 dBm (Typical)<br>(up to 5 Watts @ ± 20% Offset) | 27 dBm (Typical)<br>(up to 10 Watts @ ± 20% Offset) | 36 dBm (Typical)<br>(up to 50 Watts @ ± 20% Offset) | 28 dBm (Typical)<br>(up to 50 Watts @ ± 20% Offset) |
| 3 dB Bandwidth: | 7.5% (Typical) | 5% (Typical) | 4% (Typical) | 10 MHz (Typical) |
| Passband IP3: | +50 dBm | +50 dBm | +50 dBm | +50 dBm |
| DC Power Consumption (Static): | +5 VDC @ 10 to 250 mA<br>+100 VDC @ 2 mA | +5 VDC @ 10 to 500 mA<br>+100 VDC @ 2 mA | +5 VDC @ 400 mA to 1.5 A | +5 VDC @ 1.5 A (Max.)<br>+100 VDC @ 2 mA |
| Tuning Speed (Typical)*: | 10 µS | 10 µS | 20 µS | 40 µS |
| Size (H × W × L) in in.: | 0.6 × 1.4 × 2.3 | 1.5 × 2.5 × 3.3 | 2.6 × 3.0 × 4.0 | 3.1 × 3.5 × 7.0 |
| Size (H × W × L) in mm: | 15.2 × 35.6 × 58.4 | 38.1 × 63.5 × 83.8 | 66.7 × 76.2 × 101.6 | 79.4 × 88.9 × 177.8 |
| Weight (Typical) in oz.: | 3.2 | 9.2 | 18.7 | 56 |
| Weight (Typical) in g: | 90.7 | 260.8 | 530.1 g / 0.5 kg | 1588 g / 1.6 kg |

* Tuning Speed shown is a typical value for each filter series; the actual tune time can vary significantly based on frequency range and configuration. Please refer to the Switching Characteristics section of each filter series for the maximum tune time.

## Pre/Post-Selector

| Filter Series: | PSEL1003 |
|---|---|
| Operation: | Broadband Preselector |
| Frequency Coverage: | 20 to 3000 MHz |
| In-band IP3: | +3 dBm (Avg) |
| Noise Figure: | 8 dB (Avg) |
| Gain: | 20 dB ± 3 dB |
| Selectivity: | -35 dB @ ± 10%<br>-58 dB @ ± 20%<br>-65 dB @ ± 30% |
| Power: | +24V ± 5%<br>+12V ± 5%<br>2 Watts/path |
| Tuning Speed (Typical)*: | < 1 mS |
| Temperature Range: | -40º to +50ºC |
| Size (H × W × L) in in.: | Single: 1.0 × 6.5 × 5.0 (in.)<br>Dual: 1.0 × 8.0 × 9.5 (in.) |
| Size (H × W × L) in mm: | Single: 25.4 × 165.1 × 127.0 (mm.)<br>Dual: 25.4 × 203.2 × 241.3 (mm.) |
| Weight (Typical) in lbs.: | Single: 1.4 lbs.<br>Dual: 2.8 lbs. |
| Weight (Typical) in kg: | Single: .64 kg<br>Dual: 1.27 kg |


The **NANO-POLE®** is a low-cost, miniature, high-performance tunable filter with SPI customer interface. All filters are fully tested and aligned by Pole/Zero® for convenience and ease of use.

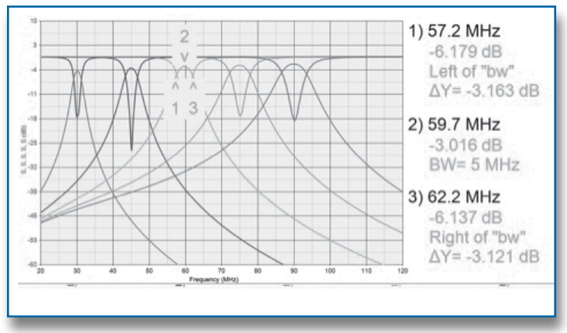
## NANO-POLE® SERIES

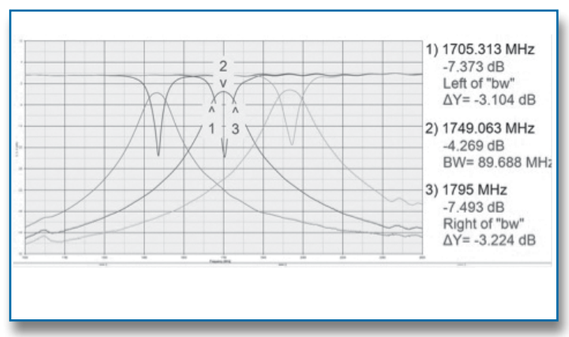
### Specifications:

| **Frequency Coverage (12 bands):** | **30 MHz to 3 GHz** |
|---|---|
| Input/Output Impedance: | 50Ω |
| In-band Input/Output VSWR: | 1.5:1 typical |
| In-band RF Power Handling: | +6 dBm (input) typical |
| Outband RF Power Handling: | +24 dBm |
| In-band Second Order Intercept Point: | +70 dBm |
| In-band Third Order Intercept Point: | +16 dBm typical |
| Center Frequency Drift: | 100 PPM/ºC |
| Tuning Control: | SPI |
| Tuning Speed: | 15 uS typical |
| DC Power Consumption (Static): | +3.3 VDC @ 20 mA typical |
| Shape Factor: | 6.9 typical |
| Operating Temperature Range: | -40°C to +85°C |
| Size: (30 to 3000 MHz): | .787 × .787 × .196 (in.) / 20 × 20 × 5 (mm.) |
| Weight: | .18 oz. / 5.1 g. |
| RF Connection: | SMT castellations |

### Performance:

The following plots illustrate approximate performance (not representative of all frequency ranges):



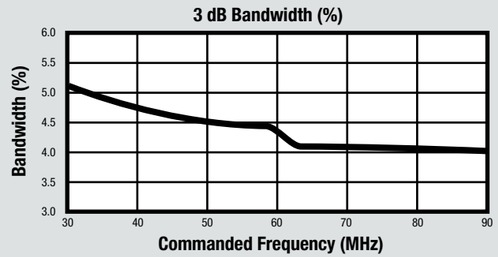





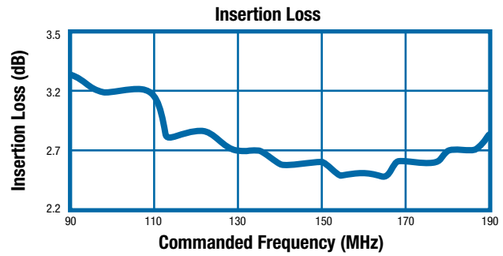

# Tunable Bandpass Filters

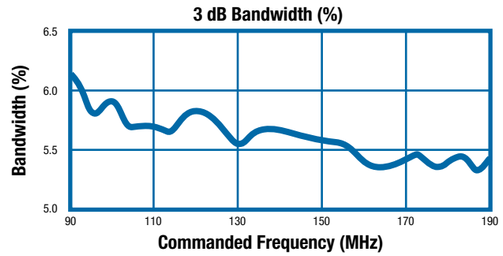
The following plots illustrate approximate insertion loss and bandwidth trends across a given frequency band, and the differences between various bands:

**NN-30-90-4**

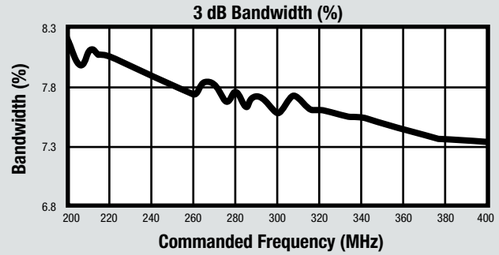




**NN-90-200-6**

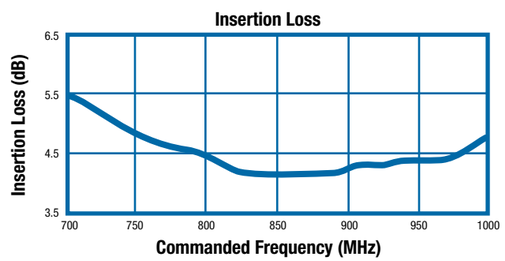


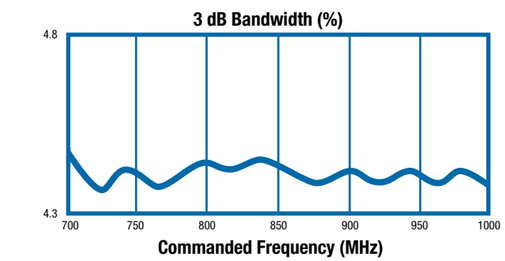




**NN-200-400-8**


**NN-700-1000-4**



## **NANO-POLE® SERIES** Selection Guide:

| Frequency Range | Suffix | % Bandwidth (3 dB) | Insertion Loss | Shape Factor (30 dB / 3 dB) | | |
|---|---|---|---|---|---|---|
| | | | | Overall | Low Side | High Side |
| 30 to 90 MHz | -3 | 3 | 8.33 | 7 | | |
| | -4 | 5 | 5 | 7 | | |
| | -10 | 10 | 2.5 | 7 | | |
| 90 to 200 MHz | -3 | 3 | 6.7 | 7 | | |
| | -5 | 5 | 4 | 7 | | |
| | -10 | 10 | 2 | 7 | | |
| 200 to 400 MHz | -3 | 3 | 8.33 | 7 | | |
| | -5 | 5 | 5 | 7 | | |
| | -10 | 9/11 | 2.5 | 7 | | |
| 225 to 512 MHz | -3 | 3 | 8.33 | 7 | | |
| | -5 | 5 | 5 | 7 | | |
| | -10 | 9/11 | 2.5 | 7 | | |
| 400 to 700 MHz | -3 | 3 | 8.33 | 7 | | |
| | -5 | 5 | 5 | 7 | | |
| | -10 | 10 | 2.5 | 7 | | |
| 700 to 1000 MHz | -3 | 3 | 8.33 | 7 | | |
| | -5 | 5 | 5 | 7 | | |
| | -10 | 10 | 2.5 | 7 | | |
| 1000 to 1500 MHz | -3 | 3 | 8.33 | 7 | | |
| | -5 | 4.8/5.5 | 4.3/5.3 | 6.8/7 | 6.6/6.8 | 7/7.1 |
| | -10 | 10 | 2.5 | 7 | | |
| 1500 to 2000 MHz | -3 | 3 | 8.33 | 7 | | |
| | -5 | 5.0/5.4 | 3.3/5.0 | 6.8/7.3 | 6.5/6.8 | 7/7.8 |
| | -10 | 10 | 2.5 | 7 | | |
| 2000 to 3000 MHz | -3 | 3 | 8.33 | 7 | | |
| | -5 | 5.3/5.8 | 6.5/7.9 | 7.6/9.8 | 7/7.7 | 7.4/12.5 |
| | -10 | 10 | 3.3 | 7 | | |

This Selection Guide illustrates approximate performance for the **NANO-POLE®** Series: Table values are shown as average/maximum.

Data shaded in blue is modeled and shown for reference only. Filter not in production at the time of printing.

## **NANO-POLE®** Series Product Number Guide:

| Series | Frequency (MHz) | % Bandwidth (3 dB) | Package |
|---|---|---|---|
| NN | 30-90<br>90-200<br>200-400<br>225-512<br>400-700<br>700-1000<br>1000-1500<br>1500-2000<br>2000-3000 | 3 thru 15 | S02 |

**Example:** Product # NN-30-90-3-S02

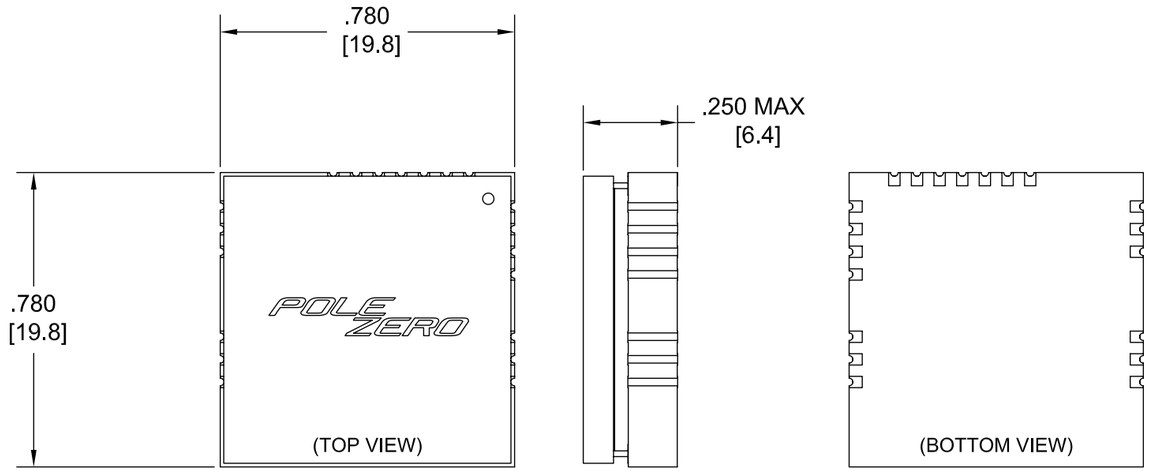
## Pinout & Ratings:

| PIN # | Reference Designator | Description | Maximum Ratings |
|---|---|---|---|
| 1 | MOSI | Master Output, Slave Input | -0.5 to ($V_{CC}$ + 0.5)V |
| 2 | MISO | Master Input, Slave Output | |
| 3 | SCLK | Serial Clock | |
| 4 | $\overline{CS}$ | Chip Select | |
| 5, 6, 8, 18-20 | N/C | No Connect[1] | – |
| 7 | $\overline{TUNE\_READY}$ | Tune Ready Output | – |
| 9, 11, 13, 14, 16, 17 | GND | Digital/RF Ground | – |
| 10 | $V_{CC}$ | +3.3V Power Supply Input | -0.3 to 4V |
| 12 | RF_IN | RF Input | +6 dBm, +24 dBm[2] |
| 15 | RF_OUT | RF Output | +6 dBm, +24 dBm[2] |

**Note(s):** 1 Leave floating for unit to function properly.
2 First number indicates maximum in-band power levels and second number indicates maximum out of band RF power levels either in CW or composite average for multi-tones.

## Mechanical Outline:

### S02: 30 - 3000 MHz




The **MINI-POLE®** Series of tunable filters is optimized for size, RF power handling, low distortion and exceptional selectivity. The product line includes several standard designs in various bands to support a myriad of applications. Approximate performance is summarized in the **MINI-POLE®** Series Selection Guide. Evaluation cards available for T01 package.

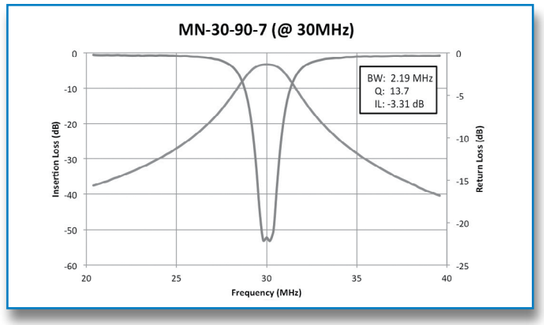
## MINI-POLE® SERIES

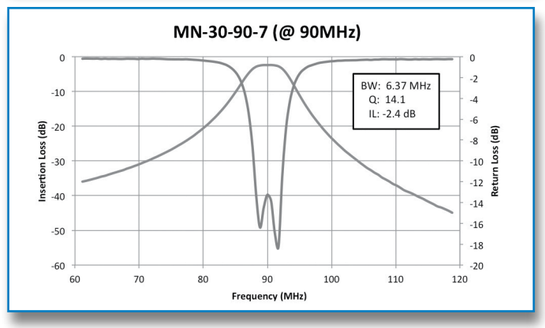
### Specifications: T02

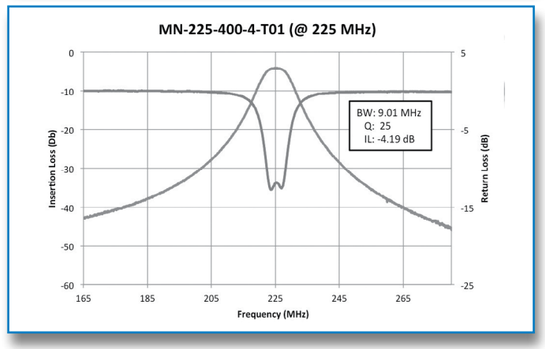
| | |
|---|---|
| **Frequency Coverage (9 bands):** | **1.5 MHz to 700 MHz** |
| Input/Output Impedance: | 50Ω |
| In-band Input/Output VSWR: | 1.5:1 typical |
| In-band RF Power Handling: | Up to 1 Watt |
| Outband RF Power Handling: | Up to 5 Watt |
| In-band Second Order Intercept Point: | +100 dBm (input) |
| In-band Third Order Intercept: | +40 dBm (input, $f_0$ > 30 MHz) |
| Center Frequency Drift: | -80 PPM/°C |
| Tuning Control: | 8 bit parallel |
| Tuning Speed: | 10 µS ($f_0$ > 30 MHz, +10 dBm reference)<br>200 µS ($f_0$ < 30 MHz, +10 dBm reference) |
| DC Power Consumption (Static): | +5 VDC @ 10 to 250 mA,<br>+100 VDC @ 2 mA |
| Shape Factor (30 dB/ 3 dB): | 6 typical |
| Operating Temperature Range: | -40°C to +85°C |
| Size: | 0.6 × 1.4 × 2.3 (in.) / 15.2 × 35.6 × 58.4 (mm.) |
| Weight: | 3.2 oz. / 90.7 g. |
| RF Connection: | Thru-hole pin |

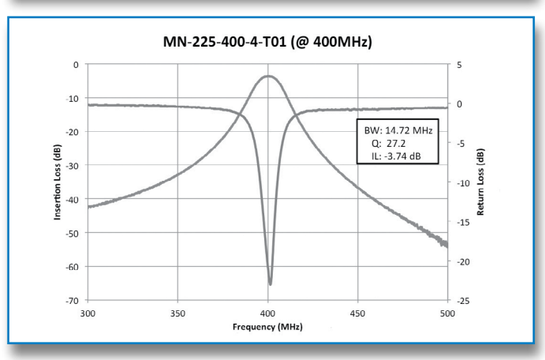
### Performance:

The following plots illustrate approximate performance (not representative of all frequency ranges):



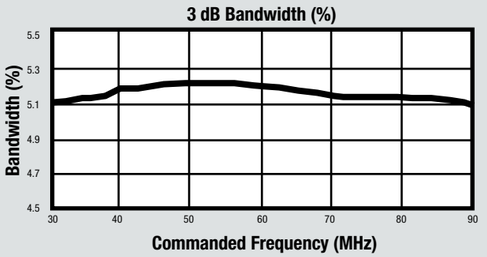





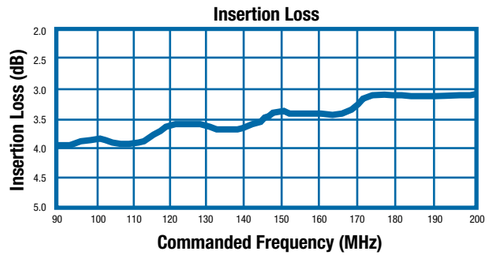

# Tunable Bandpass Filters

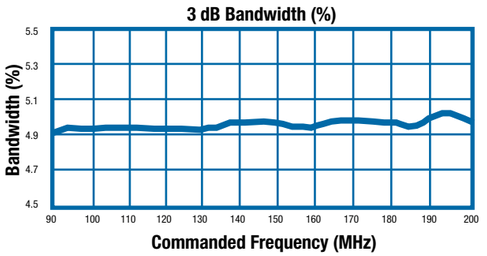
The following plots illustrate approximate insertion loss and bandwidth trends across a given frequency band, and the differences between various bands:

**MN-30-90-5**

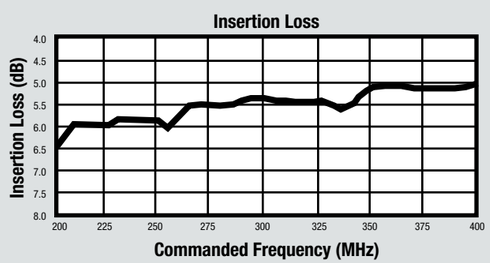



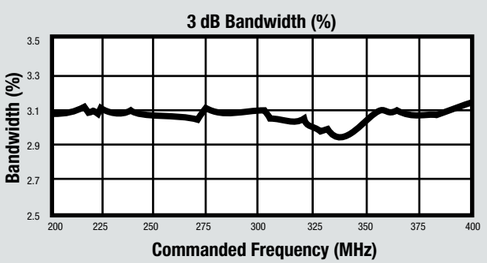

**MN-90-200-5**



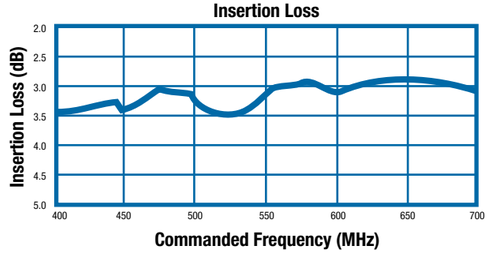



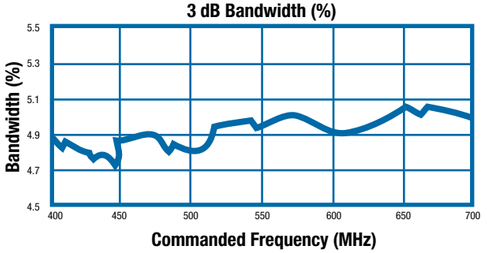

**MN-200-400-3**




**MN-400-700-5**



## **MINI-POLE® SERIES** Selection Guide

The following Selection Guide illustrates approximate performance for the **MINI-POLE®** Series. Table values are shown as average/maximum.

| Frequency Range | Suffix | % Bandwidth (3 dB) | Insertion Loss | Strobe Rate (max.) | Shape Factor (30 dB / 3 dB) Overall | Low Side | High Side | *Ultimate ($2 \times f_o$) |
|---|---|---|---|---|---|---|---|---|
| 1.5 to 4 MHz | -20 | | | 170 Hz | | | | |
| | -10 | 9.9/10.6 | 1.7/2.9 | | 6.0/6.5 | 7.1/8.0 | 4.9/5.3 | 55 dB |
| | -7 | 7.6/8.0 | 2.5/3.5 | | 5.6/5.8 | 6.1/6.5 | 5.1/5.3 | 60 dB |
| | -5 | 4.9/5.5 | 3.0/4.6 | | | | | 60 dB |
| | -4 | 4.0/4.5 | 4.2/5.7 | | 5.7/6.2 | 6.1/7.0 | 5.4/5.8 | 60 dB |
| | -3 | 3.0/3.5 | 4.4/6.4 | | 6.2/6.4 | 6.6/6.9 | 5.9/6.2 | 60 dB |
| 4 to 10 MHz | -20 | | | 170 Hz | | | | |
| | -10 | 10.0/10.6 | 1.8/2.7 | | 5.7/6.2 | 6.6/7.6 | 4.8/5.1 | 55 dB |
| | -7 | 7.2/7.9 | 2.4/3.5 | | 5.5/5.7 | 5.9/6.4 | 5.1/5.2 | 60 dB |
| | -5 | 5.0/5.5 | 3.1/4.2 | | 5.7/6.3 | 6.1/7.2 | 5.3/5.6 | 60 dB |
| | -4 | 4.2/4.5 | 3.4/5.0 | | 5.6/6.2 | 5.9/6.4 | 5.4/6.1 | 60 dB |
| | -3 | 3.1/3.5 | 5.0/8.0 | | 5.9/6.6 | 6.1/6.7 | 5.8/6.4 | 60 dB |
| 10 to 30 MHz | -20 | | | 840 Hz | | | | |
| | -10 | 9.7/11.0 | 1.8/2.7 | | 5.9/6.1 | 6.8/7.4 | 5.0/5.2 | 55 dB |
| | -7 | 7.5/7.9 | 2.4/3.0 | | 5.6/6.1 | 6.2/7.0 | 5.1/5.5 | 60 dB |
| | -5 | 5.1/5.5 | 3.5/4.4 | | 5.8/6.2 | 6.2/7.1 | 5.3/5.7 | 65 dB |
| | -4 | 4.0/4.4 | 4.2/6.1 | | 5.8/6.3 | 6.1/6.8 | 5.5/5.9 | 65 dB |
| | -3 | 3.2/3.5 | 5.2/7.1 | | 5.9/6.7 | 6.2/7.3 | 5.7/6.3 | 70 dB |
| 30 to 90 MHz | -20 | 20.2/21.7 | 1.0/1.2 | 1.5 kHz | 5.9/6.5 | 7.3/9.0 | 4.4/4.8 | 45 dB |
| | -10 | 10.3/10.9 | 1.8/2.7 | | 6.0/6.5 | 6.9/8.0 | 5.1/5.5 | 55 dB |
| | -7 | 6.9/7.9 | 2.7/3.6 | | 5.8/6.2 | 6.5/7.0 | 5.2/5.7 | 60 dB |
| | -5 | 5.2/5.5 | 3.9/4.6 | | 5.9/6.3 | 6.4/6.9 | 5.5/5.8 | 65 dB |
| | -4 | 3.9/4.5 | 4.8/6.3 | | 6.1/6.6 | 6.5/7.1 | 5.7/6.2 | 70 dB |
| | -3 | 3.2/3.5 | 6.8/8.5 | | 5.9/6.6 | 6.1/7.0 | 5.7/6.3 | 70 dB |
| 90 to 200 MHz | -20 | | | 1.8 kHz | | | | |
| | -10 | | | | | | | |
| | -7 | | | | | | | |
| | -5 | 5.0/5.5 | 3.5/4.6 | | 5.9/7.6 | 6.2/8.2 | 5.6/7.0 | 65 dB |
| | -4 | 4.0/4.5 | 4.4/6.3 | | 5.6/6.0 | 5.9/6.3 | 5.3/5.7 | 70 dB |
| | -3 | 3.0/3.5 | 6.2/8. | | 5.7/5.9 | 6.0/6.0 | 5.5/5.7 | 70 dB |
| 200 to 400 MHz | -20 | | | 2 kHz | | | | |
| | -10 | | | | | | | |
| | -7 | 6.7/7.9 | 2.1/3.5 | | 5.8/6.3 | 6.2/6.6 | 5.3/5.9 | 60 dB |
| | -5 | 5.0/5.5 | 3.1/4.6 | | 5.7/6.0 | 6.0/6.6 | 5.4/5.8 | 65 dB |
| | -4 | 3.8/4.5 | 4.5/6.3 | | 5.8/6.1 | 6.3/6.8 | 5.3/5.7 | 70 dB |
| | -3 | 3.0/3.5 | 5.8/8.5 | | 5.7/6.0 | 6.3/6.6 | 5.2/5.5 | 70 dB |
| 225 to 400 MHz | -20 | | | 2 kHz | | | | 45 dB |
| | -10 | 9.8/11.0 | 1.6/2.3 | | 5.8/6.2 | 7.0/7.7 | 4.5/5.0 | 55 dB |
| | -7 | | | | | | | |
| | -5 | 4.9/5.5 | 3.2/4.6 | | 5.4/5.9 | 5.7/6.0 | 5.2/5.8 | 65 dB |
| | -4 | 3.6/4.5 | 4.5/6.3 | | 5.6/5.7 | 6.1/6.3 | 5.1/5.3 | 70 dB |
| | -3 | 3.0/3.5 | 5.6/8.5 | | 5.6/6.0 | 6.1/6.5 | 5.1/5.5 | 70 dB |
| 225 to 512 MHz | -20 | | | 2 kHz | | | | 45 dB |
| | -10 | 9.8/11.0 | 1.6/2.7 | | 5.7/6.0 | 6.6/7.7 | 4.7/5.5 | 55 dB |
| | -7 | 7.2/8.0 | 2.1/3.6 | | 5.8/6.3 | 6.2/6.6 | 5.3/5.9 | 60 dB |
| | -5 | 5.0/5.5 | 3.3/4.7 | | 5.7/6.0 | 6.0/6.6 | 5.4/5.8 | 65 dB |
| | -4 | | | | | | | 70 dB |
| | -3 | | | | | | | 70 dB |
| 400 to 700 MHz | -20 | | | 2 kHz | | | | 45 dB |
| | -10 | | | | | | | 55 dB |
| | -7 | | | | | | | 60 dB |
| | -5 | 4.9/5.5 | 3.0/5.0 | | 5.8/6.4 | 6.4/7.9 | 5.1/5.8 | 65 dB |
| | -4 | | | | | | | |
| | -3 | | | | | | | |

* Typical performance, ultimate selectivity is not guaranteed

** Source/Load VSWR effects on power handling





## **MINI-POLE®** Filters Product Number Guide:

| Series | Frequency (MHz) | % Bandwidth (3 dB) | Package | Options |
|---|---|---|---|---|
| MN | 1.5-4<br>4-10<br>10-30<br>30-90<br>90-200<br>200-400<br>225-400<br>225-512<br>400-700 | -20<br>-10<br>-7<br>-5<br>-4<br>-3 | T01 (Standard)<br>T02 (Sealed) | B<br>C |

**Available Options:** B. Serial Interface
C. Custom Frequency Bands (Specify START and STOP frequencies in MHz)

**Note(s):** Options may be limited to particular frequency bands and/or performance levels. Consult factory for your application.

**Example:** Product # MN-90-200-7-T02

## Interface & Control Options:

### Frequency Tuning Address

There are 250 equally spaced tuning increments across each standard filter band, resulting in 251 tunewords from 00000000 to 11111010. The last 5 tunewords are reserved for housekeeping functions:

| Tune Code | Result |
|---|---|
| 00000000<br>thru<br>11111010 | Lowest tuned frequency<br>(251 total tune codes)<br>Highest tuned frequency |
| 111111011<br>thru<br>11111110 | RF In/Out Isolation<br>Filter Blanked |
| 11111111 | Power saver mode; all PIN diodes turned off |

### Calculating a Tune Address

The binary tuning word is determined by the following relationship:

$$\text{tuneword} = \left( \frac{F_{desired} - F_{low}}{F_{high} - F_{low}} \right) \times 250$$

**Example:** If you wish to tune to 322 MHz using a 225 to 400 MHz filter, the tuneword is:

$$\left( \frac{322 - 225}{400 - 225} \right) \times 250 = 138.57 \text{ (10001011 binary)}$$

**Note:** Round off to the nearest decimal integer.

Data is believed to be accurate. All data is subject to change without notice.

### Bias Voltage Requirement:

A bias voltage is required to reverse bias the PIN diodes used to tune the filter. Very little static current (less than 2 mA) is needed. A minimum of 30 Volts is recommended for proper filter operation. As this voltage is increased, the power handling capability and intermodulation are improved as shown below. A bias voltage of +100 VDC is recommended for best results, and all filters are tuned and aligned this way from the factory unless otherwise specified by the customer.

### Interface Options:

The filter comes standard with an 8 bit parallel interface, although a serial interface can be specified as an option.

### DC Control Interface Characteristics:

| Symbol | Parameter | Condition | Minimum | Maximum | Units |
|---|---|---|---|---|---|
| $V_{IL}$ | Input Low Voltage | Control signals except A0-A7 | 0.0 | 0.2 Vcc | V |
| $V_{IH}$ | Input High Voltage | Control signals except A0-A7 | 0.7 Vcc | Vcc | V |
| $V_{IL1}$ | Input Low Voltage | A0-A7 | 0.0 | 0.15 Vcc | V |
| $V_{IH1}$ | Input High Voltage | A0-A7 | 0.7 Vcc | Vcc | V |

### Switching Characteristics: (Vcc = +5 VDC, ± 10%; T = -40º to +85°C)

| Symbol | Parameter | Minimum | Maximum | Units |
|---|---|---|---|---|
| $t_S$ | Setup Time, A0-A7 to $\overline{STB}$ | 200 | | nS |
| $t_H$ | Hold Time, A0-A7 from $\overline{STB}$ | 6 | | µS |
| $t_{SH}$ | $\overline{STB}$ High Time | 25 | | µS |
| $t_W$ | $\overline{STB}$ Pulse Width | 20 | | nS |
| $t_{DW}$ | Strobe Dwell Time (from $\overline{STB}$ falling edge to next $\overline{STB}$ falling edge) | 500 | | µS |
| $t_{ACC}$ | Access Time from STB to $f_O$ | | 10 | µS |

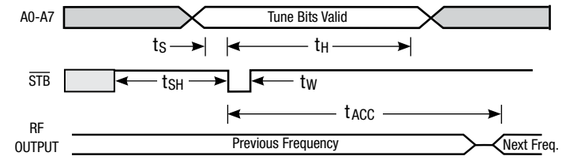



**Figure 6**

### Strobe

The filter is tuned within 10 µS (fo > 30 MHz) to the frequency designated by the tuneword existing on the eight control bit lines when the $\overline{STB}$ line is brought low. Once strobed, data existing on the tune control lines is ignored until strobed again. Consult the Selection Guide on page 12 for the maximum strobe rate in each frequency band.

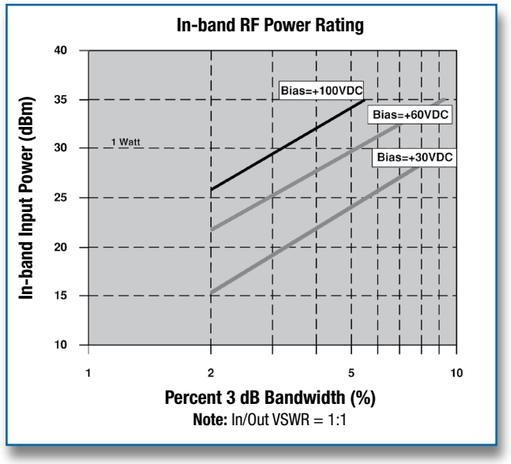
### RF Power Handling Capability

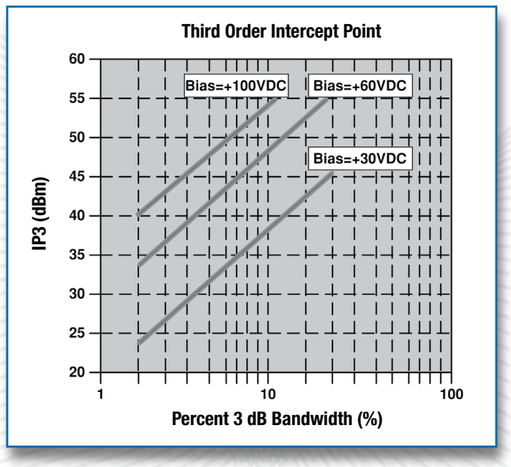
The filters are designed to operate with RF input power levels up to 1 Watt (+30 dBm) in-band. Signals in the filter stopband up to 5 Watts at the input will not cause damage to the filter.

### Temperature Effects

Over the -40ºC to +85°C temperature range, filters will exhibit a negative temperature drift of less than 80 PPM/°C, or a total of less than ± 0.5% of the center frequency.

## MINI-POLE® SERIES (Continued)




## Pinout & Ratings:

MINI-POLE®

| PARALLEL INTERFACE | | | |
|---|---|---|---|
| **PIN #** | **Reference Designator** | **Description** | **Maximum Ratings** |
| 1, 21 | RF I/O | RF Input/Output | +30 dBm |
| 2, 3, 5, 15, 16, 18-20, 22, 42 | GND | Digital/RF Ground | – |
| 4 | $V_{CC}$ | +5V Power Supply Input ± 10% | -0.5 to +6V |
| 6 | A7 | Parallel Bit 7 | -0.6 to +6.25V |
| 7 | A6 | Parallel Bit 6 | |
| 8 | A5 | Parallel Bit 5 | |
| 9 | A4 | Parallel Bit 4 | |
| 10 | A3 | Parallel Bit 3 | |
| 11 | A2 | Parallel Bit 2 | |
| 12 | A1 | Parallel Bit 1 | |
| 13 | A0 | Parallel Bit 0 | |
| 14 | $\overline{STB}$ | Strobe | -0.5 to ($V_{CC}$ + 0.5)V |
| 17 | $V_{BB}$ | High Bias +100V Supply Input | -0.5 to +125V |
| 23, 28-35 | N/C | No Connect (1) | – |
| 24-27, 36-41 | Filter Enable | Filter Enable Pins (2) | – |

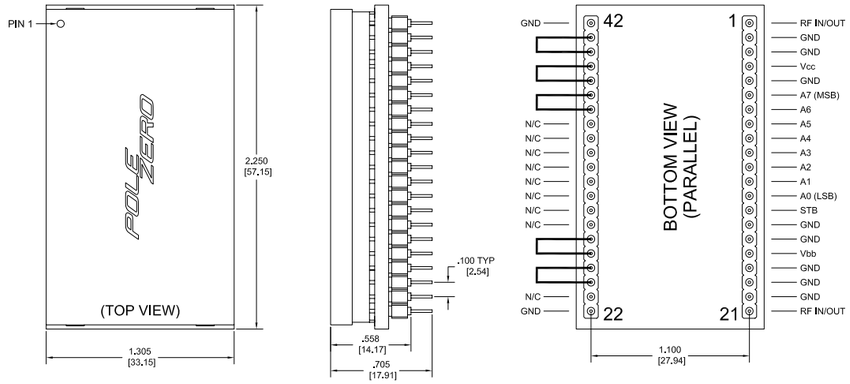
**Note(s):** 1 Leave pins disconnected for unit to function properly.
2 Pins must be jumpered as shown in package outline for filter to function properly.

| SERIAL INTERFACE | | | |
|---|---|---|---|
| **PIN #** | **Reference Designator** | **Description** | **Maximum Ratings** |
| 1, 21 | RF I/O | RF Input/Output | +30 dBm |
| 2, 3, 5, 15, 16, 18-20, 22, 42 | GND | Digital/RF Ground | – |
| 4 | $V_{CC}$ | +5V Power Supply Input ± 10% | -0.5 to +6V |
| 6-10, 23, 28-35 | N/C | No Connect (1) | – |
| 11 | SDO | Serial Data Out | -0.5 to ($V_{CC}$ + 0.5)V |
| 12 | SDI | Serial Data In | |
| 13 | SCLK | Serial Clock | |
| 14 | $\overline{STB}$ | Serial Strobe | |
| 17 | $V_{BB}$ | High Bias +100V Supply Input | 0 to +125V |
| 24-27, 36-41 | Filter Enable | Filter Enable Pins (2) | – |

**Note(s):** 1 Leave pin disconnected for unit to function properly.

## Mechanical Outline:

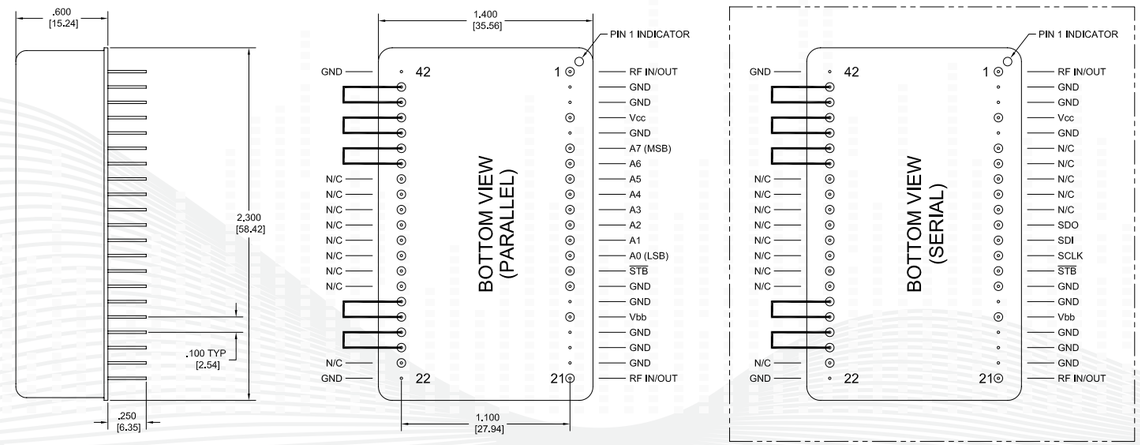
MINI-POLE® T01




**Note(s):** 1. Pin diameter is 0.020"
2. Pins must be jumpered as shown above
3. Custom pin lengths available upon request

## Mechanical Outline:

MINI-POLE® T02




**Note(s):** 1. Package can be gross leak tested upon request
2. Pin diameter is 0.020"
3. Pins must be jumpered as shown above
4. Some variations could have a pin length as low as 0.187


The **MINI-SMT™** Series of tunable filters was developed to address applications needing a small, surface mount package with higher power. Parallel or serial digital interface can be selected by a mode pin for ease of integration into your design and choose from a large variety of bandwidth and insertion loss combinations.

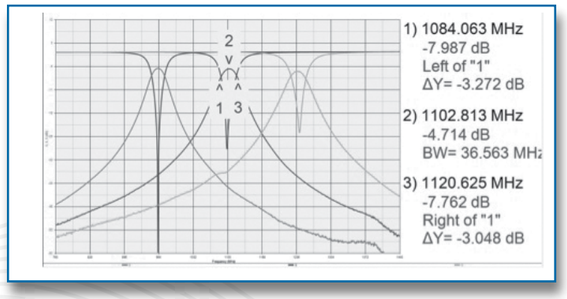
## MINI-SMT™ SERIES

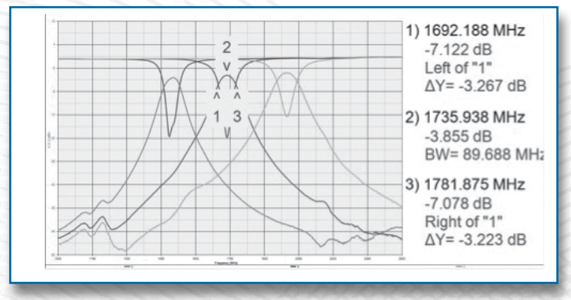
### Specifications:

| **Frequency Coverage (multiple bands): 700 MHz to 3000 MHz** | |
|---|---|
| Input/Output Impedance: | 50Ω |
| In-band Input/Output VSWR: | 1.5:1 typical, 2.2:1 max |
| In-band RF Power Handling: | +30 dBm (input) |
| Outband RF Power Handling: | +36 dBm (input) |
| In-band Second Order Intercept Point: | +100 dBm |
| In-band Third Order Intercept Point: | +40 dBm (input) |
| Center Frequency Drift: | 60 PPM/ºC |
| Tuning Control: | Parallel or Serial |
| Tuning Speed: | 4 µS |
| DC Power Consumption (Static): | 100 mA typical |
| Shape Factor (30 dB/ 3 dB): | 7 typical |
| Operating Temperature Range: | -40ºC to +85ºC |
| Size: | 1.50 × 1.50 × 0.25 (in.) / 38.1 × 38.1 × 6.35 (mm.) |
| Weight: | 0.6 oz. / 18 g. |
| RF Connection: | SMT castellation |

### Performance:

The following plots illustrate approximate performance:




### MINI-SMT® Filters Product Number Guide:

| Series | Frequency (MHz) | % Bandwidth (3 dB) | Package |
|---|---|---|---|
| MN | 700-1000<br>960-1240<br>1000-1500<br>1500-2000<br>2000-2500<br>2500-3000 | 5 | S03 |

**Example:** Product # MN-700-1000-5-S03



### Interface & Control Notes:

#### General Information

The **MINI-SMT®** filter requires only one +3.3 VDC supply voltage. An on-board +100 VDC DC-DC converter is included. If low frequency noise is of concern, then this supply can be disabled and an external +100 VDC supply may be used. This supply voltage should be adequately filtered as noise present on these pins will influence the RF signal purity.

