MN-30-520-X-S20, 30 to 520 MHz, 1 Watt, Tunable Bandpass Filter, Gen 3 ERF®

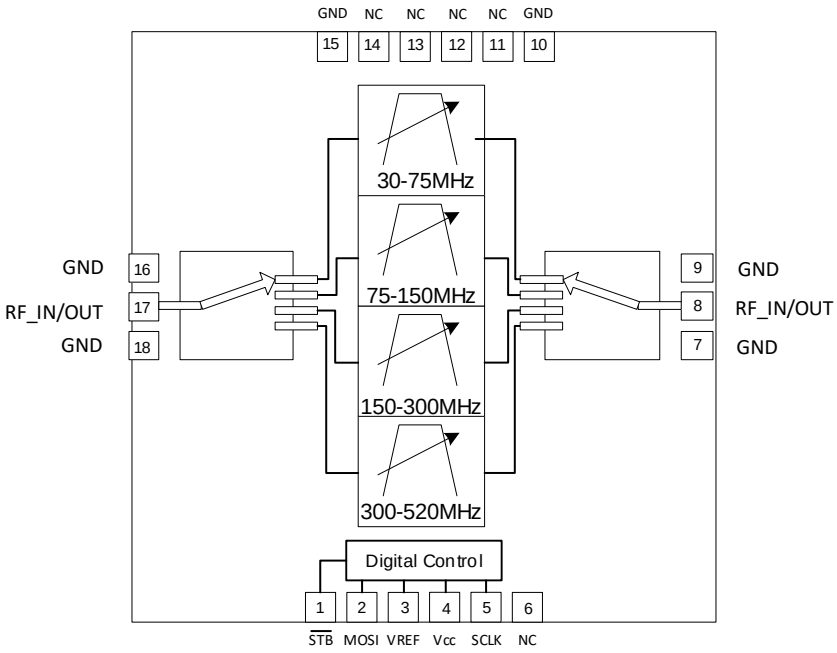
Typical Applications

- Military Radios
- Military Radar
- SATCOM
- Test and Measurement Equipment
- Industrial and Medical Equipment

Features

- Reduced SWaP-C
- 50mW (typ.) power consumption
- 1 Watt CW continuous power handling (7% BW)
- +40 dBm IIp3 (typ.)
- Low IL (5.0 dB typ., 7% filter)
- 14 dB typ. selectivity @ +/- 10%, (7% filter)

Functional Diagram



Description

The new MINI-ERF® Gen 3 is a Reduced SWaP-C, 30 to 520 MHz tunable bandpass filter:

- All MINI-ERF® are fully tuned and tested by Pole/Zero® for convenience and ease of use.
- Serial tuning interface.
- High Performance in a 1” x 1” x 0.5” (25.4mm x 25.4mm x 12.7mm) leadless surface mountable package.
- Custom designs available upon request, consult factory.

1.0 Ordering Information

Table 1. Ordering Options

Series	-	Frequency Range (MHz)	-	% Bandwidth (3 dB)	-	Package
MN	-	30-520	-	7	-	S20

Note: Options may be limited to particular frequency bands and/or configurations. Consult Pole/Zero for your application.
Example product number: MN-30-520-7-S20

