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 4.4 and 0.

1.0 Ordering Information

Table 1. Example Ordering Options

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

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

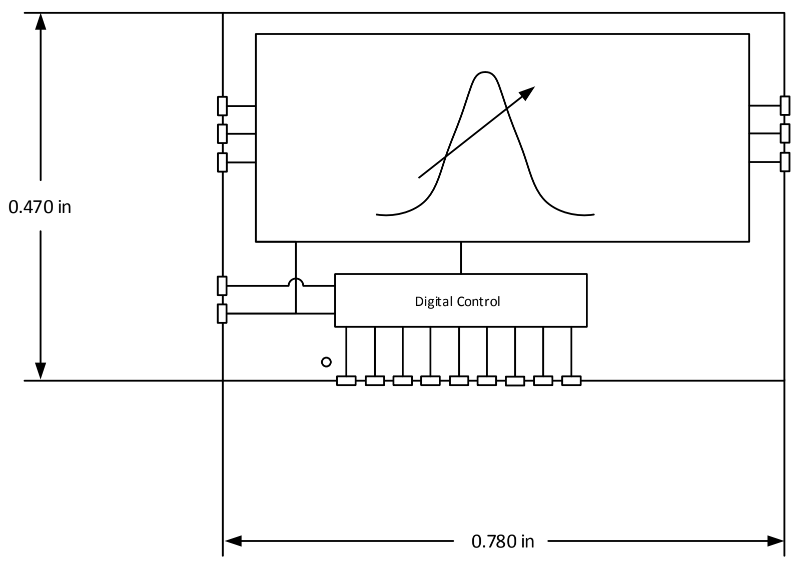

Figure 1. Technical Block Diagram

3.0 Pinout and Functional Information

3.1 Pinout

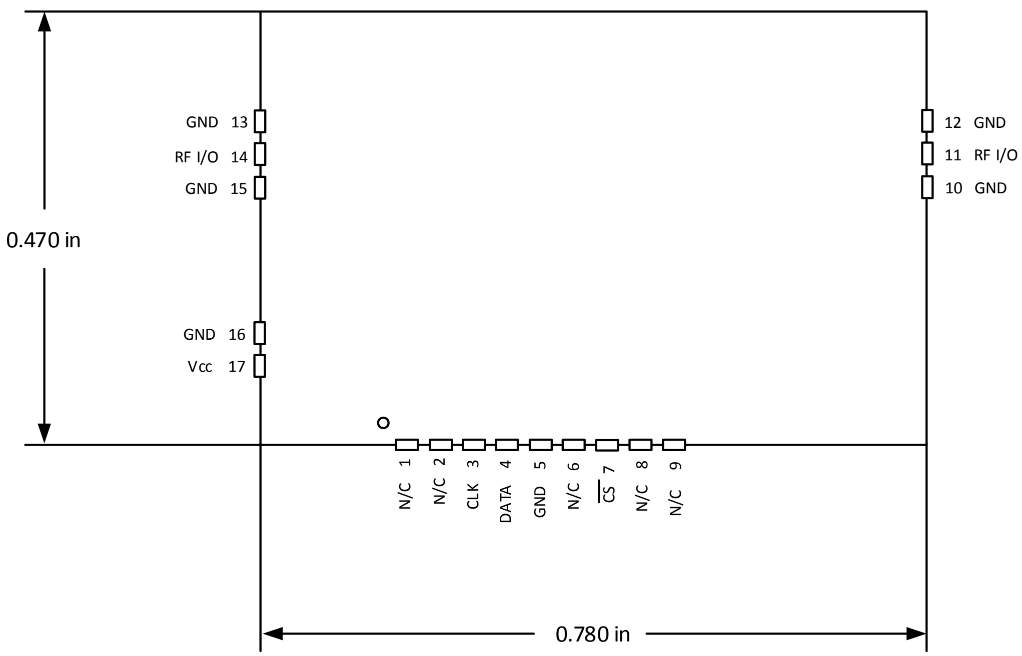

Figure 2. Pin Configuration

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 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.

4.4 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
VSWR	Voltage Standing Wave Ratio	-		-	1.5:1	2.2:1	-
RL	Return loss	At 50 Ω		8.5	14	-	dB
IL	Insertion Loss	5% BW	225 – 520 MHz		6.5	9.0	dB
			1.0 – 1.5 GHz		5.5	9.0	
			1.5 – 2.0 GHz		5.2	8.0	
			2.0 – 2.5 GHz		5.2	8.0	
			2.5 – 3.0 GHz		5.0	6.5	
		7% BW	1.5 – 2.0 GHz		3.2	5.0	
		3% BW	1.2 – 1.4 GHz		8.0	10.0	
BW	Bandwidth (3 dB)	-		3	-	12	%
$SEL_{10\%}$	Selectivity 10% removed from the center frequency	3% BW		-	24	-	dBc
		5% BW	225 – 520 MHz	14	18		
			1.0 – 3.0 GHz	18	20		
		7% BW		12	15		
$SEL_{ULTIMATE}$	Ultimate selectivity	$f_0 + 50\%\ to\ 2\,f_0$		-	30	-	dBc
IIP3	Input third order intermodulation intercept point	-		-	+42	-	dBm
$P_{Spurious}$	Spurious Level	15 dB Noise Source Reference		-	-120	-	dBm
NF	Noise figure	225 - 520 MHz		-	IL+4	-	dB
		1.0-1.5 GHz			IL+4		
		1.5-2.0 GHz			IL+4		
		2.0 – 2.5 GHz			IL+3		
		2.5 – 3.0 GHz			IL+2		
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.