#### Digital Interface Information

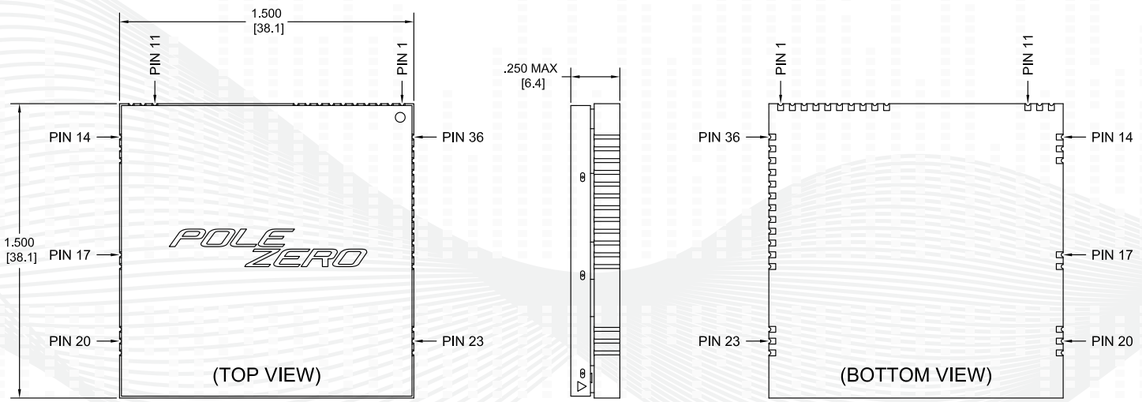
The digital interface format can be either SPI serial or parallel depending on the state of the mode control pin. All data input pins are 3.3V logic.

### MINI-SMT® SERIES Selection Guide:

| Frequency Range | Suffix | % Bandwidth (3 dB) | Insertion Loss | Shape Factor (30 dB / 3 dB) | | |
|---|---|---|---|---|---|---|
| | | | | Overall | Low Side | High Side |
| 700 to 1000 MHz | -5 | 4.7 | 3.65 | 6.5 | 6.45 | 6.48 |
| 960 to 1240 MHz | -3 | 3.2 | 4.95 | 7.0 | 7.2 | 6.5 |
| 1000 to 1500 MHz | -5 | 4.7 | 3.65 | 6.5 | 6.58 | 6.45 |
| 1250 to 1850 MHz | -5 | 5 | 3.8 | 6.8 | 6.3 | 7.6 |
| 1500 to 2000 MHz | -5 | 5.4 | 3.8 | 6.8 | 6.3 | 7.6 |
| 2000 to 2500 MHz | -5 | 4.9 | 3.55 | 7.3 | 8.6 | 6.1 |
| 2500 to 3000 MHz | -5 | 5.2 | 3.88 | 7.99 | 7.88 | 8.5 |

### Mechanical Outline:

S03

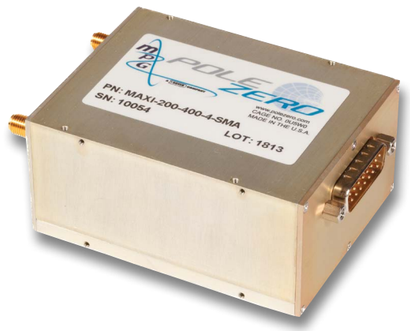



### Pinout & Ratings:

| PIN # | Reference Designator | Description | Maximum Ratings |
|---|---|---|---|
| 1, 2, 7, 8, 17, 27 | N/C | No Connect (1) | – |
| 3 | MOSI | Master Output, Slave Input | -0.5 to ($V_{CC}$ + 0.5)V |
| 4 | MISO | Master Input, Slave Output | |
| 5 | SCLK | Serial Clock | |
| 6 | $\overline{CS}$/$\overline{STB}$ | SPI Chip Select<br>Parallel Strobe | |
| 9 | SER/$\overline{PAR}$ | Serial/Parallel Mode Selection | |
| 10 | TUNE READY | Tune Ready Output | – |
| 11-16, 18, 19, 21-22, 24, 26, 36 | GND | Digital/RF Ground | – |
| 20 | RF IN | RF Input | +30 dBm, +37 dBm (2) |
| 23 | RF OUT | RF Output | +30 dBm, +37 dBm (2) |
| 25 | $V_{CC}$ | +3.3V Power Supply Input | -0.3 to 4V |
| 28 | A7 | Parallel Bit 7 | -0.5 to ($V_{CC}$ + 0.5)V |
| 29 | A6 | Parallel Bit 6 | |
| 30 | A5 | Parallel Bit 5 | |
| 31 | A4 | Parallel Bit 4 | |
| 32 | A3 | Parallel Bit 3 | |
| 33 | A2 | Parallel Bit 2 | |
| 34 | A1 | Parallel Bit 1 | |
| 35 | A0 | Parallel Bit 0 | -0.3 V to 4 V |

**Note(s):** 1. Leave pins disconnected for unit to function properly.

2. First number indicates maximum in-band power levels and second number indicates maximum out of band RF power levels either in CW or composite average for multi-tones.




The **MAXI-POLE®** Series of tunable filters provides improved passband performance (reduced insertion loss for a given bandwidth) in a slightly larger package. The product line includes several standard designs in various frequencies to support almost any application.

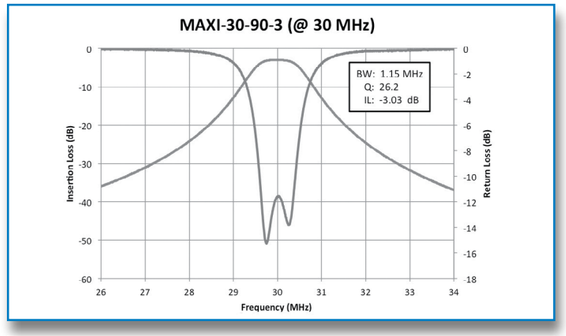
## MAXI-POLE® SERIES

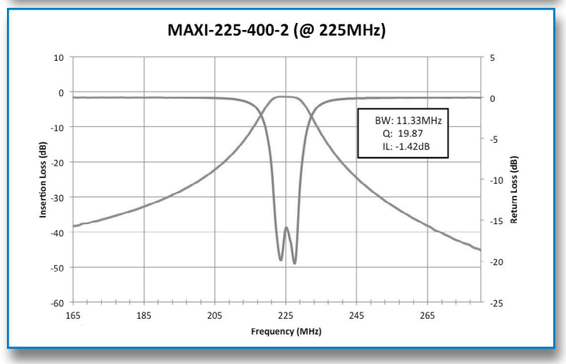
### Specifications:

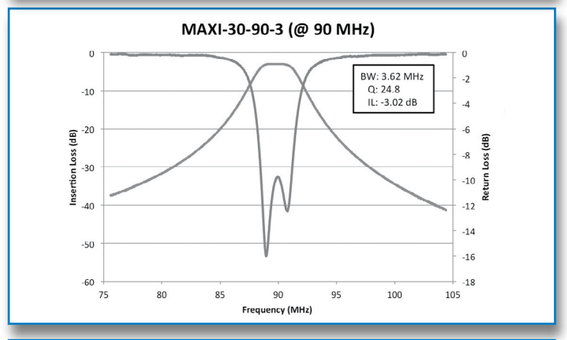
| | |
|---|---|
| **Frequency Coverage (8 bands):** | **1.5 MHz to 1 GHz** |
| Input/Output Impedance: | 50Ω |
| In-band Input/Output VSWR: | 1.5:1 typical |
| In-band RF Power Handling: | 1 Watt (input) |
| Outband RF Power Handling: | Up to 5 Watt |
| In-band Second Order Intercept Point: | +100 dBm (input) |
| In-band Third Order Intercept Point: | +40 dBm (input) |
| Center Frequency Drift: | -80 PPM/°C |
| Tuning Control: | 8 bit parallel |
| Tuning Speed: | 10 µS ($f_0$ > 30 MHz, +10 dBm reference) |
| DC Power Consumption (Static): | +5 VDC @ 10 to 500 mA<br>+100 VDC @ 2 mA |
| Shape Factor (30 dB/ 3 dB): | 6 typical |
| Operating Temperature Range: | -40°C to +85°C |
| Size: | 1.5 × 2.5 × 3.3 (in.) / 38.1 × 63.5 × 82.6 (mm.) |
| Weight: | 9.2 oz. / 260.8 g. |
| RF Connection: | SMA jack |

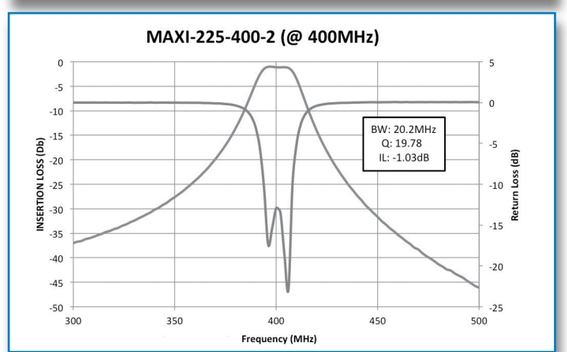
### Performance:

The following plots illustrate approximate performance (not representative of all frequency ranges):



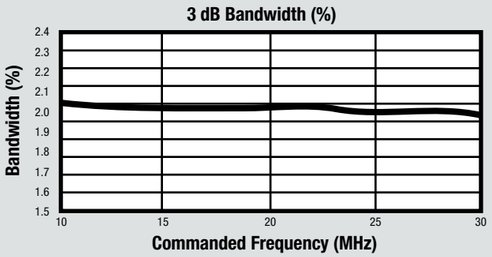





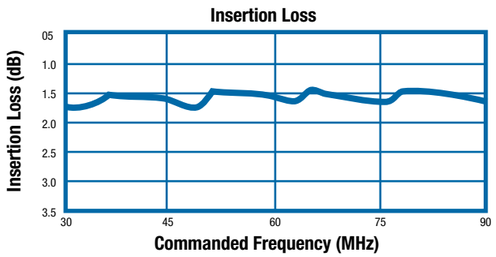

# Tunable Bandpass Filters

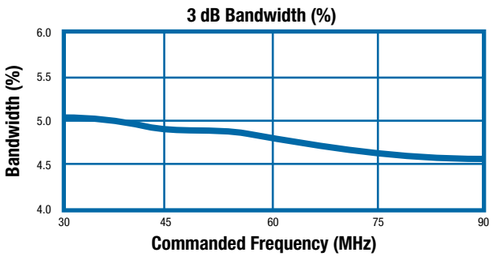
The following plots illustrate approximate insertion loss and bandwidth trends across a given frequency band, and the differences between various bands:

### MAXI-10-30-5

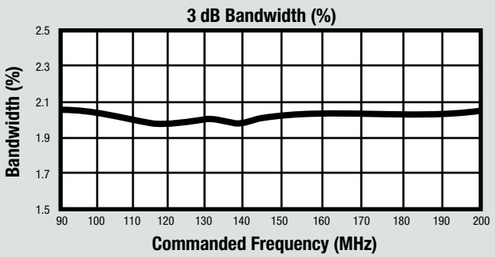




### MAXI-30-90-2

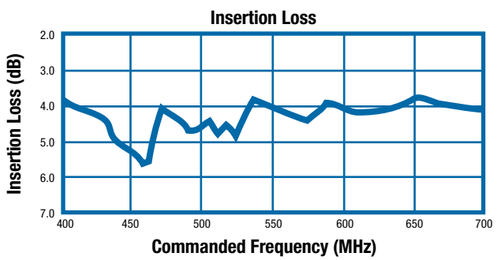


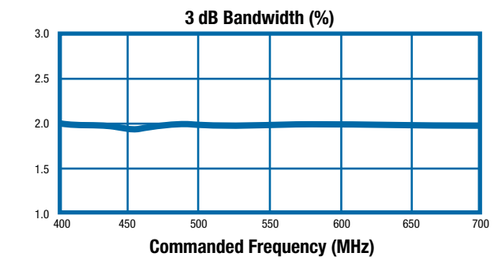




### MAXI-90-200-4


### MAXI-400-700-5



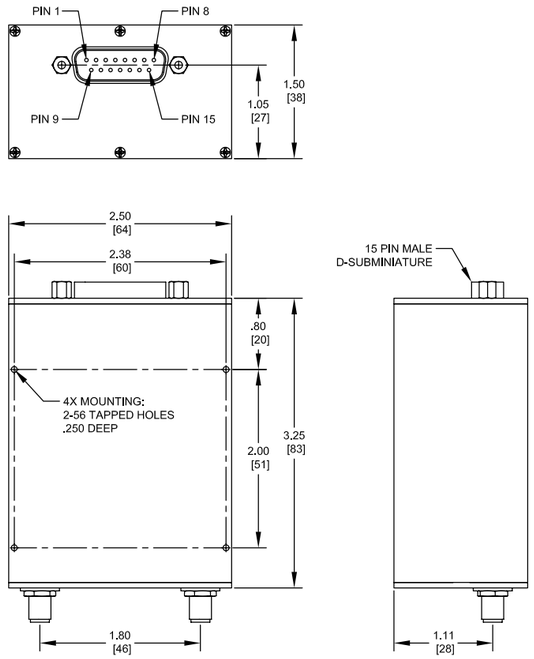

Data is believed to be accurate. All data is subject to change without notice.

## MAXI-POLE® SERIES Selection Guide:

The following Selection Guide illustrates approximate performance for the **MAXI-POLE®** Series. Table values are shown as average/maximum.

| Frequency Range | Suffix | % Bandwidth (3 dB) | Insertion Loss | Strobe Rate (max.) | SHAPE FACTOR (30 dB) Overall | Low Side | High Side |
|---|---|---|---|---|---|---|---|
| 1.5 to 4 MHz | -2 | 5.3/5.5 | 1.8/2.3 | 170 Hz | 5.8/6.1 | 6.8/7.3 | 4.8/4.9 |
| | -3 | | | | | | |
| | -4 | | | | | | |
| | -5 | | | | | | |
| 4 to 10 MHz | -2 | 5.3/5.5 | 1.8/2.3 | 170 Hz | 6.0/6.2 | 7.0/7.2 | 5.0/5.1 |
| | -3 | 3.4/3.8 | 2.2/3.5 | | 5.9/6.2 | 7.1/7.6 | 4.8/5.0 |
| | -4 | | | | | | |
| | -5 | 1.9/2.2 | 3.8/6.3 | | 6.1/6.2 | 6.9/7.0 | 5.3/5.4 |
| 10 to 30 MHz | -2 | 5.1/5.5 | 1.4/2.3 | 840 Hz | 6.1/6.3 | 7.0/7.4 | 5.1/5.2 |
| | -3 | 3.6/3.8 | 2.0/3.5 | | 6.1/6.5 | 7.3/8.0 | 4.9/5.2 |
| | -4 | 2.4/2.8 | 3.5/4.5 | | 5.9/6.0 | 6.6/6.7 | 5.2/5.4 |
| | -5 | 2.0/2.2 | 4.3/6.3 | | 5.8/6.1 | 6.6/7.2 | 5.0/6.1 |
| 30 to 90 MHz | -2 | 4.8/5.5 | 1.6/3.0 | 1.5 kHz | 6.7/7.7 | 9.2/11.3 | 4.2/4.6 |
| | -3 | 3.5/3.9 | 2.4/3.5 | | 5.9/6.3 | 6.6/7.6 | 5.2/6.0 |
| | -4 | 2.6/2.8 | 3.5/4.5 | | 5.8/5.9 | 6.8/7.1 | 4.8/4.9 |
| | -5 | 2.0/2.2 | 4.3/5.8 | | 5.5/6.3 | 6.3/7.3 | 4.7/5.3 |
| 90 to 200 MHz | -2 | 5.3/5.5 | 1.7/2.3 | 1.8 kHz | 5.9/6.1 | 6.9/7.4 | 4.9/5.1 |
| | -3 | 3.5/3.9 | 2.7/3.5 | | 5.8/6.0 | 6.7/7.2 | 4.9/5.1 |
| | -4 | 2.5/2.7 | 3.3/5.3 | | 5.8/6.1 | 6.7/7.0 | 5.0/5.2 |
| | -5 | 1.9/2.2 | 4.3/6.3 | | 5.8/6.3 | 6.4/7.0 | 5.1/5.6 |
| 200 to 400 MHz | -2 | 4.8/5.5 | 1.4/2.3 | 2 kHz | 5.9/6.5 | 7.3/8.1 | 4.6/5.0 |
| | -3 | 3.4/3.9 | 2.0/3.3 | | 5.9/6.3 | 6.9/7.5 | 4.9/5.1 |
| | -4 | 2.4/2.8 | 3.1/4.5 | | 5.8/6.3 | 6.5/7.1 | 5.0/5.3 |
| | -5 | 1.9/2.2 | 4.2/6.3 | | 5.7/6.3 | 6.5/7.1 | 5.0/5.5 |
| 225 to 400 MHz | -2 | 4.8/5.3 | 1.2/2.3 | 2 kHz | 6.4/6.6 | | |
| | -3 | 3.4/3.9 | 1.8/3.3 | | 6.4/6.6 | 8.4/9.1 | 4.4/4.6 |
| | -4 | 2.4/2.8 | 3.1/4.5 | | 6.2/6.7 | 7.6/9.0 | 4.7/5.1 |
| | -5 | 2.0/2.2 | 4.4/6.3 | | 5.8/6.0 | 6.5/6.9 | 5.0/5.2 |
| 400 to 700 MHz | -2 | 4.8/5.5 | 1.4/2.3 | 2 kHz | | | |
| | -3 | 3.4/3.9 | 2.3/3.6 | | 5.8/6.3 | 6.8/7.5 | 4.8/5.1 |
| | -4 | 2.5/2.9 | 3.2/4.6 | | 6.0/6.1 | 6.8/7.0 | 5.1/5.2 |
| | -5 | 1.9/2.2 | 4.3/6.3 | | 5.8/6.1 | 6.4/6.8 | 5.2/5.6 |
| 700 to 1000 MHz | -2 | 5.0/5.5 | 1.6/2.3 | 2 kHz | 5.6/5.8 | 5.9/6.1 | 5.4/5.9 |
| | -3 | | | | | | |
| | -4 | | | | | | |
| | -5 | 2.0/2.2 | 4.5/6.3 | | 5.8/6.1 | 6.1/6.4 | 5.5/5.7 |

## Mechanical Outline:




## Pinout & Ratings:

| PARALLEL INTERFACE | | | |
|---|---|---|---|
| **PIN #** | **Reference Designator** | **Description** | **Maximum Ratings** |
| 1 | A2 | Parallel Bit 2 | -0.5 to ($V_{CC}$ + 0.5) V |
| 2 | A3 | Parallel Bit 3 | |
| 3 | A4 | Parallel Bit 4 | |
| 4 | A5 | Parallel Bit 5 | |
| 5 | A6 | Parallel Bit 6 | |
| 6 | A7 | Parallel Bit 7 | |
| 7, 9, 11, 12 | GND | Digital/RF Ground | – |
| 8 | $V_{CC}$ | +5V Power Supply Input ±10% | -0.5 to +6 V |
| 10 | $V_{BB}$ | High Bias +100V Supply Input | 0 to +125 V |
| 13 | $\overline{STB}$ | Strobe | -0.5 to ($V_{CC}$ + 0.5) V |
| 14 | A0 | Parallel Bit 0 | |
| 15 | A1 | Parallel Bit 1 | |

| SERIAL INTERFACE | | | |
|---|---|---|---|
| **PIN #** | **Reference Designator** | **Description** | **Maximum Ratings** |
| 1 | SDO | Serial Data Out | -0.5 to ($V_{CC}$ + 0.5) V |
| 2-6 | N/C | No Connect (1) | – |
| 7, 9, 11, 12 | GND | Digital/RF Ground | – |
| 8 | $V_{CC}$ | +5V Power Supply Input ±10% | -0.5 to +6 V |
| 10 | $V_{BB}$ | High Bias +100V Supply Input | 0 to +125 V |
| 13 | $\overline{STB}$ | Strobe | -0.5 to ($V_{CC}$ + 0.5) V |
| 14 | SCLK | Serial Clock | |
| 15 | SDI | Serial Data In | |

**Note(s):** 1. Leave pins disconnected for unit to function properly.





## MAXI-POLE® Filters Product Number Guide:

| Series | Frequency (MHz) | Insertion Loss (dB) | Connector Type | Options |
|---|---|---|---|---|
| MAXI | 1.5-4<br>4-10<br>10-30<br>30-90<br>90-200<br>200-400<br>225-400<br>400-700<br>700-1000 | 1<br>2<br>3<br>4<br>5 | SMA (Female) | A<br>B<br>C<br>F |

**Available Options:** A. Internal DC-DC Converter (Eliminates need for high voltage supply. Requires additional 250 mA of 5 VDC current.)
B. Serial Interface
C. Custom Frequency Bands (Specify START and STOP frequencies in MHz.)
F. Filtered D-connector

**Note(s):**
1. Options may be limited to particular frequency bands and/or configurations. Consult factory for your application.
2. Filters are aligned and tested using a High Bias of +100 VDC unless otherwise specified by the customer.

**Example:** Product # MAXI-30-90-3-SMA

## Interface & Control Options:

### Frequency Tuning Address

There are 250 equally spaced tuning increments across each standard filter band, resulting in 251 tunewords from 00000000 to 11111010. The last 5 tunewords are reserved for housekeeping functions:

| Tune Code | Result |
|---|---|
| 00000000<br>thru<br>11111010 | Lowest tuned frequency<br>(251 total tune codes)<br>Highest tuned frequency |
| 111111011<br>thru<br>11111110 | RF In/Out Isolation<br>Filter Blanked |
| 11111111 | Power saver mode; all PIN diodes turned off |

### Calculating a Tune Address

The binary tuning word is determined by the following relationship:

$$\text{tuneword} = \left( \frac{F_{desired} - F_{low}}{F_{high} - F_{low}} \right) \times 250$$

**Example:** If you wish to tune to 322 MHz using a 225 to 400 MHz filter, the tuneword is:

$$\left( \frac{322 - 225}{400 - 225} \right) \times 250 = 138.57 \text{ (10001011 binary)}$$

**Note:** Round off to the nearest decimal integer.

Data is believed to be accurate. All data is subject to change without notice.

### Bias Voltage Requirement:

A bias voltage is required to reverse bias the PIN diodes used to tune the filter. Very little static current (less than 2 mA) is needed. A minimum of 30 Volts is recommended for proper filter operation. As this voltage is increased, the power handling capability and intermodulation are improved as shown below. A bias voltage of +100 VDC is recommended for best results, and all filters are tuned and aligned this way from the factory unless otherwise specified by the customer. An internal low EMI supply, powered from the +5 VDC input, is available as an option.

### Interface Options:

The filter comes standard with an 8 bit parallel interface, although a serial interface can be specified as an option.

### DC Control Interface Characteristics:

| Symbol | Parameter | Condition | Minimum | Maximum | Units |
|---|---|---|---|---|---|
| $V_{IL}$ | Input Low Voltage | Control signals except A0-A7 | 0.0 | 0.2 Vcc | V |
| $V_{IH}$ | Input High Voltage | Control signals except A0-A7 | 0.7 Vcc | Vcc | V |
| $V_{IL1}$ | Input Low Voltage | A0-A7 | 0.0 | 0.15 Vcc | V |
| $V_{IH1}$ | Input High Voltage | A0-A7 | 0.7 Vcc | Vcc | V |

### Switching Characteristics: (Vcc = +5 VDC, ± 10%; T = -40° to +85°C)

| Symbol | Parameter | Minimum | Maximum | Units |
|---|---|---|---|---|
| $t_S$ | Setup Time, A0-A7 to $\overline{STB}$ | 200 | | nS |
| $t_H$ | Hold Time, A0-A7 from $\overline{STB}$ | 6 | | µS |
| $t_{SH}$ | $\overline{STB}$ High Time | 25 | | µS |
| $t_W$ | $\overline{STB}$ Pulse Width | 20 | | nS |
| $t_{DW}$ | Strobe Dwell Time (from $\overline{STB}$ falling edge to next $\overline{STB}$ falling edge) | 500 | | µS |
| $t_{ACC}$ | Access Time from $\overline{STB}$ to $f_o$ | | 15 | µS |

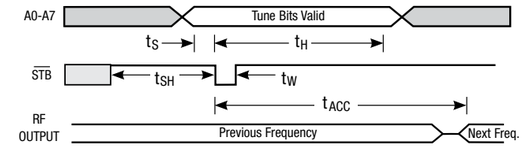



**Figure 7**

### Strobe

The filter is tuned within 10 µS (fo > 30 MHz, +10 dBm reference) to the frequency designated by the tuneword existing on the eight control bit lines when the $\overline{STB}$ line is brought low. Once strobed, data existing on the tune control lines is ignored until strobed again. Consult the Selection Guide on page 20 for the maximum strobe rate in each frequency band.

### RF Power Handling Capability

The filters are designed to operate with RF input power levels up to 1 Watt (+30 dBm) in-band (see graphs on page 26). Signals in the filter stopband up to 5 Watts at the input will not cause damage to the filter.

### Temperature Effects

Over the -40ºC to +85°C temperature range, filters will exhibit a negative temperature drift of less than 80 PPM/°C, or a total of less than ±0.5% of the center frequency.


The **MAXI/3** Series of tunable filters provides improved band rejection performance (over standard two pole MAXI series) in a slightly longer package. This tunable filter is optimized for size, RF power handling, low distortion and exceptional selectivity.

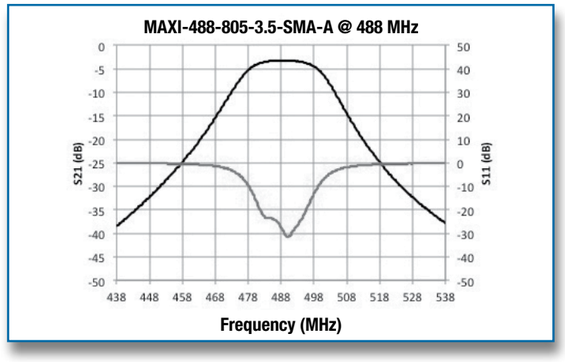
## MAXI/3 SERIES

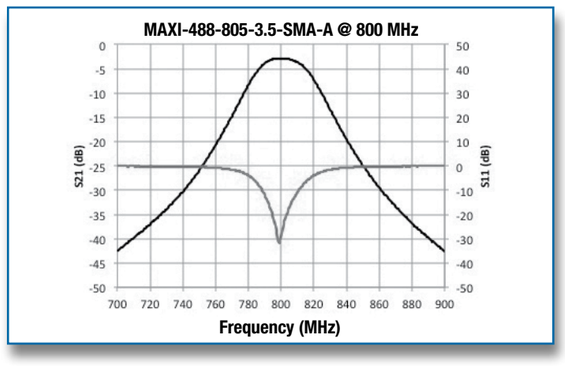
### Specifications:

| | |
|---|---|
| **Frequency Coverage:** | **300 to 805 MHz** |
| Input/Output Impedance: | 50Ω |
| In-band Input/Output VSWR: | 1.3:1 typical |
| In-band RF Power Handling: | 1 Watt (input) |
| Outband RF Power Handling: | 5 Watt (input) |
| In-band Second Order Intercept Point: | +100 dBm (input) |
| In-band Third Order Intercept Point: | +40 dBm (input) |
| Center Frequency Drift: | -80 PPM/ºC |
| Tuning Control: | 8 bit parallel |
| Tuning Speed: | < 25 µS |
| DC Power Consumption (Static): | +5 VDC @ 125 to 750 mA |
| Shape Factor (30 dB / 3 dB): | 3.3 to 3.75 typical, 4.0 max. |
| Operating Temperature Range: | -40°C to +85°C |
| Size: | 1.5 × 2.5 × 4.3 (in.) / 38.1 × 63.5 × 108 (mm.) |
| Weight: | 11.2 oz. / 317.5 g. |
| RF Connection: | SMA jack |

### Performance:

The following plots illustrate approximate performance:








### MAXI/3 Filters Product Number Guide:

| Series | Frequency (MHz) | Insertion Loss (dB) | Connector Type | Options |
|---|---|---|---|---|
| MAXI/3 | 300-550<br>500-805 | 3<br>3.5 | SMA (Female) | A<br>B<br>C<br>F |

**Available Options:** A. Internal DC-DC Converter (Eliminates need for high voltage supply. Requires additional 250 mA of 5 VDC current.)
B. Serial Interface
C. Custom Frequency Bands (Specify START and STOP frequencies in MHz.)
F. Filtered D-connector

**Note(s):** 1. Options may be limited to particular frequency bands and/or configurations. Consult factory for your application.
2. Filters are aligned and tested using a High Bias of +100 VDC unless otherwise specified by the customer.

**Example:** Product # MAXI-300-550-3-SMA-AF

## Interface & Control Options:

### Frequency Tuning Address

There are 250 equally spaced tuning increments across each standard filter band, resulting in 251 tunewords from 00000000 to 11111010. The last 5 tunewords are reserved for housekeeping functions:

| Tune Code | Result |
|---|---|
| 00000000<br>thru<br>11111010 | Lowest tuned frequency<br>(251 total tune codes)<br>Highest tuned frequency |
| 111111011<br>thru<br>11111110 | RF In/Out Isolation<br>Filter Blanked |
| 11111111 | Power saver mode; all PIN diodes turned off |

### Calculating a Tune Address

The binary tuning word is determined by the following relationship:

$$\text{tuneword} = \left( \frac{F_{desired} - F_{low}}{F_{high} - F_{low}} \right) \times 250$$

**Example:** If you wish to tune to 322 MHz using a 225 to 400 MHz filter, the tuneword is:

$$\left( \frac{322 - 225}{400 - 225} \right) \times 250 = 138.57 \text{ (10001011 binary)}$$

**Note:** Round off to the nearest decimal integer.



### Bias Voltage Requirement:

A bias voltage is required to reverse bias the PIN diodes used to tune the filter. Very little static current (less than 2 mA) is needed. A minimum of 30 Volts is recommended for proper filter operation. As this voltage is increased, the power handling capability and intermodulation are improved as shown below. A bias voltage of +100 VDC is recommended for best results, and all filters are tuned and aligned this way from the factory unless otherwise specified by the customer. An internal low EMI supply, powered from the +5 VDC input, is available as an option.

### Interface Options:

The filter comes standard with an 8 bit parallel interface, although a serial interface can be specified as an option.

### DC Control Interface Characteristics:

| Symbol | Parameter | Condition | Minimum | Maximum | Units |
|---|---|---|---|---|---|
| $V_{IL}$ | Input Low Voltage | Control signals except A0-A7 | 0.0 | 0.2 Vcc | V |
| $V_{IH}$ | Input High Voltage | Control signals except A0-A7 | 0.7 Vcc | Vcc | V |
| $V_{IL1}$ | Input Low Voltage | A0-A7 | 0.0 | 0.15 Vcc | V |
| $V_{IH1}$ | Input High Voltage | A0-A7 | 0.7 Vcc | Vcc | V |

### Switching Characteristics: (Vcc = +5 VDC, ± 10%; T = -40º to +85°C)

| Symbol | Parameter | Minimum | Maximum | Units |
|---|---|---|---|---|
| $t_S$ | Setup Time, A0-A7 to $\overline{STB}$ | 200 | | nS |
| $t_H$ | Hold Time, A0-A7 from $\overline{STB}$ | 6 | | µS |
| $t_{SH}$ | $\overline{STB}$ High Time | 25 | | µS |
| $t_W$ | $\overline{STB}$ Pulse Width | 20 | | nS |
| $t_{DW}$ | Strobe Dwell Time (from $\overline{STB}$ falling edge to next $\overline{STB}$ falling edge) | 500 | | µS |
| $t_{ACC}$ | Access Time from $\overline{STB}$ to $f_0$ | | 15 | µS |

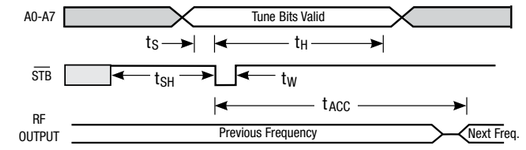



**Figure 8**

### Strobe

The filter is tuned within 25 µS to the frequency designated by the tuneword existing on the eight control bit lines when the $\overline{STB}$ line is brought low. Once strobed, data existing on the tune control lines is ignored until strobed again. Consult the MAXI-POLE® Selection Guide on page 20 for the maximum strobe rate in each frequency band.

### RF Power Handling Capability

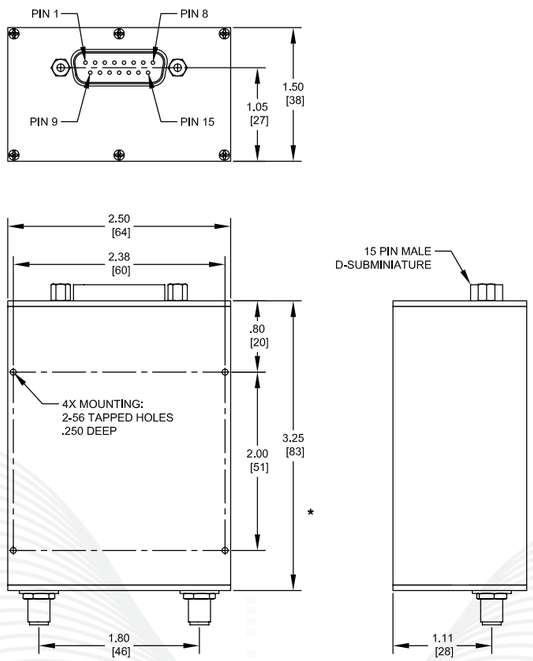
The filters are designed to operate with RF input power levels up to 1 Watt (+30 dBm) in-band (see graphs on page 26). Signals in the filter stopband up to 5 Watts at the input will not cause damage to the filter.

### Temperature Effects

Over the -40ºC to +85°C temperature range, filters will exhibit a negative temperature drift of less than 80 PPM/°C, or a total of less than ±0.5% of the center frequency.

## MAXI/3 SERIES (Continued)

### Mechanical Outline:




### Pinout & Ratings:

| PIN # | Reference Designator | Description | Maximum Ratings |
|---|---|---|---|
| 1 | A2 | Parallel Bit 2 | -0.5 to ($V_{CC}$ + 0.5) V |
| 2 | A3 | Parallel Bit 3 | |
| 3 | A4 | Parallel Bit 4 | |
| 4 | A5 | Parallel Bit 5 | |
| 5 | A6 | Parallel Bit 6 | |
| 6 | A7 | Parallel Bit 7 | |
| 7, 9, 11, 12 | GND | Digital/RF Ground | – |
| 8 | $V_{CC}$ | +5V Power Supply Input ± 10% | -0.5 to +6 V |
| 10 | $V_{BB}$ | High Bias +100V Supply Input | 0 to +125 V |
| 13 | $\overline{STB}$ | Strobe | -0.5 to ($V_{CC}$ + 0.5) V |
| 14 | A0 | Parallel Bit 0 | |
| 15 | A1 | Parallel Bit 1 | |

### **MAXI/3 SERIES** Selection Guide:

| Frequency Range | Suffix | % Bandwidth (3 dB) | Insertion Loss | Strobe Rate (max.) | SHAPE FACTOR (30 dB) Overall | Low Side | High Side |
|---|---|---|---|---|---|---|---|
| 300 to 550 MHz | -3 | 5.5/5.9 | 2.3/3.5 | 2 KHz | 3.7/4.0 | 3.4/3.6 | 4.0/4.3 |
| 500 to 805 MHz | -3.5 | 4.3/5.0 | 3.3/4.0 | 2 KHz | 3.7/4.0 | 3.4/3.6 | 4.0/4.3 |






The **MAXI/4R** Series of tunable filters provides 4-poles of filtering, for even better rejection than our standard MAXI-POLE® filters. The chassis has been ruggedized to better handle the vibration and shock environments often encountered in customer applications (ie. ground-mobile, airborne, etc.). The product line includes several standard designs in various frequencies to support almost any application.

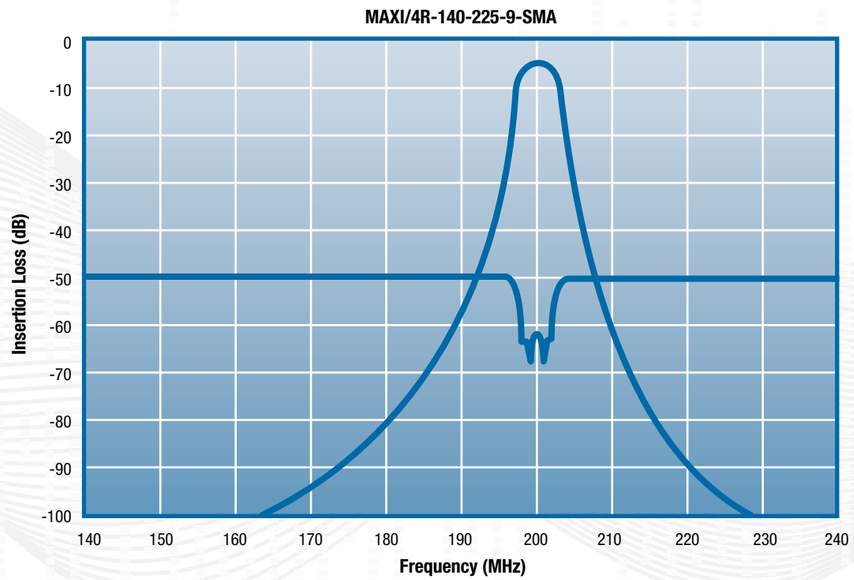
## MAXI/4R SERIES

### Specifications:

| | |
|---|---|
| **Frequency Coverage:** | **140 to 225 MHz** |
| Input/Output Impedance: | 50Ω |
| In-band Input/Output VSWR: | 1.5:1 typical |
| In-band RF Power Handling: | 1 Watt (input) |
| Outband RF Power Handling: | Up to 5 Watt |
| In-band Second Order Intercept Point: | +100 dBm (input) |
| In-band Third Order Intercept Point: | +40 dBm (input) |
| Center Frequency Drift: | -80 PPM/°C |
| Tuning Control: | 8 bit parallel |
| Tuning Speed: | 50 µS |
| DC Power Consumption (Static): | +5 VDC @ 20 to 1500 mA<br>+100 VDC @ 2 mA |
| Shape Factor (30 dB / 3 dB): | 3.3 to 3.75 typical |
| Operating Temperature Range: | -40°C to +85°C |
| Size: | 3.1 × 3.5 × 7.0 (in.) / 79.4 × 91.4 × 177.8 (mm.) |
| Weight: | 43.2 oz. / 1225 g. / 1.2 kg. |
| RF Connection: | SMA jack |

### Performance:

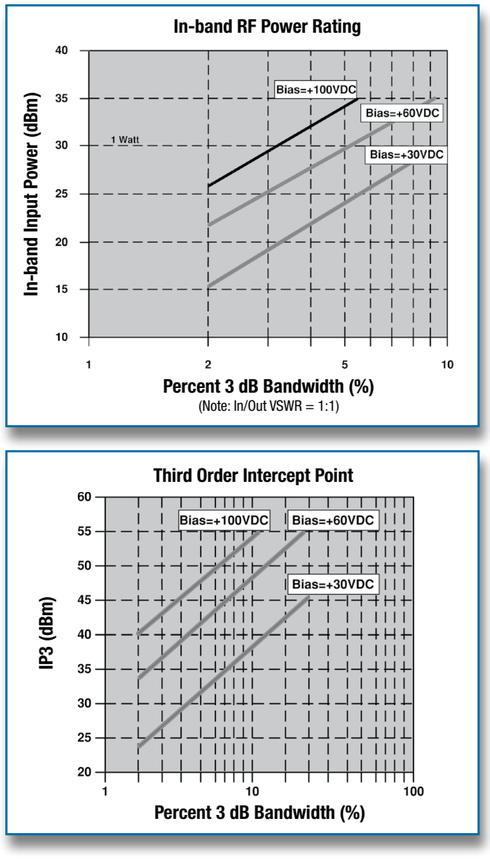
The following plot illustrates approximate performance (not representative of all frequency ranges):



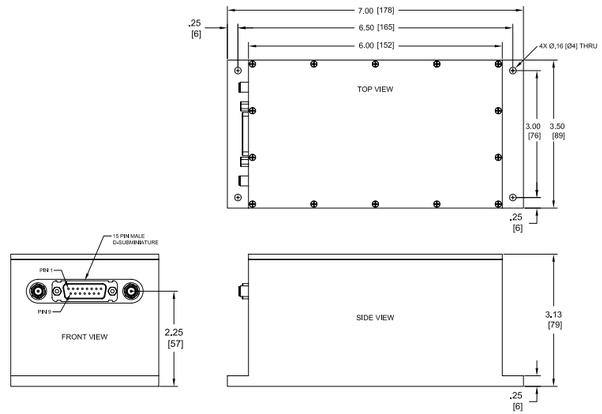
## MAXI/4R SERIES (Continued)

### Interface Options:

The filter comes standard with an 8 bit parallel interface, although a serial interface can be specified as an option.