2.0 Pinout and Functional Information

2.1 Pinout

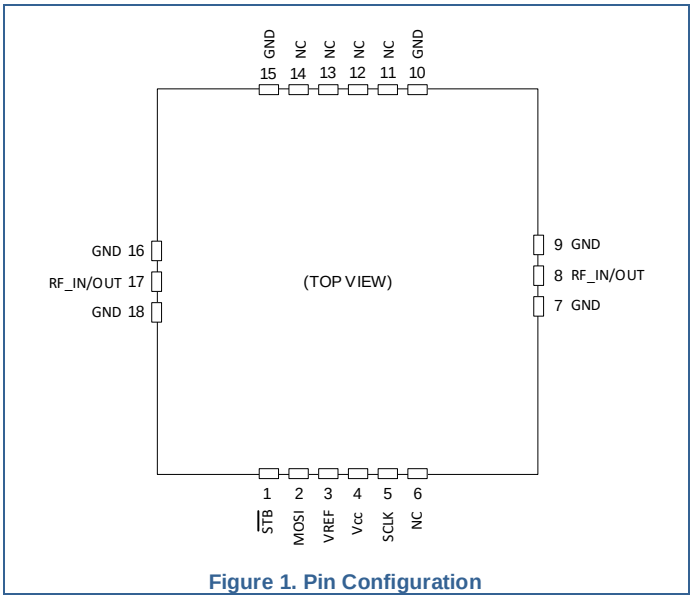


Figure 1. Pin Configuration

2.2 Pin Description

Table 2. Pin Functions and Descriptions

Pin Number	Label	Description
1	$\overline{\text{STB}}$	$\overline{\text{STB}}$ wakes the controller circuitry on a low transition.
2	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 VCC with a 27 kΩ resistor.)
3	VREF	The voltage applied to this pin directly affects how much power the unit can handle. +5V Min, +10V Max.
4	+5V	Supply Voltage Input, VCC
5	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 VCC with a 27 kΩ resistor.)
6, 11, 12, 13, 14	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.
7, 9, 10, 15, 16, 18	GND	Digital and Analog Ground.
8, 17	RF IN/OUT	RF Signal Input or Output.

3.0 Specifications

3.1 Absolute Maximum Ratings[1]

Voltages are referenced to GND (ground = 0V). Operating at room temperature (unless otherwise noted).

Symbol	Parameter	Conditions	Min	Max	Unit
V_{CC}	Supply voltage	-	-0.5	+6.0	V
V_{REF}	High supply voltage	-	-0.5	12	V
V_I	Input voltage	On all digital interface input pins	-0.5	3.6	V
V_O	Output voltage	On all digital interface output pins	-0.5	3.3	V
I_{OH}/I_{OL}	Digital interface pin sink/source current	-	-	8	mA
I_O	Output current	-	-	8	mA
P_{INBAND}	In-band RF input power level	Signal is in passband $f_0 = 30 - 520\ MHz$	-	33	dBm
$P_{OUTBAND}$	Out-of-band RF input power level	-	-	33	dBm
T_{RATE}	Maximum tune rate (frequency hopping)	-	-	2	kHz

3.2 Handling Ratings

Symbol	Parameter	Conditions	Min	Max	Unit
T_S	Storage temperature	-	-55	+125	°C

3.3 Recommended Operating Conditions

Symbol	Parameter	Conditions	Min	Nom	Max	Unit
V_{CC}	Supply voltage	-	4.7	5	5.5	V
V_{REF}	High supply voltage	-	4.5	10	10.5	V
P_{IN} (Vref = +5V)	Maximum RF input power for linear operation	Signal is in passband	-	-	30	dBm
P_{IN} (Vref = +10V)	Maximum RF input power for linear operation	Signal is in passband	-	-	31	dBm
T_A	Ambient operating temperature	-	-40	-	+85	°C

3.4 Electrical Characteristics

All specifications at T_A = 23 °C, V_{cc} = 5.0 V, V_{REF} = 10.0 V, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Nom	Max	Unit
I_{CC_STATIC}	V_{CC} current consumption, statically tuned	At nominal V_{CC} voltage	-	7.5	10	mA
I_{CC_HOP}	V_{CC} current consumption, hopping	Nominal V_{CC}, hopping at 10KHz	-	-	35	mA
I_{REF_STATIC}	V_{REF} current consumption, statically tuned	At nominal V_{REF} voltage	-	11.5	35	mA
I_{REF_HOP}	V_{REF} current consumption	Nominal V_{REF}, hopping at 2KHz	-	11.5	TBD	mA
V_{IH}	Digital high level input voltage	On all digital interface input pins	2.0	-	-	V

[1] Maximum operating conditions before damage occurs.

Symbol	Parameter	Conditions	Min	Nom	Max	Unit
V_{IL}	Digital low level input voltage	On all digital interface output pins	-	-	0.8	V
I_{IH}/I_{IL}	Digital Interface pin input logic current	-	4	-	-4	mA
F_{RANGE}	Tunable frequency range	-	30	-	520	MHz
Z_O	Input/output impedance	-	-	50	-	Ω
VSWR	Voltage Standing Wave Ratio	-	-	1.24:1	2.1:1	-
RL	Return loss	At 50 Ω	9.0	19.5	-	dB
IL	Insertion loss	-	-	5.1	7.0	dB
BW	Bandwidth (3 dB)	-	6.2	7	7.8	%
$SEL_{10\%}$	Selectivity 10% removed from the center frequency	$f_o \pm 10\%$	12	15	-	dBc
$SEL_{ULTIMATE}$	Ultimate selectivity	$2 \times f_o$	-	50	-	dBc
IIP3	Input third order intermodulation intercept point	-	-	45[2]	-	dBm
$P_{Spurious}$	Spurious Level	15 dB Noise Source Reference	-	-130	-	dBm
NF	Noise figure	-	-	IL	IL +1.0	dB
T_{TUNE}	Tune time	-	-	24.8	75	µs
F_{DRIFT}	Center frequency drift over temperature	-40 to +85°C	-40	-	-80	ppm/°C

[2] 2-Tone IIP3 measurement with tones at +10dBm.

