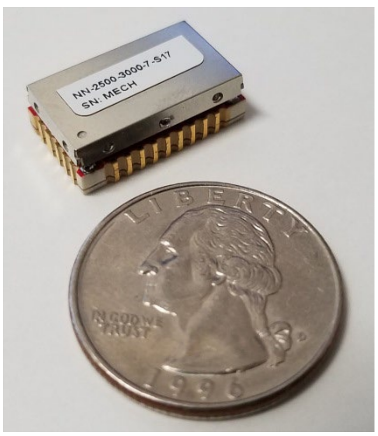
NN-X-X-X-S17, 225 – 3000 MHz, 1 Watt[1], Tunable Bandpass Filters

Typical Applications

- Applications where small size and high performance are required
- Military Manpack, Vehicular and Airborne Radios
- Radar
- SATCOM
- Test and Measurement Equipment
- Industrial and Medical Equipment

Features

- +30 dBm in-band power handling[1]
- +42 dBm IIP3 typical
- 10 µs typical tune time
- 15 dBc typical selectivity at f_c ± 10%[1]
- 4 dB typical insertion loss[2]
- +3.0 V @ 3.5 mA typical
- 0.78" x 0.47" x 0.3" (20 mm x 12 mm x 7.62 mm)
- Custom bandwidths and tuning ranges are available in this package from 225 to 3000 MHz.



Description

The **NANO-POLE®** is designed for optimal size, DC consumption, RF power handling, insertion loss, signal purity and linearity. The **NANO-POLE®** provides a minimum center frequency step size of 10 MHz typically but can be modified based upon request. The **NANO-POLE®** requires a +3.0 V supply that typically draws 5 mA when not hopping. The supply voltage should be adequately filtered as noise present on this pin will influence the RF signal purity. The **NANO-POLE®** uses SPI control interface.

[1] For BW3dB filters ≥ 7%. +27 dBm for 5% filters. +23 dBm for 3% filters. 5%, 3% filters provide more selectivity and have higher insertion loss. See sections 4.5 and 0.

1.0 Ordering Information

Table 1. Example Ordering Options

Series	-	Frequency Range (MHz)	-	% Bandwidth (3 dB)	-	Package
NN	-	225-520 400-700 700-1000 1000-1500 1500-2000 1500-2000 2000-2500 2500-3000	-	5 7	-	S17

Note: Options may be limited to particular frequency bands and/or configurations. Consult Pole/Zero for your application. Performance shown is indicative of 1.5:1 Tuning Ratio unless otherwise specified.

Example product number: NN-1000-1500-5-S17

2.0 Block Diagram

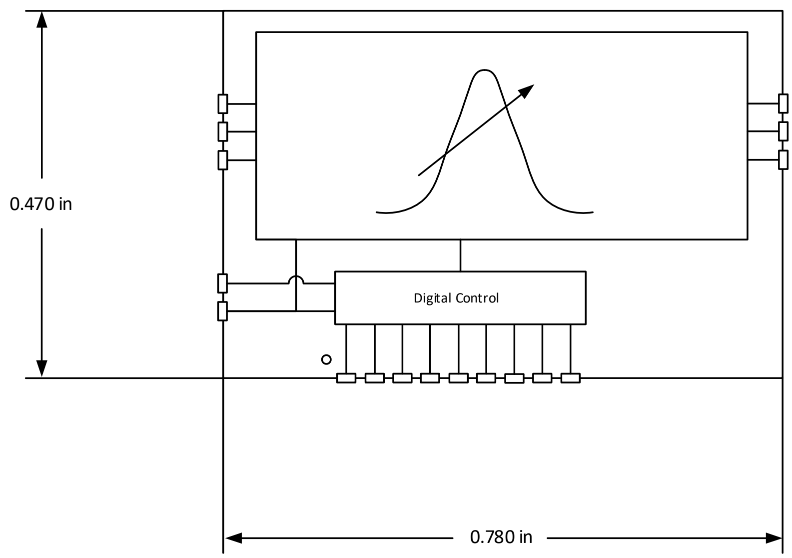


Figure 1. Technical Block Diagram

3.0 Pinout and Functional Information

3.1 Pinout

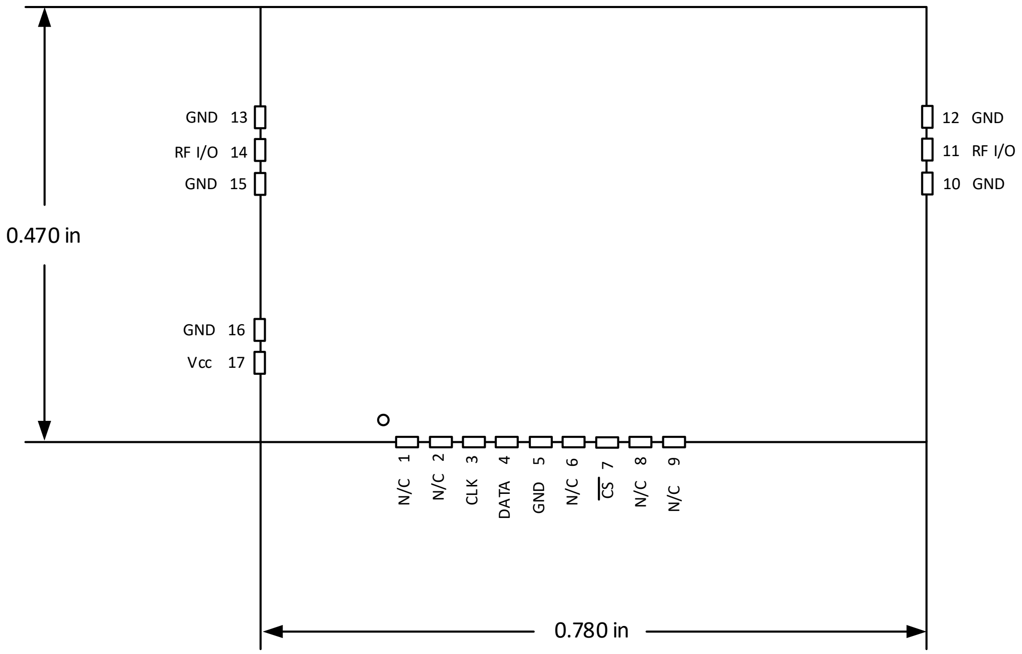


Figure 2. Pin Configuration

3.2 Pin Description

Table 2. Pin Functions and Descriptions

Pin Number	Label	Description
17	V_{CC}	Supply Voltage Input. 3.0 VDC Recommended.
5, 10, 12, 13, 15, 16	GND	GND
1, 2, 6, 8, 9	NC	No Connect. Shorting these pins may affect the performance and functionality of the filter. Please leave these pins floating.
11, 14	RF I/O	RF Signal Input or Output. Pin 14 is the input during factory alignment.
4	DATA	Serial data is applied for transferring tune commands to the device at the rising edge of CLK. The filter accepts input word lengths of 8 bits.
3	CLK	Serial data is latched on the rising edge of CLK.
7	$\overline{CS}/\overline{STB}$	SPI Chip Select. When $\overline{CS}/\overline{STB}$ is taken low, the control circuitry wakes up and CLK is enabled for shifting bits on DATA into the filter. When $\overline{CS}/\overline{STB}$ is taken high, the specified tune command is executed.

