NN-30-520-X-S06, 30 – 520 MHz, 6 dBm, Digitally Tunable Filter, NANO-ERF®

Typical Applications

- Applications where small size, low power, and high performance are needed
- Military Hand Held Radios
- Military Radar
- SATCOM
- Test and Measurement Equipment
- Industrial and Medical Equipment

Features

- +6 dBm power handling[1]
- +16 dBm IIP3 typical
- 4.7 dB Typ IL at 23°C[1]
- Typ. Tune Time: 27 µs
- Typ. Selectivity: 20 dBc @ fc ± 15%[1]

Description

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 SPI tune command format.

[1] For 6% BW filters.

1.0 Ordering Information

Table 1. Ordering Options

Series	-	Frequency Range (MHz)	-	% Bandwidth (3 dB)	-	Package	-	Options
NN	-	30-520	-	6 10	-	S06	-	C086

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

Table 2. Available Options

Option Code	Description
	If no options are specified, V_{BB} (+25V) will be generated internally and no external voltage is required.
C086	Internal power supply (+25V) is disabled and external voltage is required.

- Example product number: NN-30-520-10-S06
- Example product number: NN-30-520-6-S06-C086

2.0 Block Diagram

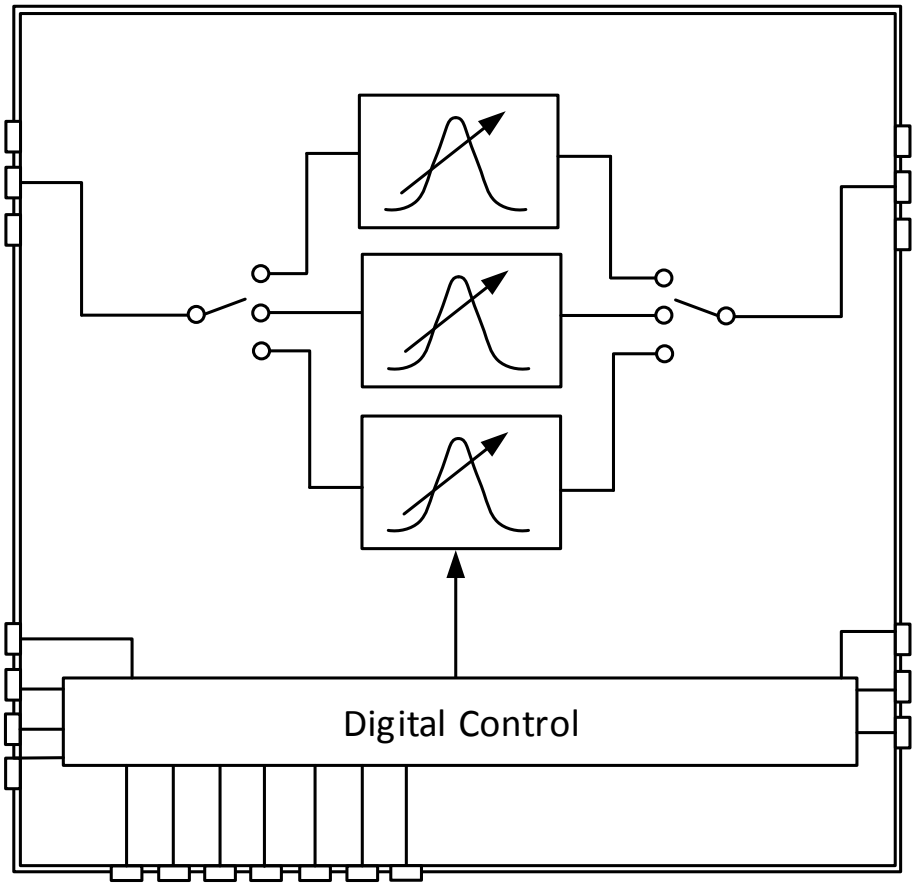


Figure 1. Technical Block Diagram

3.0 Pinout and Functional Information

3.1 Pinout

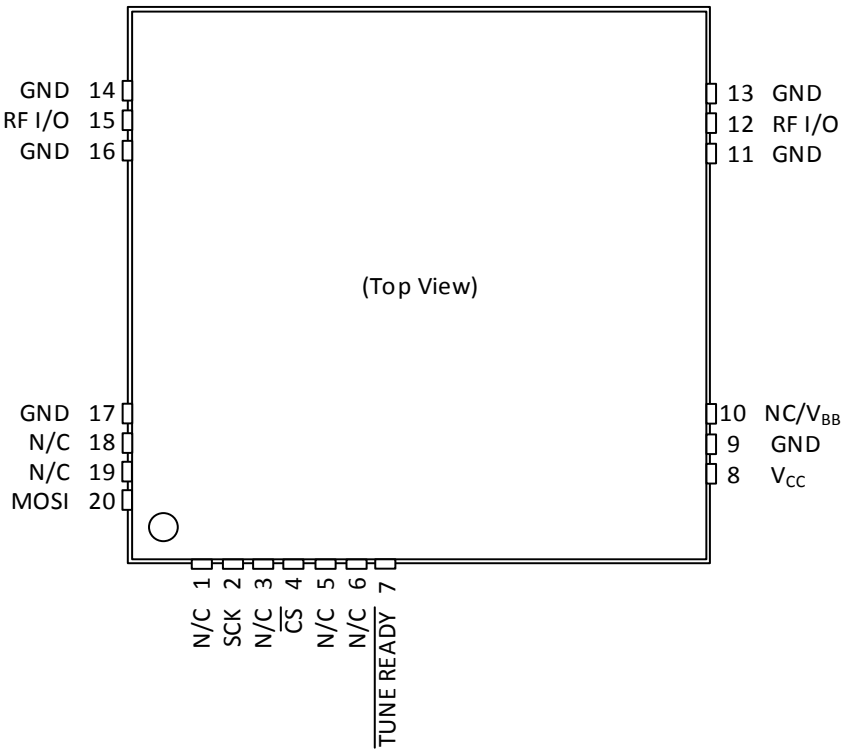


Figure 2. Pin Configuration

3.2 Pin Description

Table 3. Pin Functions and Descriptions

Pin Number	Label	Description