### Mechanical Outline:




### Pinout & Ratings:

| PARALLEL INTERFACE | | | |
|---|---|---|---|
| **PIN #** | **Reference Designator** | **Description** | **Maximum Ratings** |
| 1 | A2 | Parallel Bit 2 | -0.5 to ($V_{CC}$ + 0.5) V |
| 2 | A3 | Parallel Bit 3 | |
| 3 | A4 | Parallel Bit 4 | |
| 4 | A5 | Parallel Bit 5 | |
| 5 | A6 | Parallel Bit 6 | |
| 6 | A7 | Parallel Bit 7 | |
| 7, 9, 11, 12 | GND | Digital/RF Ground | – |
| 8 | $V_{CC}$ | +5V Power Supply Input ±10% | -0.5 to +6 V |
| 10 | $V_{BB}$ | High Bias +100V Supply Input | 0 to +125 V |
| 13 | $\overline{STB}$ | Strobe | -0.5 to ($V_{CC}$ + 0.5) V |
| 14 | A0 | Parallel Bit 0 | |
| 15 | A1 | Parallel Bit 1 | |

| SERIAL INTERFACE | | | |
|---|---|---|---|
| **PIN #** | **Reference Designator** | **Description** | **Maximum Ratings** |
| 1 | SDO | Serial Data Out | -0.5 to ($V_{CC}$ + 0.5) V |
| 2-6 | N/C | No Connect (1) | — |
| 7, 9, 11, 12 | GND | Digital/RF Ground | — |
| 8 | $V_{CC}$ | +5 V Power Supply Input ±10% | -0.5 to +6 V |
| 10 | $V_{BB}$ | High Bias +100 V Supply Input | 0 to +125 V |
| 13 | $\overline{STB}$ | Strobe | -0.5 to ($V_{CC}$ + 0.5) V |
| 14 | SCLK | Serial Clock | |
| 15 | SDI | Serial Data In | |

**Note(s):** 1 Leave pins disconnected for unit to function properly.





### MAXI/4R Filters Product Number Guide:

| Series | Frequency (MHz) | Insertion Loss (dB) | Connector Type | Options |
|---|---|---|---|---|
| MAXI/4R | 140-225 | 9 | SMA (Female) | A<br>B<br>C<br>F |

**Available Options:** A. Internal DC-DC Converter (Eliminates need for high voltage supply. Requires additional 250 mA of 5 VDC current.)
B. Serial Interface
C. Custom Frequency Bands (Specify START and STOP frequencies in MHz.)
F. Filtered D-connector

**Note(s):**
1. Options may be limited to particular frequency bands and/or performance levels. Consult factory for your application.
2. Filters are aligned and tested using a High Bias of +100 VDC unless otherwise specified by the customer.

**Example:** Product # MAXI/4R-140-225-9-SMA

## Interface & Control Options:

### Frequency Tuning Address

MAXI-POLE® Series filters utilize an 8 bit scheme for tunewords to digitally control tuning of the center frequency. There are 250 equally spaced tuning increments across each standard filter band, resulting in 251 tunewords from 00000000 to 11111010. The last 5 tunewords are reserved for housekeeping functions:

| Tune Code | Result |
|---|---|
| 00000000<br>thru<br>11111010 | Lowest tuned frequency<br>(251 total tune codes)<br>Highest tuned frequency |
| 111111011<br>thru<br>11111110 | RF In/Out Isolation<br>Filter Blanked |
| 11111111 | Power saver mode; all PIN diodes turned off |

### Calculating a Tune Address

The binary tuning word is determined by the following relationship:

$$\text{tuneword} = \left( \frac{F_{desired} - F_{low}}{F_{high} - F_{low}} \right) \times 250$$

**Example:** If you wish to tune to 322 MHz using a 225 to 400 MHz filter, the tuneword is:

$$\left( \frac{322 - 225}{400 - 225} \right) \times 250 = 138.57 \text{ (10001011 binary)}$$

**Note:** Round off to the nearest decimal integer.

Data is believed to be accurate. All data is subject to change without notice.

### Bias Voltage Requirement:

A bias voltage is required to reverse bias the PIN diodes used to tune the filter. Very little static current (less than 2 mA) is needed. A minimum of 30 Volts is recommended for proper filter operation. As this voltage is increased, the power handling capability and intermodulation are improved as shown on the right. A bias voltage of +100 VDC is recommended for best results, and all filters are tuned and aligned this way from the factory unless otherwise specified by the customer. An internal low EMI supply, powered from the +5 VDC input, is available as an option.

### DC Control Interface Characteristics:

| Symbol | Parameter | Condition | Minimum | Maximum | Units |
|---|---|---|---|---|---|
| $V_{IL}$ | Input Low Voltage | Control signals except A0-A7 | 0.0 | 0.2 Vcc | V |
| $V_{IH}$ | Input High Voltage | Control signals except A0-A7 | 0.7 Vcc | Vcc | V |
| $V_{IL1}$ | Input Low Voltage | A0-A7 | 0.0 | 0.15 Vcc | V |
| $V_{IH1}$ | Input High Voltage | A0-A7 | 0.7 Vcc | Vcc | V |

### Switching Characteristics: (Vcc = +5 VDC, ± 10%; T = -40º to +85°C)

| Symbol | Parameter | Minimum | Maximum | Units |
|---|---|---|---|---|
| $t_S$ | Setup Time, A0-A7 to $\overline{STB}$ | 100 | | nS |
| $t_H$ | Hold Time, A0-A7 from $\overline{STB}$ | 6 | | µS |
| $t_{SH}$ | $\overline{STB}$ High Time | 25 | | µS |
| $t_W$ | $\overline{STB}$ Pulse Width | 100 | | nS |
| $t_{DW}$ | Strobe Dwell Time (from $\overline{STB}$ falling edge to next $\overline{STB}$ falling edge) | 500 | | µS |
| $t_{ACC}$ | Access Time from STB to $f_0$ | | 50 | µS |

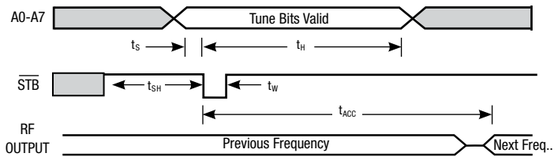



**Figure 9**

### Strobe

The filter is tuned within 50 µS to the frequency designated by the tuneword existing on the eight control bit lines when the $\overline{STB}$ line is brought low. Once strobed, data existing on the tune control lines is ignored until strobed again. Consult the MAXI-POLE® Selection Guide on page 20 for the maximum strobe rate in each frequency band.

### RF Power Handling Capability

The filters are designed to operate with RF input power levels up to 1 Watt (+30 dBm) in-band (see graphs on page 26). Signals in the filter stopband up to 5 Watts at the input will not cause damage to the filter.

### Temperature Effects

Over the -40ºC to +85°C temperature range, filters will exhibit a negative temperature drift of less than 80 PPM/°C, or a total of less than ±0.5% of the center frequency.

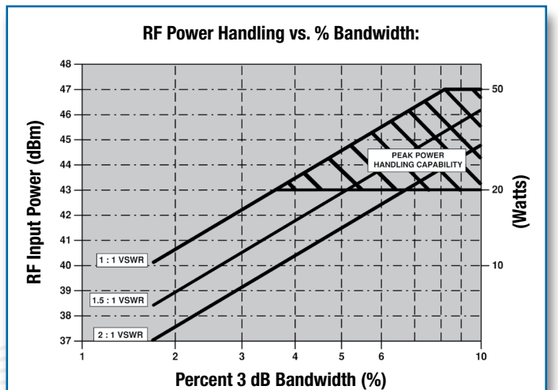
The **POWER-POLE®** Series of tunable filters provides improved RF performance with increased power handling capability and the lowest insertion loss for a given bandwidth. The product line includes several standard designs in various frequencies to support almost any application.

## POWER-POLE® SERIES

### Specifications:

| | |
|---|---|
| **Frequency Coverage (Multiple Bands):** | **30 to 400 MHz** |
| Input/Output Impedance: | 50Ω |
| In-band Input/Output VSWR: | 1.5:1 typical |
| In-band RF Power Handling: | refer to chart below |
| Outband RF Power Handling: | Up to 20 Watt |
| In-band Second Order Intercept Point: | +100 dBm (input) |
| In-band Third Order Intercept Point: | +50 dBm (input) |
| Center Frequency Drift: | -80 PPM/°C |
| Tuning Control: | 8 bit parallel |
| Tuning Speed: | 15 µS* |
| DC Power Consumption (Static): | +5 VDC @ 400 mA to 1.5 A |
| Shape Factor (30 dB / 3 dB): | 6 typical |
| Operating Temperature Range: | -40°C to +65°C |
| Size: | 2.6 × 3.0 × 4.0 (in.) / 66.7 × 76.2 × 101.6 (mm.) |
| Weight: | 18.7 oz. / 530.1 g. / .5 kg. |
| RF Connection: | SMA jack |

* 15 µS typical for UHF band filters. Consult factory for details on other bands.




### Important Application Notes:

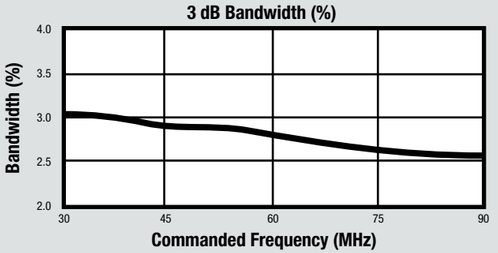
- While changing RF center frequencies, RF input power must be reduced to < +20 dBm. These filters will not support "Hot RF Switching Conditions". Please contact the factory in regards to custom features.
- Maximum strobe rate is 2 kHz; Actual rate is dependent upon frequency band.



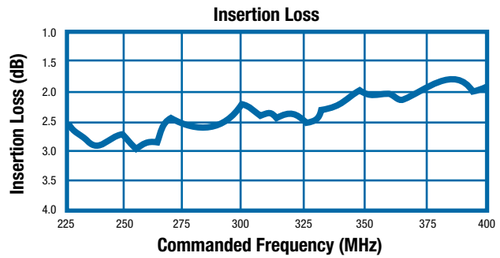


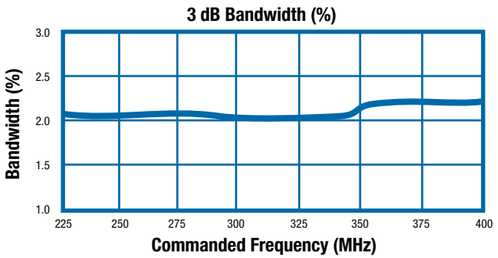
The following plots illustrate approximate insertion loss and bandwidth trends across a given frequency band, and the differences between various bands:

**POWER-30-90-3**

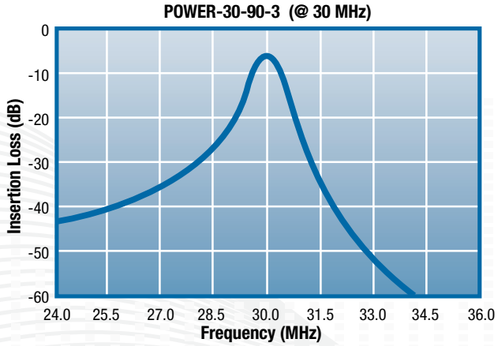

**POWER-225-400-4**

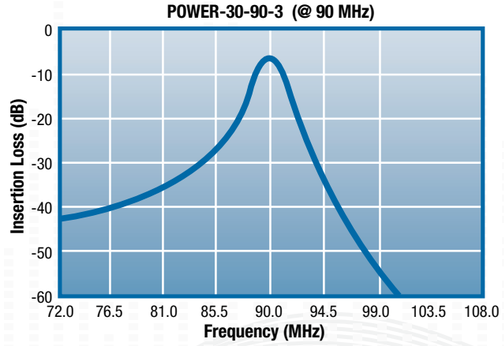


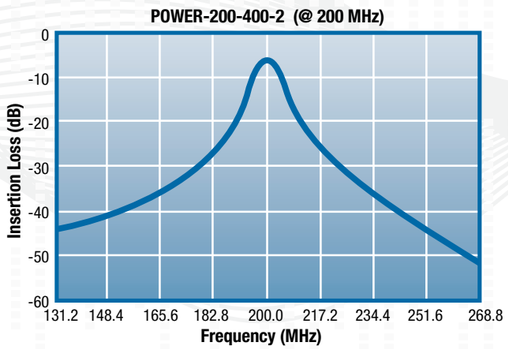



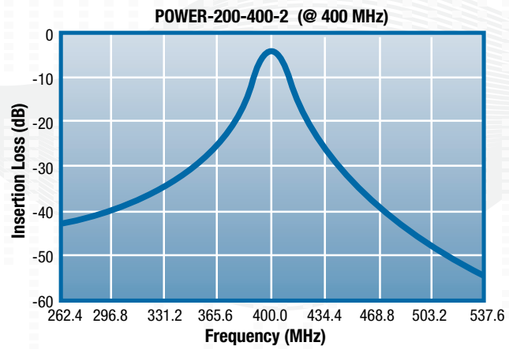

### Performance:

The following plot illustrates approximate performance (not representative of all frequency ranges):



## POWER-POLE® SERIES Selection Guide:

| Frequency Range | Suffix | % Bandwidth (3 dB) | Insertion Loss | Strobe Rate (max.) | SHAPE FACTOR (30 dB) Overall | Low Side | High Side |
|---|---|---|---|---|---|---|---|
| 30 to 90 MHz | -1 | 8.4/9.5 | 0.8/1.2 | 900 Hz | | | |
| | -2 | 4.3/4.8 | 1.6/2.4 | | 6.9/7.6 | 9.3/10.4 | 4.5/4.7 |
| | -3 | 2.8/3.2 | 2.9/4.3 | | 6.0/6.9 | 7.0/8.9 | 5.0/5.8 |
| | -4 | 2.2/2.5 | 3.4/4.6 | | | | |
| | -5 | 1.8/1.9 | 4.4/5.8 | | | | |
| 90 to 200 MHz | -1 | 8.6/9.2 | 0.8/1.2 | 2 KHz | 6.0/6.5 | 7.5/8.3 | 4.6/4.7 |
| | -2 | 4.2/4.8 | 1.2/2.3 | | | | |
| | -3 | 2.7/3.2 | 2.2/3.5 | | | | |
| | -4 | 2.2/2.5 | 3.3/5.0 | | | | |
| | -5 | 1.8/2.0 | 4.0/5.5 | | | | |
| 200 to 400 MHz | -1 | | | 2 KHz | | | |
| | -2 | 4.2/4.8 | 1.3/2.2 | | 5.6/6.1 | 6.4/7.0 | 4.8/5.3 |
| | -3 | 2.7/3.1 | 1.7/3.5 | | | | |
| | -4 | 2.2/2.5 | 2.4/3.8 | | | | |
| | -5 | | | | | | |
| 225 to 400 MHz | -1 | 8.2/9.1 | 0.6/0.9 | 2 KHz | 5.8/6.0 | 7.0/7.3 | 4.6/4.7 |
| | -2 | 4.2/4.8 | 1.0/2.2 | | | | |
| | -3 | 2.7/3.1 | 1.7/3.2 | | | | |
| | -4 | 2.1/2.5 | 2.3/3.8 | | 5.7/6.3 | 6.1/7.0 | 5.3/5.7 |
| | -5 | 1.8/2.0 | 2.5/4.2 | | 5.9/6.2 | 6.4/6.2 | 5.4/5.8 |

This Selection Guide illustrates approximate performance for the **POWER-POLE®** Series: Table values are shown as average/maximum.

## Pinout & Ratings:

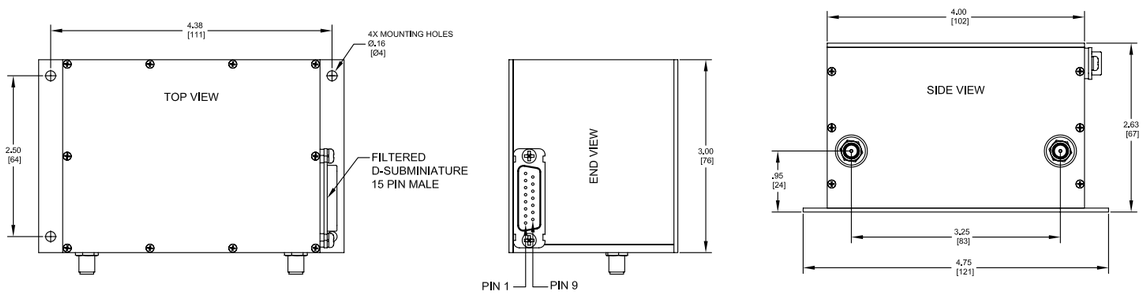
| PARALLEL INTERFACE | | | |
|---|---|---|---|
| PIN # | Reference Designator | Description | Maximum Ratings |
| 1 | A2 | Parallel Bit 2 | -0.5 to ($V_{cc}$ + 0.5) V |
| 2 | A3 | Parallel Bit 3 | |
| 3 | A4 | Parallel Bit 4 | |
| 4 | A5 | Parallel Bit 5 | |
| 5 | A6 | Parallel Bit 6 | |
| 6 | A7 | Parallel Bit 7 | |
| 7, 9, 11, 12 | GND | Digital/RF Ground | — |
| 8 | $V_{cc}$ | +5 V Power Supply Input ±10% | -0.5 to +6 V |
| 10 | N/C | No Connect (1) | — |
| 13 | $\overline{STB}$ | Strobe | -0.5 to ($V_{cc}$ + 0.5) V |
| 14 | A0 | Parallel Bit 0 | |
| 15 | A1 | Parallel Bit 1 | |

**Note(s):** 1 Leave pins disconnected for unit to function properly.

| SERIAL INTERFACE | | | |
|---|---|---|---|
| PIN # | Reference Designator | Description | Maximum Ratings |
| 1 | SDO | Serial Data Out | 0 to +6 VDC |
| 2-6, 10 | N/C | No Connect (1) | — |
| 7, 9, 11, 12 | GND | Digital/RF Ground | — |
| 8 | Vcc | +5 V Power Supply Input ±10% | -0.5 to +6 V |
| 13 | $\overline{STB}$ | Strobe | -0.5 to ($V_{cc}$ + 0.5) V |
| 14 | SCLK | Serial Clock | |
| 15 | SDI | Serial Data In | |

**Note(s):** 1 Leave pins disconnected for unit to function properly.

## Mechanical Outline:








## POWER-POLE® Filters Product Number Guide:

| Series | Frequency (MHz) | Insertion Loss (dB) | Connector Type | Options |
|---|---|---|---|---|
| POWER | 30-90<br>90-200<br>200-400<br>225-400 | 1<br>2<br>3<br>4<br>5 | SMA (Female) | B<br>C |

**Available Options:** B. Serial Interface
C. Custom Frequency Bands (Specify START and STOP frequencies in MHz.)

**Note(s):** Options may be limited to particular frequency bands and/or configurations. Consult factory for your application.

**Example:** Product # POWER-90-200-3-SMA

## Interface & Control Options:

### Frequency Tuning Address

There are 250 equally spaced tuning increments across each standard filter band, resulting in 251 tunewords from 00000000 to 11111010. The last 5 tunewords are reserved for housekeeping functions:

| Tune Code | Result |
|---|---|
| 00000000<br>thru<br>11111010 | Lowest tuned frequency<br>(251 total tune codes)<br>Highest tuned frequency |
| 111111011<br>thru<br>11111110 | RF In/Out Isolation<br>Filter Blanked |
| 11111111 | Power saver mode; all PIN diodes turned off |

### Calculating a Tune Address

The binary tuning word is determined by the following relationship:

$$\text{tuneword} = \left( \frac{F_{desired} - F_{low}}{F_{high} - F_{low}} \right) \times 250$$

**Example:** If you wish to tune to 322 MHz using a 225 to 400 MHz filter, the tuneword is:

$$\left( \frac{322 - 225}{400 - 225} \right) \times 250 = 138.57 \text{ (10001011 binary)}$$

**Note:** Round off to the nearest decimal integer.

### Interface Options:

The filter comes standard with an 8 bit parallel interface, although a serial interface can be specified as an option.

### DC Control Interface Characteristics:

| Symbol | Parameter | Condition | Minimum | Maximum | Units |
|---|---|---|---|---|---|
| $V_{IL}$ | Input Low Voltage | Control signals except A0-A7 | 0.0 | 0.2 Vcc | V |
| $V_{IH}$ | Input High Voltage | Control signals except A0-A7 | 0.7 Vcc | Vcc | V |
| $V_{IL1}$ | Input Low Voltage | A0-A7 | 0.0 | 0.15 Vcc | V |
| $V_{IH1}$ | Input High Voltage | A0-A7 | 0.7 Vcc | Vcc | V |

### Switching Characteristics: (Vcc = +5 VDC, ± 10%; T = -40º to +85°C)

| Symbol | Parameter | Minimum | Maximum | Units |
|---|---|---|---|---|
| $t_S$ | Setup Time, A0-A7 to $\overline{STB}$ | 600 | | nS |
| $t_H$ | Hold Time, A0-A7 from $\overline{STB}$ | 2.5 | | µS |
| $t_{SH}$ | $\overline{STB}$ High Time | 25 | | µS |
| $t_W$ | $\overline{STB}$ Pulse Width | 600 | | nS |
| $t_{DW}$ | Strobe Dwell Time (from $\overline{STB}$ falling edge to next $\overline{STB}$ falling edge) | 500 | | µS |
| $t_{ACC}$ | Access Time from $\overline{STB}$ to $f_O$ | | 15* | µS |

* 15 µs typical for UHF band filters. Consult factory for details on other bands.

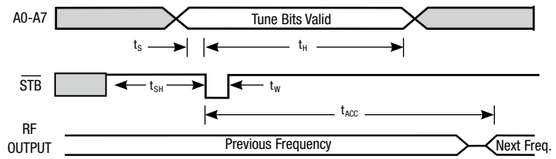



**Figure 10**

### Strobe

The filter is tuned within 15 µS to the frequency designated by the tuneword existing on the eight control bit lines when the $\overline{STB}$ line is brought low. Once strobed, data existing on the tune control lines is ignored until strobed again. Maximum strobe rate is 2 kHz; Actual rate is dependent upon frequency band.

### Temperature Effects

Over the -40ºC to +65°C temperature range, filters will exhibit a negative temperature drift of less than 80 PPM/°C, or a total of less than ± 0.5% of the center frequency.


The **MEGA-POLE®** filter series covers the standard frequency bands within the 30 to 450 MHz range with VHF-L, VHF-H or UHF versions. This new filter series provides excellent selectivity while maintaining very low insertion loss. The product line also has exceptional RF power handling capability with a high third order intercept point. The **MEGA-POLE®** filter series can be used for transmitter applications to reduce power amplifier noise, harmonics and intermodulation products, to provide bi-directional filtering directly at a transceiver's antenna port, or other applications requiring extremely linear, high power RF bandpass filtering. It has been designed for rugged environments per MIL-STD-810.

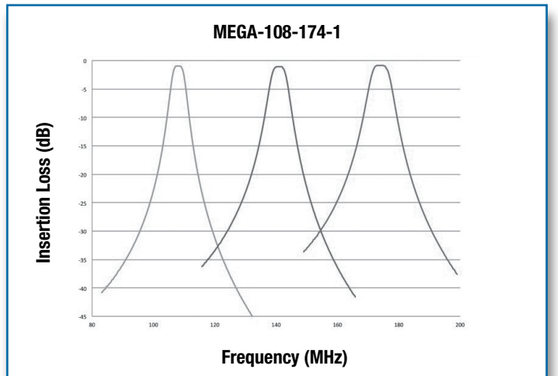
## MEGA-POLE® SERIES

### Specifications:

| **Frequency Coverage (VHF-L, VHF-H or UHF):** | **30 to 450 MHz** |
|---|---|
| Input/Output Impedance: | 50Ω |
| In-band RF Power Handling: | 50 W average<br>100 W peak |
| In-band Third Order Intercept: | > +60 dBm |
| Tuning Control: | Flexible control design for ARC-210 and VHF-4000. Standard options available. |
| Tuning Speed: | < 25 µs typical<br>Supports frequency hopping waveforms |
| DC Power: | +28 VDC, < 1A, MIL-STD-704 |
| Center Frequency Stability: | Internally compensated |
| Shape Factor (30 dB / 3 dB): | 3.3 to 3.75 typical |
| Operating Temperature Range: | -40°C to +55°C |
| Size: | 6 × 7.55 × 3.6 (in.) / 152 × 190 × 91 (mm.) |
| Available Finishes: | Chem-Film per MIL-C-5541<br>CARC Tan or Green<br>and Lusterless Grey or Black<br>available on request. |
| RF Connection: | TNC jack |

### Performance:

The following plots illustrate approximate performance (not representative of all frequency ranges):








### MEGA-POLE® Filters Product Number Guide:

| Series | Frequency (MHz) | Insertion Loss | Connector Type | Options |
|---|---|---|---|---|
| MEGA | 30-88*<br>108-174<br>225-400 | 1-1.5 dB | TNC (Female) | C |

**Available Options:** C. Custom Frequency Bands (Specify START and STOP frequencies in MHz.)

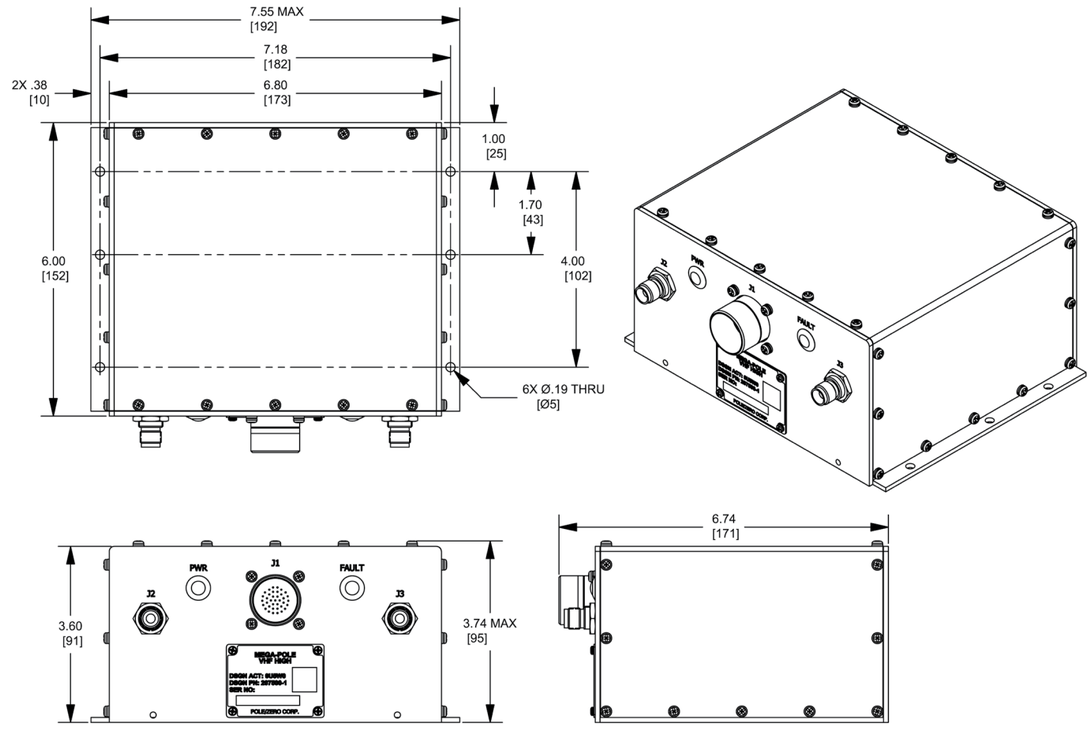
**Note(s):** Options may be limited to particular frequency bands and/or performance levels. Consult factory for your application.
* Preliminary

**Enhance the performance of your transceiver in frequency hopping cosite applications through use of the direct radio interface connection to the MEGA-POLE®.**

**MEGA-POLE® is available in multiple frequency bands with potential customizations:**

- **additional poles for sharper selectivity**
- **expanded frequency range or multi-band solutions**
- **size/selectivity trade-offs for small form factors**

### Mechanical Outline:




Data is believed to be accurate. All data is subject to change without notice.


The **HF-ERF™** is an internally switched 3-band, low cost, miniature, high performance tunable filter. The **HF-ERF™** was designed to have the best insertion loss and Q in the smallest package possible.

The size is 2.0" x 2.78" x 0.6" (50.8 mm x 70.61 mm x 15.24 mm). All **HF-ERF™** filters are fully tested and aligned by Pole/Zero® for convenience and ease of use. Both SPI and Parallel control interfaces are available in one filter. Modified variants are available upon request.

## HF-ERF™ SERIES (S13)

### Specifications:

| **Frequency Coverage:** | **1 to 30 MHz** |
|---|---|
| Input/Output Impedance: | 50Ω |
| In-band Input/Output VSWR: | 1.5:1 typical |
| In-band RF Power Handling (input): | 24 dBm typical |
| Outband RF Power Handling: | 33 dBm |
| In-band Third Order Intercept: | +34 dBm typical |
| Center Frequency Drift: | 55 PPM/ºC typical |
| Tuning Control: | Parallel or Serial |
| Tuning Speed: | 85 µs typical |
| DC Power Consumption (Static): | |
| +5 DC | 190 mA typical |
| +100V DC | 1.5 mA typical |
| Shape Factor (30 dB / 3 dB): | 6 + 0.5 typical, 7 maximum |
| Operating Temperature Range: | -40°C to +85°C |
| Size: | 2.0 × 2.78 × 0.6 (in.) / 50.8 × 70.61 × 15.24 (mm.) |
| Weight: | 1.5 oz. / 43 g. |
| RF Connection: | Surface Mount |

### HF-ERF™ (G3) Product Number Guide:

| Series | Frequency (MHz) | % Bandwidth (3 dB) | Connector Type | Options |
|---|---|---|---|---|
| MN | 1.5 - 30 | 3 | S13 | C017 (+24VDC $V_{BB}$) |

**Note(s):** Options may be limited to particular frequency bands and/or configurations. Consult factory for your application.

**Example:** Product # MN-1.5-30-3-S13 or MN-1.5-30-3-S13-C017

## Interface & Control Options:

### General Information

The **HF-ERF™** (S13) requires two supply voltages: a +5 VDC analog supply and a +100 VDC supply. These supply voltages should be adequately filtered as noise present on these pins will influence the RF signal purity. Digital Logic control signals can be anything from 1.2V to 5.5V and is set by the $V_{CCD}$ line.

### Digital Interface Information

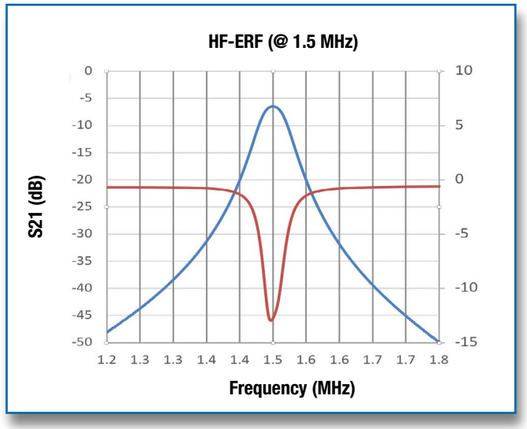
The digital interface format can be either SPI serial or parallel depending on the state of the SER/PAR pin.

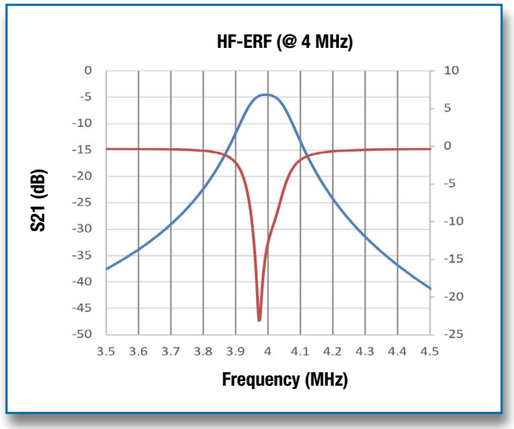
### Pinout & Ratings:

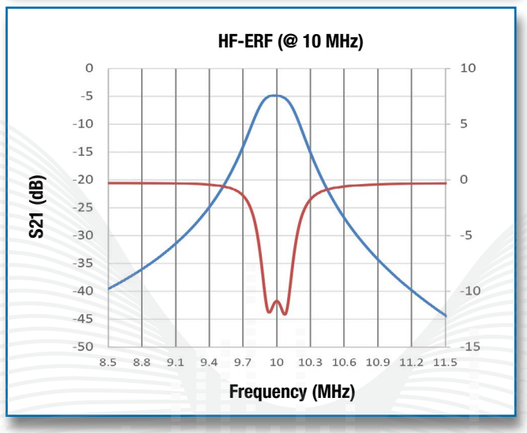
| PIN # | Reference Designator | Description |
|---|---|---|
| 1 | SER/$\overline{PAR}$ | Serial/Parallel Command Interface Selection – Leaving SER/$\overline{PAR}$ floating or pulled to $V_{CC}$ will enable the SPI (serial) tune command interface. Keeping SER/$\overline{PAR}$ pulled to GND will enable the parallel tune command interface. A power cycle is required to change modes. (This pin is internally pulled to $V_{CC}$ with a 10 kΩ resistor.) |
| 2 | TUNE READY | Tune Ready Indicator – This pin normally remains low. When $\overline{CS}$ and/or $\overline{STB}$ is taken low to initiate a tune in either SPI or Parallel tune modes, the TUNE READY pin transitions high to indicate the filter is ready to receive the SPI or Parallel data. After data has been shifted in via the tune interface, the TUNE READY pin will transition back low indicating that the tune process is finished. |
| 3 | $V_{CCD}$ | Digital Interface Supply – Used to set the **HF-ERF™** digital interface logic voltage level between 1.2 V and 5 V. If using 5 V logic to control the HF-ERF, $V_{CCD}$ should be +5 V, if using 3.3 V logic to control the **HF-ERF™**, $V_{CCD}$ should be +3.3 V, etc. |
| 4 | A7 | Parallel Data A7 (MSB) – In Parallel interface mode, data is latched on the rising edge of $\overline{STB}$ and indicates which frequency the filter should tune to (A7 = MSb, A0 = LSb). (This pin is internally pulled to $V_{CC}$ with a 10 kΩ resistor.) |
| | MOSI | Serial Tune Interface Master Output Slave Input – Data is applied to MOSI for transferring a tune command to the device. Each bit of data is latched on the rising edge of SCLK. The filter accepts tune command lengths of 16-bits. (This pin is internally pulled to $V_{CC}$ with a 10 kΩ resistor.) |
| 5 | A6 | Parallel Data A6. (This pin is internally pulled to $V_{CC}$ with a 10 kΩ resistor.) |
| 6 | A5 | Parallel Data A5. (This pin is internally pulled to $V_{CC}$ with a 10 kΩ resistor.) |
| | SCLK | Serial Tune Interface Clock – SCLK is used to clock in the tune word. Data is latched on the rising edge of SCLK. (This pin is internally pulled to $V_{CC}$ with a 10 kΩ resistor.) |
| 7 | A4 | Parallel Data A4. (This pin is internally pulled to $V_{CC}$ with a 10 kΩ resistor.) |
| | $\overline{CS}$ | Serial Tune Interface Chip Select – The master transmits logic '0' for the desired filter using the chip select line. When $\overline{CS}$ is taken low, the control circuitry wakes up and the filter is ready for a new tune command. When the entire tune word has been loaded into the filter $\overline{CS}$ is taken high to indicate the tune command is complete. **For proper operation in Serial mode, tie this pin directly to $\overline{STB}$ (pin 12).** (This pin is internally pulled to Vcc with a 10 kΩ resistor.) |
| 8-11 | A3-A0 | Parallel Data pins A3 (pin 8), A2 (pin 9), A1 (pin 10), and A0 (pin 11). (These pins are internally pulled to Vcc with a 10 kΩ resistor.) |
| 12 | $\overline{STB}$ | In Serial interface mode – $\overline{STB}$ wakes the controller circuitry on a low transition. **For proper operation in SPI mode, tie this pin directly to $\overline{CS}$ (pin 7).** In Parallel interface mode, when $\overline{STB}$ is taken low, the control circuitry wakes up and data is ready to be sent on A7-A0. When $\overline{STB}$ is transitioned high, the MSB of parallel data is latched. $\overline{STB}$ should be taken low again while the LSB is loaded on the data port. When $\overline{STB}$ is transitioned high for the second time, the LSB of parallel data is latched and the filter is commanded to the frequency specified by the parallel data interface. (This pin is internally pulled to $V_{CC}$ with a 10 kΩ resistor only when used in parallel mode.) |
| 13 | $V_{CC}$ | Supply Voltage Input: 4.75 V ≤ $V_{CC}$ ≤ 5.25 V. |
| 14, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 33, 34, 35 | GND | Digital and Analog Ground. |
| 15 | $V_{BB}$ | High Bias Supply Voltage Input: See filter version for optimum performance characteristics. |
| 20, 32 | RF IN/OUT | RF Signal Input or Output. |
| 36, 37 | NC | No Connect – Factory use only pins. Shorting or connecting these pins may affect the performance and functionality of the filter. Leave these pins floating. |

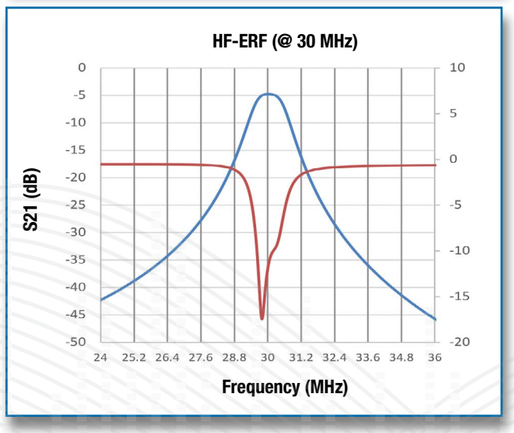
## Performance:

The following plots illustrate approximate performance (not representative of all frequency ranges)

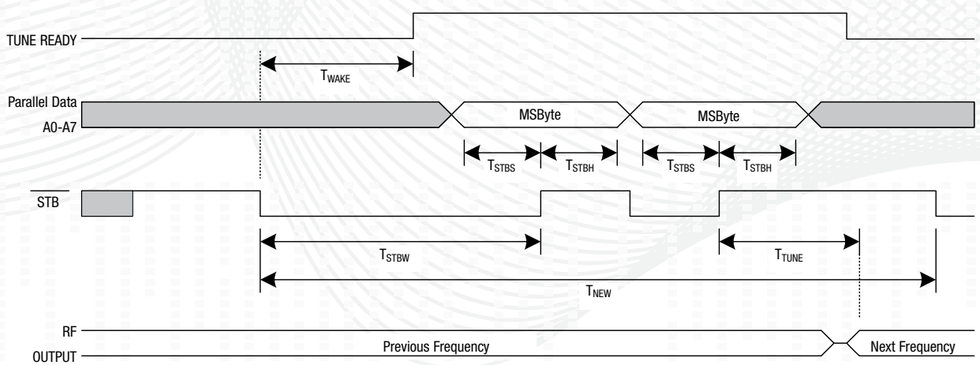


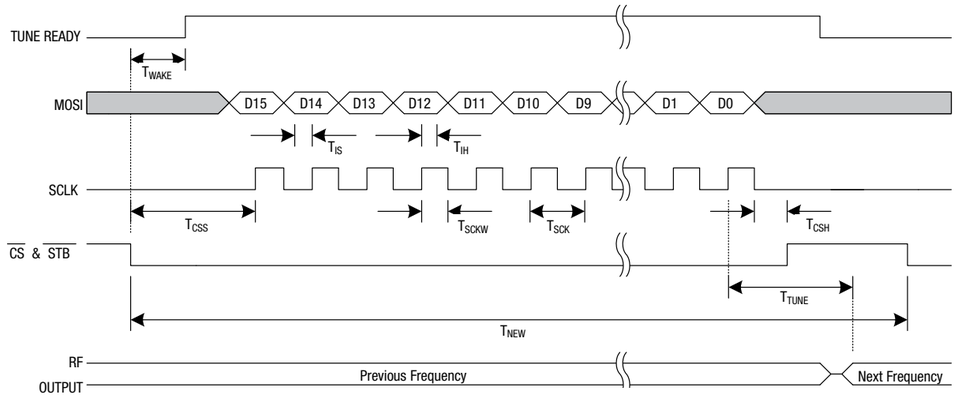

## Parallel Timing Diagram:



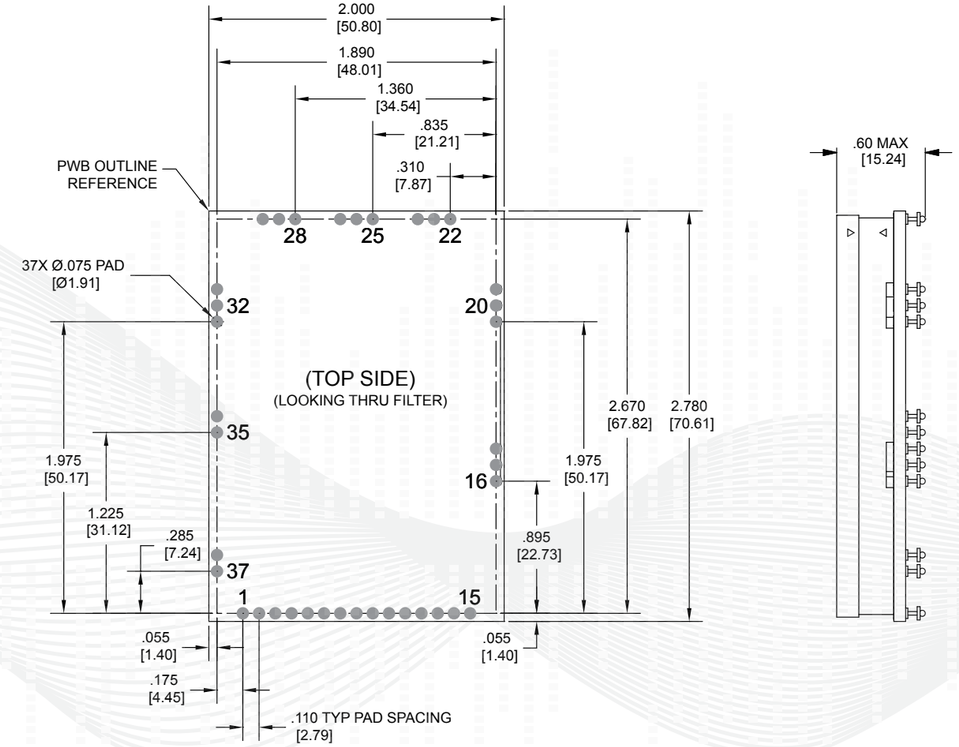





## Serial Timing Diagram:




## Mechanical Outline:




The **NANO-ERF®** is an internally switched multi-band, low-cost, miniature, high-performance tunable filter. The **NANO-ERF®** was designed to have the smallest possible dimensions while maintaining suitable electrical performance. The **NANO-ERF®** is 1.1" x 1.1" x 0.216". All filters are fully tested and aligned by Pole/Zero for convenience and ease of use. The **NANO-ERF®** uses an SPI tune interface.