4.0 Specifications

4.1 Absolute Maximum Ratings[2]

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	3.3	V
V_I	Input voltage	On all digital interface input pins	-0.3	V_{CC}	V
P_{INBAND}	In-band RF input power level.	3% BW	-	+25	dBm
		5% BW		+30	
		7% BW		+32	
$P_{OUTBAND}$	Out-of-band RF input power level	-	-	+33	dBm
T_{RATE}	Maximum tune rate (frequency hopping)	-	-	20	kHz

4.2 Handling Ratings

Symbol	Parameter	Conditions	Min	Max	Unit
T_S	Storage temperature	-	-40	85	°C

4.3

4.4 Recommended Operating Conditions

Symbol	Parameter	Conditions	Min	Nom	Max	Unit
V_{CC}	Supply voltage	-	2.7	3.0	3.1	V
P_{IN}	Maximum RF input power for linear operation	3% BW	-	+23	-	dBm
		5% BW		+27		
		7% BW		+30		
T_A	Ambient operating temperature	-	-40	-	+85	°C

[2] Maximum operating conditions before damage occurs. Performance is not specified under these conditions.

4.5 Electrical Characteristics

All specifications at T_A = 23 °C, V_{cc} = 3.0 V, unless otherwise noted.

Symbol	Parameter	Conditions	Min	Nom	Max	Unit
V_{CC}	Supply voltage	-	+2.7	+3.0	+3.1	V
I_{CC_STATIC}	V_{CC} current consumption, statically tuned	At nominal V_{CC} voltage	-	5.0	30[3]	mA
I_{CC_HOP}	V_{CC} current consumption, hopping	Nominal V_{CC}, hopping at rate	-	7.0	32	mA
V_{IH}	Digital high level input voltage	On all digital interface input pins	0.7 * Vcc	-	3.1	V
V_{IL}	Digital low level input voltage	On all digital interface output pins	0	-	0.3 * Vcc	V
I_{IH}/I_{IL}	Digital Interface pin input logic current	-	-15	-	15	uA
F_{RANGE}	Tunable frequency range (Multiple Bands)	-	225	-	3000	MHz
Z_O	Input/output impedance	-	-	50	-	Ω
$SEL_{ULTIMATE}$	Ultimate selectivity	$f_0 + 50\% \; to \; 2 f_0$	-	30	-	dBc
$P_{Spurious}$	Spurious Level	15 dB Noise Source Reference	-	-120	-	dBm
PN	Phase Noise	Residual @ $f_0 + 10 \; kHz$	-	-145	-	dBc/Hz
T_{TUNE}	Tune time	-	-	10	20	µs
F_{DRIFT}	Center frequency drift over temperature	-40°C to +85°C	-	-60	-	ppm/°C

[3] Vcc current increases with increasing temperature. Typically 18 mA when tuned, 30 mA upon start-up at +85°C.

4.6 Selection Guide

Band	3 dB BW Part Number Suffix	3 dB %BW	Insertion Loss (IL) (dB)		Return Loss (dB)		Selectivity (f_0 ± 10%) (dB)		IIP3 (dBm)	NOISE FIGURE (dB)
-	-	Typ	Nom	Max	Nom	Min	Nom	Min	Nom	Nom
225-520	5	4.5	6.5	9.0	14	8.5	18	14	+42	IL + 4
	7									
400-700	5	5.2	5.7	8.0	15	8.5	18	14	+42	IL + 4
	7	7.2	4.2	6.5	15	8.5	15	12	+42	IL + 4
700-1000	5	5.2	5.5	8.0	18	8.5	18	14	+42	IL + 4
	7	7.1	4.0	6.5	18	8.5	14	10	+42	IL + 4
1000-1500	5	4.4	6.5	9.0	14	8.5	20	18	+42	IL + 4
	7									
1200-1400	3	3.5	7.5	10.0	14	8.5	24	20	+40	IL + 4
1500-2000	5	5.1	5.2	8.0	14	8.5	20	18	+42	IL + 4
	7	7.0	3.2	5.0	14	8.5	15	12	+42	IL + 4
2000-2500	5	5.0	5.0	8.0	14	8.5	20	18	+42	IL + 3
	7									
2500-3000	5	4.8	5.1	6.5	14	8.5	20	18	+42	IL + 2
	7									

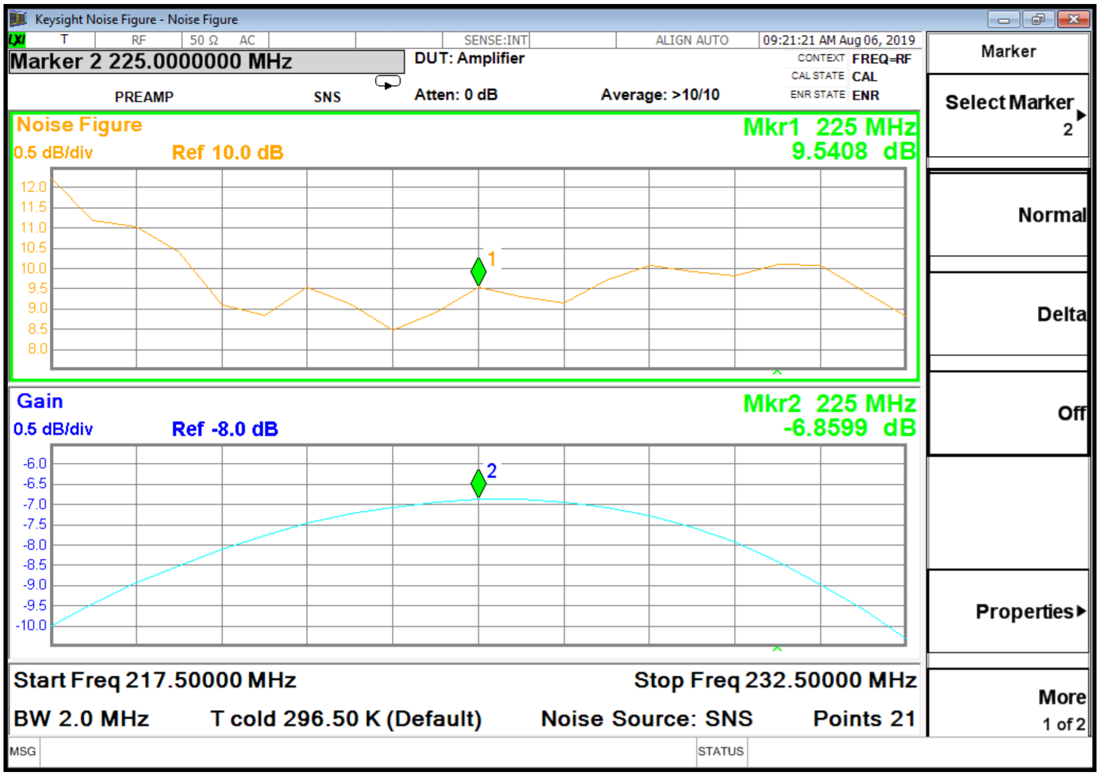


Figure 3. 225 MHz Noise Figure @ +23°C.