2	SCLK[2]	Serial Tune Interface Clock – SCLK is used to clock in the tune word. Data is latched on the rising edge of SCLK.
1, 3, 5, 6, 18, 19	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.
4	$\overline{CS}$[2]Error! Bookmark not defined.	Serial Data Chip Select – When the master transmits logic '0' to this pin, the filter 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, logic '1' can be transmitted to $\overline{CS}$ to indicate the tune command is complete.
7	$\overline{TUNE\ READY}$	Tune Ready Indicator – This pin normally remains at logic '1'. When $\overline{CS}$ is taken low to initiate a tune, $\overline{TUNE\ READY}$ transitions to logic '0' to indicate that the SPI interface is ready to start receiving the tune command. After data has been shifted in via the tune interface, $\overline{TUNE\ READY}$ will transition back to logic '1' indicating that the tune process is finished.
8	V_{CC}	Supply Voltage Input. 3.135 V ≤ V_{CC} ≤ 3.6 V.
10	NC or V_{BB}	High Bias Supply Voltage Input: +25 VDC. Standard unit comes with this voltage supplied internally (NC).
9, 11, 13, 14, 16, 17	GND	Digital and Analog Ground. GND on pin 17 is closest to the onboard digital circuitry.
12, 15	RF	RF Signal Input or Output.
20	MOSI[2]	Serial Tune Interface Data 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.

[2] Pin is internally pulled to V_{CC} with a 27 kΩ resistor.