3.5 Typical Characteristics

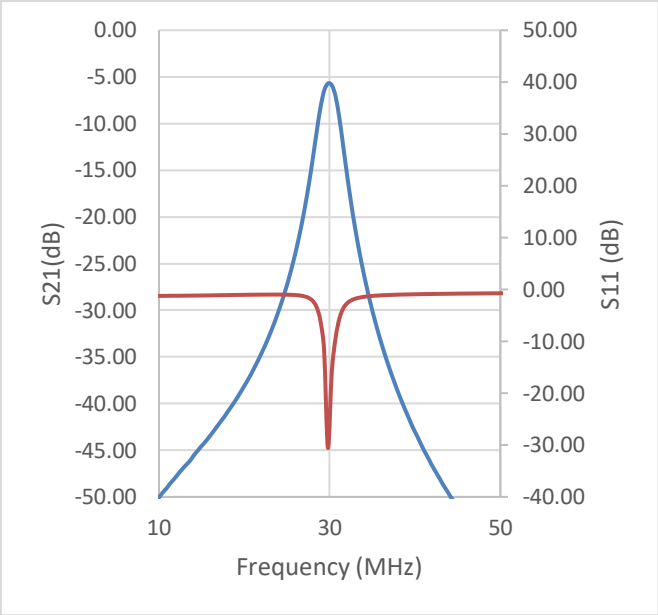


Figure 2. Filter response at 30 MHz

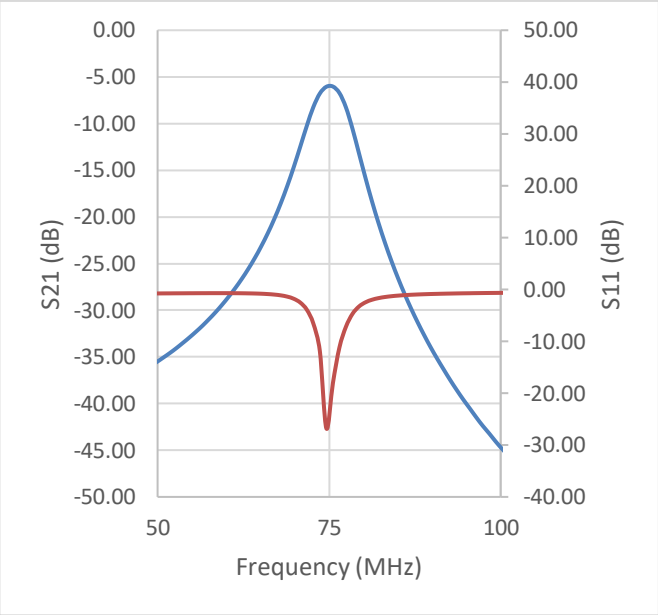


Figure 3. Filter Response at 75 MHz

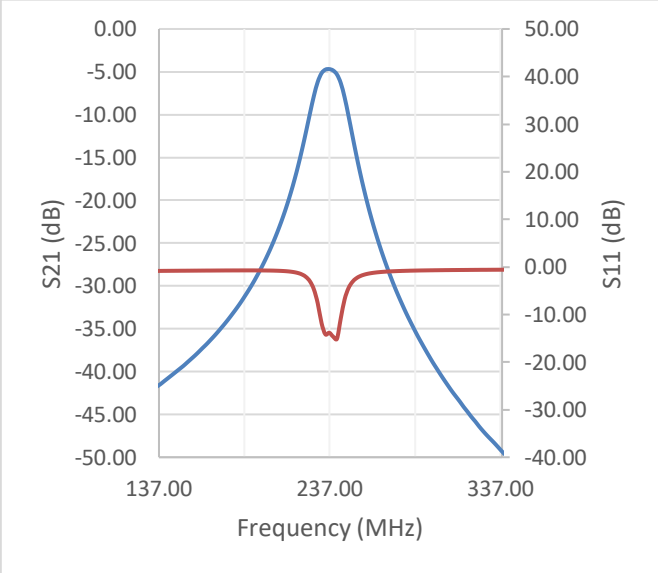


Figure 4. Filter Response at 237 MHz

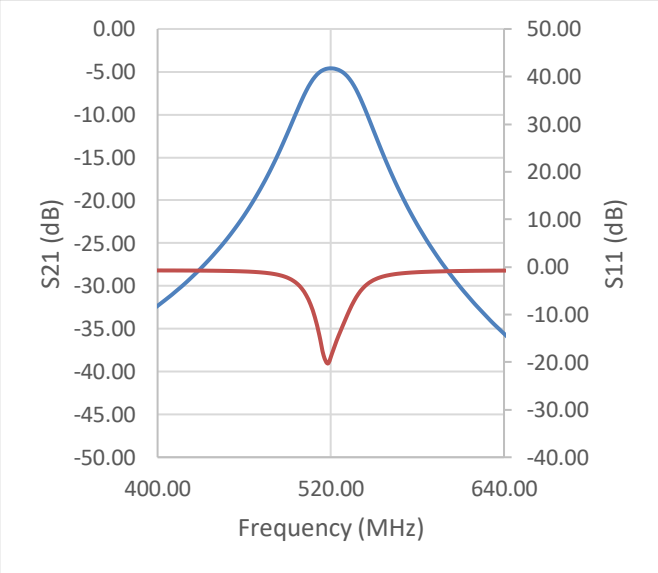


Figure 5. Filter Response at 520 MHz

3.6 Timing Requirements

3.6.1 SPI Interface Timing

The SPI tune interface is a standard SPI interface with Mode = 0 (CPOL = 0, CPHA = 0). There are always 16 data bits regardless of the band or tune command. Any bits that do not affect the frequency offset of the filter should always be set to 0. The interface receives the data most significant byte and most significant bit first.

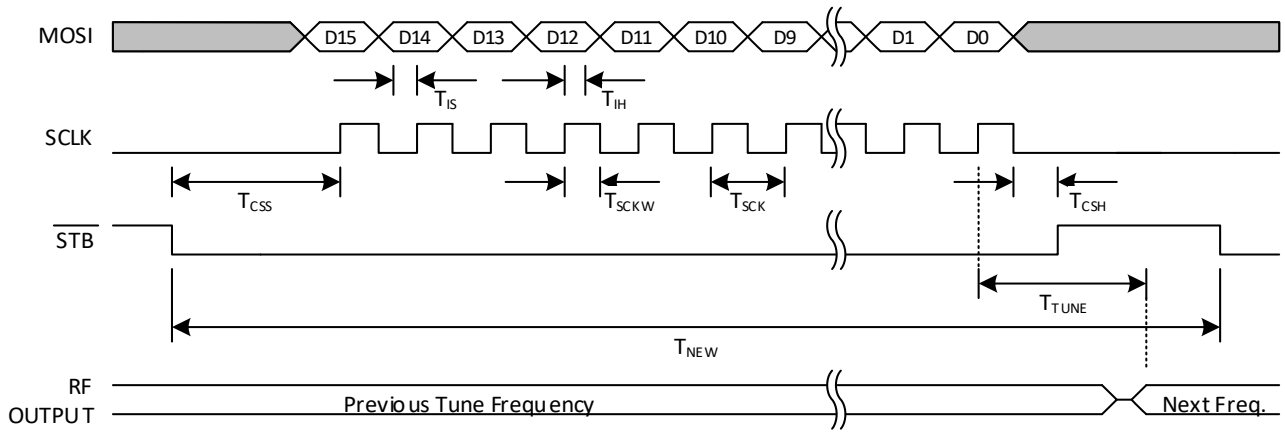


Figure 6. Serial Timing Diagram

Table 3. SPI Timing Characteristics

V_{CC} = 3.3 V +/-5%, GND = 0 V

Parameter	Parameter	Min.	Max.	Unit
T_{CSS}	$\overline{STB}$ Setup Time – The amount of time needed from when $\overline{STB}$ transitions low until the first rising edge of SCLK.	1.0	-	µs
T_{IS}	MOSI Setup – The amount of time data needs to be present on MOSI before the rising edge of SCLK.	10	-	ns
T_{IH}	MOSI Hold – The amount of time data needs to be held on MOSI after the rising edge of SCLK.	40	-	ns
T_{SCLK}	SCLK Period	143	-	ns
T_{SCW}	SCLK Duty Cycle	$\frac{T_{SCLK}}{2}$	-	ns
T_{SCLKF}	SCLK Fall Time	-	1.6	µs
T_{SCLKR}	SCLK Rise Time	-	1.6	µs
T_{CSH}	$\overline{STB}$ Hold Time – The amount of time $\overline{STB}$ needs to remain low after the last falling edge of SCLK.	50	-	ns
T_{NEW}	New Command Delay – The amount of between falling edges of $\overline{STB}$. This is the time between the start of new tune commands.	500	-	µs
T_{TUNE}	Time from the last rising edge of clock until the RF response reaches 90%.	-	150[3]	µs

[3] Worst case at -40°C.