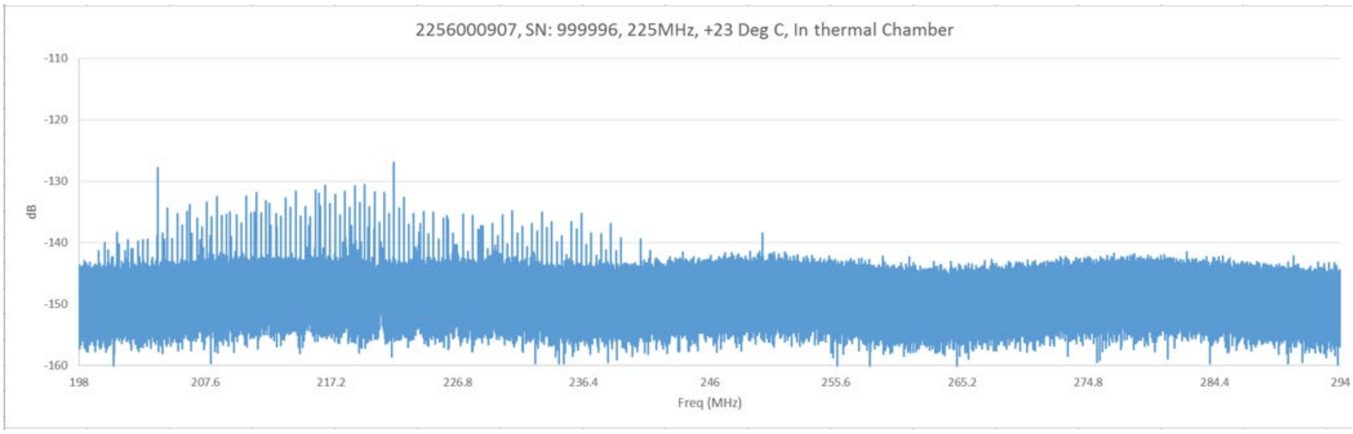


Figure 4. 225 MHz Spurious @ +23°C.

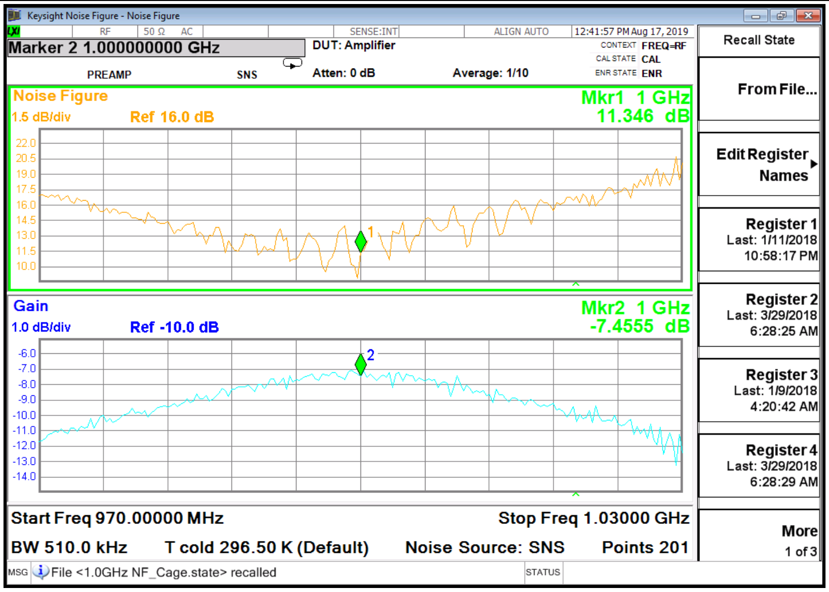


Figure 5. Typical Noise Figure Performance: NN-1000-1500-5-S17, Fc = 1000 MHz, +23°C.

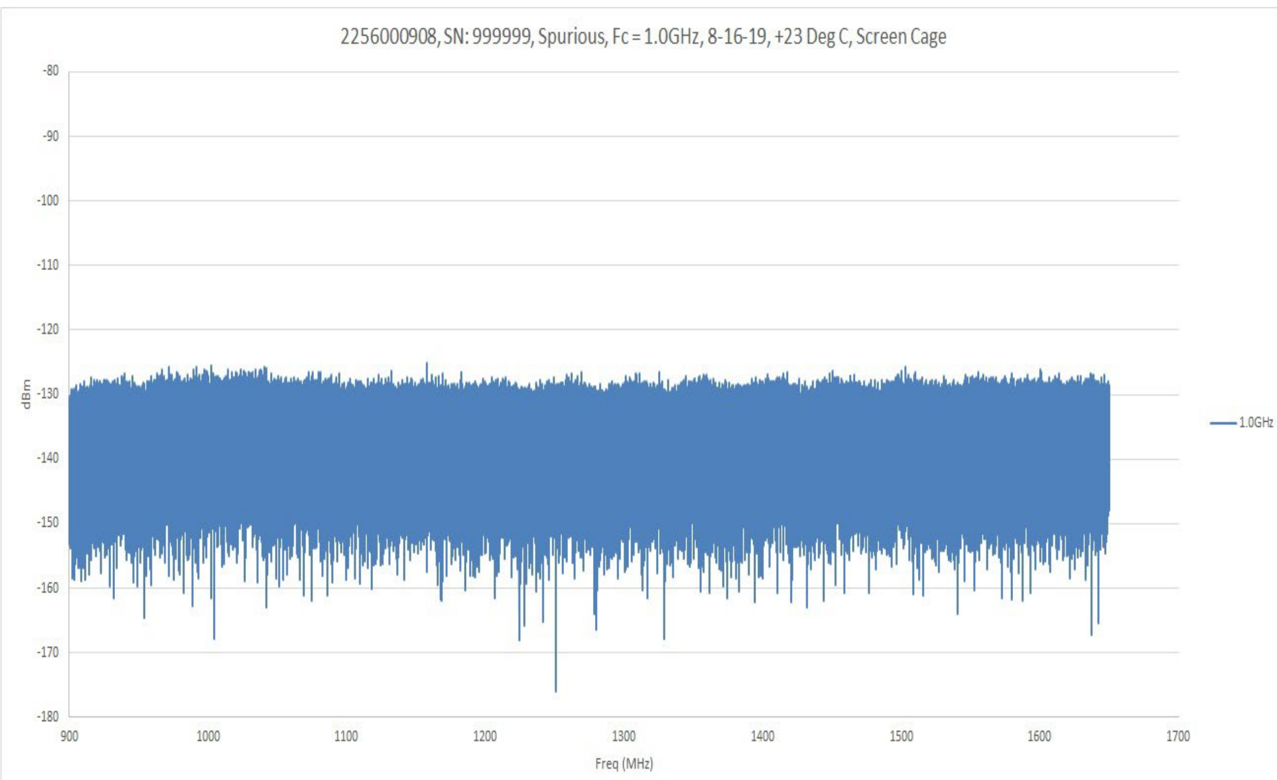


Figure 6. Typical Spurious Performance: NN-1000-1500-5-S17, Fc = 1000 MHz.