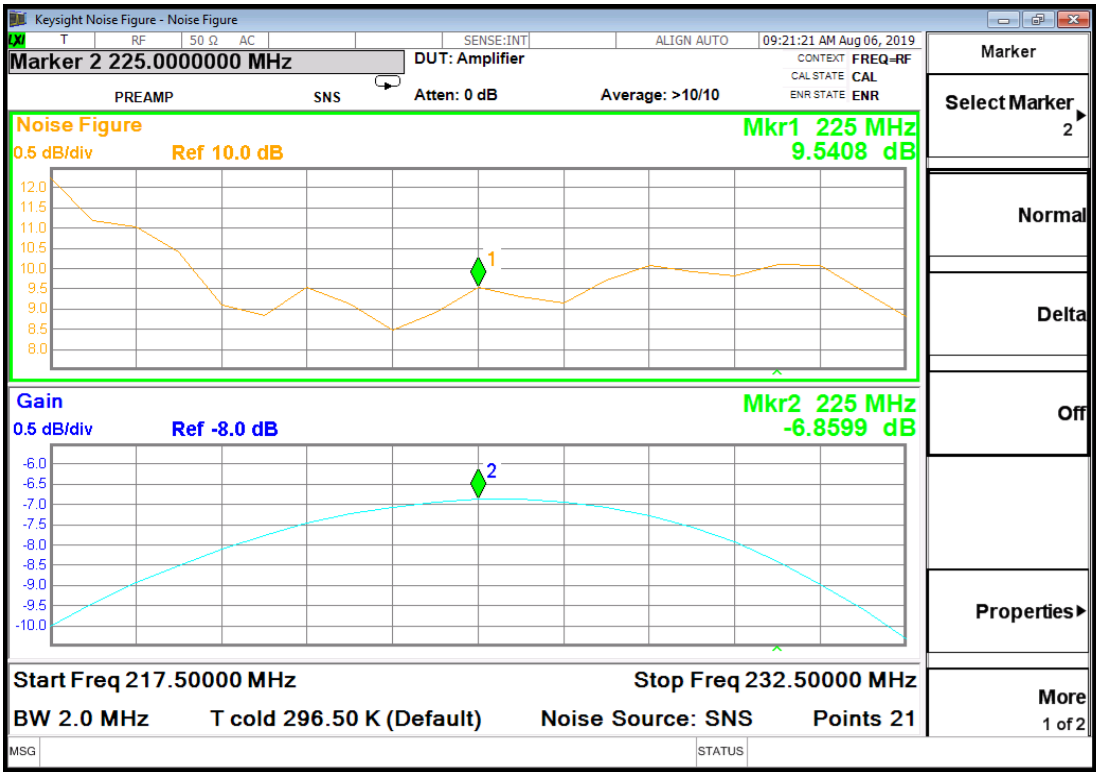

Figure 3. 225 MHz Noise Figure @ +23°C.

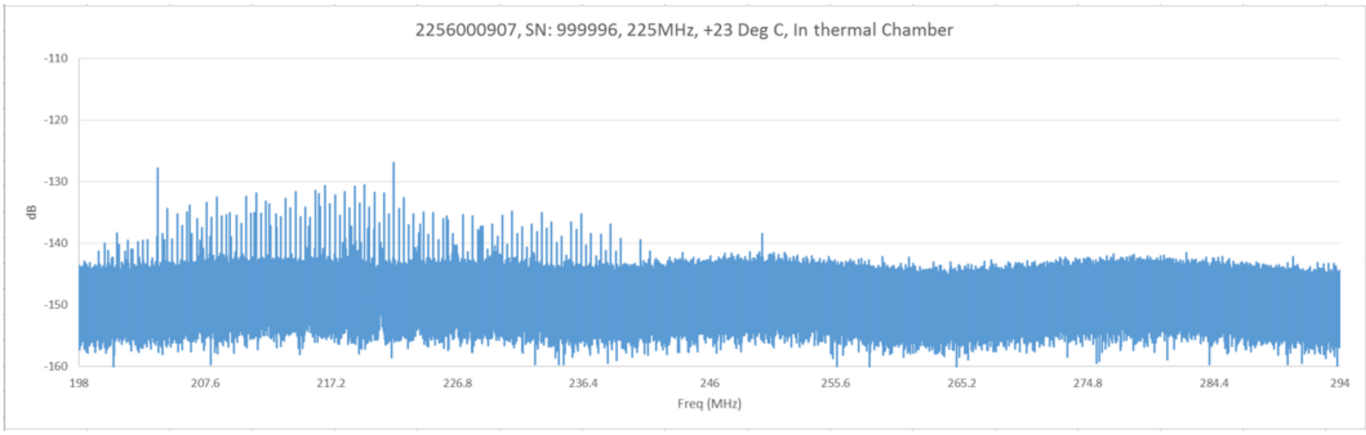

Figure 4. 225 MHz Spurious @ +23°C.