## NANO-ERF® SERIES

### Specifications:

| **Frequency Coverage:** | **30 to 520 MHz** |
|---|---|
| Input/Output Impedance: | 50Ω, nominal |
| In-band Input/Output VSWR: | 1.5:1 typical, 2.2:1 max. |
| In-band RF Power Handling: | +6 dBm (input) typical |
| Outband RF Power Handling: | +20 dBm @ ± 15% |
| In-band Second Order Intercept Point: | +70 dBm (input) typical |
| In-band Third Order Intercept Point: | +16 dBm (input) typical |
| Center Frequency Drift: | 180 PPM/ºC typical |
| Tuning Control: | Serial |
| Tuning Speed: | 25 µsec typical, 35 µsec max. |
| DC Power Consumption (Static): | +3.3 VDC @ 15 mA typical<br>Additional 15 mA during tuning interval (15 µsec) |
| Shape Factor (30 dB / 3 dB): | 6 ± 0.5 typical, 8 max. |
| Operating Temperature Range: | -40°C to +85°C |
| Size: | 1.10 × 1.10 × 0.216 (in.) / 28 × 28 × 5.5 (mm.) |
| Weight: | .2 oz. / 6 g. |
| RF Connection: | SMT castellation |

### Pinout & Ratings:

| Pin # | Reference Designator | Description | Maximum Ratings |
|---|---|---|---|
| 1, 3, 5, 6, 10, 18, 19 | N/C | No Connect[1] | — |
| 2 | SCLK | Serial Clock | -0.5 to ($V_{CC}$ + 0.5) V |
| 4 | $\overline{CS}$ | Chip Select | |
| 7 | $\overline{TUNE\ READY}$ | Tune Ready Output | — |
| 8 | $V_{CC}$ | +3.3 V Power Supply Input | -0.3 to 3.6 V |
| 9 | GND | Power Supply Ground | — |
| 11, 13, 14, 16 | GND | RF Ground | — |
| 12, 15 | RF I/O | RF Input/Output | +6 dBm, +20 dBm[2] |
| 17 | GND | Digital Ground | — |
| 20 | MOSI | Master Output, Slave Input | -0.5 to ($V_{CC}$ + 0.5) V |

**Note(s):** 1 Leave floating for unit to function properly.
2 First number indicates maximum in-band power levels and second number indicates maximum out of band RF power levels either in CW or composite average for multi-tones.

### NANO-ERF® Product Number Guide:

| Series | Frequency (MHz) | Bandwidth (3 dB) | Connector Type |
|---|---|---|---|
| NN | 30-520 | 6 | S06 |
| | | 10 | |

**Note(s):** Options may be limited to particular frequency bands and/or configurations. Consult factory for your application. Part number example 6%: NN-30-520-6-S06

**Example:** Product # NN-30-520-10-S06

### Interface & Control Options:

#### General Information

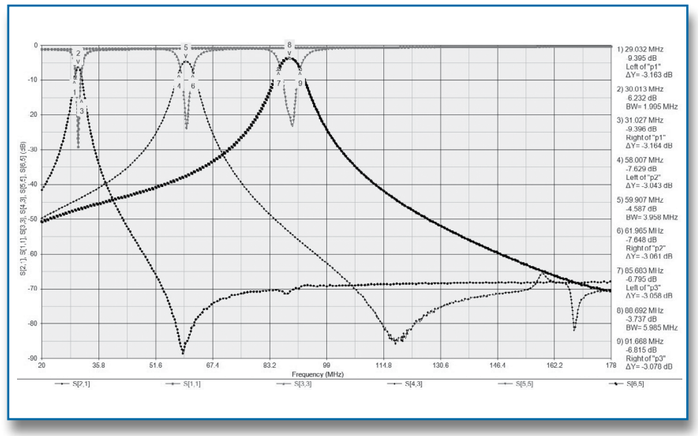
The **NANO-ERF®** tunable filter requires a +3.3 VDC supply. This supply voltage must be adequately filtered as noise present on this pin will directly influence the RF signal purity.

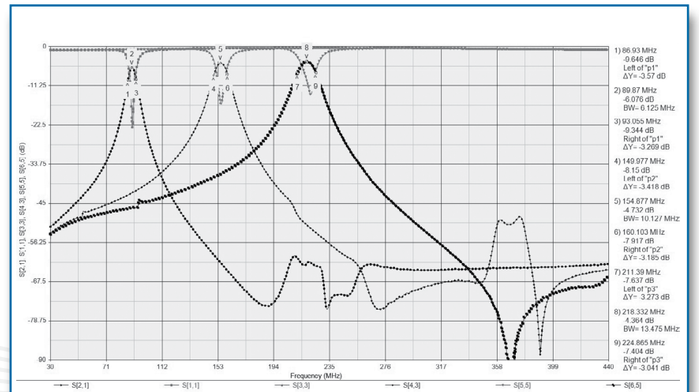
#### Digital Interface Information

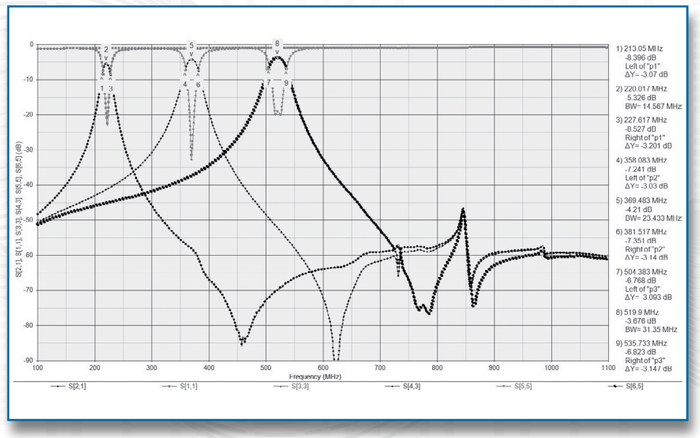
The digital interface format is SPI. All data input pins are data bus capable of 3.3 V logic levels.

### Performance:

The following plots illustrate approximate performance:



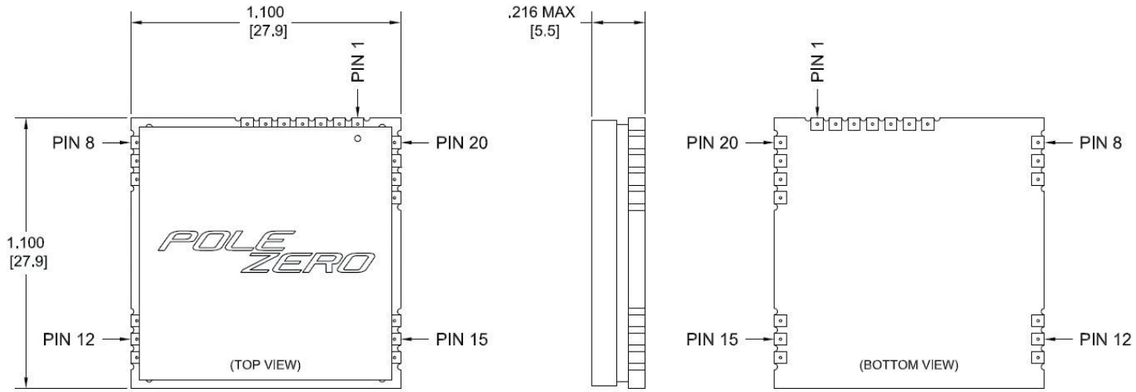




Data is believed to be accurate. All data is subject to change without notice.

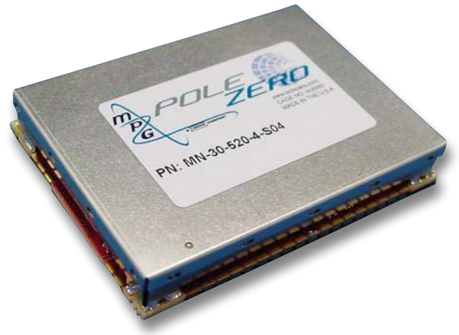
## NANO-ERF® SERIES (Continued)

### Mechanical Outline:








The **MINI-ERF®** is a low-cost, miniature, high-performance tunable band pass filter. The **MINI-ERF®** uses PIN diodes to deliver high dynamic range while fitting in a 1.75" x 2.40" x 0.387" package. Serial or parallel tuning interfaces are selectable. All **MINI-ERF®** filters are fully tuned and tested by POLE/ZERO® for convenience and ease of use.

### Pinout & Ratings:

| Pin # | Reference Designator | Description | Maximum Ratings |
|---|---|---|---|
| 1 | $V_{CC}$ | +3.3 V Power Supply Input ± 5% | -0.3 to +4 V |
| 2, 17, 19-21, 23, 24, 26-28 | GND | Digital/RF Ground | — |
| 3, 4 | N/C | No Connect[1] | — |
| 5 | A7/MOSI | Parallel Bit 7<br>Master Output, Slave Input | -0.5 to ($V_{CC}$ + 0.5) V |
| 6 | A6 | Parallel Bit 6 | |
| 7 | A5/SCLK | Parallel Bit 5, Serial Clock | |
| 8 | A4/$\overline{CS}$ | Parallel Bit 4, Chip Select | |
| 9 | A3 | Parallel Bit 3 | |
| 10 | A2 | Parallel Bit 2 | |
| 11 | A1 | Parallel Bit 1 | |
| 12 | A0 | Parallel Bit 0 | |
| 13 | TUNE READY | Tune Ready Output | — |
| 14 | SER/$\overline{PAR}$ | Serial/Parallel Mode Selection | -0.5 to ($V_{CC}$ + 0.5) V |
| 15 | $\overline{STB}$ | Parallel/Serial Strobe | |
| 16 | TUNE MODE | Tune Mode Selection Pin | |
| 18 | $V_{BB}$ | High Bias +100 V Supply Input | -0.5 to +125 V |
| 22, 25 | RF I/O | RF Input/Output | +32 dBm, +33 dBm[2] |

**Note(s):** 1 Leave floating for unit to function properly.
2 First number indicates maximum in-band power levels and second number indicates maximum out of band RF power levels either in CW or composite average for multi-tones.

## MINI-ERF® (S04) SERIES

### Specifications:

| | |
|---|---|
| **Frequency Coverage:** | **30 to 520 MHz** |
| Input/Output Impedance: | 50Ω |
| In-band Input/Output VSWR: | 1.5:1 typical, 2.2:1 max. |
| In-band RF Power Handling: | 1 Watt (input) |
| Outband RF Power Handling: | Up to 2 Watts (input) |
| In-band Second Order Intercept Point: | +90 dBm |
| In-band Third Order Intercept Point: | +40 dBm (input) |
| Center Frequency Drift: | -90 PPM/ºC |
| Tuning Control: | Parallel or Serial |
| Tuning Speed: | 15 µsec typical @ 0 dBm* |
| DC Power Consumption (Static): | +3.3 VDC @ 200 mA max.<br>+100 VDC @ 2.5 mA max. |
| Shape Factor (30 dB / 3 dB): | 6 ± 0.5 typical, 7.2 max. |
| Operating Temperature Range: | -40°C to +85°C |
| Size: | 2.40 × 1.75 × .385 (in.) / 61 × 44.5 × 9.8 (mm.) |
| Weight: | 30 g. typical / 1.05 oz. |
| RF Connection: | SMT castellation |

* Contact factory for details.

**Note:** Out of band power refers to signals at least 10% removed from the tuned center frequency.

### MINI-ERF® (S04) Product Number Guide:

| Series | Frequency (MHz) | % Bandwidth (3 dB) | Package |
|---|---|---|---|
| MN | 30-520 | 4 | S04 |
| | | 7 | |

**Note(s):** Options may be limited to particular frequency bands and/or configuration. Consult the factory for your application.

**Example:** Product # MN-30-520-4-S04

## Interface & Control Options:

### General Information

The **MINI-ERF-30-520** requires two supply voltages: a +3.3 VDC analog supply and a +100 VDC supply. These supply voltages should be adequately filtered as noise present on these pins will influence the RF signal purity. Frequency control signals are 3.3V logic level only.

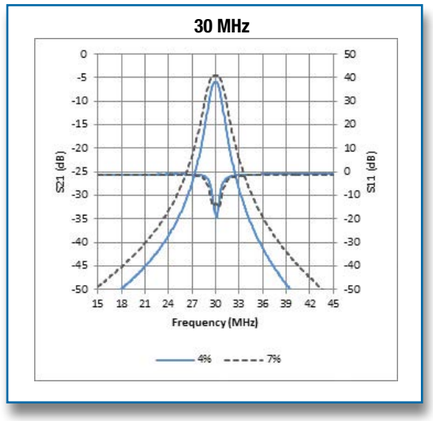
### Digital Interface Information

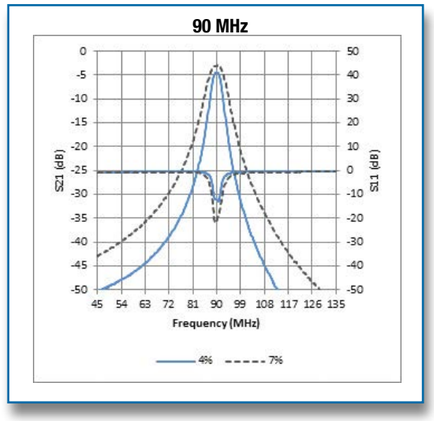
The digital interface format can be either SPI serial or parallel depending on the state of the SER/PAR pin.

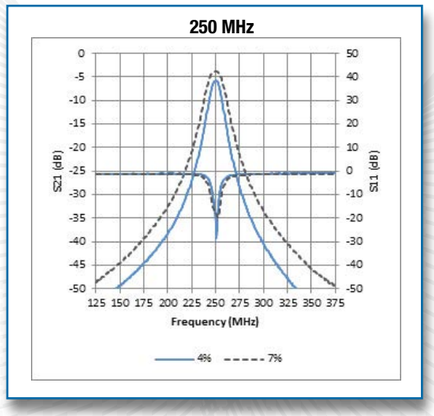
## MINI-ERF® (S04) SERIES (Continued)

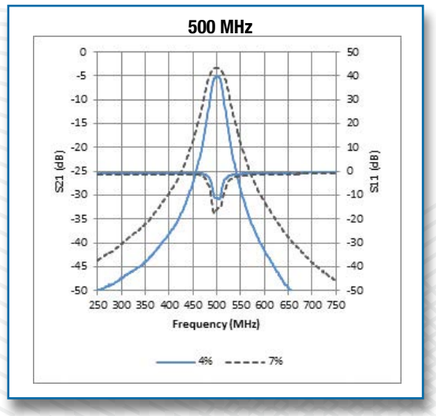
### Performance:

The following plots illustrate approximate performance:




### MINI-ERF® (S04) SERIES Selection Guide:

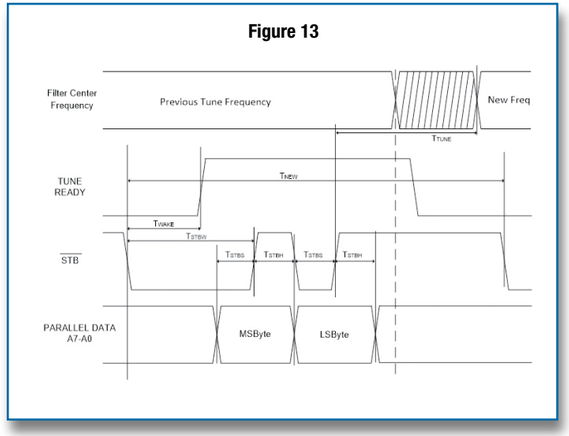
| Frequency Range | Suffix | % Bandwidth (3 dB) | Insertion Loss | Strobe Rate (max.) | Selectivity ± 10% (dB) | Selectivity ± 20% (dB) |
|---|---|---|---|---|---|---|
| 30 to 520 MHz | -4 | 4.7/5.4 | 5.2/7.0 | 2 KHz | 22 typical (19 min.) | 34 typical (30 min.) |
| | -7 | 7.2/8.2 | 3.5/5.0 | | 16 typical (14 min.) | 27 typical (24 min.) |





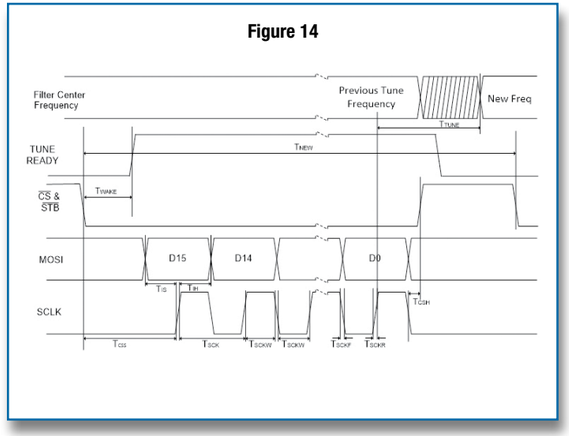
### Parallel Timing Diagram:

**Figure 13**

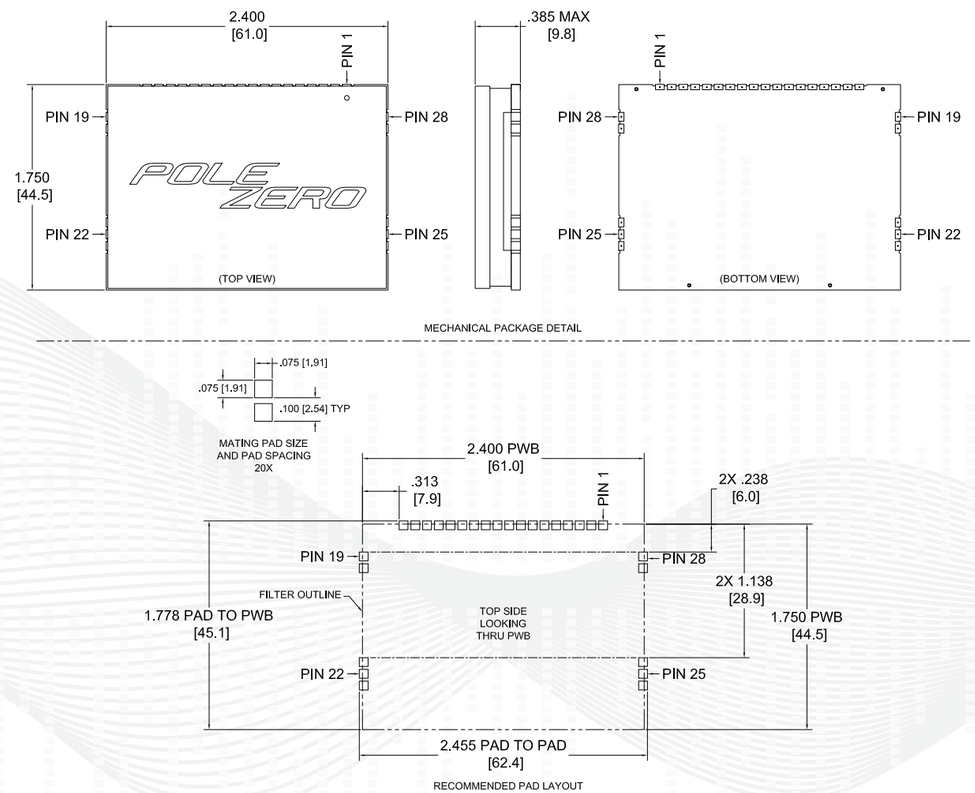



### Serial Timing Diagram:

**Figure 14**




### Mechanical Outline:




The **MINI-ERF® (S11)** is an internally switched dual band, low-cost, miniature, high-performance tunable filter. The **S11** filter was designed to have the best power handling and Q in the smallest package possible. The size is 2.0" x 2.0" x 0.293". All filters are fully tested and aligned by Pole/Zero for convenience and ease of use. SPI or Parallel control interfaces are available. Custom bandwidths are available upon request.

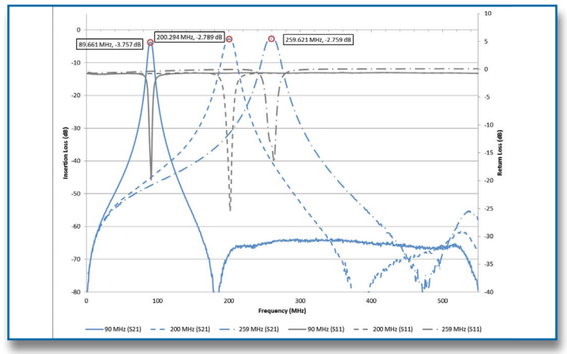
## MINI-ERF® (S11) SERIES

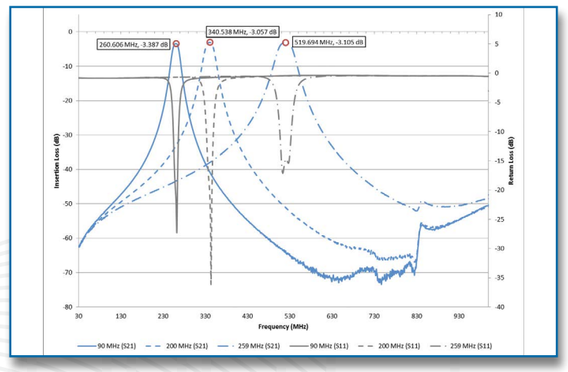
### Specifications:

| | |
|---|---|
| **Frequency Coverage:** | **90 to 520 MHz** |
| Input/Output Impedance: | 50Ω |
| In-band Input/Output VSWR: | 1.45:1 typical, 2:1 max. |
| In-band RF Power Handling: | 2 Watts (7% BW Filters)<br>1 Watt (4% BW Filters) |
| Outband RF Power Handling: | Up to 5 Watts (input)<br>30 MHz to $f_0$ – 10%<br>$f_0$+ 10% to 900 MHz |
| In-band Second Order Intercept Point: | +90 dBm |
| In-band Third Order Intercept Point: | +40 dBm typical (input) |
| Center Frequency Drift: | 60 PPM/ºC typical |
| Tuning Control: | Parallel or Serial |
| Tuning Speed: | 12 µsec typical @ 0 dBm* |
| DC Power Consumption (Static): | +3.3 VDC @ 75 mA typical<br>+100 VDC @ 1.2 mA typical |
| Shape Factor (30 dB / 3 dB): | 6 ± 0.5 typical, 7.2 max. |
| Operating Temperature Range: | 40°C to +85°C |
| Size: | 2.0 × 2.0 × .293 (in.) / 50.8 × 50.8 × 7.4 (mm.) |
| Weight: | 1.05 oz. / 30 g. typical |
| RF Connection: | SMT castellation |

### Performance:

The following plots illustrate approximate performance:




### MINI-ERF® (G3) Product Number Guide:

| Series | Frequency (MHz) | % Bandwidth (3 dB) | Package |
|---|---|---|---|
| MN | 90-520 | 7<br>4 | S11 |

**Note(s):** Options may be limited to particular frequency bands and/or configurations. Consult factory for your application.

**Example:** Product # MN-90-520-4-S11

### MINI-ERF® (S11) Selection Guide:

| Frequency Range | Suffix | % Bandwidth (3 dB) | Insertion Loss | Strobe Rate (max.) | Selectivity ± 10% (dB) | Selectivity ± 20% (dB) |
|---|---|---|---|---|---|---|
| 90 to 520 MHz | -4 | 3.5/4.8 | 5.5/8.5 | 2 KHz | 21 typical (18 min.) | 32 typical (28 min.) |
| | -7 | 6.8/7.6 | 3.0/4.5 | | 15 typical (13 min.) | 26 typical (22 min.) |



### Pinout & Ratings:

| Pin # | Reference Designator | Description | Maximum Ratings |
|---|---|---|---|
| 1 | $V_{CC}$ | 3.3 $V_{DC}$ | -0.3 $V_{DC}$ to +3.6 $V_{DC}$ |
| 2, 17, 19-21, 23, 24, 26-28 | GND | GND | N/A |
| 3, 4, 16 | N/C | No Connect [1] | N/A |
| 5 | A7<br>MOSI | Parallel Address 7<br>SPI Master Out Slave In | -0.5 $V_{DC}$ to $V_{CC}$ + 0.5 $V_{DC}$ |
| 6 | A6 | Parallel Address 6 | |
| 7 | A5<br>SCLK | Parallel Address 5<br>SPI Clock | |
| 8 | A4<br>$\overline{CS}$ | Parallel Address 4<br>SPI Chip Select (Active Low) | |
| 9 | A3 | Parallel Address 3 | |
| 10 | A2 | Parallel Address 2 | |
| 11 | A1 | Parallel Address 1 | |
| 12 | A0 | Parallel Address 0 | |
| 13 | TUNE READY | Tune Ready Output | |
| 14 | SER/$\overline{PAR}$ | Serial/Parallel Selection Pin (High or open for serial) | |
| 15 | $\overline{STB}$ | Parallel Tune Strobe<br>Serial Filter Wake | |
| 18 | $V_{BB}$ | 100 $V_{DC}$ | -0.3 to +110 V |
| 22, 25 | RF | RF In/Out | |

**Note(s):** 1 Maximum rating when recovered from will cause no permanent damage to the part.
2 Do not connect in order for the filter to function properly.
3 First number indicates maximum in-band power levels and second number indicates maximum out of band RF power levels either in CW or composite average for multi-tones.

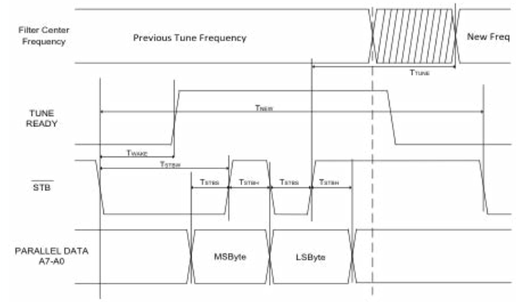
### Interface & Control Options:

#### General Information

The **MINI-ERF® (S11)** requires two supply voltages: a +3.3 VDC analog supply and a +100 VDC supply. These supply voltages should be adequately filtered as noise present on these pins will influence the RF signal purity. Frequency control signals are 3.3V logic level only.

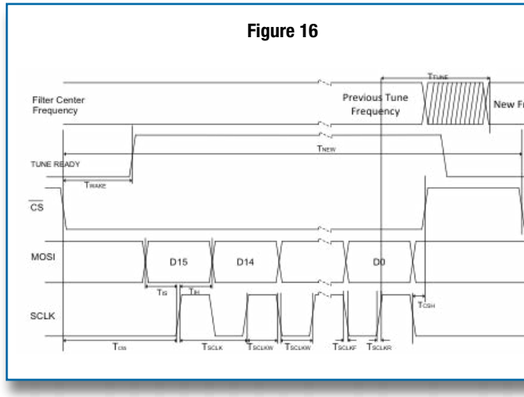
### Parallel Timing Diagram:

**Figure 15**

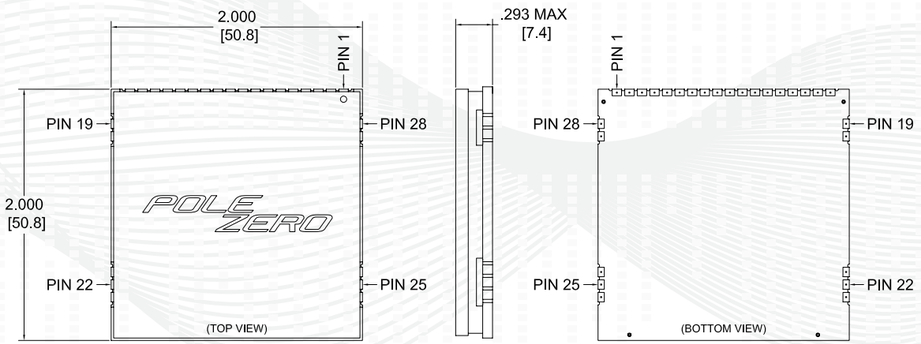



### Serial Timing Diagram:

**Figure 16**




### Mechanical Outline:




Data is believed to be accurate. All data is subject to change without notice.


The **MINI-POLE®** Extended Range Series of tunable filters was developed to address applications needing a small, surface mount package with wide tunability. Selectivity is enhanced in the **MINI/3** version by use of 3 pole filter architecture. This tunability is accomplished by the use of multiple internal tunable filters along with high performance RF band select switches all contained in one housing. The tunable filters are designed to minimize size and power consumption while maintaining high RF power handling and linearity characteristics.

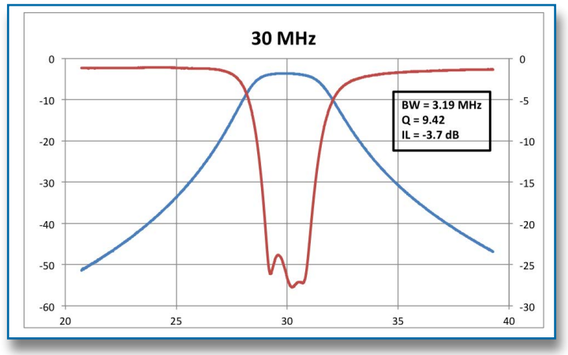
## MINI/3-ERF SERIES

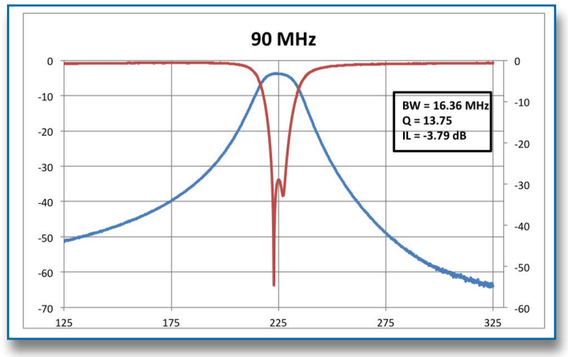
### Specifications:

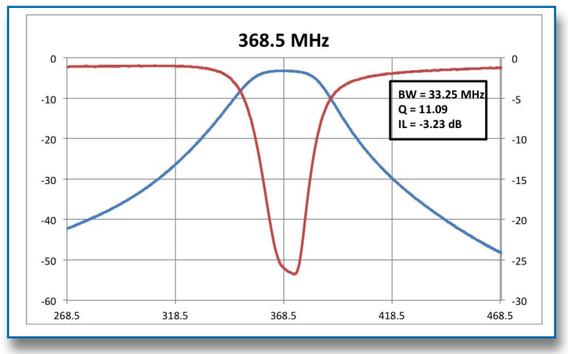
| **Frequency Coverage:** | **30 MHz to 520 MHz** |
|---|---|
| Input/Output Impedance: | 50Ω |
| In-band Input/Output VSWR: | 1.5:1 typical, 2.2:1 max |
| In-band RF Power Handling: | 1 Watt (input) |
| Outband RF Power Handling: | 2 Watts (input) |
| In-band Second Order Intercept Point: | +90 dBm |
| In-band Third Order Intercept Point: | +40 dBm (input) |
| Center Frequency Drift: | -90 PPM/ºC |
| Tuning Control: | SPI or 8 bit with load |
| Tuning Speed: | 35 µS max. at +25 dBm |
| DC Power Consumption (Static): | +5 VDC @ 200 mA, typical |
| Shape Factor (30 dB/ 3 dB): | 4 typical |
| Operating Temperature Range: | -40°C to +85°C |
| Size: | 2.00 × 2.520 × 0.393 (in.) / 51 × 64 × 10 (mm.) |
| Weight: | 1.3 oz. / 38 g. |
| RF Connection: | SMT pin |

### Performance:

The following plots illustrate approximate performance:






## MINI/3-ERF® Filters Product Number Guide:

| Series | Frequency (MHz) | % Bandwidth (3 dB) | Connector Type |
|---|---|---|---|
| MN3 | 30-520 | 10 | S05 |

**Example:** Product # MN3-30-520-10-S05

## Interface & Control Notes:

### General Information

The **MINI/3-ERF®** requires two supply voltages. A +5 VDC analog supply and a +1.65 to 5.5 VDC digital supply. These supply voltages should be adequately filtered as noise present on these pins will influence the RF signal purity. A third, high voltage supply may be applied to the filter (user enabled feature) for ultra-low EMI/ sensitivity applications.

### Digital Interface Information

The digital interface format is an 8 bit parallel, two byte write with load. The filter band is selected by the first byte and the tune frequency is selected by the second byte. All data input pins are universal data bus capable of 1.8 V, 2.5 V, 3.3 V and 5 VDC logic voltage nodes which is selected by the Vccd supply voltage used.

## Pinout & Ratings:

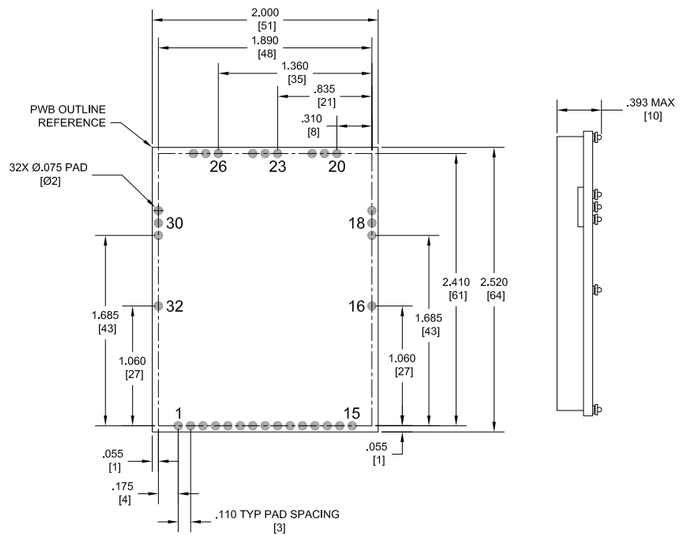
| Pin # | Reference Designator | Description | Maximum Ratings |
|---|---|---|---|
| 1 | SER/$\overline{PAR}$ | Serial/Parallel Mode Selection | -0.5 to ($V_{CC}$ + 0.5) V |
| 2 | TUNE READY | Tune Ready Output | — |
| 3 | $V_{CCD}$ | Digital Interface Supply Input | -0.5 to +6.5V |
| 4 | A7/SCLK | Parallel Bit 7, Serial Clock | -0.5 to ($V_{CCD}$ +0.5) V |
| 5 | A6 | Parallel Bit 6 | |
| 6 | A5/MOSI | Parallel Bit 5<br>Master Output, Slave Input | |
| 7 | A4/$\overline{CS}$ | Parallel Bit 4, SPI Chip Select | |
| 8 | A3 | Parallel Bit 3 | |
| 9 | A2 | Parallel Bit 2 | |
| 10 | A1 | Parallel Bit 1 | |
| 11 | A0 | Parallel Bit 0 | |
| 12 | $\overline{STB}$ | Parallel Strobe | |
| 13 | $V_{CC}$ | +5 V Power Supply Input ±10% | -0.3 to +5.5 V |
| 14, 16, 17, 19-29, 31, 32 | GND | Digital/RF Ground | — |
| 15 | $V_{BB}$ | High Bias +100 V Supply Input | -0.5 to +110 V |
| 18, 30 | RF I/O | RF Input/Output | +32 dBm, +33 $dBm_1$ |

**Note(s):** 1 First number indicates maximum in-band power levels and second number indicates maximum out of band RF power levels either in CW or composite average for multi-tones.

## MINI/3-ERF® SERIES Selection Guide:

| Frequency Range | Suffix | % Bandwidth (3 dB) | Insertion Loss | Strobe Rate (max.) | Selectivity ± 10% (dB) | Selectivity ± 20% (dB) |
|---|---|---|---|---|---|---|
| 30 to 520 MHz | -10 | 9.8/11 | 3.5/4.5 | 1.5 KHz | 16 typical (14 min.) | 34 typical (30 min.) |

## Mechanical Outline: (top view)




Data is believed to be accurate. All data is subject to change without notice.

**Single** **Dual**

The new **ERF-5W™** filter takes Pole/Zero's® MINI-ERF technology to a higher level of RF power handling, with 5 W (average) in-band power handling, and covering the entire military tactical radio tuning range of 30 to 520 MHz in one integrated package. This tunability is accomplished by the use of three poles of selectivity, multiple internal tunable filters along with high performance RF band select switches. The tunable filters are designed to minimize size and power consumption, while maintaining high RF power handling and linearity characteristics. Serial control is accomplished via a standard Serial Peripheral Interface (SPI)-based bus. **ERF-5W™** filters are available in both single and dual-channel configurations.

## ERF-5W™ SERIES

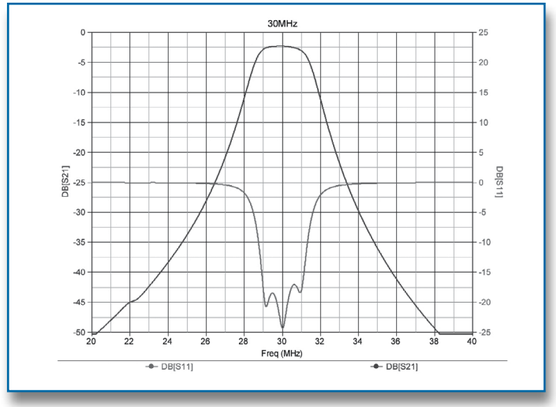
### Specifications:

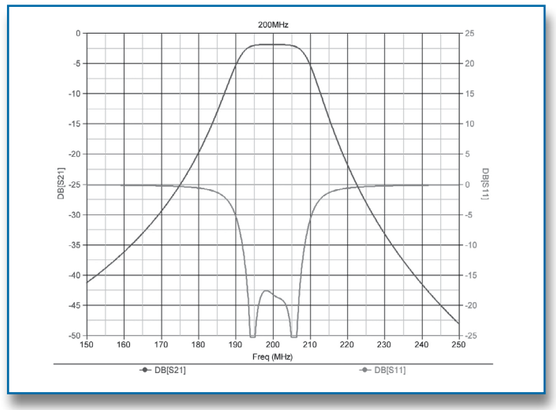
| **Frequency Coverage:** | **30 to 520 MHz** |
|---|---|
| Input/Output Impedance: | 50Ω |
| In-band Input/Output VSWR: | 1.65:1 max. |
| In-band RF Power Handling: | 5 Watts (input) average |
| Outband RF Power Handling: | (up to 10 Watts, see note 1) |
| In-band Second Order Intercept Point: | +100 dBm (input) |
| In-band Third Order Intercept Point: | +47 dBm (input) |
| Center Frequency Drift: | -80 PPM/ºC |
| Tuning Control: | Parallel or Serial |
| Tuning Speed: | 25 µsec typical, 50 µsec max. |
| DC Power Consumption (Static): | +5 VDC @ 1.5 A max. |
| Shape Factor: | 3.5 typical |
| Operating Temperature Range: | -40°C to +85°C |
| Size: **Single:** | 4.70 × 6.8 × 1.0 (in.) / 119.4 × 172.7 × 25.4 (mm.) |
| **Dual:** | 4.70 × 6.8 × 1.90 (in.) / 119.4 × 172.7 × 48.3 (mm.) |
| Weight: **Single:** | 14.08 oz. / 399.161 g. |
| **Dual:** | 24 oz. / 680.389 g. |
| RF Connection: | SMA jack |

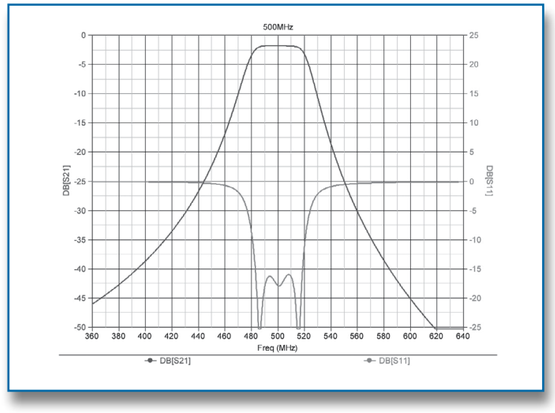
**Note 1:** Out of band RF power handling refers to signals that are at least 20% removed from the tuned center frequency and is frequency dependent: 5 W signals applied between 30 and 75 MHz, 8 W from 75 to 175 MHz, and 10 W from 175 to 520 MHz.

### Performance:

The following plots illustrate approximate performance:








## ERF-5W™ SERIES Selection Guide:

| Frequency Range | Suffix | % Bandwidth (3 dB) | Insertion Loss | Strobe Rate (max.) | Selectivity ± 10% (dB) | Selectivity ± 20% (dB) |
|---|---|---|---|---|---|---|
| 30 to 520 MHz | -10 | 9.0/11 | 2.5/3.5 | 1 KHz | 18 typical (14.5 min.) | 34 typical (30 min.) |
| Dual 30 to 520 MHz | -10 | 9.0/11 | 2.5/3.5 | 1 KHz | 18 typical (14.5 min.) | 34 typical (30 min.) |

## ERF-5W™ Filter Products Number Selection Guide:

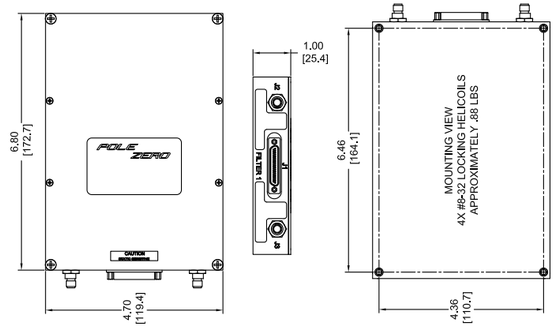
| Series | Frequency (MHz) | % Bandwidth (3 dB) | Package |
|---|---|---|---|
| 5W<br>D5W (Dual) | 30-520 | 10 | M01<br>M02 |

**Note:** Options may be limited to particular frequency bands and/or configurations. Consult factory for your application.