Typical Characteristics

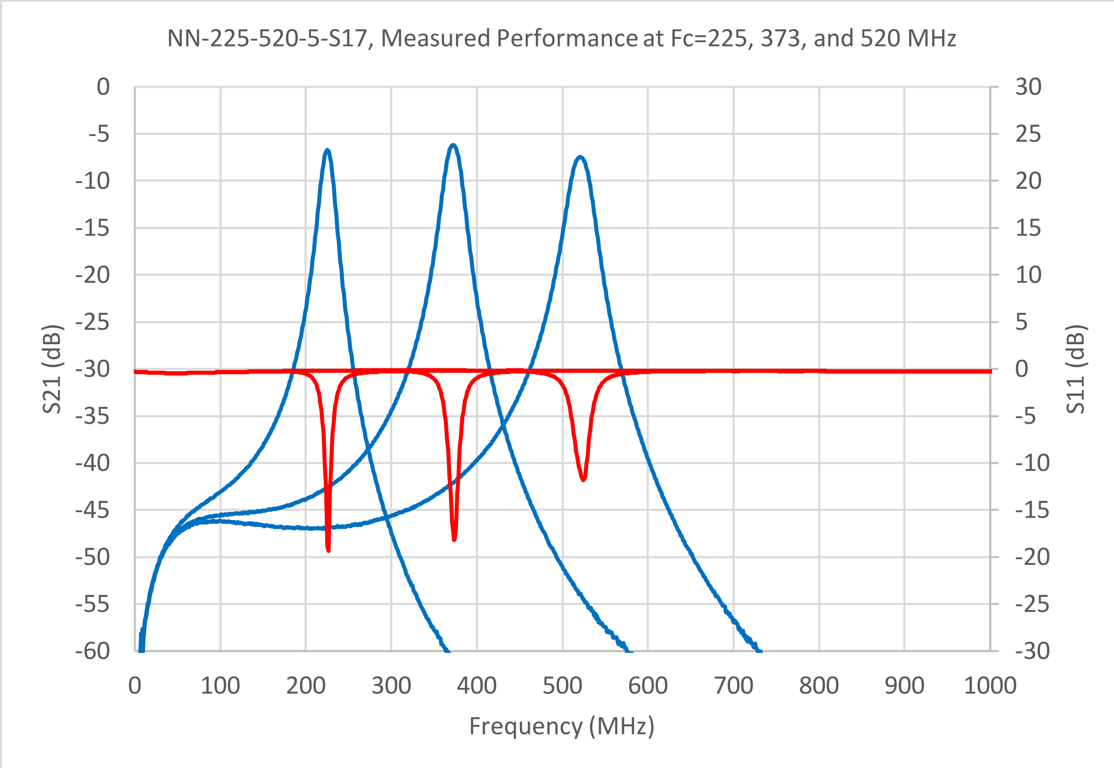


Figure 7. 5% BW, Small Signal, NN-225-520-5-S17 Measured Data. Single Filter.

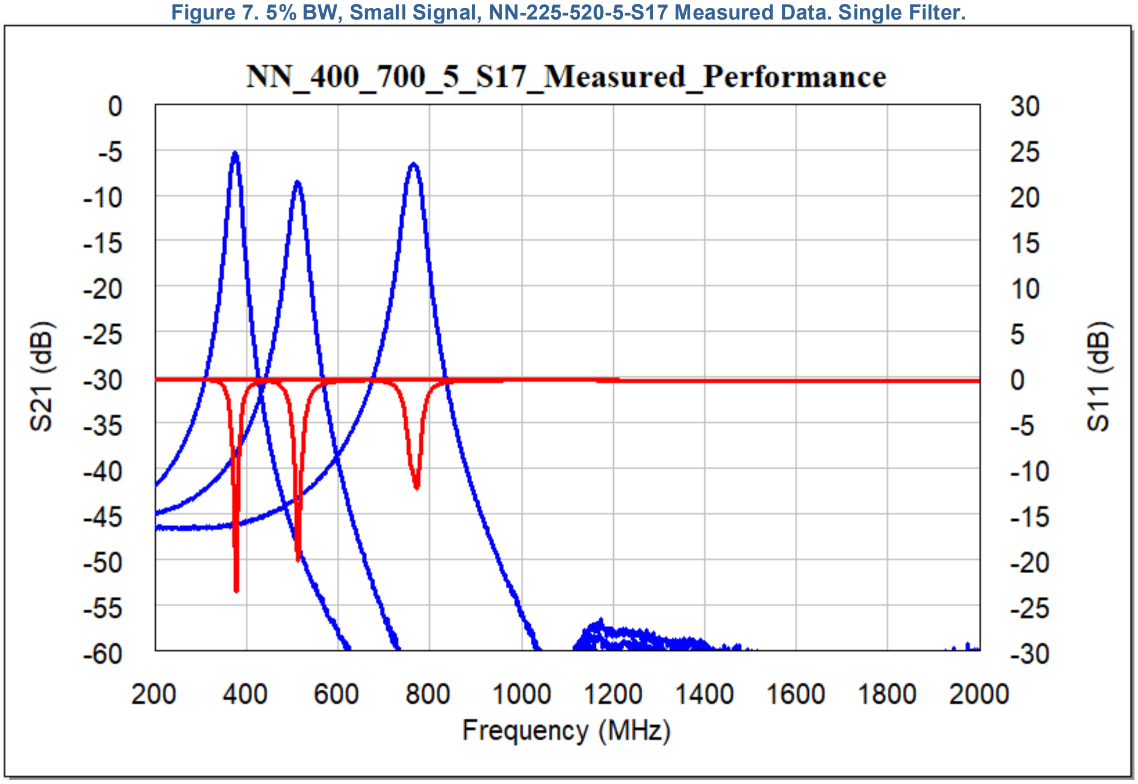


Figure 8. 5% BW, Small Signal, NN-400-700-5-S17 Measured Data. Single Filter.

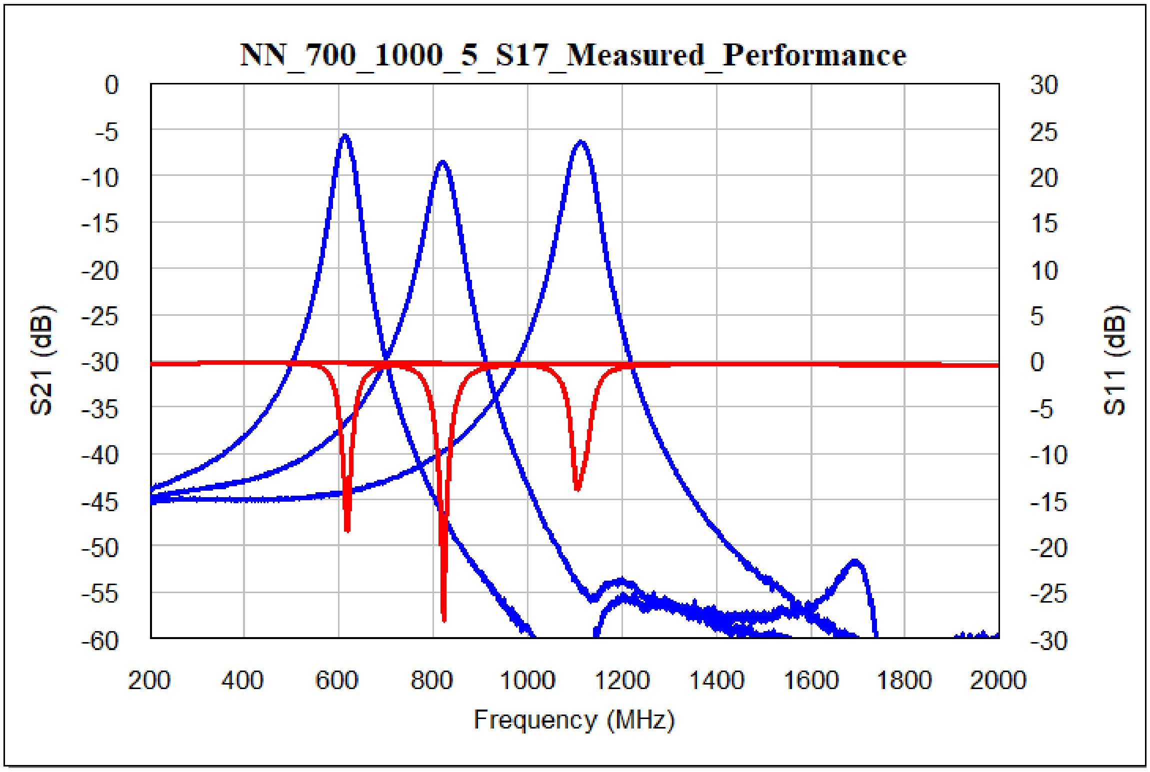


Figure 9. 5% BW, Small Signal, NN-700-1000-5-S17 Measured Data. Single Filter.