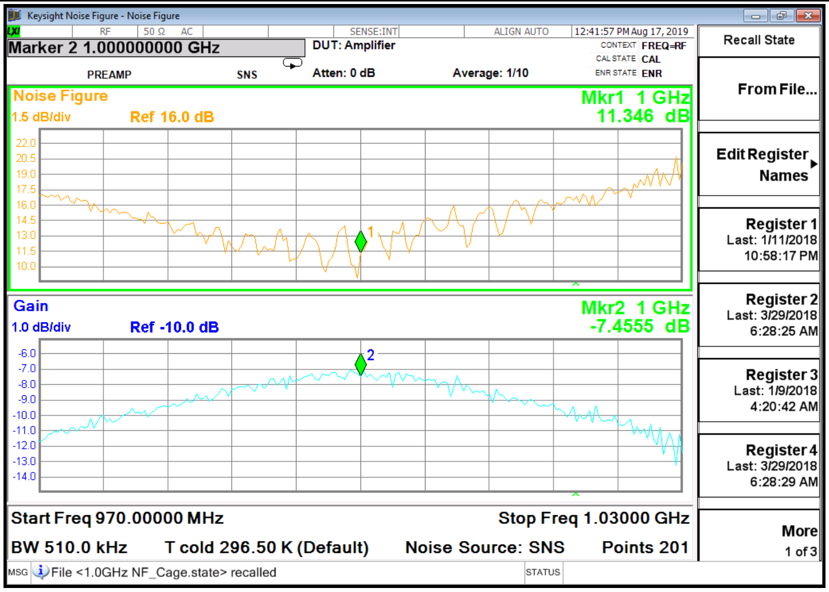

Figure 5. Typical Noise Figure Performance: NN-1000-1500-5-S17, Fc = 1000 MHz, +23°C.

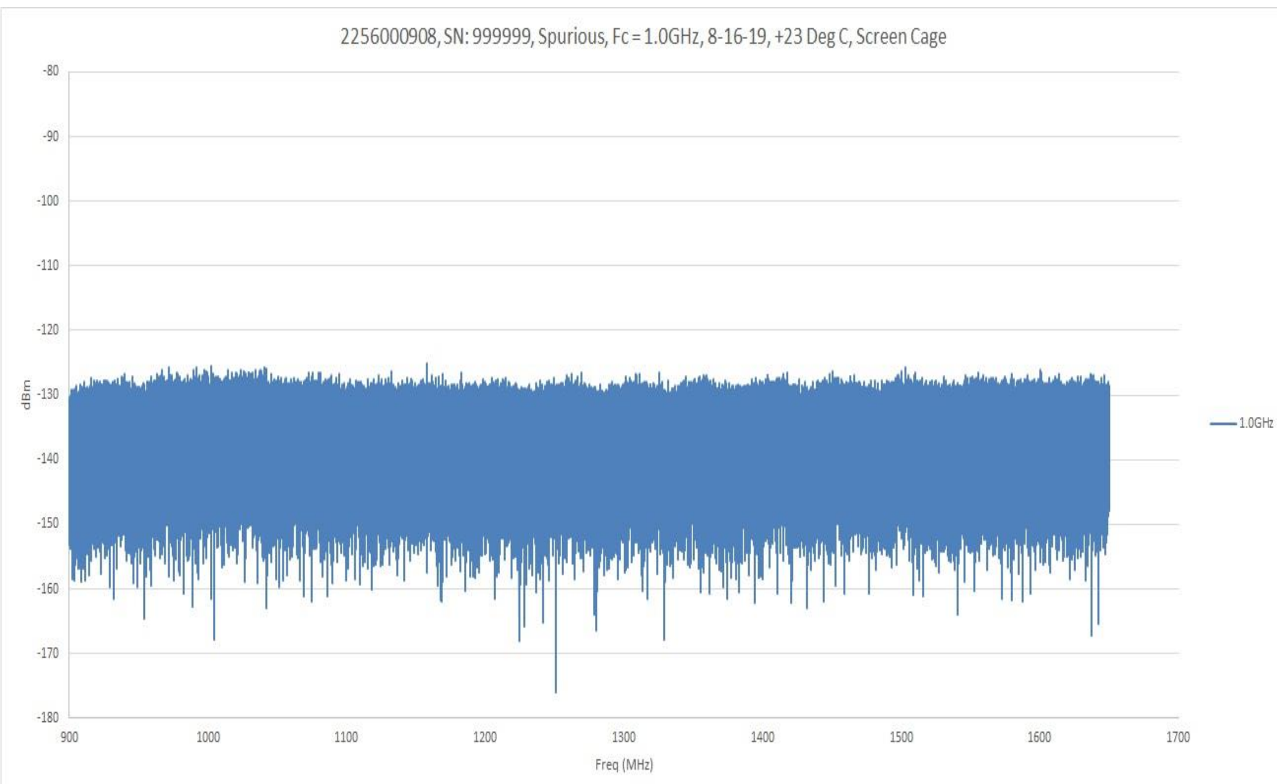

Figure 6. Typical Spurious Performance: NN-1000-1500-5-S17, Fc = 1000 MHz.