4.0 Functional Description

4.1 Tune Commands

The tune command is a two-byte load tune word. The first byte (MSB) is the band the filter should tune to. The second byte (LSB) is the frequency offset in the chosen band.

Table 4. Tune Command Properties

Symbol	Band	Value	Description
f_{MIN}	Band 0	30 MHz	Minimum Tunable Frequency. f_{MIN} is the absolute minimum frequency that the filter is capable of tuning to for the respective band.
	Band 1	75 MHz	
	Band 2	150 MHz	
	Band 3	300 MHz	
f_{MAX}	Band 0	75 MHz	Maximum Tunable Frequency. f_{MAX} is the absolute maximum frequency that the filter is capable of tuning to. Sending tune commands greater than the maximum tunable frequency will result in an invalid tune condition. The frequency response of an invalid tune is unknown. Normal frequency response will return on the next valid tune command. Varies depending on the band.
	Band 1	150 MHz	
	Band 2	300 MHz	
	Band 3	520 MHz	
f_{STEP}	Band 0	0.75 MHz	Tune step size. f_{STEP} is the minimum spacing between adjacent tune commands.
	Band 1	1.25 MHz	
	Band 2	1.50 MHz	
	Band 3	2.20 MHz	
f_{COM}	All	$round\left(\frac{(f_{DESIRED} - f_{MIN})}{f_{STEP}}\right)$	Commanded Frequency. f_{COM} is the commanded frequency that is sent over the SPI tune interface. The command can be calculated by subtracting f_{MIN} from the desired frequency for the particular band, dividing the result by the f_{STEP} of that band, and then rounding to the nearest integer command. The formula is used to select the closest possible frequency to the desired tune word. If the next lowest tune word is desired, replace the round operation with floor and if the next highest tune word is desired replace the round operation with ceil.

Table 5. Tune Command Format

Filter Model				Tune Word Format															
Part Series	f_{MIN} (MHz)	f_{MAX} (MHz)		(MSB) 15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	(LSB) 0
MN-30-520-7-S20	30	520		0	0	0	0	0	0	Band Bits		Commanded Frequency							

5.0 Detailed Description

5.1 Digital Interface

Table 6. Band Bit Selection

Band Bits			
Bit 9	Bit 8	Selected Band	Band Range (MHz)
0	0	Band 0	30 – 75
0	1	Band 1	75 – 150
1	0	Band 2	150 - 300
1	1	Band 3	300 - 520

5.2 Example Tune Commands

Table 7. Example Tune Commands

$f_{DESIRED}$ (MHz)	Req. Band	Band (Hex)	f_{MIN} of Band (MHz)	f_{STEP} of Band (MHz)	f_{COM} Calculation (Decimal)	f_{COM} (Decimal)	f_{COM} (Hex)	Tune Command (Hex)
30	Band0	0x00	30	0.75	$round\left(\frac{(30-30)}{0.75}\right)$	0	0x00	0x0000
52.5	Band0	0x00	30	0.75	$round\left(\frac{(52.5-30)}{0.75}\right)$	30	0x1E	0x001E
75	Band0	0x00	30	0.75	$round\left(\frac{(75-30)}{0.75}\right)$	60	0x3C	0x003C
75	Band1	0x01	75	1.25	$round\left(\frac{(75-75)}{1.25}\right)$	0	0x00	0x0100
131.25	Band1	0x01	75	1.25	$round\left(\frac{(131.25-75)}{1.25}\right)$	45	0x2D	0x012D
150	Band1	0x01	75	1.25	$round\left(\frac{(150-75)}{1.25}\right)$	60	0x3C	0x013C
150	Band2	0x02	150	1.5	$round\left(\frac{(150-150)}{1.5}\right)$	0	0x00	0x0200
222	Band2	0x02	150	1.5	$round\left(\frac{(222-150)}{1.5}\right)$	48	0x30	0x0230
300	Band2	0x02	150	1.5	$round\left(\frac{(300-150)}{1.5}\right)$	100	0x64	0x0264
300	Band3	0x03	300	2.2	$round\left(\frac{(300-300)}{2.2}\right)$	0	0x00	0x0300
410	Band3	0x03	300	2.2	$round\left(\frac{(410-300)}{2.2}\right)$	50	0x32	0x0332
520	Band3	0x03	300	2.2	$round\left(\frac{(520-300)}{2.2}\right)$	100	0x64	0x0364

6.0 Tune Time

Tune times include internal processing of the tune command data and the 90% settled RF amplitude response time of the filter. This time excludes the time required to load the tune command into the filter. Low level signal measurements were utilized to show the receive tune time that can be expected.