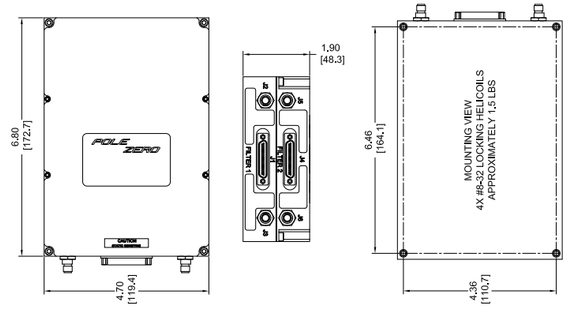
**Example:** Product # 5W-30-520-10-M01

## Mechanical Outline:

### ERF-5W™ (Single) M01




### ERF-5W™ (Dual) M02




Data is believed to be accurate. All data is subject to change without notice.

## Pinout & Ratings:

| Pin # | Reference Designator | Description | Maximum Ratings |
|---|---|---|---|
| 1-6, 8, 11, 20-23, 26, 29 | N/C | No Connect (1) | — |
| 7, 9, 12, 24, 25, 27 | GND | Digital/RF Ground | — |
| 10 | BAND 1 | Band Select Bit 1 | -0.5 to ($V_{CCD}$ + 0.5) V |
| 13 | A7/SCLK | Parallel Bit 7, Serial Clock | |
| 14 | A5/MOSI | Parallel Bit 5<br>Master Output, Slave Input | |
| 15 | A3 | Parallel Bit 3 | |
| 16 | A1 | Parallel Bit 1 | |
| 17 | TUNE READY | Tune Ready Output | — |
| 18, 36 | $V_{CCD}$ | Digital Interface Supply Input | -0.5 to +5.5 V |
| 19, 37 | $V_{CC}$ | +5 V Power Supply Input ±10% | -0.3 to +5.5 V |
| 28 | BAND 0 | Band Select Bit 0 | -0.5 to ($V_{CC}$ + 0.5) V |
| 30 | $\overline{STB}$ | Parallel Strobe | |
| 31 | A6 | Parallel Bit 6 | |
| 32 | A4/$\overline{CS}$ | Parallel Bit 4/SPI Chip Select | |
| 33 | A2 | Parallel Bit 2 | |
| 34 | A0 | Parallel Bit 0 | |
| 35 | PAR/$\overline{SER}$ | Parallel/Serial Mode Selection | |

**Note(s):** 1 Leave pins disconnected for unit to function properly.

## Interface & Control Notes:

### General Information

The **ERF-5W™** requires a single +5 VDC analog supply and a +1.65 to +5.5 VDC digital supply. These supply voltages should be adequately filtered as noise present on these pins will influence the RF signal purity.

### Digital Tune Interface

The **ERF-5W™** tune interface is capable of operating at a variable input logic level. In order to set the logic level, tie the "Digital Interface Supply", VCCD, pins to the voltage of the logic level that will interface with the **ERF-5W™**. For instance, if the tune interface should operate at +3.3 V CMOS, tie the "Digital Interface Supply" pins to +3.3 V. If the tune interface should operate at +5 V CMOS, tie the "Digital Interface Supply" pins to +5 V. The digital inputs can be driven with CMOS or TTL signals. All digital outputs are CMOS.

The **ERF-5W™** can operate in Serial Mode or Parallel mode. The tune mode is chosen at power-up by sampling the PAR/NSER input. To operate in serial mode either let the PAR/NSER pin float or tie it to ground. To operate in parallel mode, pull the PAR/NSER pin to +3.3 V or greater (this pin can be tied to VCCD if VCCD is >= +3.3 V).

### DC Control Interface Characteristics:

| Parameter | $V_{CCD}$ | Minimum | Maximum | Units |
|---|---|---|---|---|
| High-level Input Voltage | 1.65V to 1.95V | $V_{CCD}$ × 0.65 | $V_{CCD}$ | V |
| | 2.3V to 2.7V | 1.7 | | |
| | 3V to 3.6V | 2 | | |
| | 4.5V to 5.5V | $V_{CCD}$ × 0.7 | | |
| Low-level Input Voltage | 1.65V to 1.95V | | $V_{CCD}$ × 0.35 | V |
| | 2.3V to 2.7V | | 0.7 | |
| | 3V to 3.6V | | 0.8 | |
| | 4.5V to 5.5V | | $V_{CCI}$ × 0.3 | |


**MINI-POLE® NOTCH** Filters are optimized for small physical size and low power consumption. Standard package is Thru-Hole Mount. For interface and mechanical outline, please refer to the bandpass MINI-POLE® section on pages 10-15.

## MINI-POLE® NOTCH SERIES

### Specifications:

| | |
|---|---|
| **Frequency Coverage (7 Bands):** | **1.5 to 400 MHz** |
| Input/Output Impedance: | 50Ω |
| Passband Input/Output VSWR: | 2:1 max. |
| Notch RF Power Handling: | +24 dBm |
| Passband RF Power Handling: | (offset dependent)<br>> 5 Watts @ ± 20% offset typical |
| Notch Depth: | 20 dB |
| 3 dB Bandwidth: | 10% typical |
| Passband IL: | <1 dB |
| Passband IP3: | +50 dBm (input, f0 > 30 MHz) |
| Center Frequency Drift: | -80 PPM/°C |
| Tuning Control: | 8 bit parallel |
| Tuning Speed: | 10 µS ($f_0$ > 30 MHz, +10 dBm reference) |
| DC Power Consumption (Static): | +5 VDC @ 10 to 250 mA<br>+100 VDC @ 2 mA |
| Operating Temperature Range: | -40°C to +85°C |
| Size: | 0.6 × 1.4 × 2.3 (in.) / 15.2 × 35.6 × 58.4 (mm.) |
| Weight: | 3.2 oz. / 90.7 g. |
| RF Connection: | Thru-hole pin |

### Pinout & Ratings:

| PARALLEL INTERFACE | | | |
|---|---|---|---|
| **PIN #** | **Reference Designator** | **Description** | **Maximum Ratings** |
| 1, 21 | RF I/O | RF Input/Output | +30 dBm |
| 2, 3, 5, 15, 16, 18-20, 22, 42 | GND | Digital/RF Ground | — |
| 4 | $V_{CC}$ | +5 V Power Supply Input ±10% | -0.5 to +6 V |
| 6 | A7 | Parallel Bit 7 | -0.6 to +6.25 V |
| 7 | A6 | Parallel Bit 6 | |
| 8 | A5 | Parallel Bit 5 | |
| 9 | A4 | Parallel Bit 4 | |
| 10 | A3 | Parallel Bit 3 | |
| 11 | A2 | Parallel Bit 2 | |
| 12 | A1 | Parallel Bit 1 | |
| 13 | A0 | Parallel Bit 0 | |
| 14 | $\overline{STB}$ | Strobe | -0.5 to ($V_{CC}$ + 0.5) V |
| 17 | $V_{BB}$ | High Bias +100 V Supply Input | -0.5 to +125 V |
| 23, 28-35 | N/C | No Connect (1) | — |
| 24-27, 36-41 | Filter Enable | Filter Enable Pins (2) | — |

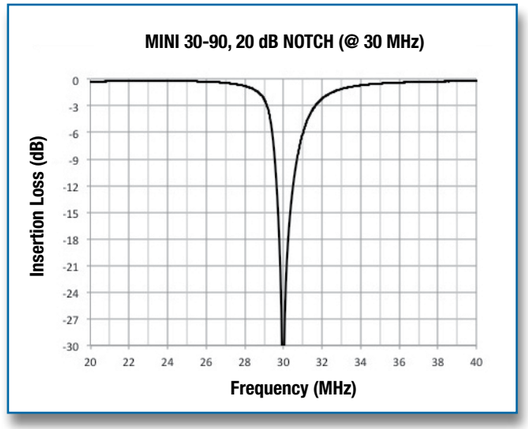
**Note(s):** 1 Leave pins disconnected for unit to function properly.
2 Pins must be connected as shown in package outline for filter to function properly.

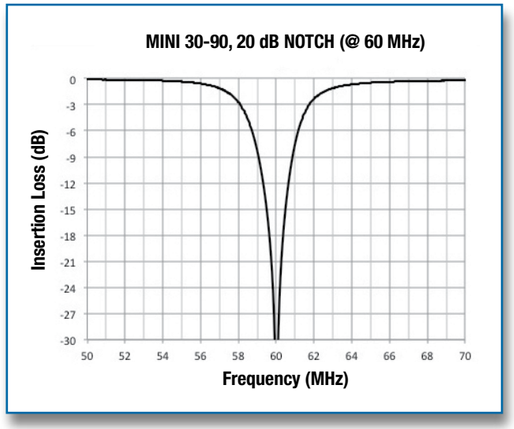
| SERIAL INTERFACE | | | |
|---|---|---|---|
| **PIN #** | **Reference Designator** | **Description** | **Maximum Ratings** |
| 1, 21 | RF I/O | RF Input/Output | +30 dBm |
| 2, 3, 5, 15, 16, 18-20, 22, 42 | GND | Digital/RF Ground | — |
| 4 | $V_{CC}$ | +5 V Power Supply Input ±10% | -0.5 to +6 V |
| 6-10, 23, 28-35 | N/C | No Connect (1) | — |
| 11 | SDO | Serial Data Out | -0.5 to ($V_{CC}$ + 0.5) V |
| 12 | SDI | Serial Data In | |
| 13 | SCLK | Serial Clock | |
| 14 | $\overline{STB}$ | Serial Strobe | |
| 17 | $V_{BB}$ | High Bias +100 V Supply Input | 0 to +125 V |

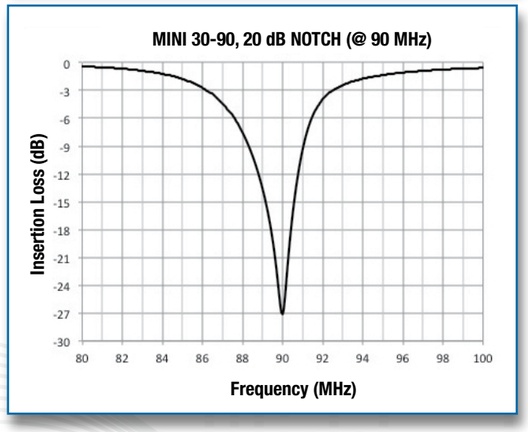
**Note(s):** 1 Leave pins disconnected for unit to function properly.

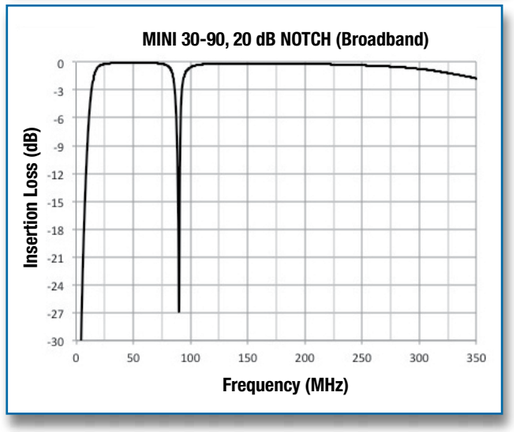
### Performance:

The following plots illustrate approximate performance (not representative of all frequency ranges)




### MINI-POLE® NOTCH Filters Product Number Guide:

| Series | Frequency (MHz) | Notch Depth (dB) | Options |
|---|---|---|---|
| MINI-NOTCH | 4-10<br>10-30<br>30-90<br>90-200 | 20 | B<br>C |

**Available Options:** B. Serial Interface
C. Custom Frequency Bands (Specify START and STOP frequencies in MHz.)

**Note(s):** 1. Options may be limited to particular frequency bands and/or configurations. Consult factory for your application.
2. Filters are aligned and tested using a High Bias of +100 VDC unless otherwise specified by the customer.

**Example:** Product # MINI-NOTCH-10-30-20

### MINI-POLE® NOTCH SERIES Selection Guide:

| Frequency Range | Suffix | Notch Depth (dB) | Strobe Rate (max.) | % Bandwidth (3 dB) Typical | | |
|---|---|---|---|---|---|---|
| | | | | Low | Mid. | High |
| 30 to 90 MHz | -20 | 20 min. | 1.5 KHz | 8.0% | 6.0% | 8.0% |
| 225 to 400 MHz | -20 | 20 min. | 2 KHz | 9.5% | 6.0% | 6.5% |


**MAXI-POLE® NOTCH** Filters offer all of the same performance features as the Mini-Notch filters, with the advantage of an improved notch shape factor. For interface and mechanical outline, please refer to the bandpass the **MAXI-POLE® NOTCH** section.

## MAXI-POLE® NOTCH SERIES

### Specifications:

| | |
|---|---|
| **Frequency Coverage (7 Bands):** | **1.5 to 400 MHz** |
| Input/Output Impedance: | 50Ω |
| Passband Input/Output VSWR: | 2:1 max. |
| Notch RF Power Handling: | +24 dBm typical |
| Passband RF Power Handling: | (offset dependent)<br>> 10 Watts @ ± 10% offset typical |
| Notch Depth: | 20 dB |
| 3 dB Bandwidth: | 5% typical |
| Passband IL: | < 1 dB |
| Passband IP3: | +50 dBm (input, $f_0$ > 30 MHz) |
| Center Frequency Drift: | -80 PPM/°C |
| Tuning Control: | 8 bit parallel |
| Tuning Speed: | 10 µS ($f_0$ > 30 MHz, +10 dBm reference) |
| DC Power Consumption (Static): | +5 VDC @ 10 to 500 mA<br>+100 VDC @ 2 mA |
| Operating Temperature Range: | -40°C to +85°C |
| Size: | 1.5 × 2.5 × 3.3 (in.) / 38.1 × 63.5 × 83.8 (mm.) |
| Weight: | 9.2 oz. / 260.8 g. |
| RF Connection: | SMA jack |

### Pinout & Ratings:

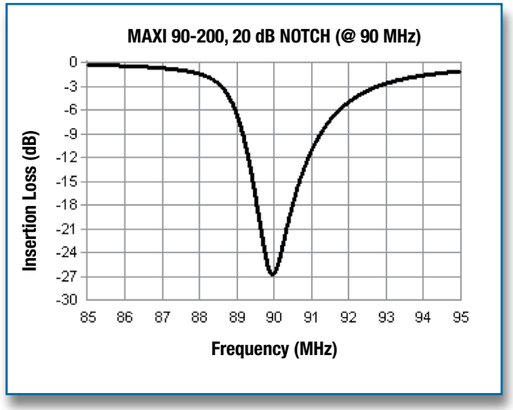
| PARALLEL INTERFACE | | | |
|---|---|---|---|
| **PIN #** | **Reference Designator** | **Description** | **Maximum Ratings** |
| 1 | A2 | Parallel Bit 2 | -0.5 to ($V_{CC}$ + 0.5) V |
| 2 | A3 | Parallel Bit 3 | |
| 3 | A4 | Parallel Bit 4 | |
| 4 | A5 | Parallel Bit 5 | |
| 5 | A6 | Parallel Bit 6 | |
| 6 | A7 | Parallel Bit 7 | |
| 7, 9, 11, 12 | GND | Digital/RF Ground | – |
| 8 | $V_{CC}$ | +5V Power Supply Input ±10% | -0.5 to +6 V |
| 10 | $V_{BB}$ | High Bias +100V Supply Input | 0 to +125 V |
| 13 | $\overline{STB}$ | Strobe | -0.5 to ($V_{CC}$ + 0.5) V |
| 14 | A0 | Parallel Bit 0 | |
| 15 | A1 | Parallel Bit 1 | |

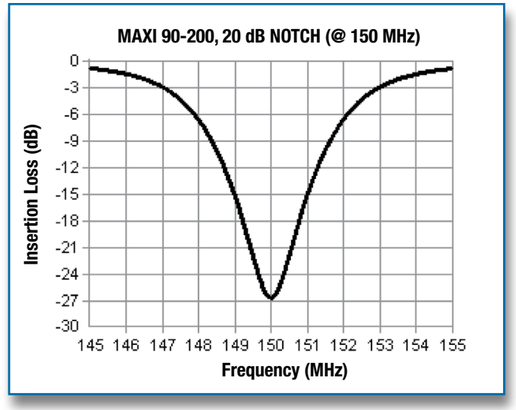
| SERIAL INTERFACE | | | |
|---|---|---|---|
| **PIN #** | **Reference Designator** | **Description** | **Maximum Ratings** |
| 1 | SDO | Serial Data Out | -0.5 to ($V_{CC}$ + 0.5) V |
| 2-6 | N/C | No Connect (1) | – |
| 7, 9, 11, 12 | GND | Digital/RF Ground | – |
| 8 | $V_{CC}$ | +5V Power Supply Input ±10% | -0.5 to +6 V |
| 10 | $V_{BB}$ | High Bias +100V Supply Input | 0 to +125 V |
| 13 | $\overline{STB}$ | Strobe | -0.5 to ($V_{CC}$ + 0.5) V |
| 14 | SCLK | Serial Clock | |
| 15 | SDI | Serial Data In | |

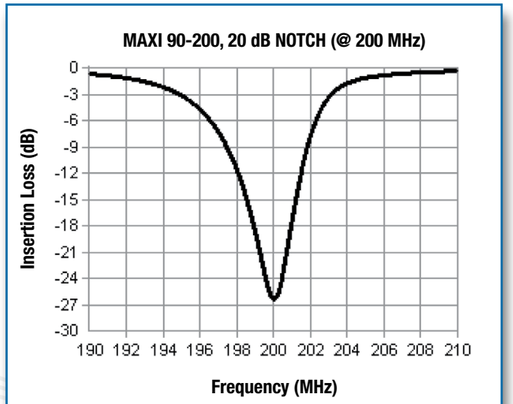
**Note(s):** 1 Leave pins disconnected for unit to function properly.

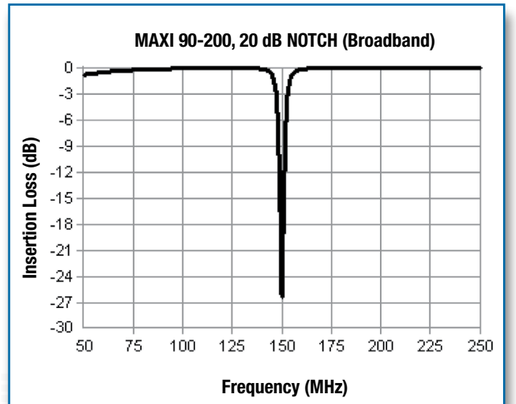
### Performance:

The following plots illustrate approximate performance (not representative of all frequency ranges)




### MAXI-POLE® NOTCH Filters Product Number Guide:

| Series | Frequency (MHz) | Notch Depth (dB) | Options |
|---|---|---|---|
| MAXI-NOTCH | 1.5-4<br>4-10<br>10-30<br>30-90<br>90-200<br>200-400<br>225-400 | 20 | A<br>B<br>C<br>F |

**Available Options:** A. Internal DC-DC converter (eliminates need for high voltage supply. Requires additional 250 mA of 5 VDC current.)
B. Serial Interface
C. Custom Frequency Bands (Specify START and STOP frequencies in MHz.)
F. Filtered D-connector

**Note(s):**
1. Options may be limited to particular frequency bands and/or configurations. Consult factory for your application.
2. Filters are aligned and tested using a High Bias of +100 VDC unless otherwise specified by the customer.

**Example:** Product # MAXI-NOTCH-10-30-20

### MAXI-POLE® NOTCH SERIES Selection Guide:

| Frequency Range | Suffix | Notch Depth (dB) | Strobe Rate (max.) | % Bandwidth (3 dB) Typical | | |
|---|---|---|---|---|---|---|
| | | | | Low | Mid. | High |
| 4 to 10 MHz | -20 | 20 min. | 170 Hz | 8.0% | 5.5% | 6.0% |
| 10 to 30 MHz | -20 | 20 min. | 840 Hz | 6.5% | 6.0% | 7.5% |
| 200 to 400 MHz | -20 | 20 min. | 2 KHz | 5.0% | 3.0% | 3.0% |
| 225 to 400 MHz | -20 | 20 min. | 2 KHz | 5.0% | 3.0% | 3.0% |


The **MAXI/4R NOTCH** contains 4 “poles” of filtering to provide additional rejection at the tuned frequency of the notch when compared to our standard MAXI-POLE® Notches. The unit has been designed for applications in UHF receiver front ends (nearby transmitter carrier rejection) and/or transmitter back ends (broadband noise rejection at the frequency of a nearby receiver). For interface and mechanical outline, please refer to the bandpass MAXI/4R.

## MAXI/4R NOTCH SERIES

### Specifications:

| **Frequency Coverage:** | **225 to 400 MHz*** |
|---|---|
| Input/Output Impedance: | 50Ω |
| Passband Input/Output VSWR: | 2:1 max. |
| Notch RF Power Handling: | 1 Watt |
| Passband RF Power Handling: | 50 Watt @ FN ± 20 MHz typical |
| Notch Depth: | 35 dB min. |
| Notch Width: | FN ± 300 KHz min. |
| 3 dB Bandwidth: | 10 MHz typical |
| Passband IL: | < 1 dB |
| Passband IP3: | +50 dBm (10/20 MHz) |
| Center Frequency Drift: | (internal temp. comp.) |
| Tuning Control: | 9 bit serial |
| Tuning Speed: | 40 µS (1 MHz clock) |
| DC Power Consumption (Static): | +5 VDC @ 1.5 A max.<br>+100 VDC @ 2 mA |
| Operating Temperature Range: | -40°C to +70°C |
| Size: | 3.1 × 3.5 × 7.0 (in.) / 79.4 × 88.9 × 177.8 (mm.) |
| Weight: | 56 oz. / 1588 g. / 1.6 kg. |
| RF Connection: | SMA jack |

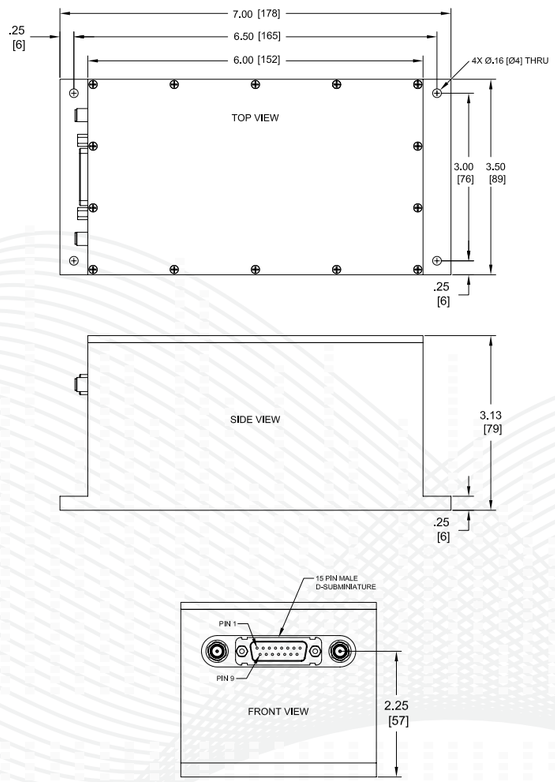
* Consult factory for additional ranges.

### Pinout & Ratings:

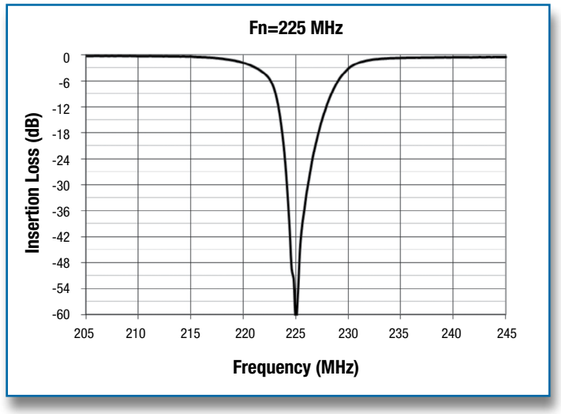
| PIN # | Reference Designator | Description | Maximum Ratings |
|---|---|---|---|
| 1 | SDO | Serial Data Out | -0.5 to ($V_{CC}$ + 0.5) V |
| 2-6 | N/C | No Connect (1) | — |
| 7, 9, 11, 12 | GND | Digital/RF Ground | — |
| 8 | $V_{CC}$ | +5 V Power Supply Input ±10% | -0.5 to +6 V |
| 10 | $V_{BB}$ | High Bias +100 V Supply Input | 0 to +125 V |
| 13 | STB | Strobe | -0.5 to ($V_{CC}$ + 0.5) V |
| 14 | SCLK | Serial Clock | |
| 15 | SDI | Serial Data In | |

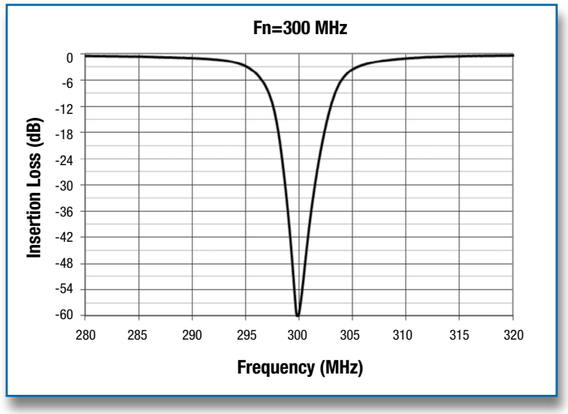
**Note(s):** 1 Leave pins disconnected for unit to function properly.

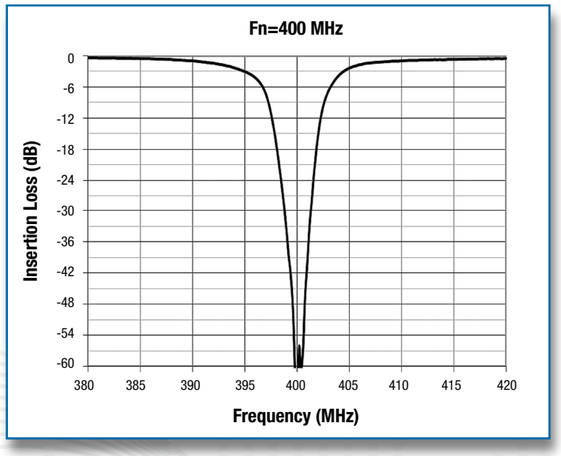
### Mechanical Outline:

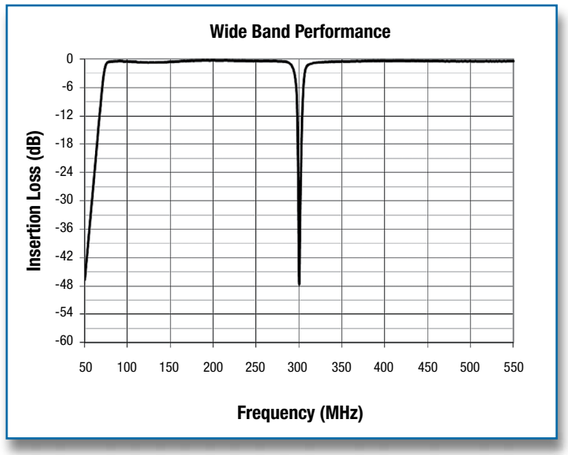



### Performance:




**POWER-POLE® NOTCH** Filters offer improved performance and power handling over our MINI and MAXI-NOTCH Filters.

For interface and mechanical outline, please refer to the bandpass POWER-POLE® section.

## POWER-POLE® NOTCH SERIES

### Specifications:

| | |
|---|---|
| **Frequency Coverage (3 bands):** | **30 to 90 MHz** |
| Input/Output Impedance: | 50Ω |
| Passband Input/Output VSWR: | 2:1 max. |
| Notch RF Power Handling: | 2 Watt |
| Passband RF Power Handling: | (offset dependent) > 50 Watts @ ± 20% offset typical) |
| Notch Depth: | 20 dBm |
| 3 dB Bandwidth: | 4% typical |
| Passband IL: | < 1 dB |
| Passband IP3: | +50 dBm (input, $f_0$ > 30 MHz) |
| Center Frequency Drift: | -80 PPM/°C |
| Tuning Control: | 8 bit parallel |
| Tuning Speed: | 20 µS |
| DC Power Consumption (Static): | +5 VDC @ 400 mA to 1.5 A |
| Operating Temperature Range: | -40°C to +65°C |
| Size: | 2.6 × 3.0 × 4.0 (in.) / 66.7 × 76.2 × 101.6 (mm.) |
| Weight: | 18.7 oz. / 530.1 g. / .5 kg. |
| RF Connection: | SMA jack |

### Pinout & Ratings:

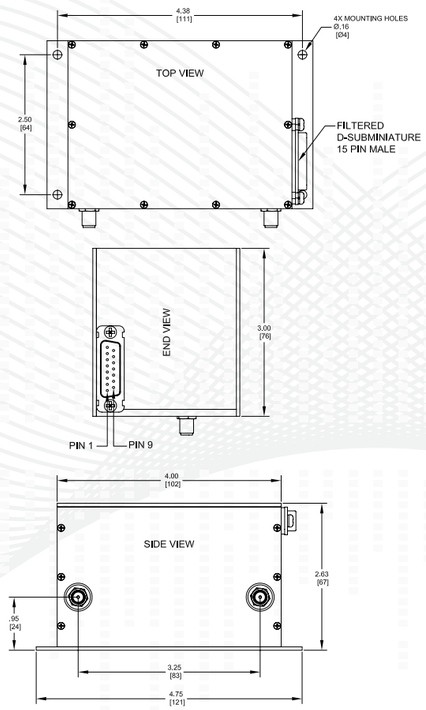
| PARALLEL INTERFACE | | | |
|---|---|---|---|
| **PIN #** | **Reference Designator** | **Description** | **Maximum Ratings** |
| 1 | A2 | Parallel Bit 2 | -0.5 to ($V_{CC}$ + 0.5) V |
| 2 | A3 | Parallel Bit 3 | |
| 3 | A4 | Parallel Bit 4 | |
| 4 | A5 | Parallel Bit 5 | |
| 5 | A6 | Parallel Bit 6 | |
| 6 | A7 | Parallel Bit 7 | |
| 7, 9, 11, 12 | GND | Digital/RF Ground | — |
| 8 | $V_{CC}$ | +5 V Power Supply Input ±10% | -0.5 to +6 V |
| 10 | N/C | No Connect (1) | — |
| 13 | $\overline{STB}$ | Strobe | -0.5 to ($V_{CC}$ + 0.5) V |
| 14 | A0 | Parallel Bit 0 | |
| 15 | A1 | Parallel Bit 1 | |

**Note(s):** 1 Leave pins disconnected for unit to function properly.

| SERIAL INTERFACE | | | |
|---|---|---|---|
| **PIN #** | **Reference Designator** | **Description** | **Maximum Ratings** |
| 1 | SDO | Serial Data Out | 0 to +6 VDC |
| 2-6, 10 | N/C | No Connect (1) | — |
| 7, 9, 11, 12 | GND | Digital/RF Ground | — |
| 8 | Vcc | +5 V Power Supply Input ±10% | -0.5 to +6 V |
| 13 | $\overline{STB}$ | Strobe | -0.5 to ($V_{CC}$ + 0.5) V |
| 14 | SCLK | Serial Clock | |
| 15 | SDI | Serial Data In | |

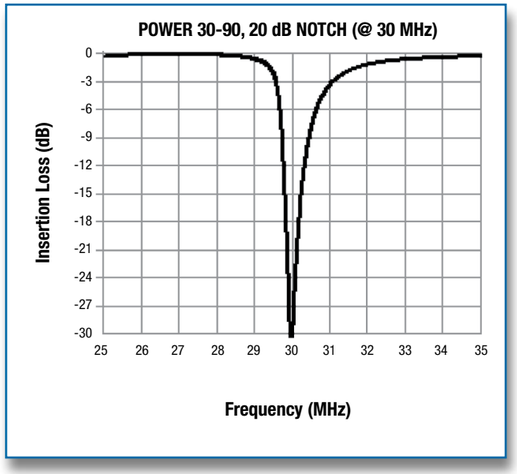
**Note(s):** 1 Leave pins disconnected for unit to function properly.

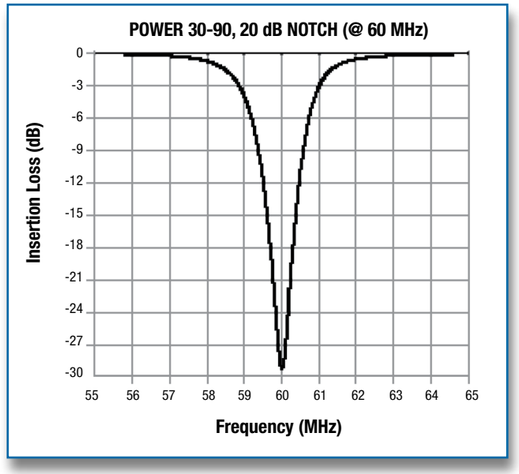
### Mechanical Outline:

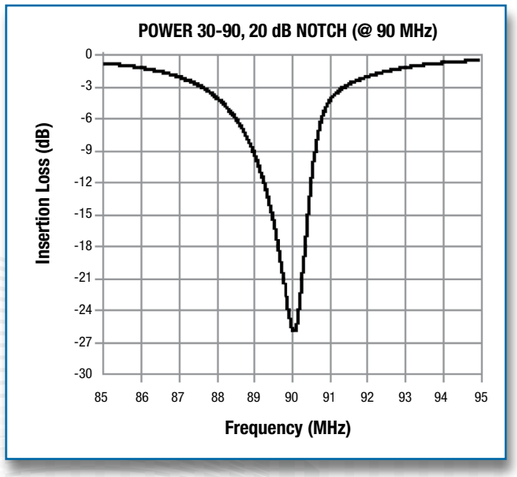



### Performance:

The following plots illustrate approximate performance (not representative of all frequency ranges)



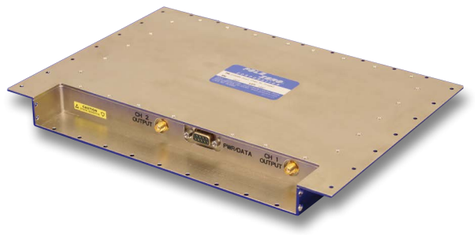

## POWER-POLE® NOTCH
### Filters Product Number Guide:

| Series | Frequency (MHz) | Notch Depth (dB) | Options |
|---|---|---|---|
| POWER-NOTCH | 30-90 | 20 | B<br>C |

**Available Options:** B. Serial Interface
C. Custom Frequency Bands (Specify START and STOP frequencies in MHz.)

**Note(s):** Options may be limited to particular frequency bands and/or configurations. Consult factory for your application.

**Example:** Product # POWER-NOTCH-30-90-20



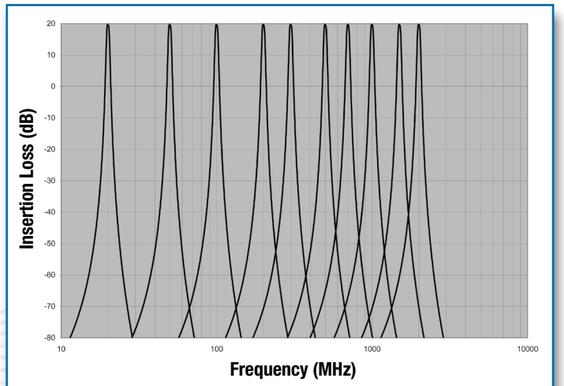
The **PSEL1003** is a broadband preselector designed for applications, such as JTRS, requiring light weight, small size and low power consumption. It provides digitally tunable bandpass filtering from 20 MHz to 2 GHz and high pass filtering from 2 to 3 GHz. The **PSEL1003** provides 20 dB of gain for your receiver application and includes an RS-485 interface for easy integration. It can be ordered to provide filtering for one or two receive paths.

## PSEL1003

### Specifications:

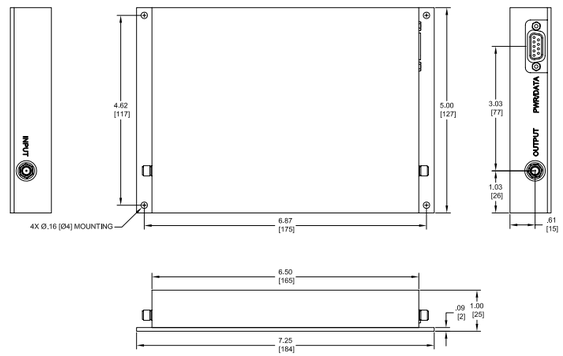
| **Frequency Coverage:** | **20 to 3000 MHz** |
|---|---|
| Operation: | Broadband Preselector |
| Receive Gain: | 20 dB ± 3 dB |
| Receive Noise Figure: | 8 dB avg. |
| Receive Input IP3: | +3 dBm avg. |
| Transmit RF Output Power: | 100 mW max. |
| Selectivity: | -35 dB @ ± 10% avg.<br>-58 dB @ ± 20% avg.<br>-65 dB @ ± 30% avg. |
| Tuning Speed: | < 1 mS |
| Power: | +24V ± 5% or<br>+12V ± 5%<br>2 Watts/path |
| Operating Temperature Range: | -40°C to +50°C |
| Size: **Single:** | 1.0 × 6.5 × 5.0 (in.) / 25.4 × 165.1 × 127 (mm.) |
| **Dual:** | 1.0 × 8.0 × 9.5 (in.) / 25.4 × 203.2 × 241.3 (mm.) |
| Weight: **Single:** | 1.4 lbs. / .64 kg. |
| **Dual:** | 2.8 lbs. / 1.27 kg. |
| RF Connection: | SMA jack |

### Performance:

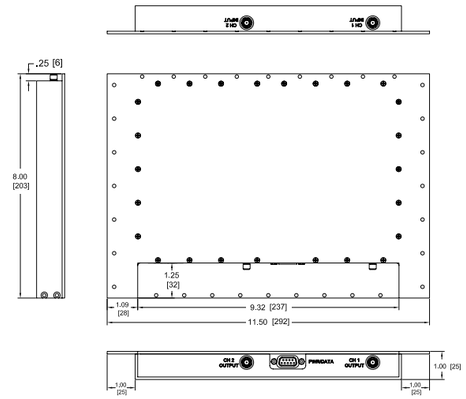



### Chassis Outline:

Single Channel




Dual Channel




### PSEL1003 Product Number Guide:

| Series | Frequency (MHz) |
|---|---|
| PSEL1003 | R-20-3000 |

## The Cosite Communications Interference Challenge

Today's military communications transceivers operate over many frequency bands with features such as embedded cryptography, frequency hopping, networking and waveform upgradeability via field software change-all contained in the small package that modern electronics packaging allows.

When these transceivers are operated in close proximity to other RF emitters, these "other" RF emissions constitute interference to the transceiver when receiving. While the interference can be created either intentionally (i.e. jamming) or not, the transceiver's receive performance degrades rapidly due to a phenomenon termed "cosite communications interference."

Receivers differ in their vulnerability to cosite interference. While most communications receivers use superheterodyne architectures with very selective Intermediate Frequency (IF) circuitry, the level of RF selectivity prior to the IF circuitry, termed "preselection," may be minimal or even non-existent – especially in modern multiband, software defined radios. In cosite operation, the lack of preselection renders the RF and frequency conversion circuitry vulnerable to nonlinear effects created by the high level interference. These nonlinear effects allow translation of unwanted frequency components into the receiver's IF circuitry and demodulator, which both work to degrade the cosite receiver's sensitivity to weak, desired signals.

Additionally, the cosite RF emitter, although commonly operating at a frequency offset from the local receiver, may create spurious emissions (harmonics, intermodulation products, noise, etc.) that fall directly on the cosite receiver's operating frequency. These spurious emissions create an effective "noise floor" in the cosite receiver that can be 10's of decibels higher than the receiver's inherent noise floor yielding severe degradation of the receiver's sensitivity and commensurate degradation in the communication link's range.

## Potential Interference Mitigation Strategies

To consider interference mitigation strategies for these cosite interference effects, the following three generalized interference scenarios viewed from the perspective of the sensitive cosite receiver will be illustrative.

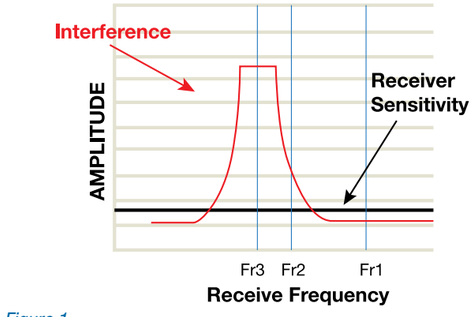



*Figure 1*

Figure 1 is a spectral plot at the cosite receiver's antenna port, showing a generalized interference spectrum, shown in red, in relation to three potential reception frequencies. This interference spectrum can be either narrowband or wideband, intentionally generated (jamming) or unintentionally generated merely through the act of "friendly" cosite communications. While the figure shows the interference spectrum generally lower in frequency than the desired reception frequencies, the pertinent issue is really the level of frequency offset, if any, between the interference and desired reception.

If appreciable frequency offset exists between the interference spectrum and the desired receive frequency, frequency selective filtering in the form of bandpass, low pass, high pass or band reject (notch) filtering can be employed to reject the interference spectrum. In the event that $F_{r1}$ is offset in another operational band, fixed tuned, "cross band" selective filtering can be employed. As the offset between $F_{r1}$ and the interference spectrum diminishes, greater selectivity must be employed. Further, in the event that either the interference or the desired reception frequency is changing rapidly with time ("hopping"), tunable selective filtering approaches must be utilized.

In the event that very limited or no frequency offset is available between the interfering waveform and the desired receive frequency, frequency selective filtering may render insufficient rejection. In these situations, cancellation or "outphasing" techniques can be employed where a replica of the interfering spectrum is either directly coupled from the local, cosite interferer (termed a "reference") or synthesized at the receive site ("referenceless") with appropriate level and phase adjustment such that destructive interference between the interference replica and the actual interference occurs in the receive signal path. Figure 2 illustrates the cancellation technique using a directly coupled interference replica approach. This technique can result in interference rejection of >40 dB at the receiver.

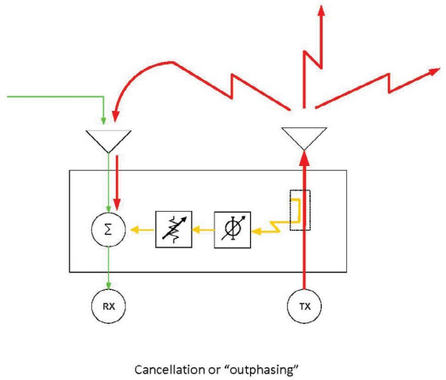



*Figure 2*

## Cosite Communications Interference Scenarios and Appropriate Mitigation Approaches

We will now consider general interference mitigation strategies for the three reception scenarios identified in figure 1.