Typical Characteristics

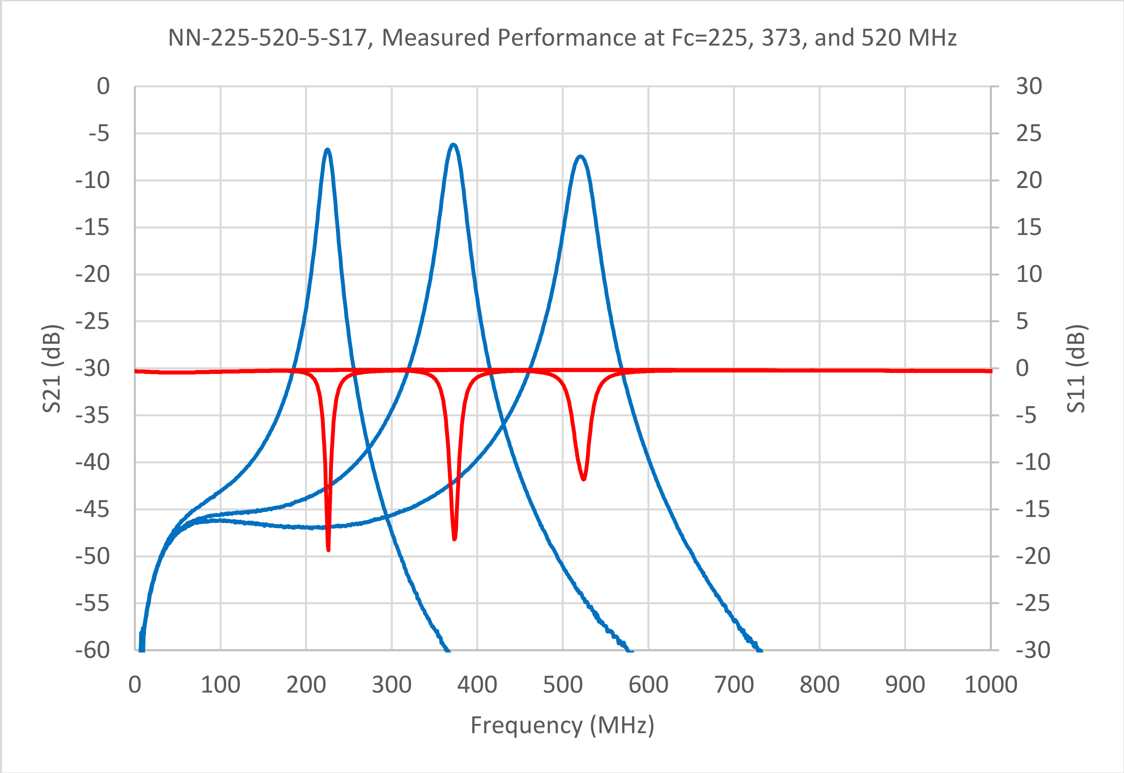

Figure 7. 5% BW, Small Signal, NN-225-520-5-S17 Measured Data. Single Filter.