In addition, RF power in excess of +10 dBm is considered to be “hot switching” of the filter. While portions of the data taken in “Table 8. Typical RF Tune Times” was taken via “hot switching,” this does not imply that tuning operation of the filter into these levels can be done reliably. It is recommended that RF is less than 10 dBm during a tune event.

Table 8. Typical RF Tune Times

All specifications at T_A = 23 °C

Freq. (MHz)		Band	Input Power			Units
From	To		0	5	10	dBm
30	75	Band 0	-	-	11.5	µs
75	30	Band 0	-	-	36.0	
75	150	Band 1	-	-	7.50	
150	75	Band 1	-	-	30.5	
150	300	Band 2	-	-	12.5	
300	175	Band 2	-	-	42.5	
300	520	Band 3	-	-	5.50	
520	300	Band 3	-	-	51.5	
30	520	Band 0 to Band 3	-	-	14.0	
520	30	Band 3 to Band 0	-	-	36.0	

7.0 Application Information

7.1 Application Circuits

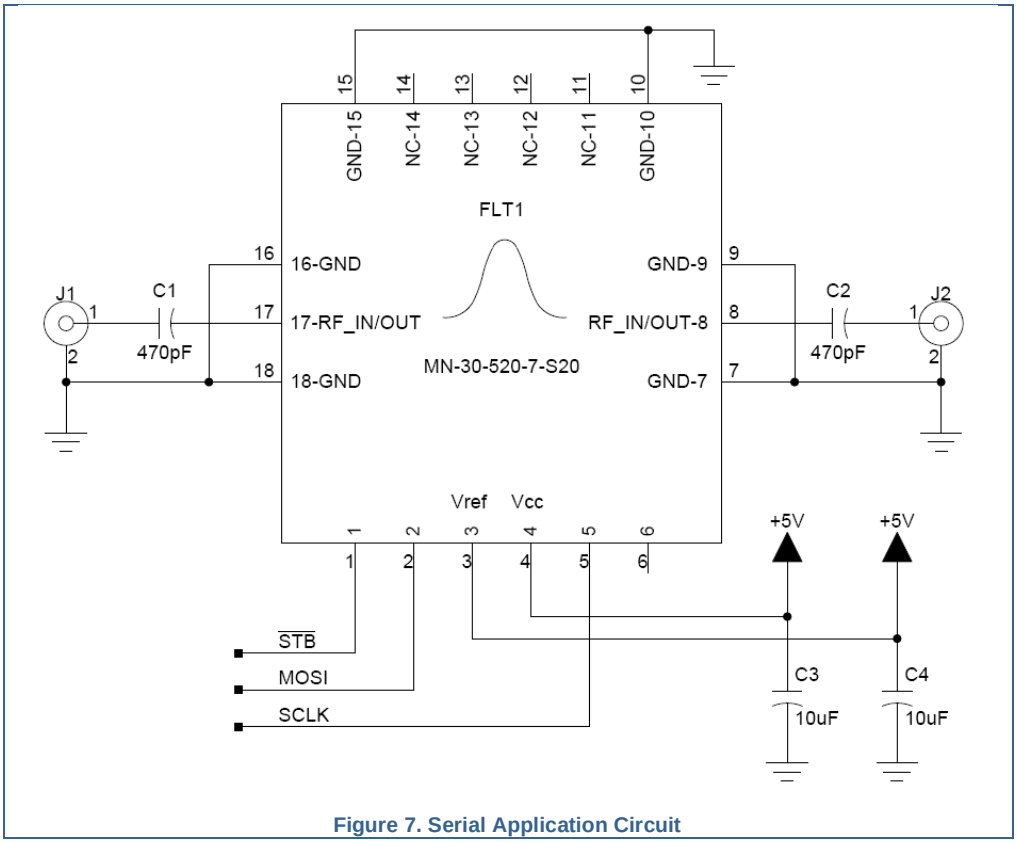


Figure 7. Serial Application Circuit

NOTE: Vref can be connected to +10V for higher Power Handling
Vref can be connected to Vcc (externally via zero Ohm resistor) if desired Vref = +5V