4.0 Specifications

4.1 Absolute Maximum Ratings[3]

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	3.6	V
V_{BB}	High supply voltage	-	-	28	V
V_I	Input voltage	On all digital interface input pins	-0.3	3.6	V
V_O	Output voltage	On all digital interface output pins	-0.3	3.6	V
I_{OH}/I_{OL}	Digital interface pin sink/source current	-	-15	15	mA
I_O	Output current	-	-	-	mA
P_{INBAND}	In-band RF input power level	Signal is in passband $f_0 = 30 - 520\ MHz$	-	13[4]	dBm
$P_{OUTBAND}$	Out-of-band RF input power level	-	-	20	dBm
T_{RATE}	Maximum tune rate (frequency hopping)	-	-	2	kHz

4.2 Handling Ratings

Symbol	Parameter	Conditions	Min	Max	Unit
T_S	Storage temperature	-	-40	+125	°C

4.3 Recommended Operating Conditions

Symbol	Parameter	Conditions	Min	Nom	Max	Unit
V_{CC}	Supply voltage	-	3.135	3.3	3.6	V
V_{BB}[5]	High supply voltage	-	23.75	25	26.25	V
P_{IN}	Maximum RF input power for linear operation	Signal is in passband	-	-	6	dBm
T_A	Ambient operating temperature	-	-40	-	+85	°C

4.4 Electrical Characteristics

Voltages are referenced to GND (ground = 0 V. All parameters: TA= +23°C, VCC = +3.3V, RF Impedance = 50 Ω).

Symbol	Parameter	Conditions	Min	Nom	Max	Unit
V_{CC}	Supply voltage	-	3.135	3.3	3.6	V
I_{CC_STATIC}	V_{CC} current consumption, statically tuned	At nominal V_{CC} voltage	-	15	30	mA
I_{CC_HOP}	V_{CC} current consumption, hopping	Nominal V_{CC}, hopping at -	-	-	-	mA
V_{BB}	High supply voltage	At nominal V_{BB} voltage	23.75	25	26.25	
I_{BB_STATIC}	V_{BB} current consumption, statically tuned	At nominal V_{BB} voltage	-	-	2	mA

[3] Maximum operating conditions before damage occurs. Filter performance is not specified under these conditions.
[4] Indicates degraded performance under the specified operating condition.
[5] Standard unit comes with this voltage supplied internally.

Symbol	Parameter	Conditions		Min	Nom	Max	Unit
I_{BB_HOP}	V_{BB} current consumption	Nominal V_{BB}, hopping at -		-	-	-	mA
V_{IH}	Digital high level input voltage	On all digital interface input pins		0.7* V_{cc}	-	-	V
V_{IL}	Digital low level input voltage	On all digital interface output pins		-	-	0.3* V_{cc}	V
I_{IH}/I_{IL}	Digital Interface pin input logic current	-		-10	-	10	mA
F_{RANGE}	Tunable frequency range	-		30	-	520	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	For NN-30-520-6-S06		-	4.7	7	dB
		For NN-30-520-10-S06		-	3.2	5	
%BW	Bandwidth (3 dB)	For NN-30-520-6-S06		-	6.5	7	%
		For NN-30-520-10-S06		-	9.5	11	
$SEL_{15\%}$	Selectivity 15% removed from the center frequency	$f_0 \pm 15\%$	6%BW	-	22	-	dBc
			10%BW	-	17	-	
$SEL_{ULTIMATE}$	Ultimate selectivity	$2 \times f_0$		-	50	-	dBc
IIP3	Input third order intermodulation intercept point	-		-	16	-	dBm
NF	Noise Figure	-		-	8[6]	-	dB
-	Noise Floor			-	-100[7]	-85[7]	dBm
$P_{Spurious}$	Spurious Output Level				-100[7]	-85[7]	dBm
$P_{Sidebands}$	Internal Power Supply Modulation Sideband Level				-50[7]	-40[7]	dBc
T_{TUNE}	Tune time	-		-	27	35	µs
F_{DRIFT}	Center frequency drift over temperature	Fill in temperature range		-	160	275	ppm/°C

[6] Measured at f_0.

[7] Spectrum Analyzer Settings: RBW = 20 kHz, VBW = 100Hz, Span = f_0 ± 5 MHz, Atten = 0 dB, Ref Level = -25 dBm.

4.5 Typical Characteristics

6% Filter: Captured at +6 dBm, 23°C (s2p files available upon request).