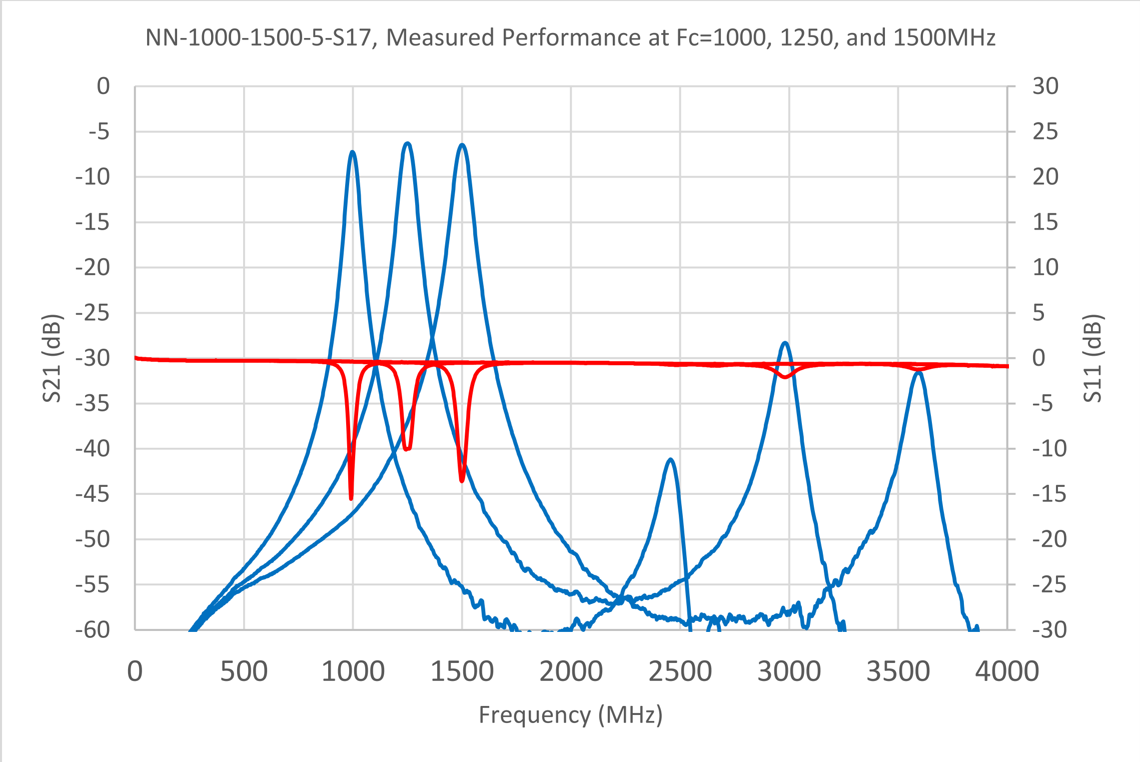

Figure 8. 5% BW, Small Signal, NN-1000-1500-5-S17 Measured Data. Single Filter.

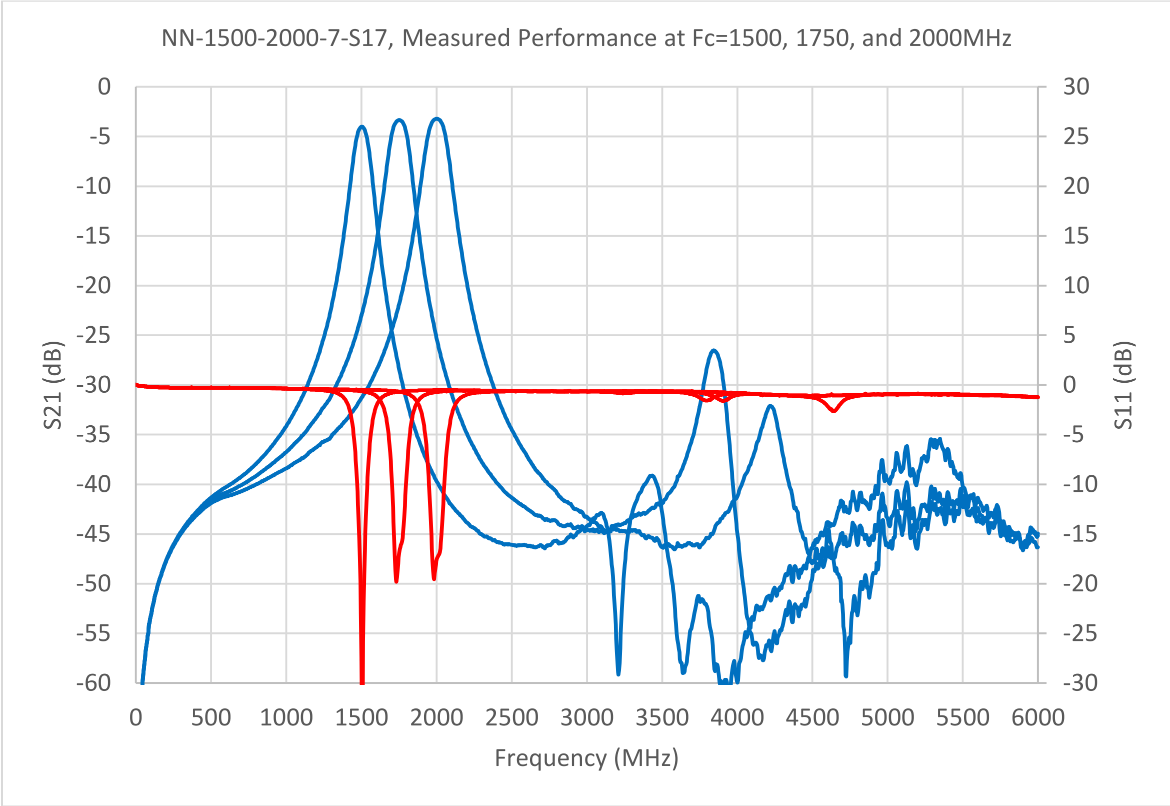

Figure 9. 7% BW, Small Signal, NN-1500-2000-7-S17 Measured Data. Single Filter.