8.0 Package Information

8.1 Package Detail

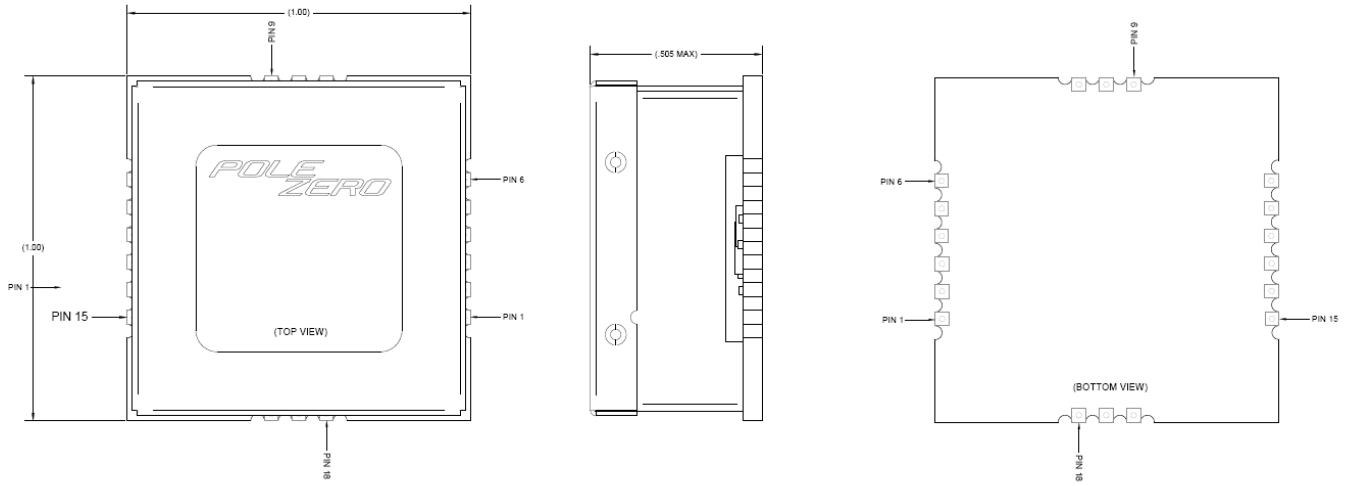


Figure 8. Package Detail

8.2 Recommended Pad Layout

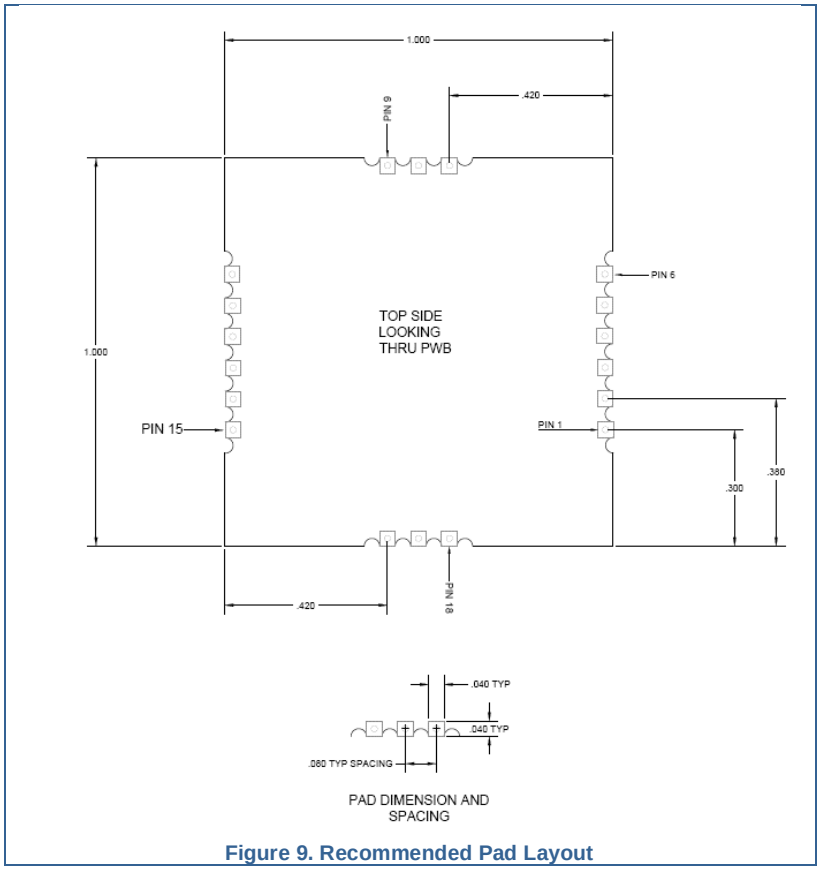


Figure 9. Recommended Pad Layout

9.0 Mounting Instructions

9.1 Solder Reflow Profile

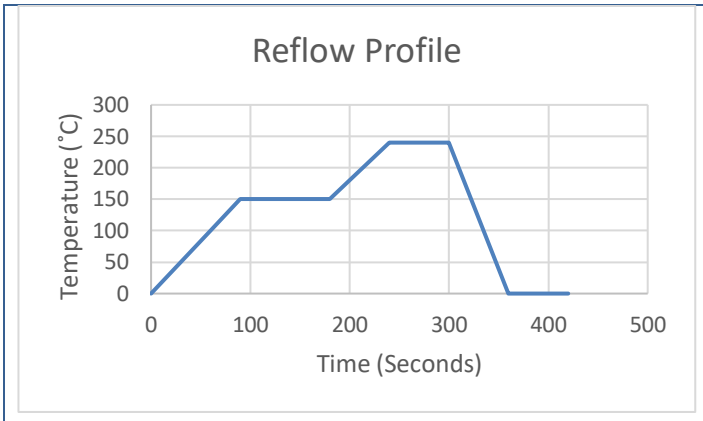


Figure 10. Recommended Solder Reflow Profile

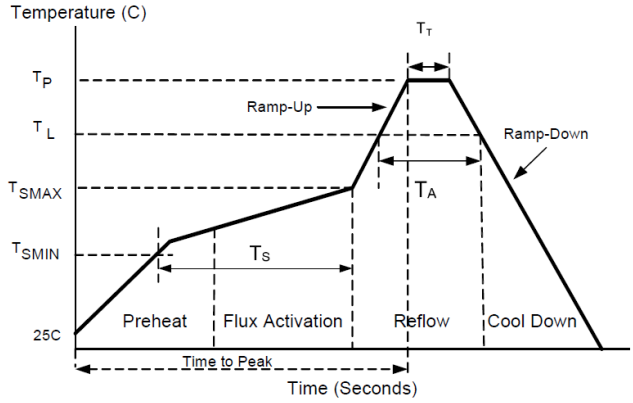


Figure 11. Reflow Profile Key

9.2 Temperature Options

Option	PWB Solder Mask Color	Reflowable?	Other Designators
High Temperature	Black	Yes	-
Standard Temperature	Green	No	-

9.3 Temperature Guidelines

9.3.1 Place the unit on the recommended layout pattern specified in this document in section **Error! Reference source not found.**. The parameters below describe the reflow profiles for Standard and Lead Free solder pastes. All temperatures are referenced to the PCB surface of the unit.

Parameter	Description	SAC305 Solder Paste	Sn63Pb37 Solder Paste
Ramp-up	Average ramp rate from T_{S_MAX} to T_P	3 °C/second average maximum	3 °C/second average maximum
T_{SMIN}	Preheat Peak Minimum	175 °C	150 °C
T_{SMAX}	Preheat Peak Minimum	200 °C	175 °C
T_P	Maximum Reflow Temperature	230 °C	225 °C
T_S	Time between T_{S_MAX} and T_{S_MIN}	75 – 120 seconds	45 – 90 seconds
T_L	Solder melting point	217 °C – 218 °C	183 °C
T_A	Time Above Liquidus (TAL)	60 – 120 seconds	45 – 90 seconds
T_T	Time within 5 °C of T_P	20 – 30 seconds	10 – 30 seconds