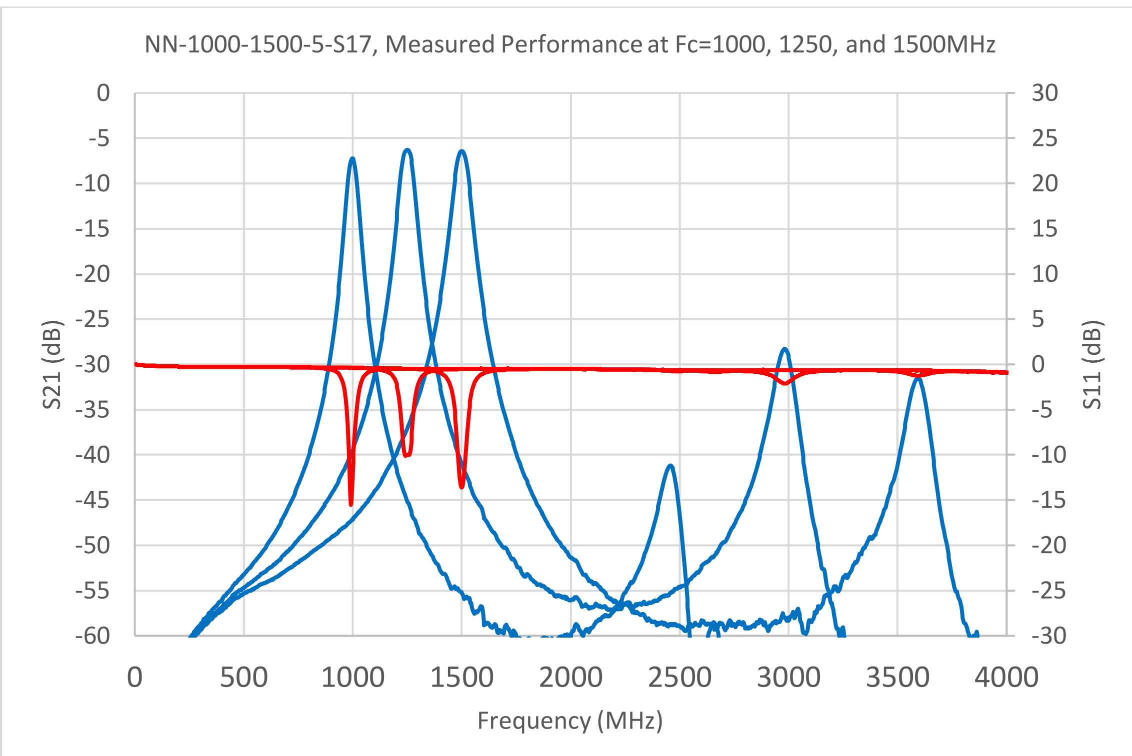


Figure 10. 5% BW, Small Signal, NN-1000-1500-5-S17 Measured Data. Single Filter.

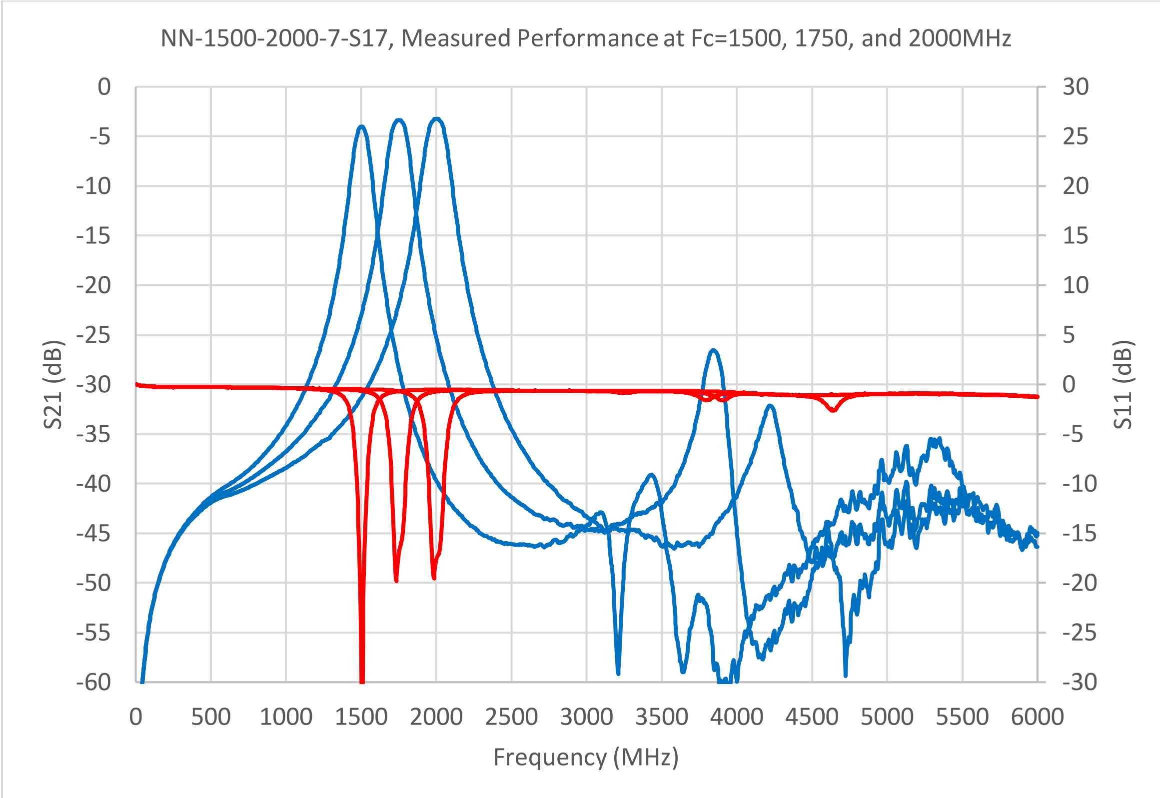


Figure 11. 7% BW, Small Signal, NN-1500-2000-7-S17 Measured Data. Single Filter.