### Reception at $F_{r1}$

In this scenario, there is significant frequency offset between the interference and receive signal frequency. Additionally, the spurious (noise) from the interferer at the receive location is well below the receive sensitivity and, therefore, not likely to result in degradation of the receiver's sensitivity. Under the assumption that the interference level at the receiver exceeds the linear dynamic range of the receiver, the nonlinear effects described above will degrade receive sensitivity. If the receive frequency to interference offset will remain large and generally constant, fixed tuned selective filtering (LPF, BPF, HP, Notch) in the receive signal path can be used to further isolate these signals. Note that in the event notch filtering is employed, the notch frequency must be tuned to the interferer's frequency of operation and not the receiver frequency which involves careful coordination between radio frequency systems which may be difficult to obtain. In the event of multiple interferers, multiple notch filters must be employed – all tuned to the frequency of the various interferences.

If the interference and receive signal offset is changing with time due to frequency hopping of either signal, the selective filtering employed must also adapt or "tune" to maintain the appropriate level of isolation.

Cancellation can also be employed to reject the interferer's amplitude at the receive location. If the interference is narrowband (<100 KHz), a "referenceless" canceller can be employed to reject the interference at the receive site. This approach finds greatest application for Signal Intelligence (SIGINT) applications where wide receive bandwidths contribute to greater vulnerability to high level, narrowband interference.

### Reception at $F_{r2}$

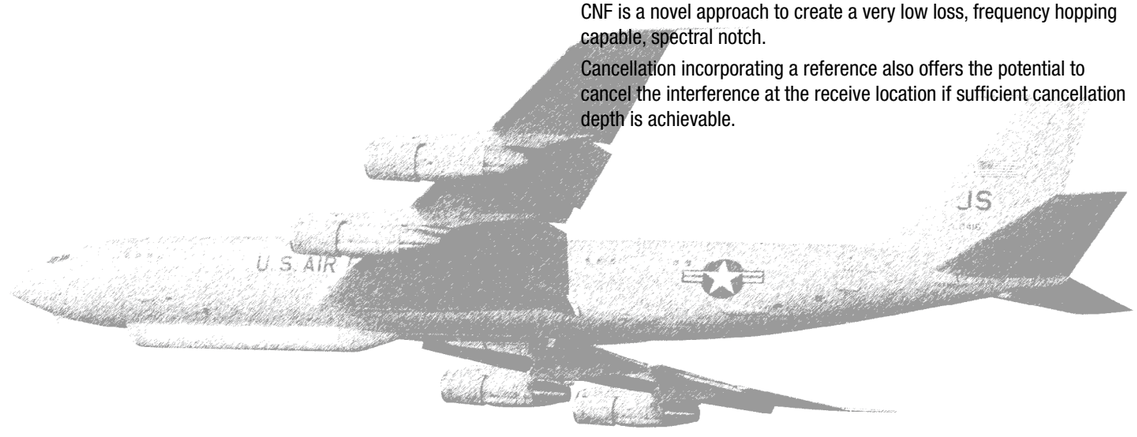
This scenario is similar to the above scenario in that high level interference exists with an unspecified offset from the desired receive frequency, but differs in that the interference's spurious (noise) energy at the receive location is sufficient to degrade the receiver's sensitivity. Interference mitigation for this scenario can utilize frequency selective filtering described above to reject the interferer's signal energy although with less frequency offset, the level of selectivity must increase. Further, since interference spurious exists at the receive frequency, selective filtering at the receiver will not remove this energy, but must be employed in the cosite emitter's (i.e. transmitter's) signal path.

Interference rejection using cancellation approaches can be utilized, but must be limited to approaches using interference references with sufficient rejection bandwidths to simultaneously reject both the high level interference and spurious to appropriate levels. Since the bandwidth of a referenced cancellation approach is a function of the interfering antenna to receiving antenna's amplitude and delay characteristics, which may be changing with time, the fielded cancellation approach must be adaptive.

### Reception at $F_{r3}$

Reception at $F_{r3}$ where desired reception is within the bandwidth of the interference can be reflective of both jamming and wideband communications applications (MUOS, SRW, WNW, ANW2). Selective filtering is not useful in this scenario unless the interference waveform can be slightly modified by placing a spectral notch in the interference bandwidth at the emitter to assist reception at $F_{r3}$. The spectral notch can be achieved by using classical selective notch filtering at the emitter's output or via Pole/Zero's Cosite Notch Filter (CNF). The CNF is a novel approach to create a very low loss, frequency hopping capable, spectral notch.

Cancellation incorporating a reference also offers the potential to cancel the interference at the receive location if sufficient cancellation depth is achievable.



## Cosite Communications Interference Mitigation Specifics

The mitigation strategies presented above for each scenario are summarized in the following table. To capture the level of selectivity required in each scenario, a benchmark must be used. The benchmark used in this catalog incorporates the 50 dB selectivity point's frequency offset of the filter as a percentage of tune frequency.

| Mitigation Strategy | | Interference Scenario | | |
|---|---|---|---|---|
| | | Reception at $F_{r1}$ | Reception at $F_{r2}$ | Reception at $F_{r3}$ |
| **Selective Filtering** | | | | |
| | Fixed or Cross Band | | | |
| | Modest Performance | | | |
| | High Performance | | | |
| | Ultra High Performance | | | |
| **Cancellation** | | | | |
| | Referenced | | | |
| | Referenceless | | | |
| | CNF | | | |

*Table 1*

For example, a bandpass filter tuned at 100 MHz that achieves 50 dB selectivity at 110 MHz, is a modest performance filter (10% offset, 50 dB point).

## How To Use This Catalog

Pole/Zero suggests the following methodology to develop an optimal interference mitigation strategy for your application:

1. Determine the interference scenario that meets your application
2. Use table 1 to consider general mitigation strategies
3. Use table 2 to consider specific Integrated Cosite Equipment for your application
4. Call Pole/Zero Business Development Engineers for additional assistance

| Equipment | Catalog Page | VHF-L | VHF-H | UHF | SATCOM |
|---|---|---|---|---|---|
| ICE1006 | 60 | | | | |
| ICE2002 | 62 | | | | |
| ICE3009 | 64 | | | | |
| ICE3001 | 66 | | | | |
| ICE3002 | 67 | | | | |
| ICE3003 | 68 | | | | |
| ICE3005 | 69 | | | | |
| ICE3006 | 70 | | | | |
| ICE3007 | 71 | | | | |
| ICE3008 | 72 | | | | |
| ICE4003 | 73 | | | | |
| ICE4004 | 74 | | | | |
| ICE4005 | 75 | | | | |
| ICE5001 | 76 | | | | |
| ICE5002 | 77 | | | | |
| Referenced | 80 | | | | |
| Referenceless | 81 | | | | |
| CNF | 78 | | | | |

*Table 2*

| Legend |
|---|
| Approx. >5% |
| Approx. 1.5%-5% |
| Approx. <1.5% |





Command & Control (C2) platforms require multiple RF communications channels to ensure force coordination over long distances. Unbeknownst to the warfighter, quite often these critical communication requirements are not met due to self-generated or cosite interference that severely degrades communication range. To ensure this does not happen to your platform, Pole/Zero® can provide a comprehensive evaluation of your platform's communication performance level, enabling peak operation even in the most dense electromagnetic environments. Pole/Zero®'s Cosite Interference Analysis takes into account the adversaries to your communications link including:

- Radio spurious signals output
- Broadband noise
- Simultaneous co-channel operation
- Limited antenna isolation
- Receiver desensitization
- Reciprocal mixing
- Cross modulation

The dynamic interaction of these phenomenons in your Command & Control (C2) communication architecture can severely hinder the warfighter's ability to communicate if not properly addressed. Whether during the development phase, a communication upgrade or on an existing deployed system, Pole/Zero® will assist your team to ensure optimum performance without the risk of either inadequate interference mitigation or costly overdesign. The end result is a cost-effective solution with maximum communication range!

## Cosite Analysis & Support Capability:

Analysis support for system integration

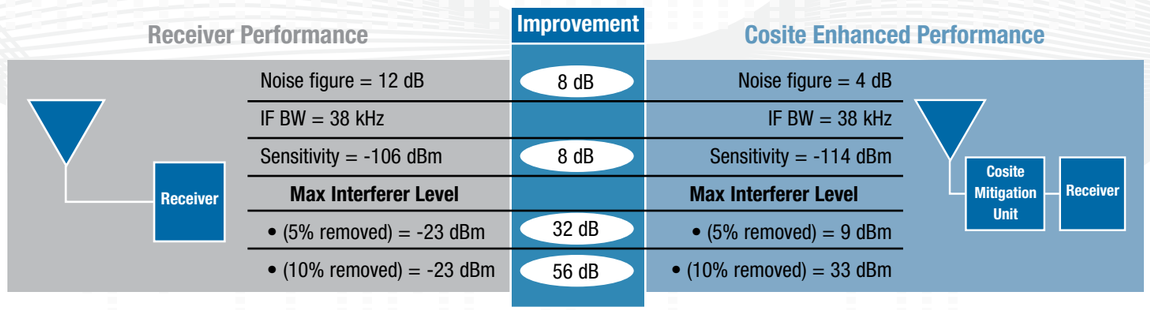
- Derive platform configuration
- Interpret performance requirements
- Derive comm scenarios
- Determine and resolve cosite effects on system performance

## Process Analysis Components:

- Leverages equipment performance database
- Utilizes proprietary routines for predictions of interference effects

## Cosite Analysis Overview


## Example Receiver Performance Improvement




The **MEGA-POLE®** filter series covers the standard frequency bands within the 30 to 450 MHz range with VHF-L, VHF-H or UHF versions. This new filter series provides excellent selectivity while maintaining very low insertion loss. The product line also has exceptional RF power handling capability with a high third order intercept point. The **MEGA-POLE®** filter series can be used for transmitter applications to reduce power amplifier noise, harmonics and intermodulation products, to provide bi-directional filtering directly at a transceiver's antenna port, or other applications requiring extremely linear, high power RF bandpass filtering. It has been designed for rugged environments per MIL-STD-810.

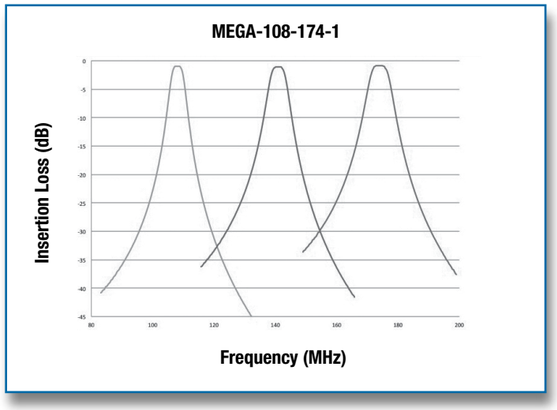
## MEGA-POLE® SERIES

### Specifications:

| | |
|---|---|
| **Frequency Coverage (VHF-L, VHF-H or UHF):** | **30 to 450 MHz** |
| Input/Output Impedance: | 50Ω |
| In-band RF Power Handling: | 50 W average<br>100 W peak |
| In-band Third Order Intercept: | > +60 dBm |
| Tuning Control: | Flexible control design for ARC-210 and VHF-4000. Standard options available. |
| Tuning Speed: | < 25 µs typical<br>Supports frequency hopping waveforms |
| DC Power: | +28 VDC, < 1A, MIL-STD-704 |
| Center Frequency Stability: | Internally compensated |
| Shape Factor (30 dB / 3 dB): | 3.3 to 3.75 typical |
| Operating Temperature Range: | -40°C to +55°C |
| Size: | 6 × 7.55 × 3.6 (in.) / 152 × 190 × 91 (mm.) |
| Available Finishes: | Chem-Film per MIL-C-5541<br>CARC Tan or Green<br>and Lusterless Grey or Black<br>available on request. |
| RF Connection: | TNC jack |

### Performance:

The following plots illustrate approximate performance (not representative of all frequency ranges):






### MEGA-POLE® Filters Product Number Guide:

| Series | Frequency (MHz) | Insertion Loss | Connector Type | Options |
|---|---|---|---|---|
| MEGA | 30-88*<br>108-174<br>225-400 | 1-1.5 dB | TNC (Female) | C |

**Available Options:** C. Custom Frequency Bands (Specify START and STOP frequencies in MHz.)

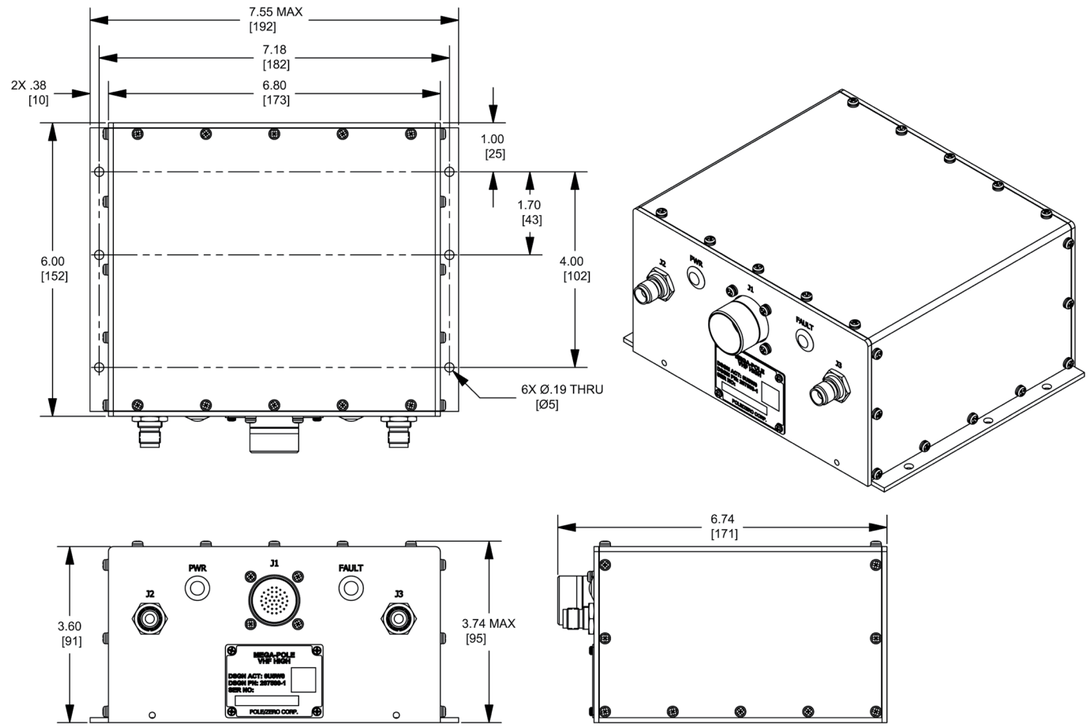
**Note(s):** Options may be limited to particular frequency bands and/or performance levels. Consult factory for your application.
* Preliminary

**Enhance the performance of your transceiver in frequency hopping cosite applications through use of the direct radio interface connection to the MEGA-POLE®.**

**MEGA-POLE® is available in multiple frequency bands with potential customizations:**

- **additional poles for sharper selectivity**
- **expanded frequency range or multi-band solutions**
- **size/selectivity trade-offs for small form factors**

### Mechanical Outline:




Data is believed to be accurate. All data is subject to change without notice.



Selective Filtering - Modest Performance

Intended for operation with modern handheld transceivers, the **ICE1006** will enhance performance in retransmission (radio relay), frequency hopping (SINCGARS/HQ) and single channel tactical communications applications where cosite interference limits communications range. Potential applications include UAVs and tactical ground and vehicular systems. Please contact your sales representative at 513-870-9060 for further details.

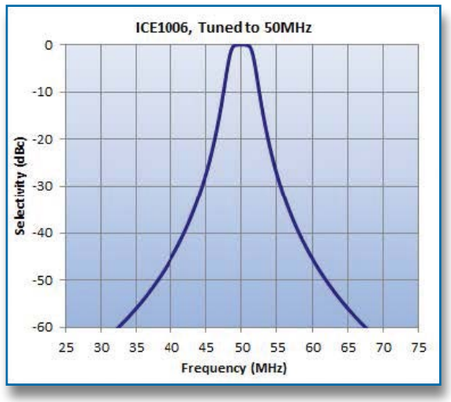
## ICE1006

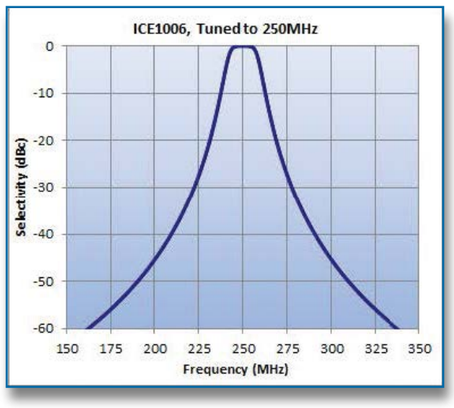
### Specifications:

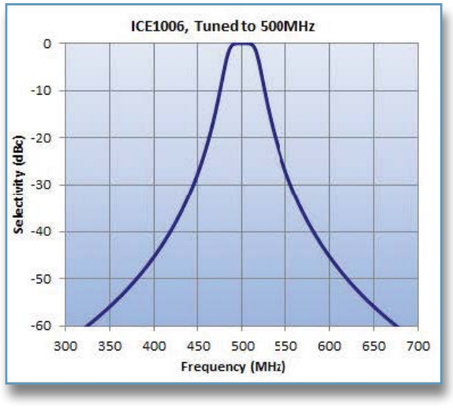
| **Part Number:** | **ICE1006-TR-30-512** |
|---|---|
| Frequency Coverage: | 30 to 512 MHz |
| Input/Output Impedance: | 50Ω, 1.5:1 typical |
| Receive Gain (Typical): | 3 dB min. |
| Receive Noise Figure: | 7 dB max. |
| Receive Input P1 dB | +8 dBm typical |
| Tx/Rx Minimum Selectivity | -23 dB @ ± 10%<br>-40 dB @ ± 20% |
| Ultimate Attenuation | -60 dB typical |
| Transmit RF Output Power: | 5-10 W |
| Tuning Control | Standard SPI or PRC-148 |
| Tuning Speed: | 25 µs typical |
| Power: | +12 to +32 VDC<br><40 W typical |
| Operating Temperature Range: | -40°C to +55°C |
| Size: | 1 × 3.75 × 2.75 (in.) / 25.4 × 95.25 × 69.85 (mm.) |
| Weight: | <8 oz. / <.23 kg. |

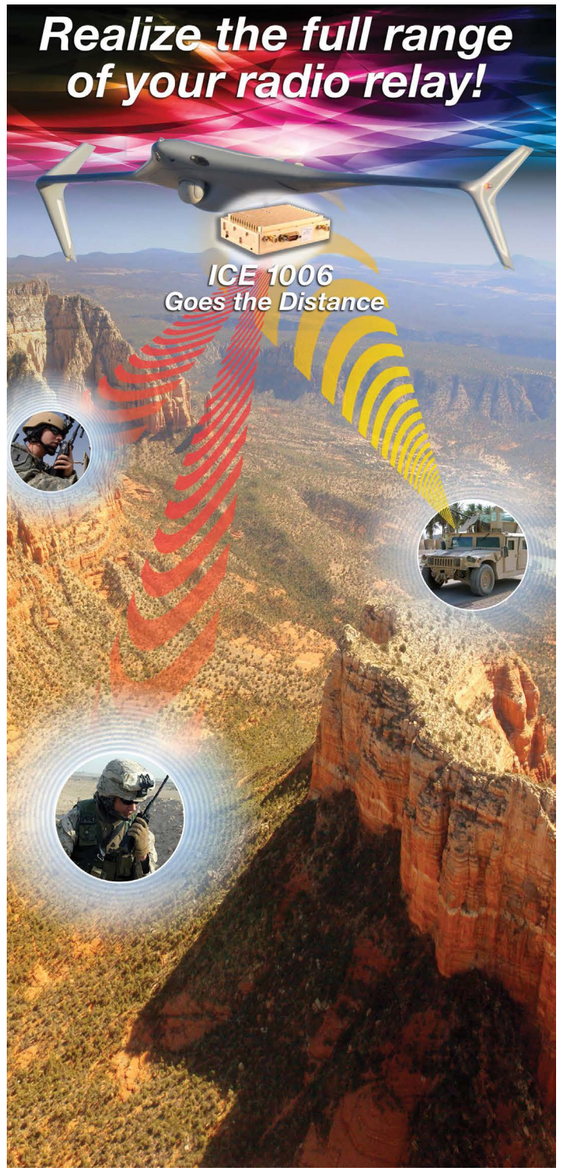
### Performance:

The following plots illustrate approximate performance:

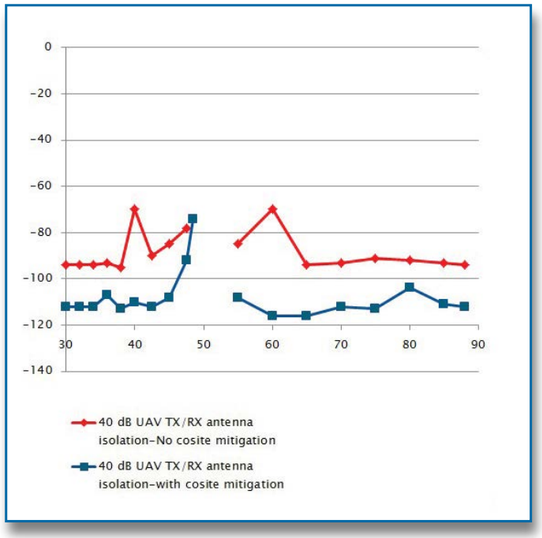


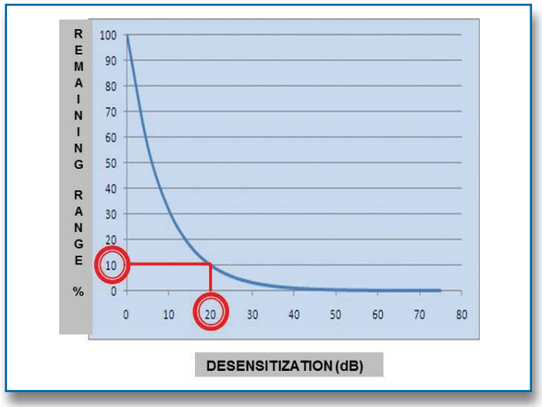




### Performance:




The experimental data above was collected from a laboratory set-up depicted in the UAV operational scenario pictured here. This experiment utilized a 50 MHz downlink, assumed 40 dB of isolation between antennas on the UAV, and illustrated that a 20 dB improvement is achievable by incorporating ICE1006 in your system. A video of the laboratory set-up that describes the full experiment is available on our website.




**Note that a 20 dB desensitization of your receiver results in the loss of 90% of your range! Regain the operating range of your system by incorporating ICE1006 in your retransmission system today!**

Selective Filtering - Modest Performance

The **ICE2002** is a dual channel, half duplex transmit and receive filter/amplifier designed for UAV applications. When used with modern, lightweight transceivers, interference free, full range, communications are realized for communications relay and vehicle control applications. The transceiver interface supports modern frequency hopping algorithms with Guard channel monitoring and protection via internal filtering. The unit is cooled by an internal fan that draws ambient air.

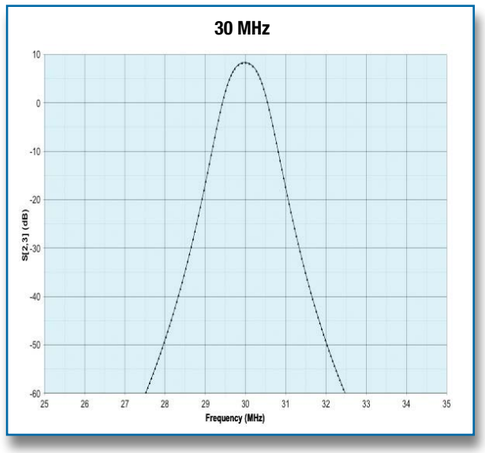
## ICE2002

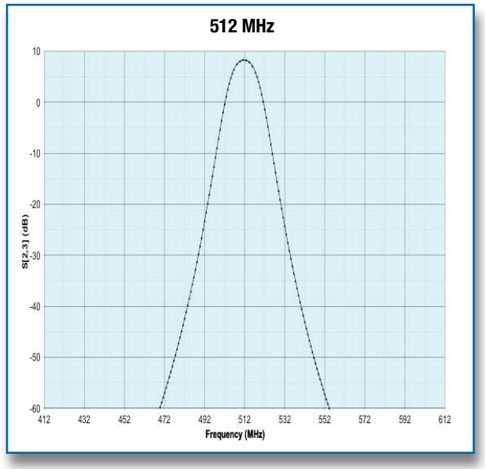
### Specifications:

| **Part Number:** | **ICE2002-2TR-30-512** |
|---|---|
| Frequency Coverage: | 30 to 88 MHz (VHFL)<br>108 to 174 MHz (VHFH)<br>225 to 512 MHz (UHF)<br>One Guard Channel<br>-121.5 MHz (VHF Guard)<br>-243 MHz (UHF Guard) |
| Receive Gain (Typical): | 10 dB (Main Channel) |
| Receive Noise Figure (Typical): | 5.0 dB nominal (Main Channel) |
| Transmit Noise Floor: | 30 to 88 MHz<br>-132 dBm/Hz @ 10% removed<br>108 to 174, 225-512 MHz<br>-132 dBM/Hz @ 10% removed |
| Transmit RF Output Power: | 50 W FM, 15 W AM (carrier) |
| Selectivity: | 30 to 88 MHz<br>27 dB @ ±5%<br>55 dB @ ±10%<br>108 to 174, 225-512 MHz<br>35 dB @ ±5%<br>55 dB @ ±10% |
| Harmonics: | Transmit:<br>Per MIL-STD-461E |
| Tuning Speed: | 200 µs max. |
| Power: | 1 Channel RX +28V @ 2.2A<br>1 Channel Tx +28V @ 12.8 A<br>2 Channel Tx +28V @25.6A |
| Operating Temperature Range: | -40°C to +55°C |
| Size: | 4.25 x 9.0 x 22 (in.) / 108 x 228.6 x 559 (mm.) |
| Weight: | 23 lbs. / 10 kg. |

### Performance:

The following plots illustrate approximate performance:



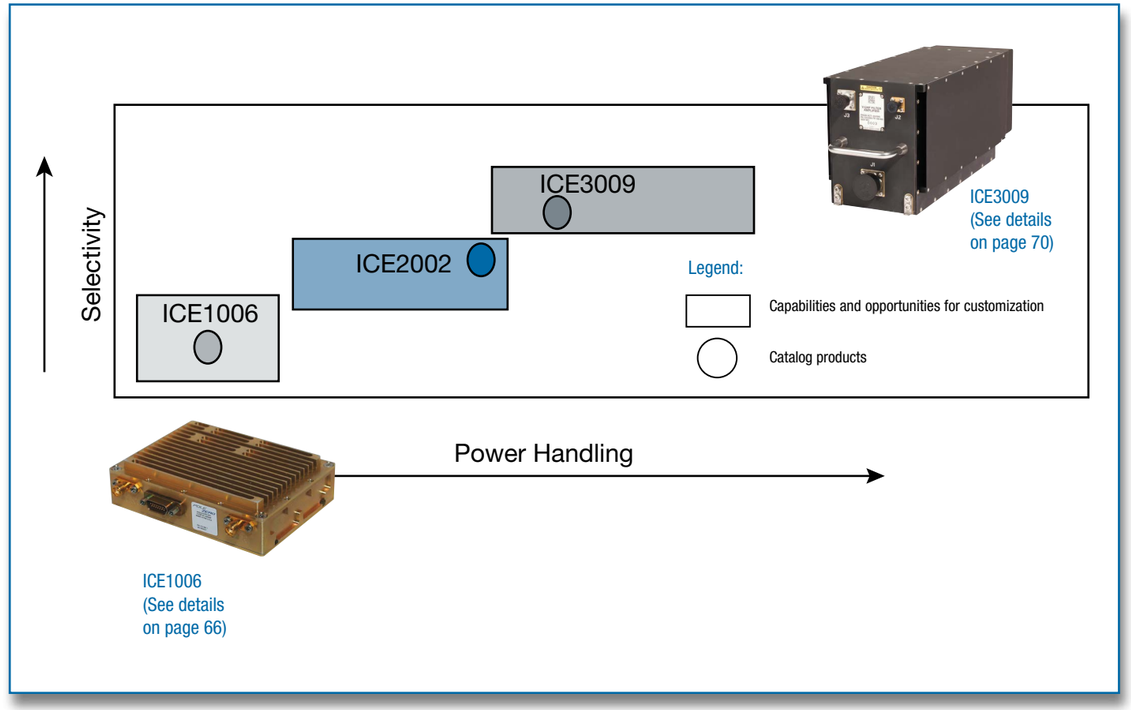








## Pole/Zero's multi-band units have the right selectivity/size combination for your application.

Please contact us to discuss your specific needs. With our broad range of products, we have the optimal solution for your program.




## The ICE2002 offers multi-band, high selectivity in a 12 lb. per channel form factor!

Customizations can involve:

- A single channel version with similar performance
- A lightweight model with selectivity trade-offs

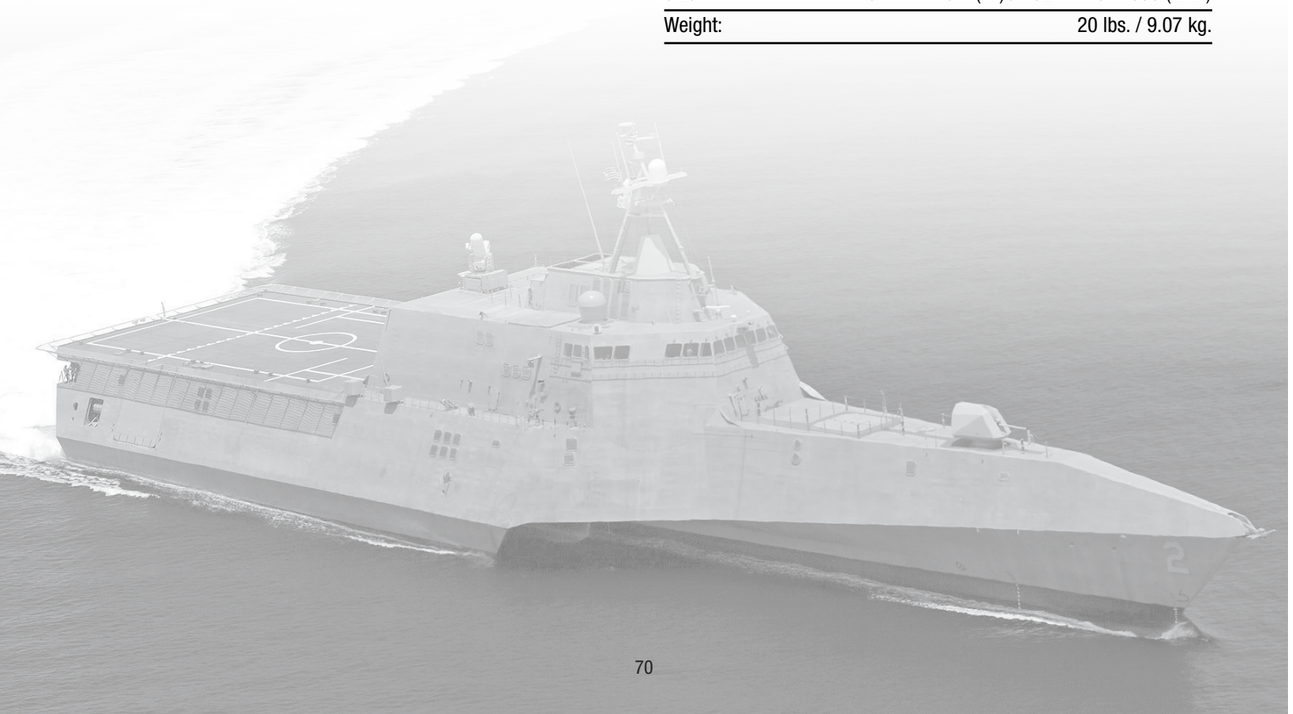
This subsystem is an agile filter for the VHF-L, VHF-H and UHF frequency bands. It allows operation of a number of transceivers in a cosite environment. The VHF/UHF filter provides multiple poles of RF selectivity to reduce broadband noise in transmit mode of operation and to reduce interfering signals at the transceiver's RF input in receive mode at Have Quick II/IIa and SATURN tuning speeds. This design incorporates a flexible control scheme that can be configured at the factory for various radio interfaces (ARC-210, ARC-231, ARINC 429, etc.). The design is highly integrated and includes all filters, amplifiers, power supply, transmit and receive switching (including a bypass mode) and Built-in-Test (BIT). A mounting tray is available as an option for easy incorporation on your platform. This system is qualified for military applications.

Cost-effective modifications are available on the **ICE3009**. Please contact your sales representative at 513-870-9060 for further details.

## ICE3009

### Specifications:

| **Part Number:** | | **ICE3009-TR-30-400** |
|---|---|---|
| Operation: | | Half duplex transmit and receive |
| Frequency Coverage: | | **VHFL:** 30 to 88 MHz<br>**VHFH:** 108 to 174 MHz<br>**UHF:** 225 to 400 MHz |
| Receive Gain (Typical): | | 5.0 to 10.0 dB |
| Receive Noise Figure (Typical): | | 9.0 dB |
| Receive Input IP3: | | +52 dBm @ 5 & 10% offset |
| Transmit RF Output Power: | | 20 W (AM) to 100 W (FM) depending on frequency band configuration |
| Selectivity (Typical): | | -35 dB @ > ± 3.0%<br>-55 dB @ > ± 5.0% |
| Broadband Noise: | | -140 dBm/Hz @ > 5% |
| Harmonics (Typical): | | -70 dBc (2nd, 3rd harmonic)<br>-80 dBc (others) |
| Spurious Signals: | **Receive:** | < -90 dBm (> 3%) |
| | **Transmit:** | -80 dBc min. per MIL-STD 461E |
| Tuning Speed: | | **UHF:** < 50 µs<br>**VHF:** < 100 µs |
| Power: | +28 VDC | **Tx:** 386 W<br>**Rx:** 125 W<br>**Bypass:** 80 W |
| Operating Temperature Range: | | -20°C to +55°C |
| Size: | | 6 × 7 × 15.7 (in.) / 152 × 178 × 398 (mm.) |
| Weight: | | 20 lbs. / 9.07 kg. |





### Configuration Selection Guide:

The ICE3009 design provides a flexible ICE platform that can be configured for your specific application. Your requirements can be achieved by tailoring the design through choices such as multiple frequency bands, multiple interface options, output power levels and various additional features such as Guard band options. Please review the guide below to tailor your ICE3009 to meet your needs:

**#1: Choose one (1) to three (3) of the required frequency bands below:**

- VHFL: 30 to 88 MHz
- VHFH: 108 to 174 MHz
- UHF: 225 to 400 MHz

**#2: Choose the radio/tuning interface you need for your application:**

- ARC-210
- PRC-117
- ARC-231
- TRA2030
- Custom (please provide details from your system design)

**#3: Determine your output power requirements for your application:**

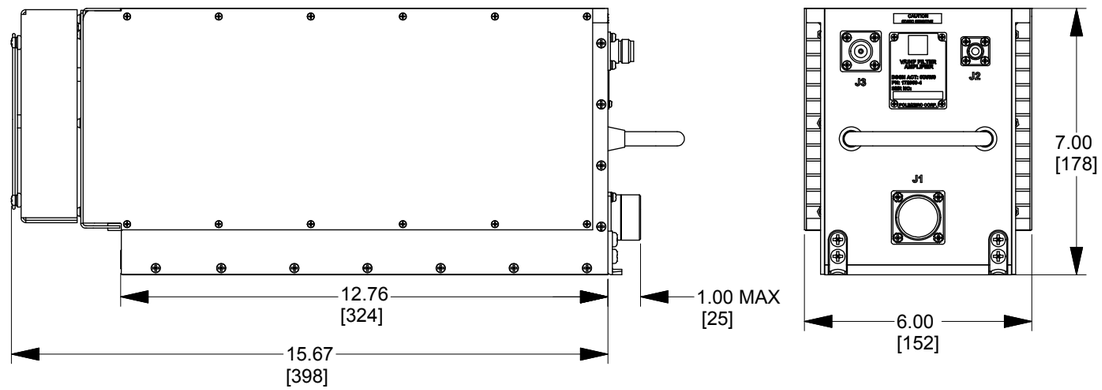
- 20 W (AM), 50 W (FM) for Tri-Band (VHFL, VHFH, and UHF)
- 25 W (AM), 50 W (FM) for Dual Band VHFH and UHF
- 40 W (AM), 100 W (FM) for Single Band UHF

**#4: Identify other requirements for your application:**

- Input RF power level you will be providing (0 to +43 dBm)
- Incorporation of a Guard channel
- Modified frequency range

Please contact a Pole/Zero Business Development Engineer for further customization to meet your needs.

### Chassis Outline:




Data is believed to be accurate. All data is subject to change without notice.



Selective Filtering - Modest Performance


This subsystem is an agile filter for the SATCOM frequency band, capable of acting as either a receive or a transmit filter. It enables simultaneous operation of multiple transceivers in extreme cosite environments. The **ICE3001** provides multiple poles of RF selectivity to reduce broadband noise, harmonics, and spurious signals for either receive or transmit applications. This filter is a highly integrated design incorporating complete Built-in-Test (BIT) capability. The design has been qualified for military applications. A dual-mount tray is also available as an option for easy incorporation on your platform.

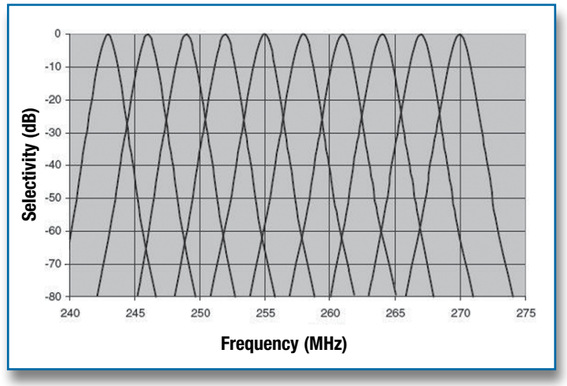
Cost-effective modifications are available on the **ICE3001**. Please contact your sales representative at 513-870-9060 for further details.

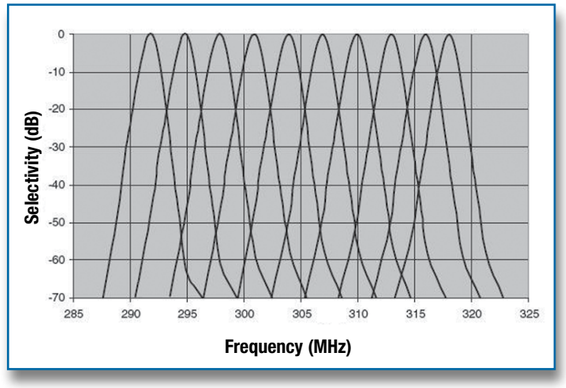
## ICE3001

### Specifications:

| **Part Number:** | | **ICE3001-TR-243-318** |
|---|---|---|
| Operation: | | Tx or Rx |
| Frequency Coverage: | **Receive:** | 243 to 270 MHz |
| | **Transmit:** | 292 to 318 MHz |
| Receive Gain (Typical): | **Receive:** | 5.0 dB |
| | **Transmit:** | 11.0 dB |
| Receive Noise Figure (Typical): | | 10.5 dB |
| Receive Input IP3: | | 65 dBm @ 12 & 24 MHz offset |
| Transmit RF Output Power: | | +18 dBm |
| Selectivity (Typical): | **Receive Band:** | **Transmit Band:** |
| | -30 dB @ ± 0.75% | -25 dB @ ± 0.75% |
| | -45 dB @ ± 1.0% | -42 dB @ ± 1.0% |
| | -65 dB @ ± 1.5% | -65 dB @ ± 1.5% |
| | -80 dB @ > 6.0 MHz | -80 dB @ > 6.0 MHz |
| Spurious Signals: | | -126 dBm (< 300 kHz)<br>-70 dB (> 300 kHz) |
| Tuning Speed: | | 100 µS |
| Power: | | +28 VDC @ 2.2 A |
| Operating Temperature Range: | | -20°C to +55°C |
| Size: | | 3 × 5.5 × 13 (in.) / 75 × 139 × 337 (mm.) |
| Weight: | | 9 lbs. / 4.08 kg. |

### Performance:









The **ICE3002** is an agile filter for the SATCOM receive frequency band and is factory configured for an ARC-231 interface. It enables simultaneous operation of multiple transceivers in extreme cosite environments. The **ICE3002** provides multiple poles of selectivity to mitigate interference from collocated transmitters and other spurious signals present at the receive antenna. This SATCOM receive filter is a highly integrated design incorporating complete Built-in-Test (BIT) capability and is qualified for use in military applications.

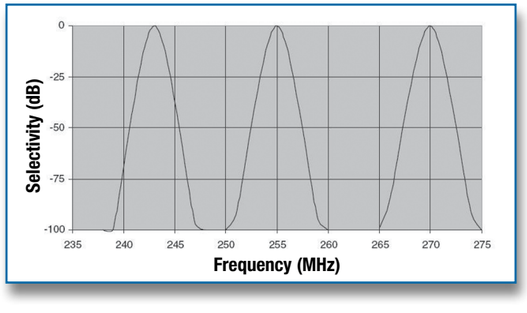
Cost-effective modifications are available on the **ICE3002**. Please contact your sales representative at 513-870-9060 for further details.