Ramp-Down	Ramp-down rate	6 °C per second maximum	6 °C per second maximum
Time to Peak	From 25 °C to peak temperature	270 seconds maximum	270 seconds maximum

9.4 Other Restrictions

9.4.1 Pole/Zero recommends a no-clean Sn63Pb37 solder paste.

9.4.2 If necessary to clean this product after assembly, Pole/Zero recommends the customer perform adequate experimentation to ensure their cleaning process is compatible with these filters.

9.4.3 Only subject the unit to one SMT reflow process.

9.4.4 Stencil thickness recommendation is between 0.005” and 0.008”.

9.4.5 Bake out process per J-STD-033B Package Thickness > 2.0 mm and ≤ 4.5 mm.

10.0 Safety Notes

10.1 Handling Information

Caution

This device contains electrostatic discharge sensitive devices and is sensitive to electrostatic discharge (ESD). Observe all precautions for handling electrostatic sensitive devices.

Caution

This device may produce potentially hazardous voltages. Take necessary precautions when handling this device while power is enabled.

Caution

This device is an MSD (moisture sensitivity device) level 4 component and should be packaged and handled according to the guidelines in J-STD-033.

11.0 Legal Information

11.1 Disclaimers

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Pole Zero Corporate Office
5558 Union Centre Drive
West Chester, OH 45069, USA
513-870-9060 (Phone)
513-870-9064 (Fax)