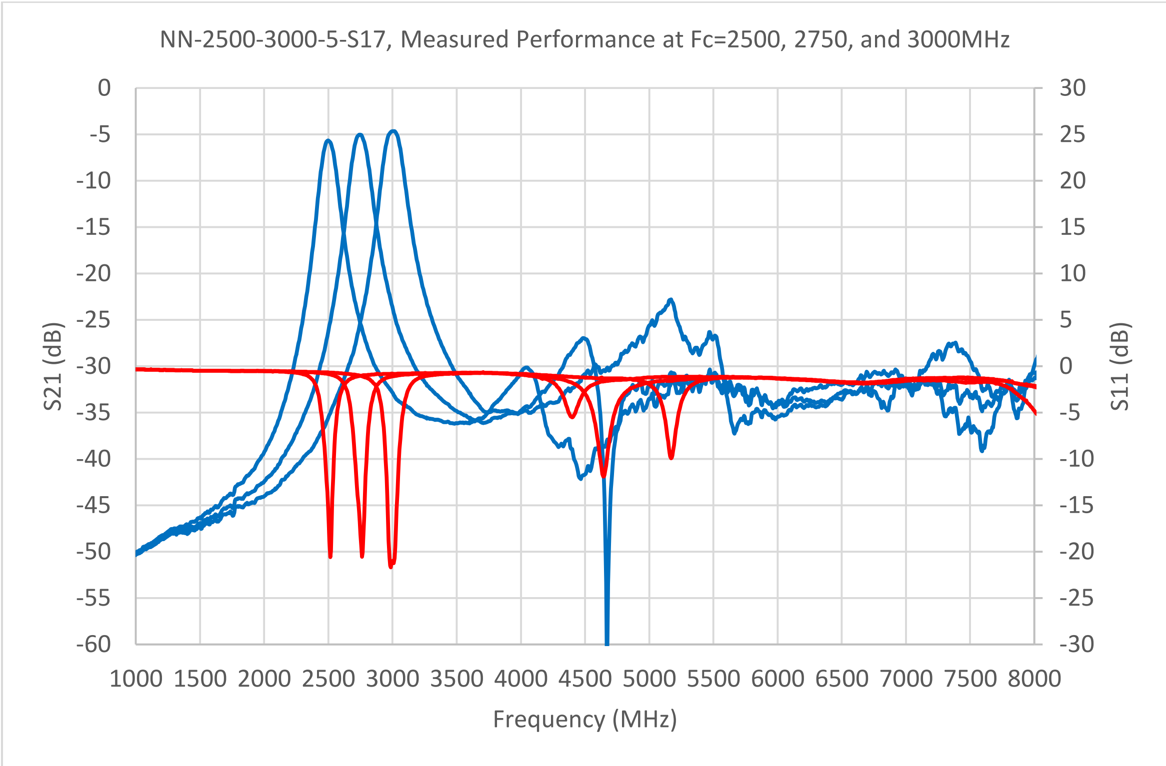

Figure 10. 5% BW, Small Signal, NN-2500-3000-5-S17 Measured Data. Single Filter.

4.5 Timing Requirements

4.5.1 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’.

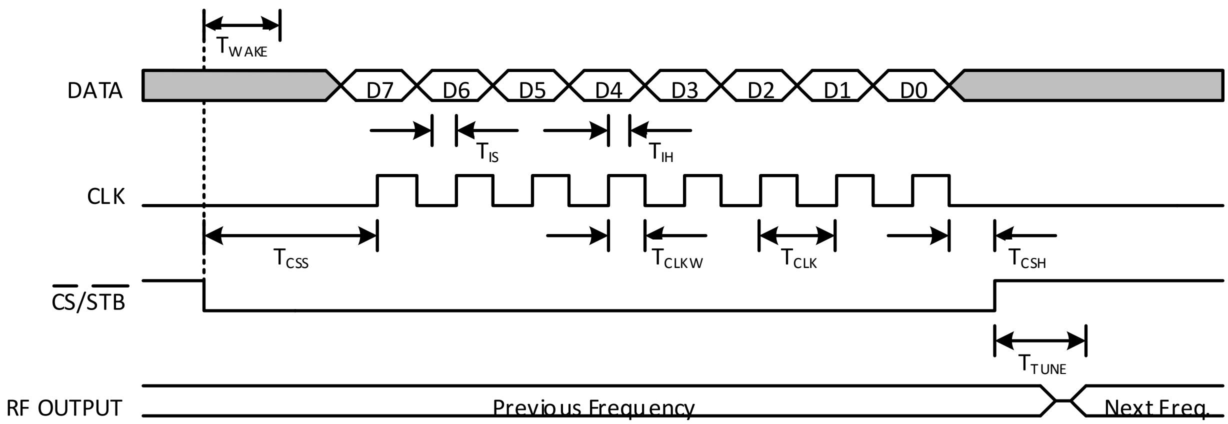

Figure 11. Serial Timing Diagram

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 Range	Value (MHz)	Description
f_{MIN}	-	-	Minimum Tunable Frequency. f_{MIN} is the absolute minimum frequency that the filter is capable of tuning to for the respective band.
	-	-	
	225-520	225	
	1000-1500	1000	
	1500-2000	1500	
	2000-2500	2000	
	2500-3000	2500	
f_{MAX}	-	-	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.
	-	-	
	225-520	520	
	1000-1500	1500	
	1500-2000	2000	
	2000-2500	2500	
	2500-3000	3000	
f_{STEP}	-	-	Tune step size. f_{STEP} is the minimum spacing between adjacent tune commands.
	-	-	
	225-520	4.0	
	1000-1500	10.0	
	1500-2000	10.0	
	2000-2500	10.0	
	2500-3000	10.0	
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 or parallel 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 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	4.0
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-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