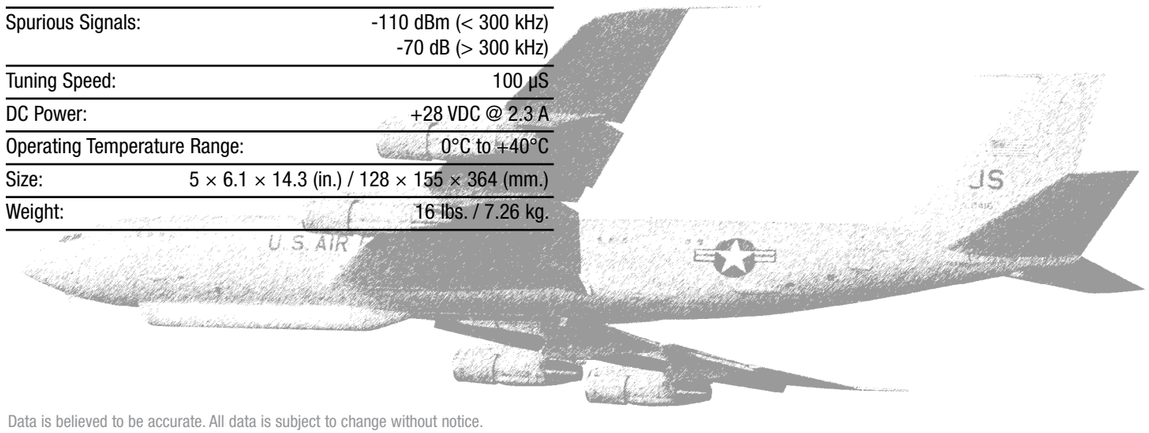
## ICE3002

### Specifications:

| **Part Number:** | **ICE3002-R-243-270** |
|---|---|
| Operation: | Rx |
| Frequency Coverage: | 243 to 270 MHz |
| Receive Gain (Typical): | 11.0 to 14.0 dB |
| Receive Input IP3: | +55 dBm @ 4 & 8 MHz offset |
| Selectivity (Typical): | -65 dB @ ± 4.0 MHz<br>-80 dB @ > 5.0 MHz |
| Spurious Signals: | -110 dBm (< 300 kHz)<br>-70 dB (> 300 kHz) |
| Tuning Speed: | 100 µS |
| DC Power: | +28 VDC @ 2.3 A |
| Operating Temperature Range: | 0°C to +40°C |
| Size: | 5 × 6.1 × 14.3 (in.) / 128 × 155 × 364 (mm.) |
| Weight: | 16 lbs. / 7.26 kg. |

### Performance:



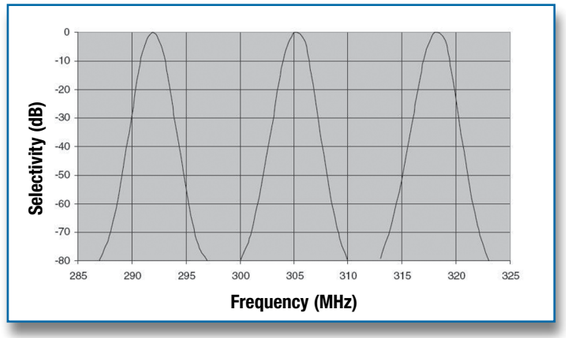




Data is believed to be accurate. All data is subject to change without notice.

The **ICE3003** is an agile filter for the SATCOM transmit frequency band and is factory configured for an ARC-231 interface. It enables simultaneous operation of multiple transmitters and receivers in extreme cosite environments. The **ICE3003** provides multiple poles of selectivity to reduce broadband noise, harmonics, and spurious signals from propagating to the antenna. This SATCOM transmit filter is a highly integrated design incorporating complete Built-in-Test (BIT) capability and is qualified for use in military applications.

Cost-effective modifications are available on the **ICE3003**. Please contact your sales representative at 513-870-9060 for further details.

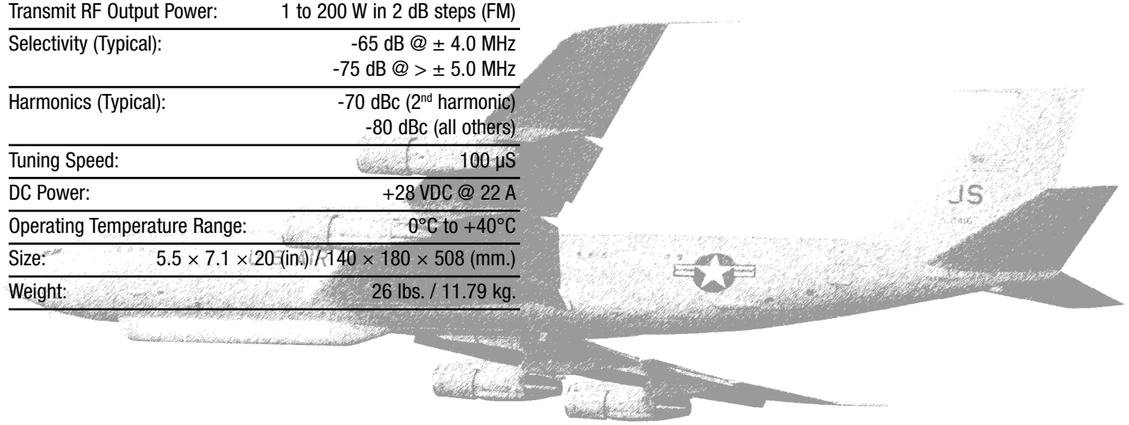
## Performance:




## ICE3003

### Specifications:

| **Part Number:** | **ICE3003-T-292-318** |
|---|---|
| Operation: | Tx |
| Frequency Coverage: | 292-318 MHz |
| Transmit RF Output Power: | 1 to 200 W in 2 dB steps (FM) |
| Selectivity (Typical): | -65 dB @ ± 4.0 MHz<br>-75 dB @ > ± 5.0 MHz |
| Harmonics (Typical): | -70 dBc (2nd harmonic)<br>-80 dBc (all others) |
| Tuning Speed: | 100 µS |
| DC Power: | +28 VDC @ 22 A |
| Operating Temperature Range: | 0°C to +40°C |
| Size: | 5.5 × 7.1 × 20 (in.) / 140 × 180 × 508 (mm.) |
| Weight: | 26 lbs. / 11.79 kg. |









The **ICE3005** is an agile filter/amplifier cascade for the UHF frequency band with a VHF bypass. It enables simultaneous operation of multiple transceivers in a cosite environment and is factory configured for an ARC-210 interface. This filter/amplifier provides multiple poles of RF selectivity to reduce broadband noise, harmonics, and spurious signals while still providing full output power in transmit mode and excellent selectivity to interfering signals at the transceiver's RF input in receive mode. All transmit, receive, and bypass switching is incorporated into the two-port design. The **ICE3005** also includes a separate audio processor circuit that mitigates popping and drop-outs in the R/T audio that are common in hopping or blanked waveforms. The **ICE3005** incorporates extensive Built-in-Test (BIT) capability and is qualified for military applications. A mounting tray is also available as an option for easy incorporation on your platform.

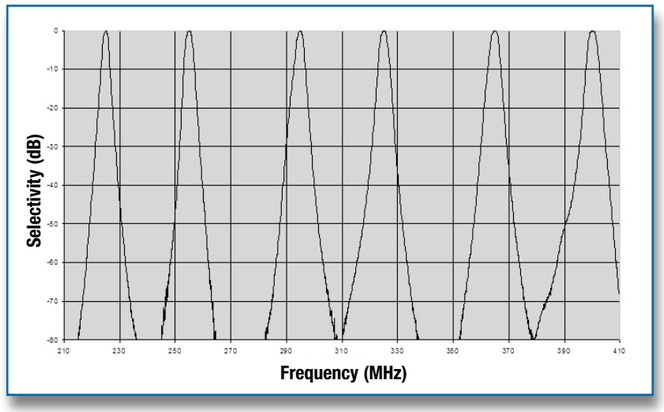
Cost-effective modifications are available on the **ICE3005**. Please contact your sales representative at 513-870-9060 for further details.

## ICE3005

### Specifications:

| **Part Number:** | **ICE3005-TR-225-400** | |
|---|---|---|
| Operation: | Tx & Rx filter/amplifier with bypass | |
| Frequency Coverage: | 30 to 174 MHz filtered bypass<br>225 to 400 MHz AM/FM Rx/Tx<br>Have Quick (HQ)/HQ II<br>30 to 512 MHz bypass | |
| Receive Gain (Typical): | 7.0 to 11.0 dB | |
| Receive Noise Figure (Typical): | 9.5 dB | |
| Receive Input IP3: | +60 dBm @ 5 & 10% offset | |
| Transmit RF Output Power: | 30 W AM/FM | |
| Selectivity (Typical): | **UHF Transmit:** | **UHF Receive:** |
| | -10 dB @ ± 1.0% | -10 dB @ ± 1.0% |
| | -30 dB @ ± 2.0% | -35 dB @ ± 2.0% |
| | -40 dB @ ± 3.0% | -50 dB @ ± 3.0% |
| | -47 dB @ ± 4.0% | -57 dB @ ± 4.0% |
| | -55 dB @ ± 5.0% | -65 dB @ ± 5.0% |
| Broadband Noise: | -142 dBm/Hz @ ± 10 MHz<br>-145 dBm/Hz @ ± 5.0% | |
| Harmonics (Typical): | < -80 dBc | |
| Spurious Signals: | -135 dBc @ > 3% | |
| Tuning Speed: | 200 µS | |
| Power: | +28 VDC @ 13 A | |
| Operating Temperature Range: | -20°C to +55°C | |
| Size: | 7.8 × 6 × 19.4 (in.) / 198 × 152 × 493 (mm.) | |
| Weight: | 24.5 lbs. / 11.1 kg. | |

## Performance:








Selective Filtering - High Performance

## ICE3006

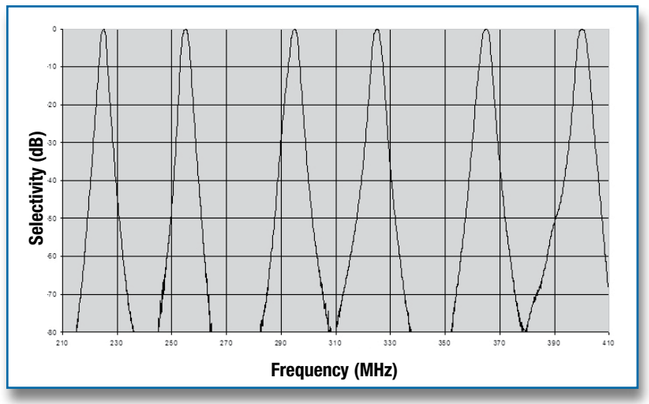
### Specifications:

| **Part Number:** | **ICE3006-TR-225-400** |
|---|---|
| Operation: | Tx & Rx filter/amplifier with bypass |
| Frequency Coverage: | 30 to 174 MHz bypass<br>225 to 400 MHz AM/FM Rx/Tx<br>Have Quick (HQ)/HQ II, SATCOM<br>400 to 406.025 MHz AM/FM Receive<br>only and automatic bypass |
| Receive Gain (Typical): | 7.0 to 11.0 dB |
| Receive Noise Figure (Typical): | 9.5 dB max. @ 225 to 395 MHz<br>10.0 dB max. @ 395 to 397.5 MHz<br>10.5 dB max. @ 397.5 to 400 MHz |
| Receive Input IP3: | +60 dBm @ 5 & 10% offset |
| Transmit RF Output Power: | 30 W (AM)<br>110 W (FM/FSK 225 to 400 MHz)<br>125 W (FM/PSK 292 to 318 MHz) |
| Selectivity (Typical): | **UHF Transmit:** / **UHF Receive:**<br>-10 dB @ ± 1.0% / -10 dB @ ± 1.0%<br>-30 dB @ ± 2.0% / -35 dB @ ± 2.0%<br>-40 dB @ ± 3.0% / -50 dB @ ± 3.0%<br>-47 dB @ ± 4.0% / -57 dB @ ± 4.0%<br>-55 dB @ ± 5.0% / -65 dB @ ± 5.0% |
| Broadband Noise: | -142 dBm/Hz @ ± 10 MHz<br>-145 dBm/Hz @ ± 5.0% |
| Harmonics (Typical): | < -90 dBc |
| Spurious Signals: | -150 dBc @ > 4% |
| Tuning Speed: | 200 µS |
| Power: | 115 VAC, 400 Hz @ 861 VA |
| Operating Temperature Range: | -20°C to +55°C |
| Size: | 9 × 6 × 19.3 (in.) / 228 × 152 × 491 (mm.) |
| Weight: | 26.2 lbs. / 11.88 kg. |

The **ICE3006** is an agile filter/amplifier cascade for the UHF frequency band with a VHF bypass. It enables simultaneous operation of multiple transceivers in the cosite environment. This filter/amplifier provides multiple poles of RF selectivity to reduce broadband noise, harmonics and spurious signals while still providing full output power in transmit mode and excellent selectivity to interfering signals at the transceiver's RF input in receive mode. All transmit, receive and bypass switching is incorporated into the three-port design (LOS and SATCOM). The **ICE3006** also includes a separate audio processor circuit that mitigates popping and dropouts in the R/T audio that are common in hopping or blanked waveforms. The **ICE3006** incorporates extensive Built-in-Test (BIT) capability and is qualified for airborne applications. A mounting tray is also available as an option for easy incorporation on your platform.

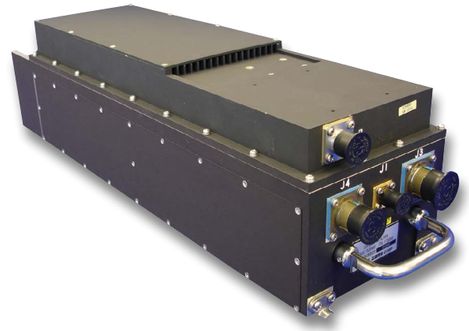
Cost-effective modifications are available on the **ICE3006**. Please contact your sales representative at 513-870-9060 for further details.

### Performance:




Data is believed to be accurate. All data is subject to change without notice.

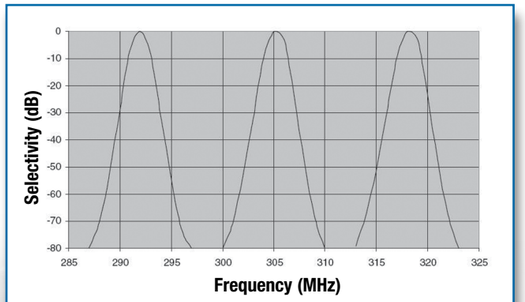




The **ICE3007** is an agile filter for the SATCOM frequency band and is factory configured for an ARC-210 interface. The **ICE3007** provides multiple poles of selectivity to reduce broadband noise and spurious signals from propagating to the antenna. The **ICE3007** is cooled by an internal fan that draws ambient air.

Cost-effective modifications are available on the **ICE3007**. Please contact your sales representative at 513-870-9060 for further details.

### Performance:



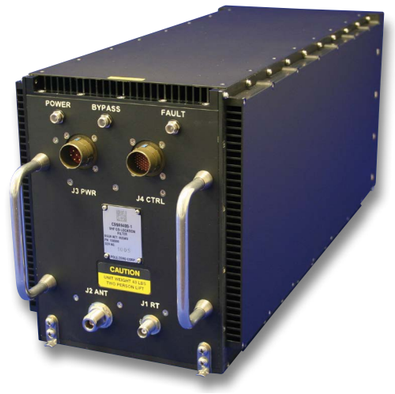

## ICE3007

### Specifications:

| **Part Number:** | **ICE3007-T-292-318** |
|---|---|
| Operation: | Tx filter/amplifier |
| Frequency Coverage: | 292 to 318 MHz |
| Transmit Noise Floor: | -140 dBm/Hz @ ± 4 MHz |
| Transmit RF Output Power: | 30 to 42 dBm in 2 dB steps,<br>43.6 dBm max. |
| Selectivity (Typical): | -65 dB @ ± 4.0 MHz<br>-75 dB @ > ± 5.0 MHz |
| Harmonics (Typical): | -60 dBc (2nd, 3rd harmonic) |
| Tuning speed: | 100 µs |
| Power: | +28 VDC Input, 8 A max. |
| Operating Temperature Range: | -20°C to +55°C |
| Size: | 5.5 × 5.5 × 20 (in.) / 140 × 140 × 508 (mm.) |
| Weight: | 18.5 lbs. / 8.3 kg. |

Data is believed to be accurate. All data is subject to change without notice.

Selective Filtering - High Performance

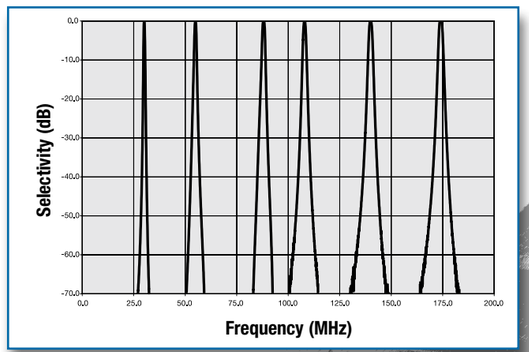



## ICE3008

### Specifications:

| **Part Number:** | | **ICE3008-TR-30-174** |
|---|---|---|
| Operation: | | Half duplex Tx & Rx filter/amplifier |
| Frequency coverage: | **VHFL:** | 30 to 88 MHz |
| | **VHFH:** | 108 to 174 MHz |
| | **Bypass:** | 30 to 512 MHz |
| Receive Gain (Typical): | | 7.0 to 11.0 dB |
| Receive Noise Figure (Typical): | | 10.0 dB |
| Transmit Noise Floor: | **VHFL:** | -135 dBm/Hz @ ± 4 MHz |
| | **VHFH:** | -140 dBm/Hz @ ± 4 MHz |
| Receive Input IP3: | | +54 dBm @ 4 & 8 MHz offset |
| Transmit Output Power: | **VHFL:** | 16, 25, 50 W FM (selectable) |
| | **VHFH:** | 18 W FM, 12 W AM (carrier) |
| Selectivity (Typical): | **VHFL RX/TX:** | -25 dB @ ± 2.0 MHz |
| | | -52 dB @ ± 4.0 MHz |
| | **VHFH RX/TX:** | -14 dB @ ± 2.0 MHz (-17 dB typ.) |
| | | -36 dBc @ ± 4.0 MHz |
| | | -50 dBc @ ± 6.0 MHz |
| Harmonics (Typical): | | -70 dBc (2nd, 3rd harmonic) |
| | | -80 dBc (others) |
| Spurious Signals: | **Receive:** | -112 dBm (< 300 kHz) |
| | | -80 dBm (elsewhere) |
| | **Transmit:** | -80 dBm (2 to 4 MHz) |
| | | -100 dBm (4 to 10 MHz) |
| | | -110 dBm (elsewhere in-band) |
| | | -130 dBm (elsewhere out-of-band) |
| Tuning Speed: | | 200 µs |
| Power: | | +28 VDC Input |
| | **VHFL:** | 350 W |
| | **VHFH:** | 250 W |
| Operating Temperature Range: | | 0°C to +50°C |
| Size: | | 8.4 × 10 × 22.76 (in.) / 213 × 253 × 578 (mm.) |
| Weight: | | 43 lbs. / 19.5 kg. |

### Performance:




The **ICE3008** is a half duplex transmit and receive filter amplifier that provides cosite mitigation throughout the VHF band. The design incorporates a flexible control interface that can be configured at the factory for various radios (ARC-201D, ARC-210, ARC-231, etc.) and supports operation in fast hopping modes, such as SINCGARS. In addition, our MEGA-POLE® technology is utilized as an output stage to further enhance the performance of the filter amplifier. An optional mounting tray is available for easy integration onto your platform.

Cost-effective modifications are available on the **ICE3008**. Please contact your sales representative at 513-870-9060 for further details.









The **ICE4003** is a Dual Channel Filter that provides two independent UHF TX/RX channels in a single package. Each channel can operate autonomously into a dedicated antenna or both channels can be combined into a single antenna. Furthermore, the combiner used in the **ICE4003** is capable of combining any combination of TX/RX signals while minimizing path loss. Currently, supported radios include the ARC-225 and ARC-210. The **ICE4003** is also designed with a flexible interface to support future radio requirements, such as JTRS. A mounting tray is also available as an option for easy incorporation on your platform.

Cost-effective modifications are available on the **ICE4003**. Please contact your sales representative at 513-870-9060 for further details.

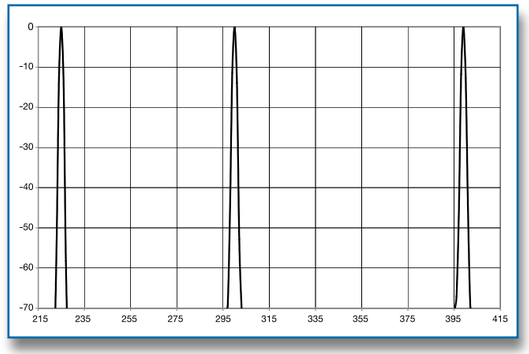
## ICE4003

### Specifications:

| **Part Number:** | **ICE4003-2TR-225-400** |
|---|---|
| Operation: | Dual channel Tx & Rx filter/amplifier |
| Frequency Coverage: | 225 to 400 MHz (2 channels) |
| Receive Gain (Typical): | 1.0 to 5.0 dB |
| Receive Noise Figure (Typical): | 10 dB* |
| Receive Input IP3: | +55 dBm @ 4 & 8 MHz offset |
| Transmit RF Output Power: | 25 W per channel |
| Selectivity (Typical): | **Transmit or Receive:** |
| | -8 dBc @ ± 1.0 MHz |
| | -40 dBc @ ± 2.0 MHz |
| | -60 dBc @ ± 3.0 MHz |
| Harmonics (Typical): | -70 dBc (2nd harmonic) |
| | -105 dBc (3rd harmonic) |
| | -90 dBc (others) |
| Spurious Signals: | -85 dBm/Hz @ ± 4 MHz |
| | -75 dBm/Hz @ ± 25 MHz |
| Tuning Speed: | 200 µS |
| Power: | 115 VAC, 400 Hz @ 6.3 A |
| Operating Temperature Range: | 0°C to +40°C |
| Size: | 8.3 × 11.3 × 20 (in.) / 211 × 287 × 505 (mm.) |
| Weight: | 71 lbs. / 32.2 kg. |

* Performance varies around guard band (243 MHz).

### Performance:




Selective Filtering - Ultra High Performance

The **ICE4004** is an agile filter for both the VHF and UHF frequency bands. It allows simultaneous operation of a number of transceivers in the cosite environment. The VHF/UHF Filter provides significant RF selectivity to reduce broadband noise in transmit mode of operation and to reduce interfering signals at the transceiver's RF input in receive mode. The design is highly integrated, including Built-in-Test (BIT), a fail-safe bypass mode and an ARC-210 interface. The **ICE4004** fits the standard ATR-1 Long mounting tray.

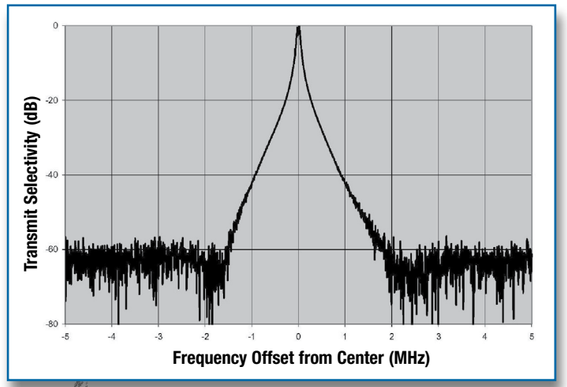
Cost-effective modifications are available on the **ICE4004**. Please contact your sales representative at 513-870-9060 for further details.

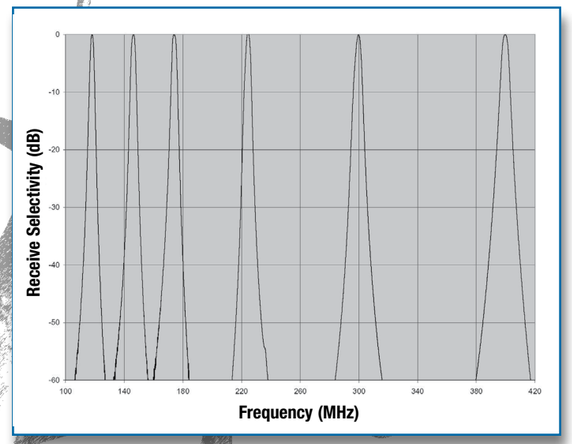
## ICE4004

### Specifications:

| **Part Number:** | **ICE4004-TR-118-400** |
|---|---|
| Operation: | VHF/UHF frequency agile filter/amplifier |
| Frequency Coverage: | 118 to 174 MHz<br>225 to 400 MHz<br>30 to 512 MHz Automatic bypass |
| Receive Gain (Typical): | 4.0 to 15.0 dB |
| Receive Noise Figure (Typical): | 9.0 dB |
| Receive Input IP3: | +40 dBm |
| Transmit RF Output Power: | 10 W, 15 W, 20 W (selectable) |
| Selectivity (Typical): **Receive:** | **Transmit:** |
| -30 dBc @ ± 4.0 MHz (VHF) | -60 dBc @ (> 4 MHz) |
| -55 dBc @ ± 8.0 MHz (VHF) | |
| -14 dBc @ ± 4.0 MHz (UHF) | |
| -36 dBc @ ± 8.0 MHz (UHF) | |
| Broadband Noise: | -140 dBm/Hz @ 10 MHz |
| Harmonics (Typical): | -60 dBc |
| Spurious Signals: | -80 dBc |
| Tuning Speed: | 300 µS |
| Power: | +28 VDC @ 23 A |
| Operating Temperature Range: | 0°C to +55°C |
| Size: | 8 × 10.1 × 19.5 (in.) / 193 × 257 × 495 (mm.) |
| Weight: | 37 lbs. / 16.8 kg. |

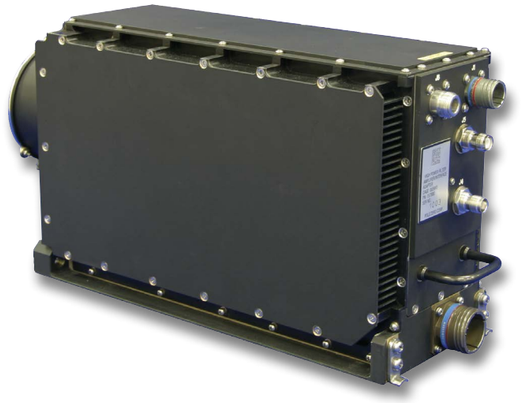
### Performance:







The **ICE4005** is a UHF SATCOM High Power Transmit Filter/Amplifier (HPTF/A) designed to provide 125 Watts minimum RF output power in the 290 to 320 MHz frequency range. This system provides excellent selectivity and broadband noise performance. It enables simultaneous operation of multiple transceivers in a cosite environment. This filter incorporates extensive Built-In-Test (BIT) capability, has been qualified for airborne platforms and has applications on ground-mobile and shipboard communication systems. This unit is qualified for use in military applications. A mounting tray is also available for easy incorporation on your platform.

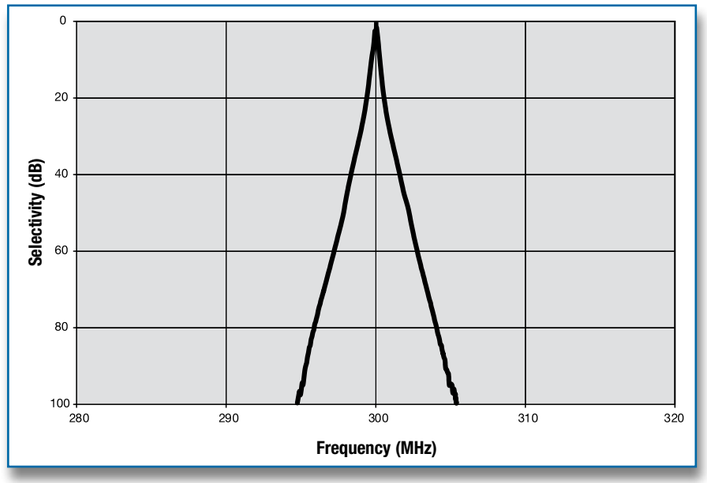
Cost-effective modifications are available on the **ICE4005**. Please contact your sales representative at 513-870-9060 for further details.

## ICE4005

### Specifications:

| **Part Number:** | **ICE4005-T-290-320** |
|---|---|
| Operation: | Selectable dual-radio Tx filter amplifier |
| Frequency coverage: | UHF SATCOM Transmit<br>290 to 320 MHz |
| Transmit Noise Floor: | ≤ -139 dBm/Hz @ ≥ ± 10 MHz removed |
| Transmit RF Output Power: | 51.0 to 37.0 dBm<br>(adjustable with 1 dB steps) |
| Selectivity (Typical): | -45 dBc min. @ ± 2.5 MHz<br>-50 dBc typical @ ± 2.5 MHz |
| Harmonics (Typical): | -80 dBc max. (2nd harmonic)<br>-90 dBc typical (2nd harmonic)<br>-90 dBc max. (3rd harmonic)<br>-100 dBc typical (3rd harmonic) |
| Tuning Speed: | 750 µs max. |
| Power: | 18 to 32V @ ≤ 22.5 A<br>MIL-STD-704F compliant |
| DC Output: | +28V @ 100 mA for external LNA |
| Operating Temperature Range: | -40°C to +45°C @ 100% duty cycle<br>-45°C to +70°C @ 20% duty cycle |
| Size: | Modified ½ ATR Short<br>4.9 × 7.7 × 12.5 (in.) / 124 × 195 × 318 (mm.) |
| Weight: | 16 lbs. / 7 kg. |
| Software: | DO-178B Level D compliant |

### Performance:



The **ICE5200™** is a highly integrated, high-performance, fast-tuning Cosite Filter/Amplifier system for mitigating severe cosite interference caused by collocated RF systems on airborne, sea, and ground mobile platforms. **ICE5200** is a radio ancillary device that is installed in between the radio and the antenna to help prevent receiver desensitization and to purify the transmit spectrum to protect other RF equipment on board.

As the flagship model of the Integrated Cosite Equipment (**ICE™**) product line, **ICE5200** replaces first-generation **ICE5001** and **ICE5002** models with improved RF performance, modern waveform support, and a lower size, weight, and power (SWaP) profile.

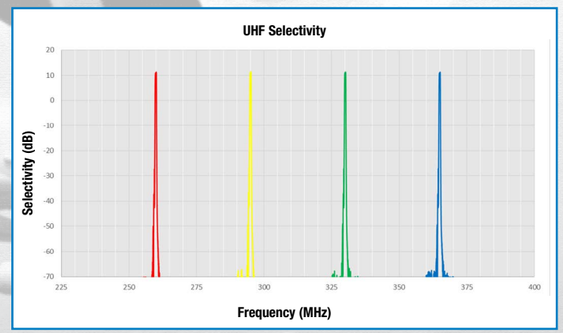
- Qualified to MIL-STD-810 and MIL-STD-461
- Direct radio tuning interface (AN/ARC-210)
- Reduced size, weight, and power (SWaP) from first-generation ICE5000 series
- Line of Sight (LOS) and Satellite Communication (SATCOM) waveform support
- Available MUOS SATCOM configuration
- Customizations available upon request

## ICE5200™

### Specifications:

| **Part Number:** | **ICE5200-TR-30-406** |
|---|---|
| Operation: | Full duplex (SATCOM)<br>Half duplex (LOS)<br>Tx & Rx filter/amplifier |
| Frequency Coverage: | 30 to 88 MHz (VHF Low)<br>118 to 174 MHz (VHF High)<br>225 to 406 MHz (UHF) |
| Receive Gain (Min.): | 10 dB |
| Receive Noise Figure (Max.): | 11 dB |
| Receive Spurious Level (Receive): | -112 dBm (<300 kHz) |
| Output Third Order Intermodulation Distortion (Max.): | -60 dBm (4 MHz offsets) |
| Transmit RF Output Power: | 95 W (FM)<br>30 W (AM) |
| Selectivity (Max.) (VHF Low): | -10 dBc @ ± 2.0 MHz<br>-30 dBc @ ± 3.0 MHz<br>-48 dBc @ ± 4.0 MHz<br>-60 dBc @ ± 6.0 MHz |
| Selectivity (Max.) (VHF High): | -13 dBc @ ± 2.0 MHz<br>-38 dBc @ ± 3.0 MHz<br>-62 dBc @ ± 4.0 MHz<br>-65 dBc @ ± 6.0 MHz |
| Selectivity (Max.) (UHF): | -60 dBc @ ± 2.0 MHz<br>-75 dBc @ ± 4.0 MHz<br>-80 dBc @ ± 6.0 MHz |
| Tune Time: | 50 µS (UHF) |
| Supply Voltage: | 115 VAC (Three phase, 400 Hz) |
| Power Consumption (Max.): | 970 VA |
| Operating Temperature Range: | -20°C to +55°C |
| Size: | 7.0 × 10 × 19.3 (in.) / 178 × 256 × 491 (mm.) |
| Weight: | 56 lbs. / 25.40 kg. |

### Performance:




Data is believed to be accurate. All data is subject to change without notice.





Selective Filtering - Ultra High Performance

## Ordering Information:

**Product Configuration Builder**

*Configure your ICE5200 Cosite Filter/Amplifier by filling in the fields below:*

ICE5200-TR-30-406-X-RGX-OPXXYY-PPXXYY-APBXXZZ-AAX-BXXX-GDX-TX-OBX-FRX-PDX

**Operation**
[TR] = Transmit/Receive

**Lowest Frequency**
[30] = 30 (MHz) (default)

**Highest Frequency**
[406] = 406 (MHz) (default)

**Unique Number**
[X] = Manufacturer Assigned

**Option RG[X]**
Receive Gain
[X] = 0 to 12 (dB)

**Option OP[XXYY]**
Nominal Output Power
[XX] FM = 40 to 50 (dBm)
[YY] AM = 40 to 45 (dBm)

**Option PP[XXYY]**
Primary R/T Port TX Input Power
[XX] FM = 20 to 41 (dBm)
= N (not supported)
[YY] AM = 20 to 41 (dBm)
= N (not supported)

**Option AP[BXXZZ]**
Alternate R/T Port TX Input Power
[B] = Y (present)
= N (not present)
[X] FM = 20 to 41 (dBm)
= N (not supported)
[Z] AM = 20 to 41 (dBm)
= N (not supported)

**Option AA[X]**
Alternate Antenna Port
[X] = Y (present)
= N (not present)

**Option B[$X_1X_2X_3$]**
Bands (1-3)
[$X_n$] = N (not present)
= 1 (VHF Low (30-88))
= 2 (VHF High (108-174))
= 3 (UHF (225-400))
= 4 (UHF Ext. (225-406))
= 5 (UHF 512 (225-512))
= 6 (MUOS)

**Option GD[X]**
Guard
[X] = Y (present)
= N (not present)

**Option T[X]**
Radio Tuning Interface
[X] = 1 (ARC-210)
= 2 (ARC-231)
= 3 (future use)

**Option OB[X]**
Out-of-Band Frequency Operation
[X] = 1 (No Action)
= 2 (Bypass)
= 3 (Fault)
= 4 (Bypass + Fault)

**Option FR[X]**
Fault Recovery Method
[X] = 1 (Frequency Tune)
= 2 (Mode Change)
= 3 (Freq. Tune or Mode Change)

**Option PD[X]**
MIL-STD -704 Power Dropout Behavior
[X] = 1 (Reboot/Restart)
= 2 (Maintain State/Fast Recovery)

**Configuration Examples:**

ICE5200-TR-30-406-1-RG12-OP5045-PP4136-APY2020-AAY-B124-GDY-T1-OB2-FR3-PD1

ICE5200-TR-225-406-5-RG9-OP5045-PP4136-APN-AAY-B46N-GDY-T1-OB2-FR3-PD2

**Note:**

This tool is used to specify the unique product configuration required for your application. A part number will be generated by Pole/Zero based on this product configuration.

## Electronic Warfare / Communications Integration

EW compatibility requires high power tolerance on Tx and high dynamic range on-channel mitigation solutions for Rx.

**Tx: High Power Notch Filters**

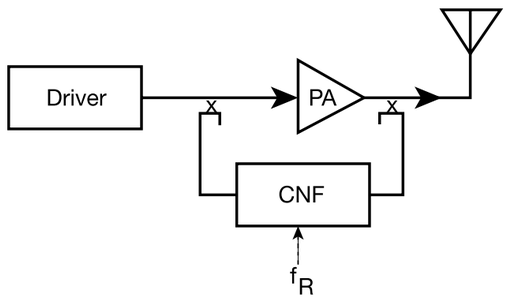
**Rx: High Dynamic Range Cancellation Technology**

### Maxi/4R Notch

High power post PA filtering opens channels in your system


### Multichannel Interference Canceller

Protects your receiver from local emitters – compatible with frequency hopping applications!




### Cosite Notch Filter Development

Low loss parallel solution easily integrates into your EW system


### Referenceless Canceller

Attacks off board emitters for your ISR applications!






The **MAXI/4R NOTCH** contains 4 “poles” of filtering to provide additional rejection at the tuned frequency of the notch when compared to our standard MAXI-POLE® Notches. The unit has been designed for applications in UHF receiver front ends (nearby transmitter carrier rejection) and/or transmitter back ends (broadband noise rejection at the frequency of a nearby receiver). For interface and mechanical outline, please refer to the bandpass MAXI/4R.

## MAXI/4R NOTCH SERIES

### Specifications:

| **Frequency Coverage:** | **225 to 400 MHz*** |
|---|---|
| Input/Output Impedance: | 50Ω |
| Passband Input/Output VSWR: | 2:1 max. |
| Notch RF Power Handling: | 1 Watt |
| Passband RF Power Handling: | 50 Watt @ FN ± 20 MHz typical |
| Notch Depth: | 35 dB min. |
| Notch Width: | FN ± 300 KHz min. |
| 3 dB Bandwidth: | 10 MHz typical |
| Passband IL: | < 1 dB |
| Passband IP3: | +50 dBm (10/20 MHz) |
| Center Frequency Drift: | (internal temp. comp.) |
| Tuning Control: | 9 bit serial |
| Tuning Speed: | 40 µS (1 MHz clock) |
| DC Power Consumption (Static): | +5 VDC @ 1.5 A max.<br>+100 VDC @ 2 mA |
| Operating Temperature Range: | -40°C to +70°C |
| Size: | 3.1 × 3.5 × 7.0 (in.) / 79.4 × 88.9 × 177.8 (mm.) |
| Weight: | 56 oz. / 1588 g / 1.6 kg. |
| RF Connection: | SMA jack |

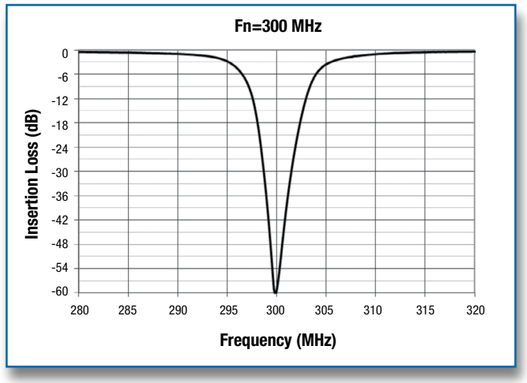
* Consult factory for additional ranges.

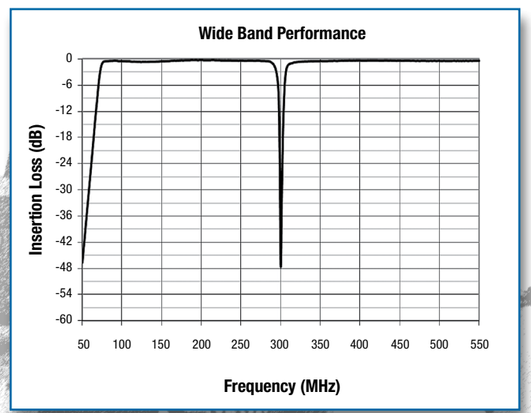
### Pinout & Ratings:

| PIN # | Reference Designator | Description | Maximum Ratings |
|---|---|---|---|
| 1 | SDO | Serial Data Out | -0.5 to ($V_{CC}$ + 0.5) V |
| 2-6 | N/C | No Connect (1) | — |
| 7, 9, 11, 12 | GND | Digital/RF Ground | — |
| 8 | $V_{CC}$ | +5 V Power Supply Input ±10% | -0.5 to +6 V |
| 10 | $V_{BB}$ | High Bias +100 V Supply Input | 0 to +125 V |
| 13 | $\overline{STB}$ | Strobe | -0.5 to ($V_{CC}$ + 0.5) V |
| 14 | SCLK | Serial Clock | |
| 15 | SDI | Serial Data In | |

**Note(s):** 1 Leave pins disconnected for unit to function properly.

### Performance:






Electronic Warfare Solutions


Pole/Zero's **MULTICHANNEL INTERFERENCE CANCELLER** (MIC) system is a five channel VHF/UHF Cosite Interference Mitigation System (CIMS) designed to be installed between receivers and antennas with reference signals derived from coupling from offending, cosite emitters. The equipment significantly reduces the undesired RF signals from each associated emitter in order to mitigate against interference to the associated receivers. This is accomplished by injection of accurately scaled anti-phase image of the reference (interfering) signal.

The unit contains five channels, each of which can be selected to cover 30-88 MHz, 116-174 MHz or 225-400 MHz.

The canceller detects frequency changes automatically and the revised interference is cancelled – even with frequency hopping signals. Please contact your sales representative at 513-870-9060 for further details.

## MULTICHANNEL INTERFERENCE CANCELLER

### Specifications:

| **Part Number:** | **Multichannel Interference Canceller** |
|---|---|
| Operation: | Five channels of VHF/UHF cancellation for undesired signals |
| Frequency Coverage: | 30 to 88 MHz (VHFL)<br>108 to 174 MHz (VHFH)<br>225 to 400 MHz (UHF) |
| Receive IL: | 5 dB |
| Interference Null Depth: | 45 dB (Typical) |
| Operating Temperature Range: | -40°C to +55°C |
| Size: | 3U 19 (in.) rack mounting |
| Weight: | 19 lbs. / 8.6 kg. |





The **ICE2004** is an 8-channel RF interference canceller system that achieves 40 dB of attenuation without the need for cumbersome reference signals from local transmitters. It is a simple two-port RF assembly that covers the 30 to 512 MHz frequency range. The ICE2004 unit is placed directly between the receiver and its antenna. The **ICE2004** enables the reception of low-level RF signals in the presence of up to 8 strong interferers as a result of its inherent low loss path for all non-cancelled signals.

The **ICE2004** provides fast canceller acquisition and is compatible with SINCGARS and Have Quick hopping waveforms. The canceller system is also designed for minimal harmonics and spurious and is MIL-STD-461F compliant. The power is MIL-STD-704F compatible. The unit will mount with standard military trays.