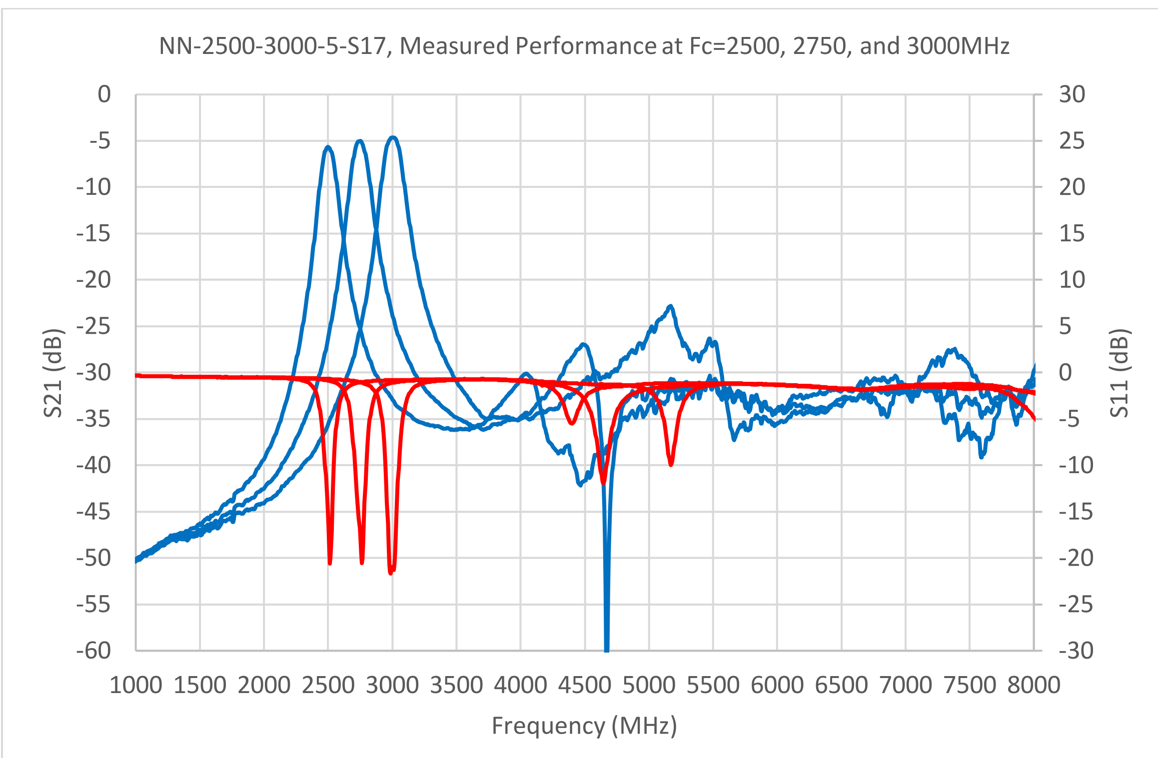


Figure 12. 5% BW, Small Signal, NN-2500-3000-5-S17 Measured Data. Single Filter.

4.7 Timing Requirements

4.7.1 SPI Interface Timing

The SPI tune command interface is a standard SPI interface with Mode = 0 (CPOL = 0, CPHA = 0). There are 8 data bits. The interface receives data MSB first. If a bit is not used in the tune position, leave it set to logic low, ‘0’.

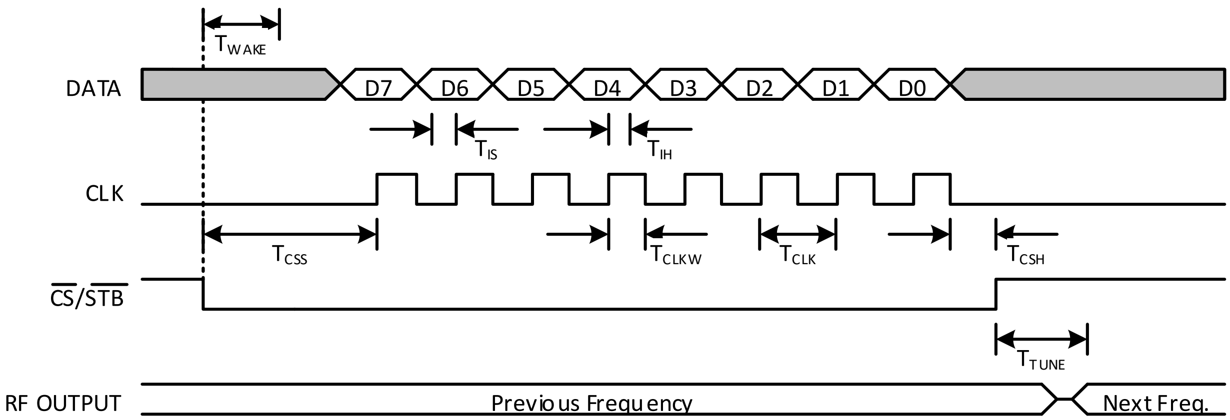


Figure 13. Serial Timing Diagram

Table 3. SPI Timing Characteristics

V_{CC} = 3.0 V +/-5%, GND = 0 V.

Parameter	Parameter	Min.	Max.	Unit
T_{WAKE}	Wakeup Time – The amount of time from $\overline{CS}/\overline{STB}$ transitioning low until data can be clocked.	-	6.5	µs
T_{CSS}	$\overline{CS}/\overline{STB}$ Setup Time – The amount of time needed from when $\overline{CS}/\overline{STB}$ transitions low until the first rising edge of CLK.	6.8	-	µs
T_{IS}	MOSI Setup CLK – The amount of time data needs to be valid on MOSI before the rising edge of CLK.	10	-	ns
T_{IH}	MOSI Hold CLK – The amount of time data needs to be valid on MOSI after the rising edge of CLK.	40	-	ns
T_{CLK}	CLK Period	143	-	ns
T_{SCW}	CLK Duty Cycle	$\frac{T_{CLK}}{2}$	-	ns
T_{CLKF}	CLK Fall Time (not shown)	-	1.6	µs
T_{CLKR}	CLK Rise Time (not shown)	-	1.6	µs
T_{CSH}	$\overline{CS}/\overline{STB}$ Hold Time – The amount of time $\overline{CS}/\overline{STB}$ needs to remain low after the last falling edge of CLK.	50	-	ns
T_{NEW}	New Command Delay (not shown) – The amount of time needed to wait before sending a new tune command (next falling edge of $\overline{CS}/\overline{STB}$).	50	-	µs
T_{TUNE}	Tune Time – Please refer to section on tune time.	-	15	µs

5.0 Functional Description

5.1 Tune Commands

The tune command is a one-byte load tune word.

Table 4. Tune Command Properties

Symbol	Filter Freq. Range	Value	Description
f_{MIN}	See Table 5 for specific values		Minimum Tunable Frequency. f_{MIN} is the absolute minimum frequency that the MINI-POLE is capable of tuning to for the respective band.
f_{MAX}			Maximum Tunable Frequency. f_{MAX} is the absolute maximum frequency that the filter is capable of tuning to.
f_{STEP}			Tune step size. f_{STEP} is the minimum spacing between adjacent tune commands.
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 command. If the next lowest tune command is desired, replace the round operation with floor and if the next highest tune command is desired replace the round operation with ceil.