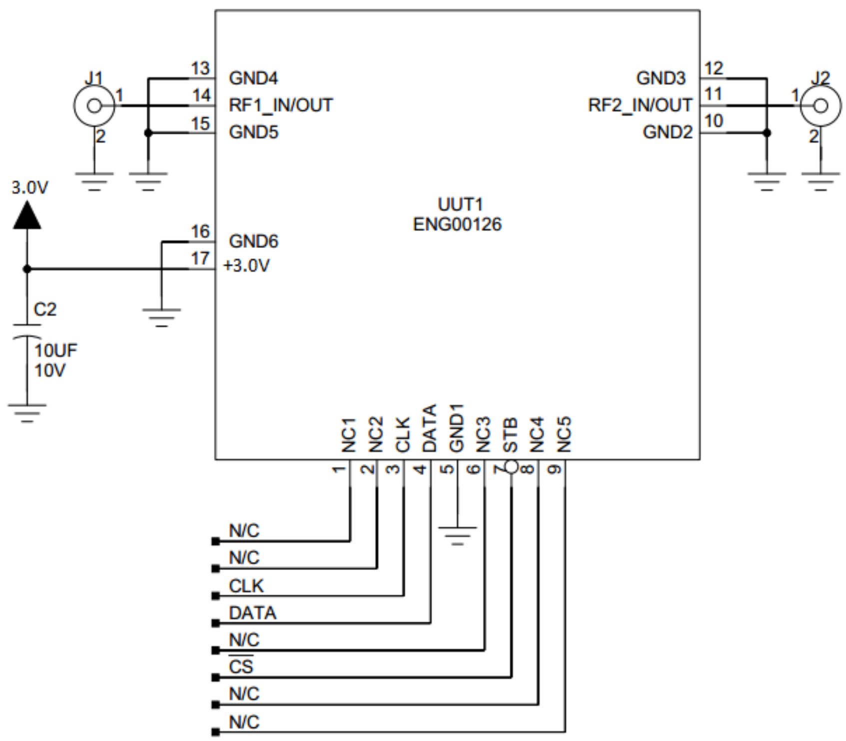

Figure 12. Serial Application Circuit

9.0 Package Information

9.1 Package Detail

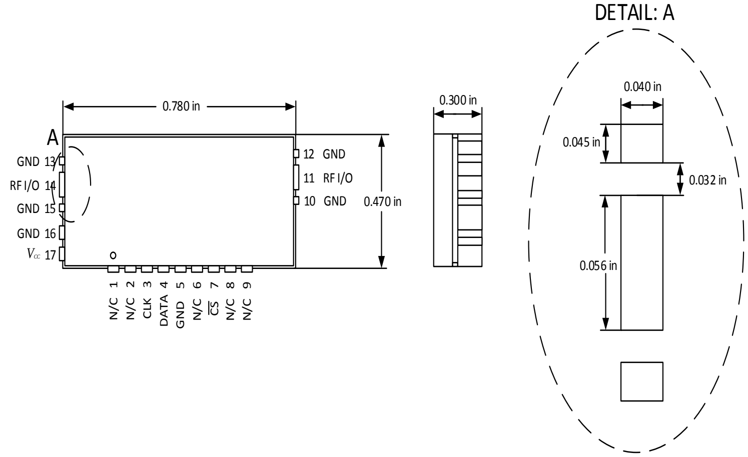

Figure 13. Package Detail

9.2 Recommended Pad Layout

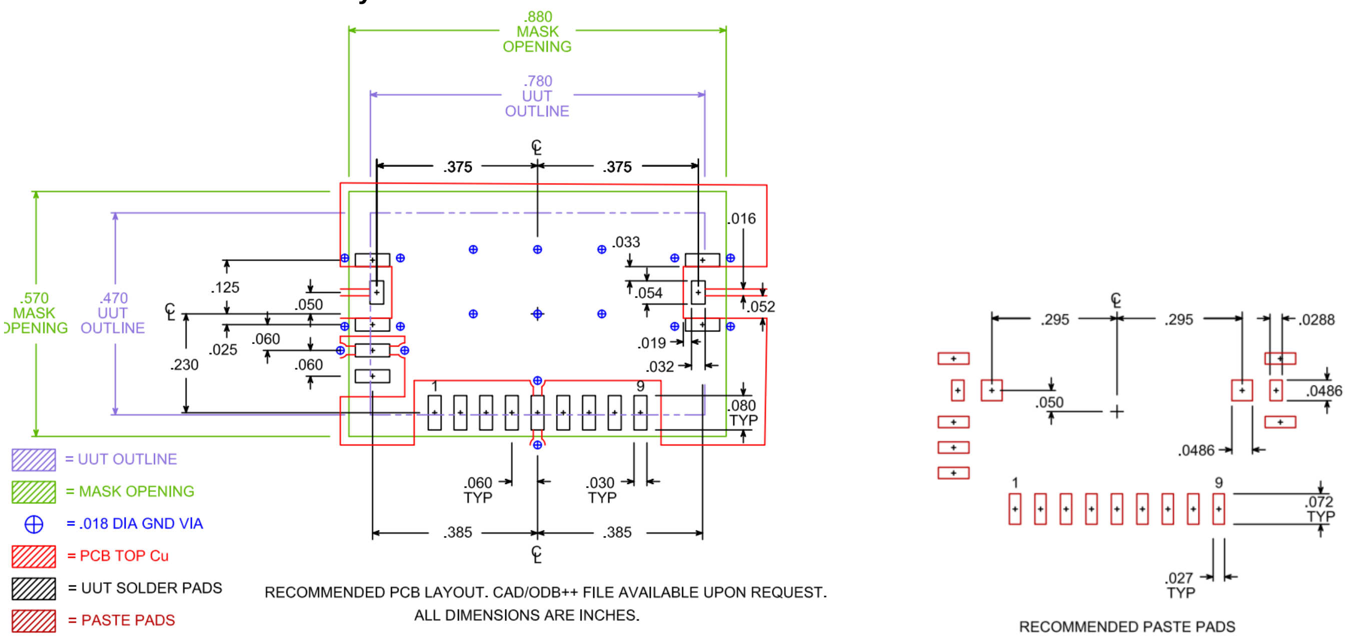

Figure 14. Recommended Test PCB Layout. CAD/ODB++ file available upon request.

4- MATERIAL: RO4350 / FR4 COPPER CLAD EPOXY GLASS. HIGH TEMP FR4, UL94V-0, PER IPC-4101/24 CLASS B.
TOTAL FINISHED THICKNESS .055 +/- .005 (PLATED COPER TO PLATED COPER)

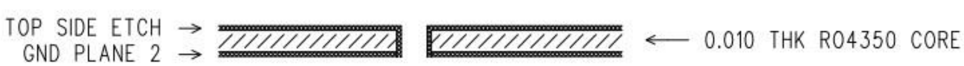

Figure 15. Recommended Test PCB Stack-up.

10.0 Mounting Instructions

10.1 Solder Reflow Profile

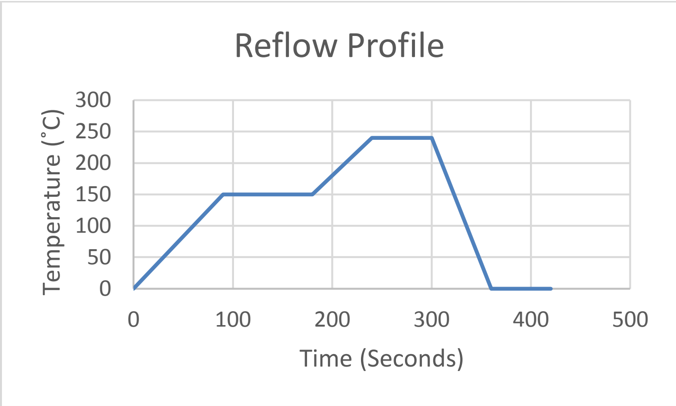

Figure 16. Recommended Solder Reflow Profile