Figure 3. 30-89 MHz Measured Data

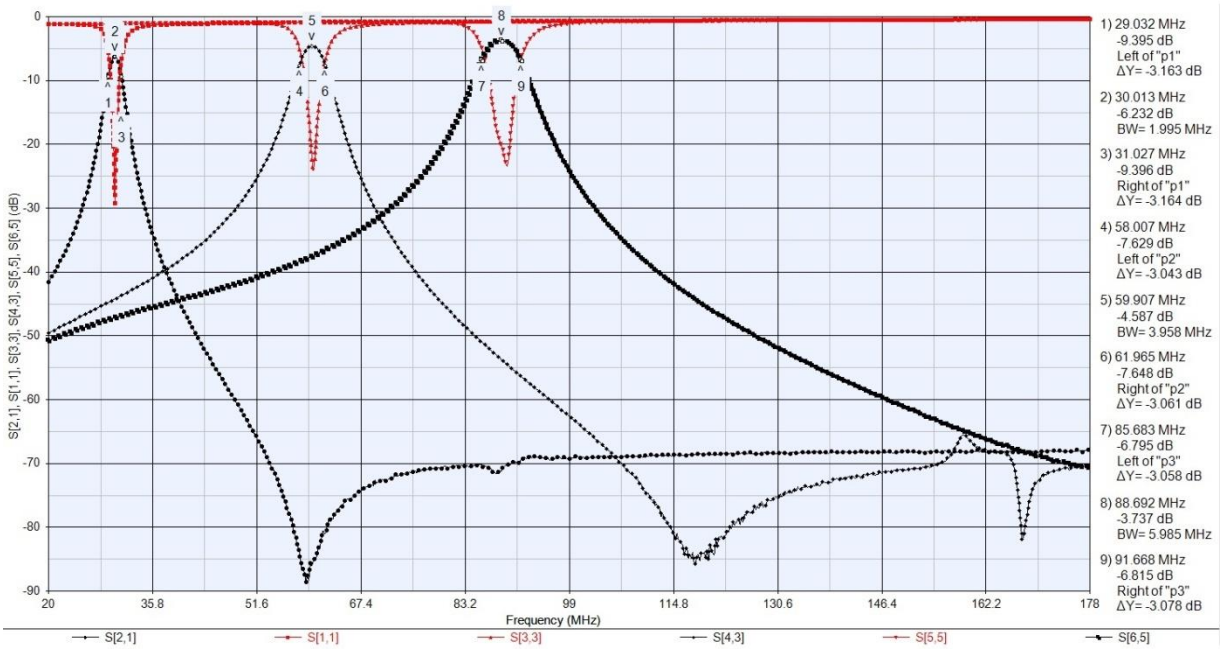


Figure 4. 89.52-219 MHz Measured Data

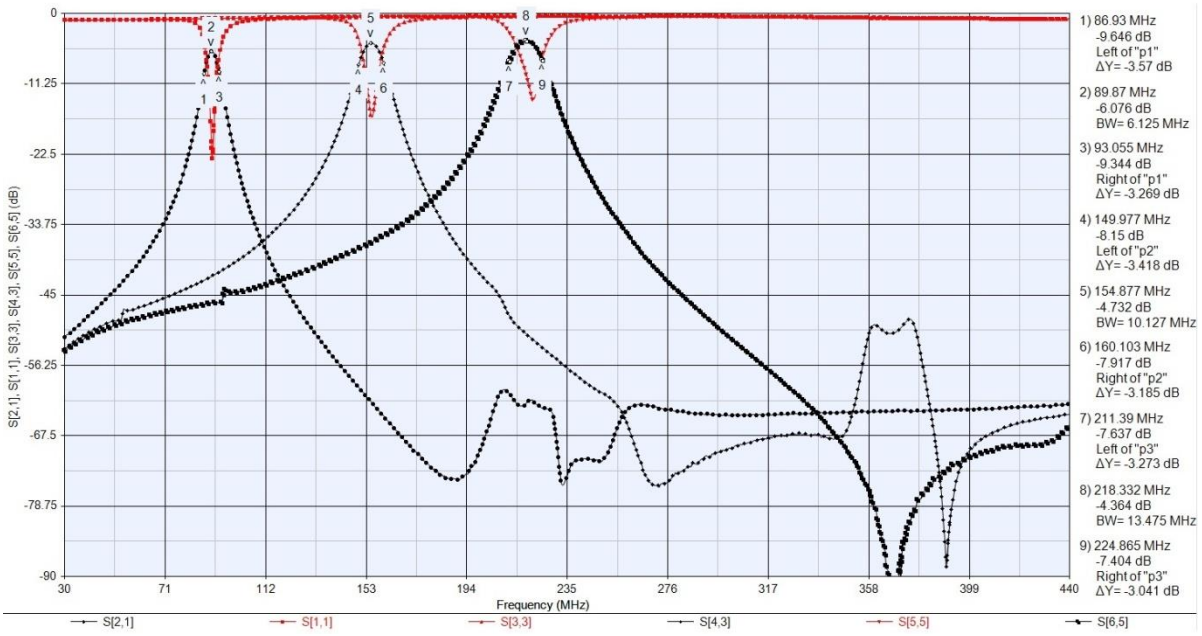