Table 5. Tune Command Format

Filter Model			Tune Word Bit Weight (MHz)							
Part Series	f_{MIN} (MHz)	f_{MAX} (MHz)	(MSB) 7	6	5	4	3	2	1	(LSB) 0
225-520	225	520	0	256	128	64	32	16	8	4
400-700	400	700	0	256	128	64	32	16	8	4
700-1000	700	1000	0	256	128	64	32	16	8	4
1000-1500	1000	1500	0	0	320	160	80	40	20	10
1500-2000	1500	2000	0	0	320	160	80	40	20	10
2000-2500	2000	2500	0	0	320	160	80	40	20	10
2500-3000	2500	3000	0	0	320	160	80	40	20	10

6.0 Detailed Description

6.1 Example Tune Commands

Table 6. Example Tune Commands

$f_{DESIRED}$ (MHz)	f_{MIN} of Filter (MHz)	f_{STEP} of Filter (MHz)	f_{COM} Calculation (Decimal)	f_{COM} (Decimal)	Tune Command (Hex)
NN-225-520-X-S17 Examples					
225	225	4.0	$round\left(\frac{(225 - 225)}{4}\right)$	0	00
316.2	225	4.0	$round\left(\frac{(316.2 - 225)}{4}\right)$	23	17
520	225	4.0	$round\left(\frac{(520 - 225)}{4}\right)$	74	4A
NN-400-700-X-S17 Examples					
400	400	4.0	$round\left(\frac{(400 - 400)}{4}\right)$	0	00
552	400	4.0	$round\left(\frac{(552 - 400)}{4}\right)$	38	26
700	400	4.0	$round\left(\frac{(700 - 400)}{4}\right)$	75	4B
NN-700-1000-X-S17 Examples					
700	700	4.0	$round\left(\frac{(700 - 700)}{4}\right)$	0	00
848	700	4.0	$round\left(\frac{(848 - 700)}{4}\right)$	37	26
1000	700	4.0	$round\left(\frac{(1000 - 700)}{4}\right)$	75	4B
NN-1000-1500-X-S17 Examples					
1000	1000	10	$round\left(\frac{(1000 - 1000)}{10}\right)$	0	00
1260	1000	10	$round\left(\frac{(1260 - 1000)}{10}\right)$	26	1A
1500	1000	10	$round\left(\frac{(1500 - 1000)}{10}\right)$	50	32
NN-1500-2000-X-S17 Examples					
1500	1500	10	$round\left(\frac{(1500 - 1500)}{10}\right)$	0	00
1828	1500	10	$round\left(\frac{(1828 - 1500)}{10}\right)$	33	21
2000	1500	10	$round\left(\frac{(2000 - 1500)}{10}\right)$	50	32

7.0 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 0 dBm is considered to be “hot switching” of the filter. Tuning operation of the filter into levels greater than 0 dBm cannot be done reliably. It is recommended that RF input power is less than 0 dBm during a tune event.

8.0 Application Information

8.1 Application Circuits

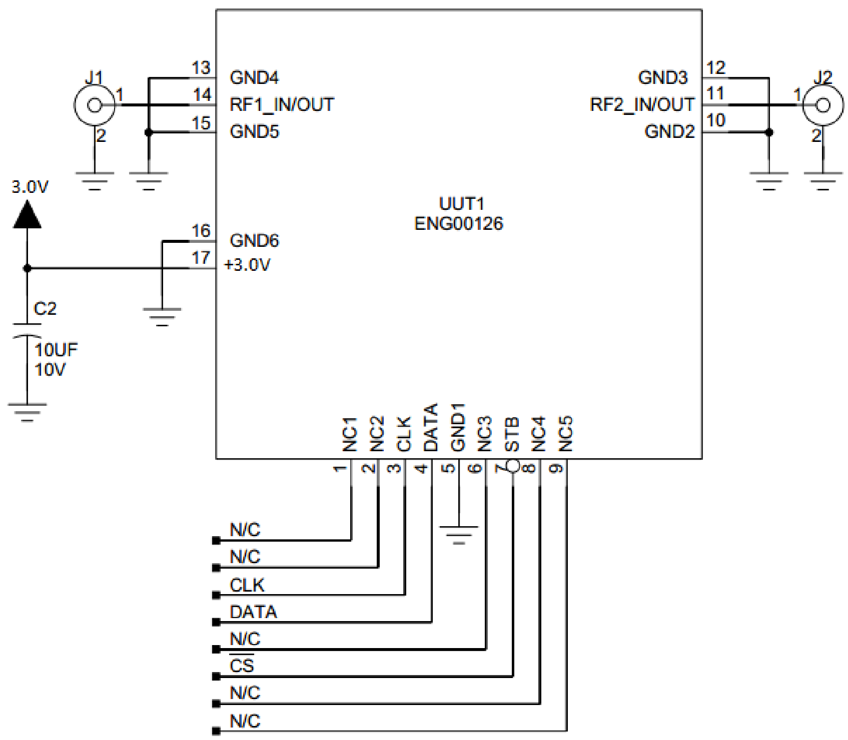


Figure 14. Serial Application Circuit

9.0 Package Information

9.1 Package Detail

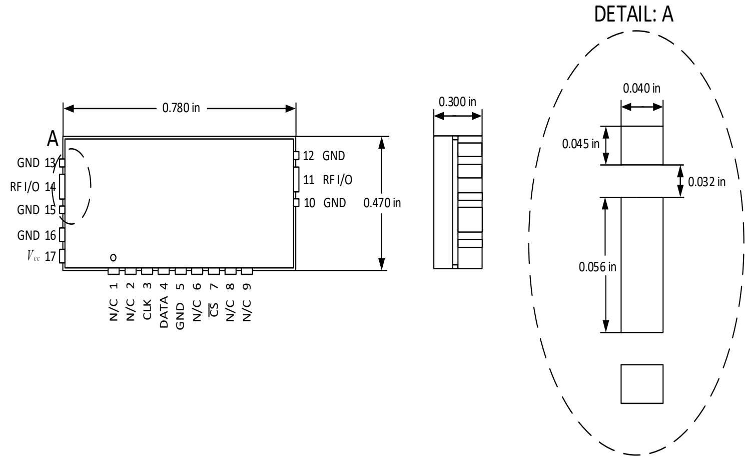


Figure 15. Package Detail

9.2 Recommended Pad Layout

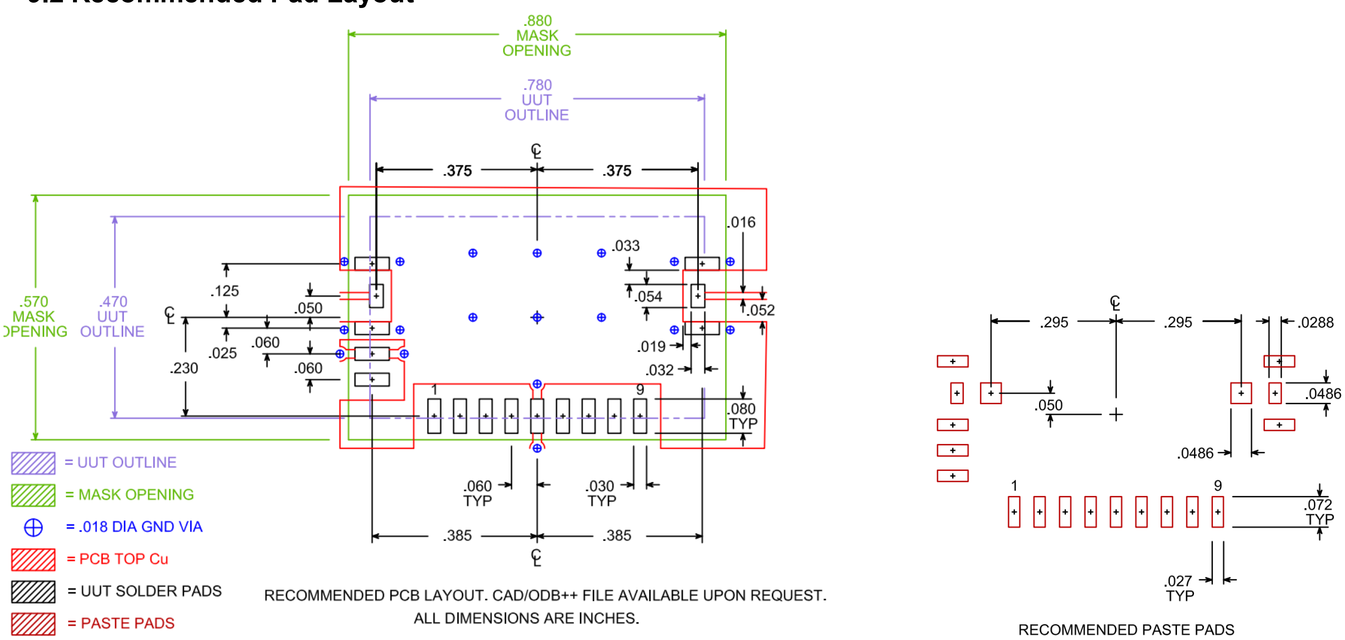


Figure 16. Recommended Test PCB Layout. CAD/ODB++ file available upon request.