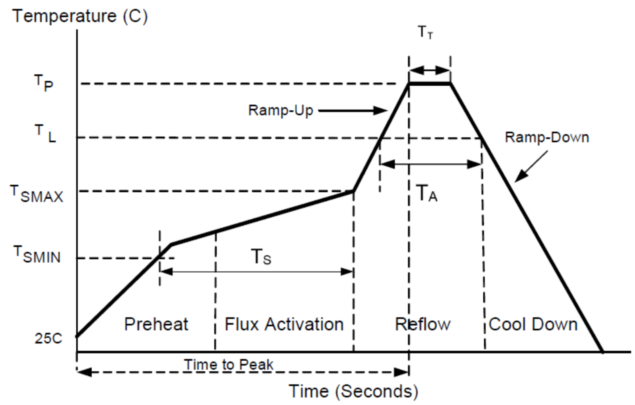

Figure 17. Reflow Profile Key

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

10.4 Other Restrictions

10.4.1 Pole/Zero recommends a no-clean Sn63Pb37 solder paste.
10.4.2 Do not clean the product after reflow process.
10.4.3 Only subject the unit to one SMT reflow process.
10.4.4 Stencil thickness recommendation is between 0.005” and 0.008”.
10.4.5 Bake out process per J-STD-033B Package Thickness > 2.0 mm and ≤ 4.5 mm.

11.0 Safety Notes

11.1 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 4 component and should be packaged and handled according to the guidelines in J-STD-033.

12.0 Legal Information

12.1 Disclaimers

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