The **ICE2004** can auto-tune to on or off board cosite emitters and also support radio tuning. The canceller system supports IP addressable Ethernet for Built-In-Test (BIT) and system monitoring.

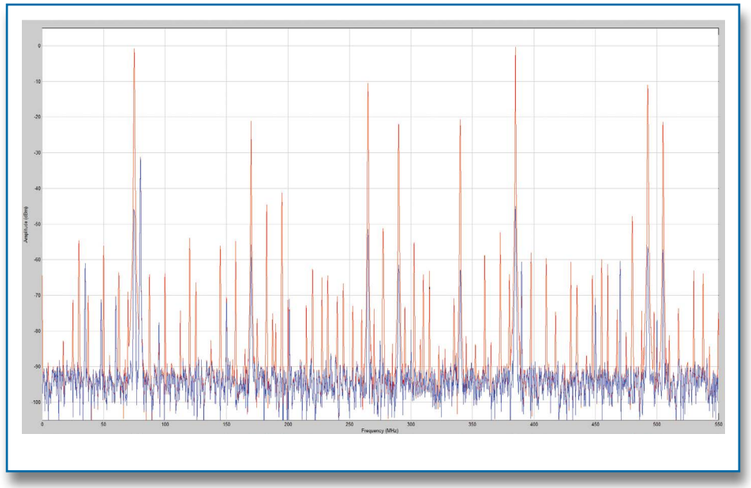
Cost-effective modifications are available on the **ICE2004**. Please contact your sales representative at 513-870-9060 for further details.

## Referenceless Canceller

### Specifications:

| **Part Number:** | **ICE2004-R-30-512** |
|---|---|
| Operation: | 8-Channel RF Interference Canceller |
| Frequency Coverage: | 30 to 512 MHz |
| Insertion Loss: | 2 dB |
| Harmonics (Typical): | -70 dBc |
| Spurious Signals: | -111 dBm |
| Tuning Speed: | 200 µS<br>SINCGARS & Have Quick compatible |
| Power: | 115 VAC / 400 Hz Single Phase, 450 W |
| Operating Temperature Range: | -15° to +55°C |
| Interference Suppression: | 40 dB |
| Input Amplitude Range: | -40 to +10 dBm |
| Interfaces: | Ethernet, ARC-210, ARC-231 |
| Size: | 10.1 × 10.7 × 12.6 (in.) / 256.5 × 272 × 320 (mm.) |
| Weight: | 40 lbs. / 18 kg. |

### Performance:



**Note:** There are eight (8) large interfering signals in **RED** that are now attenuated by at least 40 dB in **BLUE** in this receive spectrum, which simultaneously reduces associated products in the receiver. The remaining desired signals are now readily discernible and receivable as a result of improved sensitivity in your collection/receiver system.





Electronic Warfare Solutions

Pole/Zero offers an integrated **AIS Splitter/Receiver** system in a rugged flange mount or DZUS chassis. The splitter taps off a path from an existing transceiver, auto-blanks the secondary path during primary high-power transmissions (fast attack, slow decay), and provides high selectivity bandpass filtering for receiver protection and interference mitigation. This **Splitter/Receiver** enables maritime Automatic Identification System (AIS) monitoring from an existing VHF antenna path. In addition, an onboard converter provides RS-422 balanced outputs from unbalanced RS-232 inputs. Includes mounting accommodations for Smart Radio, Shine Micro and Protec receivers (wiring harnesses available).

This **Splitter/Receiver** supports frequency hopping or single channel tactical communications; SDR, test/measurement, and other applications needing multiple receive outputs and high power handling. Potential installations include avionics, UAVs, ground systems and vehicles, as well as shipboard or lab environments.

In addition to the AIS application, this splitter design can be tailored for other applications such as adding a Guard path to an existing antenna.

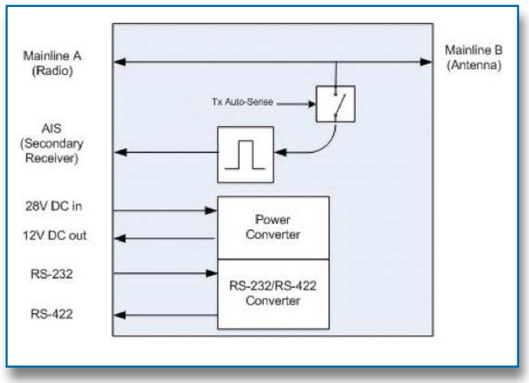
## AIS Splitter

### Specifications:

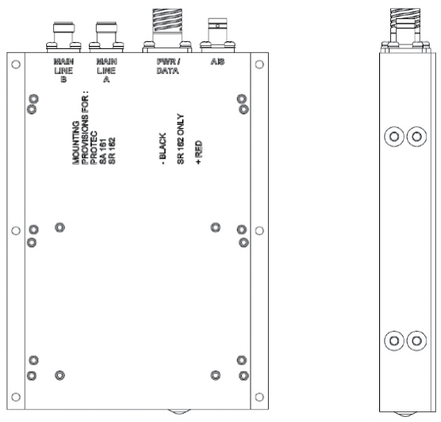
| **Part Number:** | **218000** |
|---|---|
| Frequency Coverage: | 30 to 512 MHz |
| Input/Output Impedance: | 50Ω |
| VSWR: | 1.5:1 typical |
| Mainline Insertion Loss, Isolated: | <0.5 dB |
| Mainline Insertion Loss, Shared Rx: | <1.0 dB |
| Transmit RF Power Handling: | 100 W |
| Secondary Receive Frequency (1): | 156.025 to 162.025 MHz |
| Secondary Receive Gain: | 8 dB typical |
| Secondary Receive NF (w/ Split Loss): | 14 dB typical |
| Secondary Receive Selectivity: | -65 dBc @ ±10 MHz |
| Transmitter-Secondary Isolation (2): | -50 dB |
| DC Input Power: | 28 VDC, <250 mA |
| DC Output Power: | 12 VDC, <250 mA |
| Temperature Range: | -40ºC to +55ºC |
| Size (excluding connectors) (3): | 5.0 × 7.5 × 1.2 (in.)<br>65.405 × 146.05 × 215.392 (mm.) |
| Weight: | Approximately 24 oz. / .68 kg. |

**Note(s):**
1. Other secondary frequencies are available upon request.
2. The secondary path is blanked when the transmitter frequency is close enough to cause non-linear effects.
3. DZUS package also available including mounting provision for AIS receiver.

### Block Diagram:




### Mechanical Outline:




**Note:** Flange mount shown





# Low Noise/High Dynamic Range Amplifiers

Pole/Zero® designs and manufactures low noise amplifiers (LNAs) for applications throughout the RF spectrum, from HF to above 1 GHz. These LNAs are utilized extensively as additional building blocks within our Integrated Cosite Equipment (ICE). They are also available as individual elements to support your RF system. The information on this page provides insight into our LNA capabilities. Please call the factory with your specific needs.

## SATCOM LNA

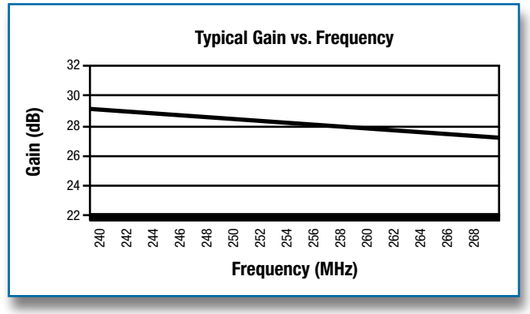
### Specifications:

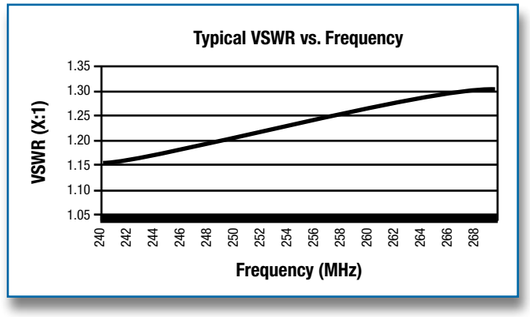
| **Part Number:** | **138750** |
|---|---|
| Frequency coverage: | 243 to 270 MHz |
| Gain: | 20.5 ± 1.5 dB |
| Noise Figure: | 2.0 dB max. |
| VSWR: | 1.35:1 max. |
| OIP3: | +50 dBm (two tone test) |
| RF Connectors: | **RF In:** SMA Female (J1)<br>**RF Out:** SMA Female (J2) |
| DC Power Connector: | 9-pin Male D-subminiature (P1)<br>(P1 pin1 GND, P1 pin5 +24 VDC ± 5%) |

**Note:** P1 includes Amp locking posts

### Typical Performance:

The plots below are provided in order to demonstrate typical performance available from the Low Noise Amplifier (LNA) (illustrated performance is typical, not guaranteed).




The **SATCOM LIMITER AMPLIFIER** provides exceptional receive sensitivity and system overload protection in the presence of large interfering signals. Operating over the 243 to 270 MHz SATCOM receive band, the Limiter/Amp provides less than 1.8 dB noise figure, greater than 14 dB return loss, 19.5 ± 1 dB gain and 48 dBm OIP3, while limiting output power under extreme conditions to +35 dBm. Various frequency ranges and limiting levels are also available as a factory set option.

## SATCOM LIMITER AMPLIFIER

### Specifications:

| **Part Number:** | **138900** |
|---|---|
| Frequency Coverage: | 243 to 270 MHz |
| Gain: | 19.5 ± 1 dB |
| Noise Figure: | 1.8 dB |
| RF Output Power Limiting: | < 35 dBm<br>(< 45 dBm for initial 20 us) |
| Input/Output Impedance: | 50Ω |
| Modulation Types: | FM, FSK, PSK |
| DC Power: | +28 VDC @ 1800 mA max. |
| Operating Temperature Range: | 0°C to +50°C |
| RF Connectors: | **RF In:** TNC Female (J1)<br>**RF Out:** N Female (J2) |
| DC Power Connector: | M38999/42WB99PN (J3)<br>(7-pin Circular) |


The **ICELT1™** is an integrated Low Noise Amplifier (LNA) and Triplexer. When paired with an Airborne Radio Terminal and Pole/Zero's ICE5200 Cosite Filter/Amplifier, ICELT1's frequency band multiplexing and high dynamic range low noise amplification provides a means to operate UHF SATCOM - including MUOS - while in the presence of strong RF Interference.

## ICELT1™

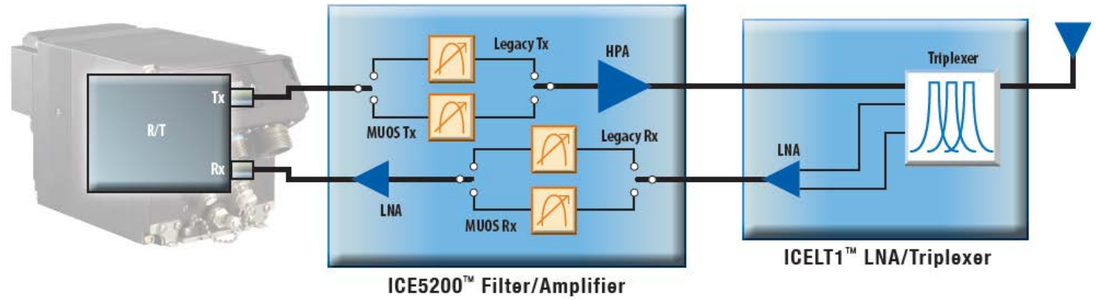
### *Preliminary* Specifications:

| **Part Number:** | **ICELT1-243-380** |
|---|---|
| Operation: | Full duplex (SATCOM)<br>Half duplex (LOS)<br>Low Noise Amplifier/Triplexer |
| Frequency Coverage: | 243 to 270 MHz (Dedicated SATCOM Rx)<br>291 to 318 MHz (Dedicated SATCOM Tx)<br>300 to 320 MHz (MUOS SATCOM Tx)<br>360 to 380 MHz (MUOS SATCOM Rx) |
| Selectivity (Min.): | -70 dB |
| Return Loss (Min.): | 10 dB |
| Insertion Loss (Nom.: | 1.3 dB |
| Receive Gain (Nom.): | 15 dB |
| Receive Noise Figure (Max.): | 4 dB |
| Input Gain Compression (P1dB) (Min.): | +10 dBm |
| Output Third-Order Intercept Point (OIP3) (Min.): | +35 dBm |
| Group Delay Variation (Max.): | 5 ns |
| Peak RF Input Power (Nom.): | 200 W |
| Supply Voltage (Nom.): | +28 VDC |
| Power Dissipation (Full Duplex) (Max.): | 95 W |
| Operating Temperature Range: | -20 to +55 °C |
| Size: | 11 x 8.5 x 3.5 (in.) / 279 x 261 x 89 (mm.) |
| Weight: | 15 pounds / 5.4 kg |





ICE MUOS Suite Block Diagram:



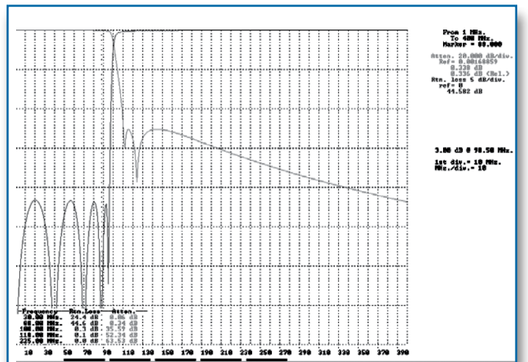

Data is believed to be accurate. All data is subject to change without notice.

# Cross Band Cosite Filtering

## Specifications:

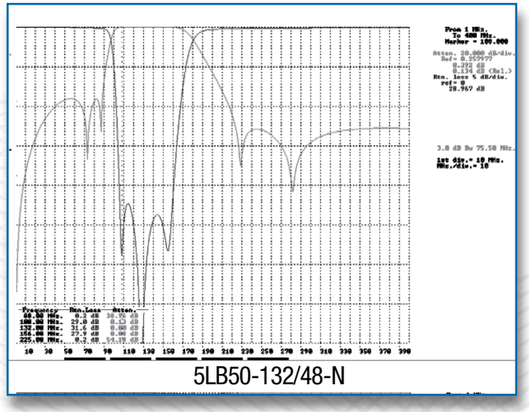
| **Part Number:** | **5LL50-88/400-N** |
|---|---|
| Filter Passband: | 30 to 88 MHz |
| Filter Form: | LPF |
| Passband Loss: | .5 dB max. |
| Rejection: | 30 dB @ 108 MHz<br>40 dB @ 118 to 174 MHz<br>40 dB @ 225 to 400 MHz |
| Power Handling: | 100 Watts |
| Operating Temperature Range: | -40°C to +85°C |
| Size: | 4.50 × 1.25 × 1.0 (in.) / 114.3 × 31.75 × 25.4 (mm.) |

## Performance:



5LL50-88/400-N

| **Part Number:** | **5LB50-132/48-N** |
|---|---|
| Filter Passband: | 108 to 156 MHz |
| Filter Form: | BPF |
| Passband Loss: | .5 dB max. |
| Rejection: | 30 dB @ 30 to 88 MHz<br>30 dB @ 225 to 400 MHz |
| Power Handling: | 100 Watts |
| Operating Temperature Range: | -40°C to +85°C |
| Size: | 4.50 × 1.25 × 1.0 (in.) / 114.3 × 31.75 × 25.4 (mm.) |

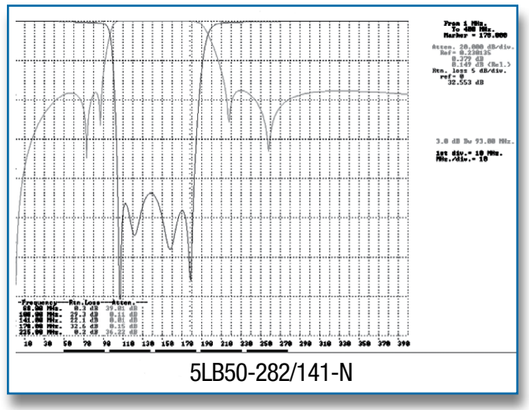


5LB50-132/48-N

## Specifications:

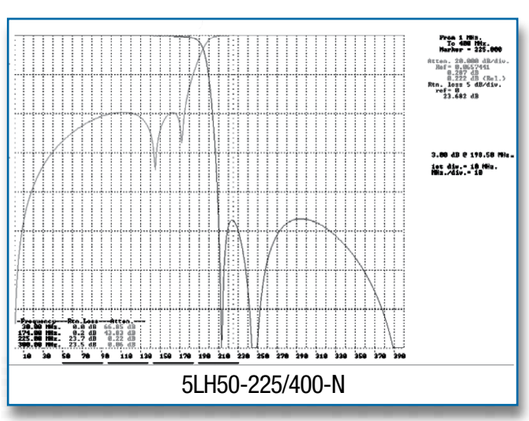
| **Part Number:** | **5LB50-282/141-N** |
|---|---|
| Filter Passband: | 108 to 174 MHz |
| Filter Form: | BPF |
| Passband Loss: | .5 dB max. |
| Rejection: | 30 dB @ 30 to 88 MHz<br>30 dB @ 225 to 400 MHz |
| Power Handling: | 100 Watts |
| Operating Temperature Range: | -40°C to +85°C |
| Size: | 4.50 × 1.25 × 1.0 (in.) / 114.3 × 31.75 × 25.4 (mm.) |

## Performance:

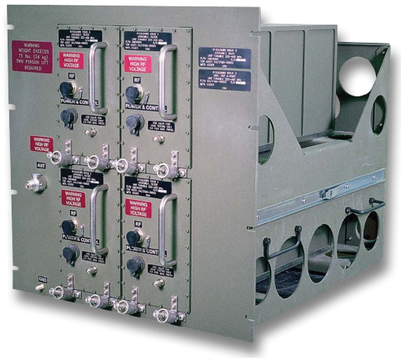


5LB50-282/141-N

| **Part Number:** | **5LH50-225/400-N** |
|---|---|
| Filter Passband: | 225 to 400 MHz |
| Filter Form: | HPF |
| Passband Loss: | .5 dB max. |
| Rejection: | 30 dB @ 30 to 174 MHz |
| Power Handling: | 100 Watts |
| Operating Temperature Range: | -40°C to +85°C |
| Size: | 1.5 × 1.0 × 1.0 (in.) / 38.1 × 25.4 × 25.4 (mm.) |
| MIL-STD 810 vibration and shock | |



5LH50-225/400-N



The TMC-100/160 are **TUNABLE MULTICOUPLERS** enabling up to four transceivers to operate simultaneously in transmission and reception mode using a common antenna. The four digitally controlled bandpass filters within the **MULTICOUPLERS** cover the VHF or UHF communication band. Each filter is a three pole design to provide high selectivity with a nominal 3 dB bandwidth of 0.7 (VHF), 0.3 (UHF), 1.0 or 2.0%. Each filter is controlled remotely through an independent digital interface. When a frequency command is received control circuitry drives a stepper motor to properly position the filter shaft. The **MULTICOUPLERS** may be optimized for custom interface, mechanical and performance requirements.

## Specifications:

| **Part Number:** | **TMC-100/160** |
|---|---|
| Operation: | Half duplex, transmit & receive, four-port multicoupler |
| Frequency Coverage: | 100 to 160 MHz |
| Bandwidth: | 0.7, 1.0 or 2.0% of Fc, nominal, -3 dB |
| Insertion Loss: | 2.5, 2.0 or 1.5 dB, respectively, max. @ min. Co-channel separation |
| Co-channel Separation for 50 dB isolation: | + 3.0, 4.0 or 8.0%, respectively, min. |
| Power Handling: | 60 Watts avg., 160 Watts pk. per channel |
| Minimum Channel Separation: | 4 MHz |
| Shape Factor (30 dB / 3 dB): | 3.1 nominal |
| Ultimate Isolation: | 80 dB, min. |
| Tuning Speed: | 10 sec. max. |
| Power: | 24 VDC Input |
| Standby: | 24 Watts |
| Peak: | 200 Watts |
| Weight: | 145 lbs. nominal / 65.78 kg |
| Operating Temperature Range: | 0°C to +50°C |
| Size: | 20 × 20 × 25 (in.) / 508 × 508 × 635 (mm.) |

| **Part Number:** | **TMC-225/400** |
|---|---|
| Operation: | Half duplex, transmit & receive, four-port multicoupler |
| Frequency Coverage: | 225 to 400 MHz |
| Bandwidth: | 0.3, 1.0 or 2.0% of Fc, nominal, -3 dB |
| Insertion Loss: | 2.5, 2.0 or 1.5 dB, respectively, max. @ min. Co-channel separation |
| Co-channel Separation for 50 dB isolation: | + 2.0, 4.0 or 8.0%, respectively, min. |
| Power Handling: | 100 Watts pk. per channel |
| Min. Channel Separation: | 5 MHz |
| Shape Factor (30 dB / 3 dB): | 3.5:1 nominal, 4.5:1 max. |
| Ultimate Isolation: | 80 dB, min. |
| Tuning Speed: | 10 sec. max. |
| Power: | 24 VDC Input |
| Standby: | 24 Watts |
| Peak: | 200 Watts |
| Weight: | 145 lbs. nominal / 65.78 kg. |
| Operating Temperature Range: | 0°C to +50°C |
| Size: | 20 × 20 × 25 (in.) / 508 × 508 × 635 (mm.) |







**ATTENUATION** – The reduction in amplitude, measured in dB, of a signal passing through a dissipative network or other medium.

**BANDWIDTH** – The width in frequency of a filter's response, typically measured between the 3 dB points.

**BANDPASS FILTER** – A filter that passes one band of frequencies, while rejecting both higher and lower frequencies.

**BUTTERWORTH FILTER** – A filter with a maximally flat (minimum ripple) amplitude response in the passband.

**CENTER FREQUENCY ($f_0$)** – A measure of the central frequency, between the upper and lower cutoff frequencies. It can be defined as the either the arithmetic mean or geometric mean.

Arithmetically: $f_0 = (f_1 + f_2) / 2$

Geometrically: $f_0 = \sqrt{(f_1 \times f_2)}$

**COSITE INTERFERENCE** – Interference, typically self-generated, in communication systems caused by transceivers located within close proximity to one another without appropriate isolation.

**DECIBEL** – A logarithmic unit of measurement expressing signal magnitude relative to a specified or implied reference level.

**FALL TIME** – The time required for a signal to change from a specified high value to a specified low value, typically defined as 90% and 10% of the steady state value.

**FILTER Q** – The Q Factor (Quality Factor) is a dimensionless parameter giving an indication of the 'quality' of a filter.

$Q = f_0 / 3$ dB bandwidth

**INSERTION LOSS** – The decrease in transmitted signal power resulting from the insertion of a device. It is usually expressed relative to the signal power delivered to that same part before insertion, and is usually expressed in decibels (dB).

**NOTCH FILTER** – A filter that rejects one band of frequencies, while passing both higher and lower frequencies. Also known as a band reject filter.

**PASSBAND** – The range of frequencies that can be passed through a filter, bounded by limits often specified as the half-power points (i.e. 3 dB below the nominal).

**PERCENT BANDWIDTH** – The width of a filter's response between the 3 dB points, based on a percentage of the center frequency.

**RESPONSE** – A description of how a filter reacts to input signals versus frequency, and is defined as the ratio of the input signal compared to the output signal.

**RISE TIME** – The time required for a signal to change from a specified low value to a specified high value, typically defined as 10% and 90% of the steady state value.

**SELECTIVITY** – A measure of the attenuation provided at frequencies removed from the center frequency relative to the center frequency response.

**SHAPE FACTOR** – A dimensionless parameter giving an indication of the amount of selectivity provided by a given filter. Typically calculated as the ratio between the 30 dB bandwidth and 3 dB bandwidth.

## The Effect of VSWR on Transmitted Power

| VSWR | Return Loss (dB) | Trans. Loss (dB) | Volt Refl. Coeff. | Power Trans. (%) | Power Refl. (%) | VSWR | Return Loss (dB) | Trans. Loss (dB) | Volt Refl. Coeff. | Power Trans. (%) | Power Refl. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.00 | ∞ | .000 | .00 | 100.0 | .0 | 1.60 | 12.7 | .238 | .23 | 94.7 | 5.3 |
| 1.01 | 46.1 | .000 | .00 | 100.0 | .0 | 1.62 | 12.5 | .250 | .24 | 94.4 | 5.6 |
| 1.02 | 40.1 | .000 | .01 | 100.0 | .0 | 1.64 | 12.3 | .263 | .24 | 94.1 | 5.9 |
| 1.03 | 36.6 | .001 | .01 | 100.0 | .0 | 1.66 | 12.1 | .276 | .25 | 93.8 | 6.2 |
| 1.04 | 34.2 | .002 | .02 | 100.0 | .0 | 1.68 | 11.9 | .289 | .25 | 93.6 | 6.4 |
| 1.05 | 32.3 | .003 | .02 | 99.9 | .1 | 1.70 | 11.7 | .302 | .26 | 93.3 | 6.7 |
| 1.06 | 30.4 | .004 | .03 | 99.9 | .1 | 1.72 | 11.5 | .315 | .26 | 93.0 | 7.0 |
| 1.07 | 29.4 | .005 | .03 | 99.9 | .1 | 1.74 | 11.4 | .329 | .27 | 92.7 | 7.3 |
| 1.08 | 28.3 | .006 | .04 | 99.9 | .1 | 1.76 | 11.2 | .342 | .28 | 92.4 | 7.6 |
| 1.09 | 27.3 | .008 | .04 | 99.8 | .2 | 1.78 | 11.0 | .356 | .28 | 92.1 | 7.9 |
| 1.10 | 26.4 | .010 | .05 | 99.8 | .2 | 1.80 | 10.9 | .370 | .29 | 91.8 | 8.2 |
| 1.11 | 25.7 | .012 | .05 | 99.7 | .3 | 1.82 | 10.7 | .384 | .29 | 91.5 | 8.5 |
| 1.12 | 24.9 | .014 | .06 | 99.7 | .3 | 1.84 | 10.6 | .398 | .30 | 91.3 | 8.7 |
| 1.13 | 24.3 | .016 | .06 | 99.6 | .4 | 1.86 | 10.4 | .412 | .30 | 91.0 | 9.0 |
| 1.14 | 23.7 | .019 | .07 | 99.6 | .4 | 1.88 | 10.3 | .426 | .31 | 90.7 | 9.3 |
| 1.15 | 23.1 | .021 | .07 | 99.5 | .5 | 1.90 | 10.2 | .440 | .31 | 90.4 | 9.6 |
| 1.16 | 22.6 | .024 | .07 | 99.5 | .5 | 1.92 | 10.0 | .454 | .32 | 90.1 | 9.9 |
| 1.17 | 22.1 | .027 | .08 | 99.4 | .6 | 1.94 | 9.9 | .468 | .32 | 89.8 | 10.2 |
| 1.18 | 21.7 | .030 | .08 | 99.3 | .7 | 1.96 | 9.8 | .483 | .32 | 89.5 | 10.5 |
| 1.19 | 21.2 | .033 | .09 | 99.2 | .8 | 1.98 | 9.7 | .497 | .33 | 89.2 | 10.8 |
| 1.20 | 20.8 | .036 | .09 | 99.2 | .8 | 2.00 | 9.5 | .512 | .33 | 88.9 | 11.1 |
| 1.21 | 20.4 | .039 | .10 | 99.1 | .9 | 2.50 | 7.4 | .881 | .43 | 81.6 | 18.4 |
| 1.22 | 20.1 | .043 | .10 | 99.0 | 1.0 | 3.00 | 6.0 | 1.249 | .50 | 75.0 | 25.0 |
| 1.23 | 19.7 | .046 | .10 | 98.9 | 1.1 | 3.50 | 5.1 | 1.603 | .56 | 69.1 | 30.9 |
| 1.24 | 19.4 | .050 | .11 | 98.9 | 1.1 | 4.00 | 4.4 | 1.938 | .60 | 64.0 | 36.0 |
| | | | | | | 4.50 | 3.9 | 2.255 | .64 | 59.5 | 40.5 |
| 1.25 | 19.1 | .054 | .11 | 98.8 | 1.2 | 5.00 | 3.5 | 2.553 | .67 | 55.6 | 44.4 |
| 1.26 | 18.8 | .058 | .12 | 98.7 | 1.3 | 5.50 | 3.2 | 2.834 | .69 | 52.1 | 47.9 |
| 1.27 | 18.5 | .062 | .12 | 98.6 | 1.4 | 6.00 | 2.9 | 3.100 | .71 | 49.0 | 51.0 |
| 1.28 | 18.2 | .066 | .12 | 98.5 | 1.5 | 6.50 | 2.7 | 3.351 | .73 | 46.2 | 53.8 |
| 1.29 | 17.9 | .070 | .13 | 98.4 | 1.6 | 7.00 | 2.5 | 3.590 | .75 | 43.7 | 56.2 |
| | | | | | | 7.50 | 2.3 | 3.817 | .76 | 41.5 | 58.5 |
| 1.30 | 17.7 | .075 | .13 | 98.3 | 1.7 | 8.00 | 2.2 | 4.033 | 78 | 39.5 | 60.5 |
| 1.32 | 17.2 | .083 | .14 | 98.1 | 1.9 | 8.50 | 2.1 | 4.240 | .79 | 37.7 | 62.3 |
| 1.34 | 16.8 | .093 | .15 | 97.9 | 2.1 | 9.00 | 1.9 | 4.437 | .80 | 36.0 | 64.0 |
| 1.36 | 16.3 | .102 | .15 | 97.7 | 2.3 | 9.50 | 1.8 | 4.626 | .81 | 34.5 | 65.5 |
| 1.38 | 15.9 | .112 | .16 | 97.5 | 2.5 | 10.00 | 1.7 | 4.807 | .82 | 33.1 | 66.9 |
| | | | | | | 11.00 | 1.6 | 5.149 | .83 | 30.6 | 69.4 |
| 1.40 | 15.6 | .122 | .17 | 97.2 | 2.8 | 12.00 | 1.5 | 5.466 | .85 | 28.4 | 71.6 |
| 1.42 | 15.2 | .133 | .17 | 97.0 | 3.0 | 13.00 | 1.3 | 5.762 | .86 | 26.5 | 73.5 |
| 1.44 | 14.9 | .144 | .18 | 96.7 | 3.3 | 14.00 | 1.2 | 6.042 | .87 | 24.9 | 75.1 |
| 1.46 | 14.6 | .155 | .19 | 96.5 | 3.5 | 15.00 | 1.2 | 6.301 | .88 | 23.4 | 76.6 |
| 1.48 | 14.3 | .166 | .19 | 96.3 | 3.7 | 16.00 | 1.1 | 6.547 | .88 | 22.1 | 77.9 |
| | | | | | | 17.00 | 1.0 | 6.780 | .89 | 21.0 | 79.0 |
| 1.50 | 14.0 | .177 | .20 | 96.0 | 4.0 | 18.00 | 1.0 | 7.002 | .89 | 19.9 | 80.1 |
| 1.52 | 13.7 | .189 | .21 | 95.7 | 4.3 | 19.00 | 0.9 | 7.212 | .90 | 19.0 | 81.0 |
| 1.54 | 13.4 | .201 | .21 | 95.5 | 4.5 | 20.00 | 0.9 | 7.413 | .90 | 18.1 | 81.9 |
| 1.56 | 13.2 | .213 | .22 | 95.2 | 4.8 | 25.00 | 0.7 | 8.299 | .92 | 14.8 | 85.2 |
| 1.58 | 13.0 | .225 | .22 | 94.9 | 5.1 | 30.00 | 0.6 | 9.035 | .94 | 12.5 | 87.5 |

## Decibels-Volts-Watts Conversion Table, 50-ohm System Terminated

| dBm | V | Po | dBm | mV | Po | dBm | µV | Po | dBm | nV | Po |
|---|---|---|---|---|---|---|---|---|---|---|---|
| +53 | 100.0 | 200 W | | | | | | | | | |
| +50 | 70.7 | 100 W | 0 | 225 | 1.0 mW | -50 | 710 | .01 µW | -100 | 2250 | .1 pW |
| +49 | 64.0 | 80 W | -1 | 200 | .80 mW | -51 | 640 | | -101 | 2000 | |
| +48 | 58.0 | 64 W | -2 | 180 | .64 mW | -52 | 570 | | -102 | 1800 | |
| +47 | 50.0 | 50 W | -3 | 160 | .50 mW | -53 | 500 | | -103 | 1600 | |
| +46 | 44.5 | 40 W | -4 | 141 | .40 mW | -54 | 450 | | -104 | 1410 | |
| +45 | 40.0 | 32 W | -5 | 125 | .32 mW | -55 | 400 | | -105 | 1270 | |
| +44 | 35.4 | 25 W | -6 | 115 | .25 mW | -56 | 355 | | -106 | 1180 | |
| +43 | 32.0 | 20 W | -7 | 100 | .20 mW | -57 | 320 | | -107 | 1000 | |
| +42 | 28.0 | 16 W | -8 | 90.0 | .16 mW | -58 | 280 | | -108 | 900 | |
| +41 | 26.2 | 12.5 W | -9 | 80.0 | .125 mW | -59 | 251 | | -109 | 800 | |
| +40 | 22.5 | 10 W | -10 | 71.0 | .10 mW | -60 | 225 | .001 µW | -110 | 710 | .01 pW |
| +39 | 20.0 | 8 W | -11 | 64.0 | | -61 | 200 | | -111 | 640 | |
| +38 | 18.0 | 6.4 W | -12 | 58.0 | | -62 | 180 | | -112 | 580 | |
| +37 | 16.0 | 5 W | -13 | 50.0 | | -63 | 160 | | -113 | 500 | |
| +36 | 14.1 | 4 W | -14 | 44.5 | | -64 | 141 | | -114 | 450 | |
| +35 | 12.5 | 3.2 W | -15 | 40.0 | | -65 | 128 | | -115 | 400 | |
| +34 | 11.5 | 2.5 W | -16 | 35.5 | | -66 | 115 | | -116 | 355 | |
| +33 | 10.0 | 2 W | -17 | 31.5 | | -67 | 100 | | -117 | 320 | |
| +32 | 9.0 | 1.6 W | -18 | 28.5 | | -68 | 90 | | -118 | 285 | |
| +31 | 8.0 | 1.25 W | -19 | 25.1 | | -69 | 80 | | -119 | 251 | |
| +30 | 7.10 | 1.0 W | -20 | 22.5 | .01 mW | -70 | 71 | .1 nW | -120 | 225 | .001 pW |
| +29 | 6.40 | 800 mW | -21 | 20.0 | | -71 | 65 | | -121 | 200 | |
| +28 | 5.80 | 640 mW | -22 | 17.9 | | -72 | 58 | | -122 | 180 | |
| +27 | 5.00 | 500 mW | -23 | 15.9 | | -73 | 50 | | -123 | 160 | |
| +26 | 4.45 | 400 mW | -24 | 14.1 | | -74 | 45 | | -124 | 141 | |
| +25 | 4.00 | 320 mW | -25 | 12.8 | | -75 | 40 | | -125 | 128 | |
| +24 | 3.55 | 250 mW | -26 | 11.5 | | -76 | 35 | | -126 | 117 | |
| +23 | 3.20 | 200 mW | -27 | 10.0 | | -77 | 32 | | -127 | 100 | |
| +22 | 2.80 | 160 mW | -28 | 8.9 | | -78 | 29 | | -128 | 90 | |
| +21 | 2.52 | 125 mW | -29 | 8.0 | | -79 | 25 | | -129 | 80 | |
| +20 | 2.25 | 100 mW | -30 | 7.1 | .001 mW | -80 | 22.5 | .01 nW | -130 | 71 | .1 fW |
| +19 | 2.00 | 80 mW | -31 | 6.25 | | -81 | 20.0 | | -131 | 61 | |
| +18 | 1.80 | 64 mW | -32 | 5.8 | | -82 | 18.0 | | -132 | 58 | |
| +17 | 1.60 | 50 mW | -33 | 5.0 | | -83 | 16.0 | | -133 | 50 | |
| +16 | 1.41 | 40 mW | -34 | 4.5 | | -84 | 11.1 | | -134 | 45 | |
| +15 | 1.25 | 32 mW | -35 | 4.0 | | -85 | 12.9 | | -135 | 40 | |
| +14 | 1.15 | 25 mW | -36 | 3.5 | | -86 | 11.5 | | -136 | 35 | |
| +13 | 1.00 | 20 mW | -37 | 3.2 | | -87 | 10.0 | | -137 | 33 | |
| +12 | .90 | 16 mW | -38 | 2.85 | | -88 | 9.0 | | -138 | 29 | |
| +11 | .80 | 12.5 mW | -39 | 2.5 | | -89 | 8.0 | | -139 | 25 | |
| +10 | .71 | 10 mW | -40 | 2.25 | .1 µW | -90 | 7.1 | .001 nW | -140 | 23 | .01 fW |
| +9 | .64 | 8 mW | -41 | 2.0 | | -91 | 6.1 | | | | |
| +8 | .58 | 6.4 mW | -42 | 1.8 | | -92 | 5.75 | | | | |
| +7 | .500 | 5 mW | -43 | 1.6 | | -93 | 5.0 | | | | |
| +6 | .445 | 4 mW | -44 | 1.4 | | -94 | 4.5 | | | | |
| +5 | .400 | 3.2 mW | -45 | 1.25 | | -95 | 4.0 | | | | |
| +4 | .355 | 2.5 mW | -46 | 1.18 | | -96 | 3.51 | | | | |
| +3 | .320 | 2.0 mW | -47 | 1.00 | | -97 | 3.2 | | | | |
| +2 | .280 | 1.6 mW | -48 | .90 | | -98 | 2.9 | | | | |
| +1 | .252 | 1.25 mW | -49 | .80 | | -99 | 2.51 | | | | |

## Fraction-Decimal-Millimeter Conversion Table

| Fraction | Decimal | Millimeter | Fraction | Decimal | Millimeter |
|---|---|---|---|---|---|
| 1/64 | .015625 | 0.397 | 33/64 | .515625 | 13.097 |
| 1/32 | .03125 | 0.794 | 17/32 | .53125 | 13.494 |
| 3/64 | .046875 | 1.191 | 35/64 | .546875 | 13.891 |
| 1/16 | .0625 | 1.588 | 9/16 | .5625 | 14.288 |
| 5/64 | .078125 | 1.984 | 37/64 | .578125 | 14.684 |
| 3/32 | .09375 | 2.381 | 19/32 | .59375 | 15.081 |
| 7/64 | .109375 | 2.778 | 39/64 | .609375 | 15.478 |
| 1/8 | .125 | 3.175 | 5/8 | .625 | 15.875 |
| 9/64 | .140625 | 3.572 | 41/64 | .640625 | 16.272 |
| 5/32 | .15625 | 3.969 | 21/32 | .65625 | 16.669 |
| 11/64 | .171875 | 4.366 | 43/64 | .671875 | 17.066 |
| 3/16 | .1875 | 4.762 | 11/16 | .6875 | 17.462 |
| 13/64 | .203125 | 5.159 | 45/64 | .703125 | 17.859 |
| 7/32 | .21875 | 5.556 | 23/32 | .71875 | 18.256 |
| 15/64 | .234375 | 5.953 | 47/64 | .734375 | 18.653 |
| 1/4 | .250 | 6.350 | 3/4 | .750 | 19.050 |
| 17/64 | .265625 | 6.747 | 49/64 | .765625 | 19.447 |
| 9/32 | .28125 | 7.144 | 25/32 | .78125 | 19.844 |
| 19/64 | .296875 | 7.541 | 51/64 | .796875 | 20.241 |
| 5/16 | .3125 | 7.938 | 13/16 | .8125 | 20.638 |
| 21/64 | .328125 | 8.334 | 53/64 | .828125 | 21.034 |
| 11/32 | .34375 | 8.731 | 27/32 | .84375 | 21.431 |
| 23/64 | .359375 | 9.128 | 55/64 | .859375 | 21.828 |
| 3/8 | .375 | 9.525 | 7/8 | .875 | 22.225 |
| 25/64 | .390625 | 9.921 | 57/64 | .890625 | 22.622 |
| 13/32 | .40625 | 10.319 | 29/32 | .90625 | 23.019 |
| 27/64 | .421875 | 10.716 | 59/64 | .921875 | 23.416 |
| 7/16 | .4375 | 11.112 | 15/16 | .9375 | 23.812 |
| 29/64 | .453125 | 11.509 | 61/64 | .953125 | 24.209 |
| 15/32 | .46875 | 11.906 | 31/32 | .96875 | 24.606 |
| 31/64 | .484375 | 12.303 | 63/64 | .984375 | 25.003 |
| 1/2 | .500 | 12.700 | 1 | 1.00 | 25.400 |



## Length-Mass Conversion Table

**How to Use this Table:**

Find the term that you are currently using in Column 1.

Multiply by the conversion factor in column 2 to obtain the equivalent in column 3.

If you want to convert column 3 back to column 1, reverse the process by dividing by the conversion factor in column 2.

| 1 | | 2 | | 3 |
|---|---|---|---|---|
| Centimeters | × | 0.3937 | = | Inches |
| Millimeters | × | 0.03937 | = | Inches |
| Meters | × | 39.37 | = | Inches |
| Feet | × | 12 | = | Inches |
| Yards | × | 36 | = | Inches |
| Inches | × | 25.4 | = | Millimeters |
| Inches | × | 25,400 | = | Microns |
| Meters | × | 3.281 | = | Feet |
| Feet | × | 0.3048 | = | Meters |
| Meters | × | 1.093 | = | Yards |
| Yards | × | 0.9144 | = | Meters |
| Kilometers | × | 0.621 | = | Miles |
| Mile | × | 1.609 | = | Kilometers |
| Mils | × | 0.0254 | = | Millimeters |
| Microns | × | 0.03937 | = | Mils |
| Grams | × | 0.03527 | = | Ounces |
| Grams | × | 0.0022 | = | Pounds |
| Pounds/Inch | × | 17.512685 | = | Newtons/100 Millimeters |
| Ounces/Inch | × | 10.94543 | = | Newtons/Meter |

### Temperature Conversion

- To convert °C to °F, multiply by 1.8 and add 32 (ie. 100°C × 1.8 + 32 = 212°F)
- To convert °F to °C, subtract 32 and divide by 1.8 (ie. 212°F - 32 / 1.8 = 100°C)

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