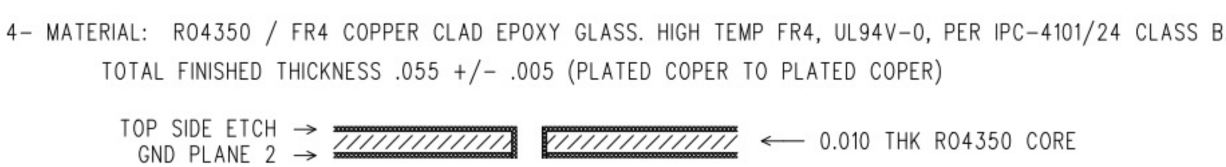


Figure 17. Recommended Test PCB Stack-up.

10.0 Mounting Instructions

10.1 Solder Reflow Profile

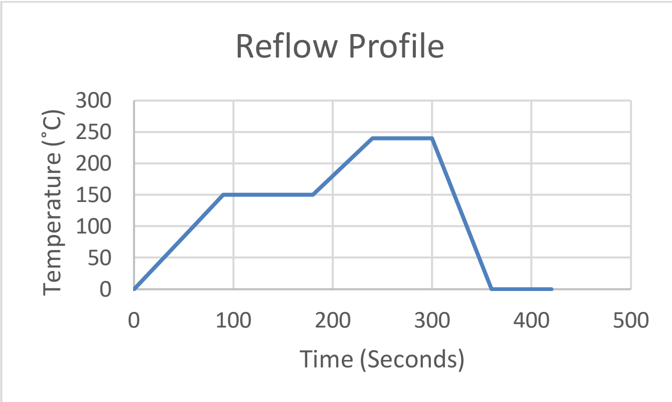


Figure 18. Recommended Solder Reflow Profile

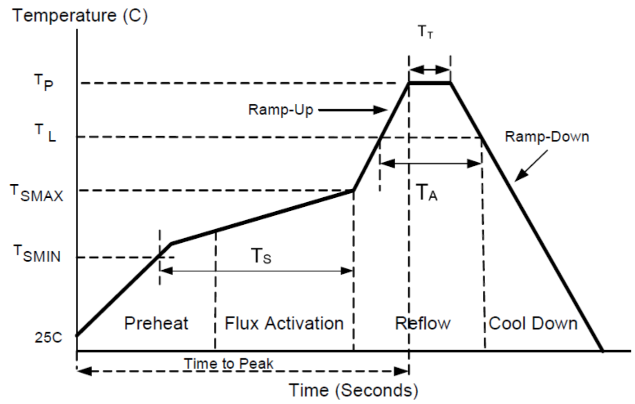


Figure 19. Reflow Profile Key

10.2 Temperature Options

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

10.3 Temperature Guidelines

10.3.1 Place the unit on the recommended layout pattern specified in this document in section 9.2. The parameters below describe the reflow profiles for ROHS-compliant and non-ROHS-compliant 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

11.0 Removal Instructions

11.1 Purpose:

This is only to offer recommendations to assist in the removal of the **NANO-POLE®.** Pole Zero is not responsible for any damage caused by the attempted removal of a unit from a PWB. It is the Customer's responsibility to decide what is the best process for removal and extensive thermal analysis is recommended. Proceed with extreme cation!

11.1.1 Tools Needed:

- Soldering iron with fine tip
- Flux: Tacky or liquid
- Low melting point solder (e.g. Indium 46Bi 34Sn 20Pb solder, Zephyrtronics low-melt De-solder wire or equivalent)
- 3-4 K-type thermocouple probes, meter and logging method
- Board warmer or BGA rework station

11.2 Removal Procedure:

11.2.1 Add flux to existing solder joints

11.2.2 Using soldering iron with pencil point tip, heat each individual solder joint until liquidus and generously feed in the low melt solder into the joint.

11.2.3 Repeat process for all 37 solder connections.

11.2.4 Add 3-4 thermocouples to close proximity of solder connections. Caution: Do not obstruct solder connections with thermocouple or Kapton tape.

11.2.5 Add additional flux to all solder connections.

11.2.6 Install onto board warmer or BGA Rework station.

11.2.7 Heat from the bottom side of board slowly (2.5°C/sec or less) initially set to 170°C.

11.2.8 If heat is also applied from the top side, ensure it is controlled and only applied to solder ball pins of unit and it is not applied to units shield.

11.2.9 Observe temperature rise as flux starts to activate.

11.2.10 Begin to go around board feeding more low temperature solder into the joints. This will continue to drop the liquidus point of the alloy mixture. Note: Process times and temperatures will vary.

11.2.11 Begin gently pulling upward as the solder joints liquefy.

11.2.12 Continue to gently pull upward until the unit pulls loose from the PWB.

11.2.13 Clean/Remove excess solder and allow PWB to cool down.

11.2.14 Record all process parameters and save for future removals.

11.3 Other Restrictions

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

11.3.2 Do not clean the product after reflow process.

11.3.3 Only subject the unit to one SMT reflow process.

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

12.0 Safety Notes

12.1 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 MSL 1 component and should be packaged and handled according to the guidelines in J-STD-033.

13.0 Legal Information

13.1 Disclaimers

Limited warranty and liability – Information in this document is believed to be accurate and reliable. Pole/Zero and its suppliers disclaim all warranties, whether express or implied, including implied warranties of merchantability, fitness for a particular purpose, and non-infringement. The entire risk arising out of use or performance of this information remains with Licensee. Pole/Zero and its suppliers do not make any representations regarding the results of the use of the information in this document.

To the maximum extent permitted by applicable law, in no event will Pole/Zero or its directors, employees, distributors, licensors, suppliers, agents or resellers or suppliers (“Pole/Zero parties”) be liable for any indirect, special, incidental, consequential, or exemplary damages, even if such party has been advised of the possibility thereof. The Pole/Zero parties’ entire liability will not exceed the sum of the replacement of defective product or provision of a reasonably similar product, at Pole/Zero’s discretion. Some jurisdictions do not allow the exclusion or limitation of incidental, consequential or special damages, so this exclusion and limitation may not be applicable to Licensee. The Pole/Zero Parties will not be liable for any claims or damages arising out of content provided by Licensee.

13.2 Right to Make Changes

Pole/Zero Corporation reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

14.0 Learn More

For additional information, please visit http://www.dovermpg.com/polezero

15.0 Contact and Support

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