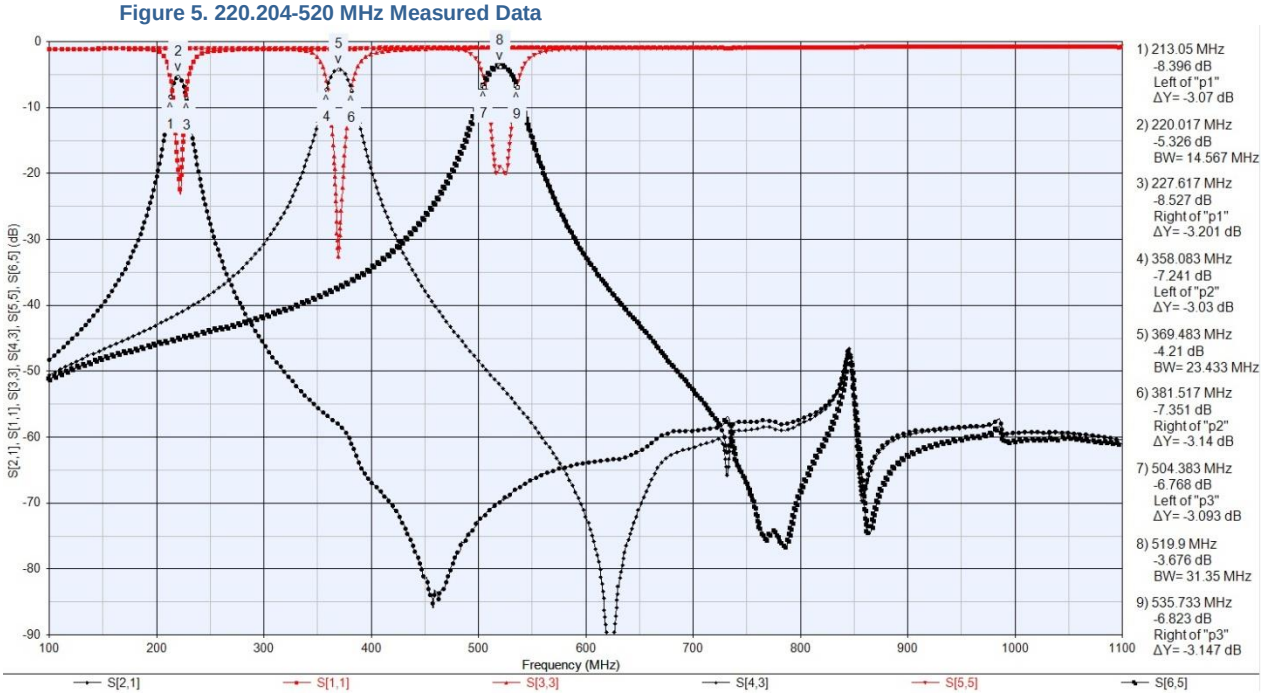


Figure 5. 220.204-520 MHz Measured Data



4.6 6% Filter: Temperature Response Summary Data

Figure 6. Selectivity Over Temperature

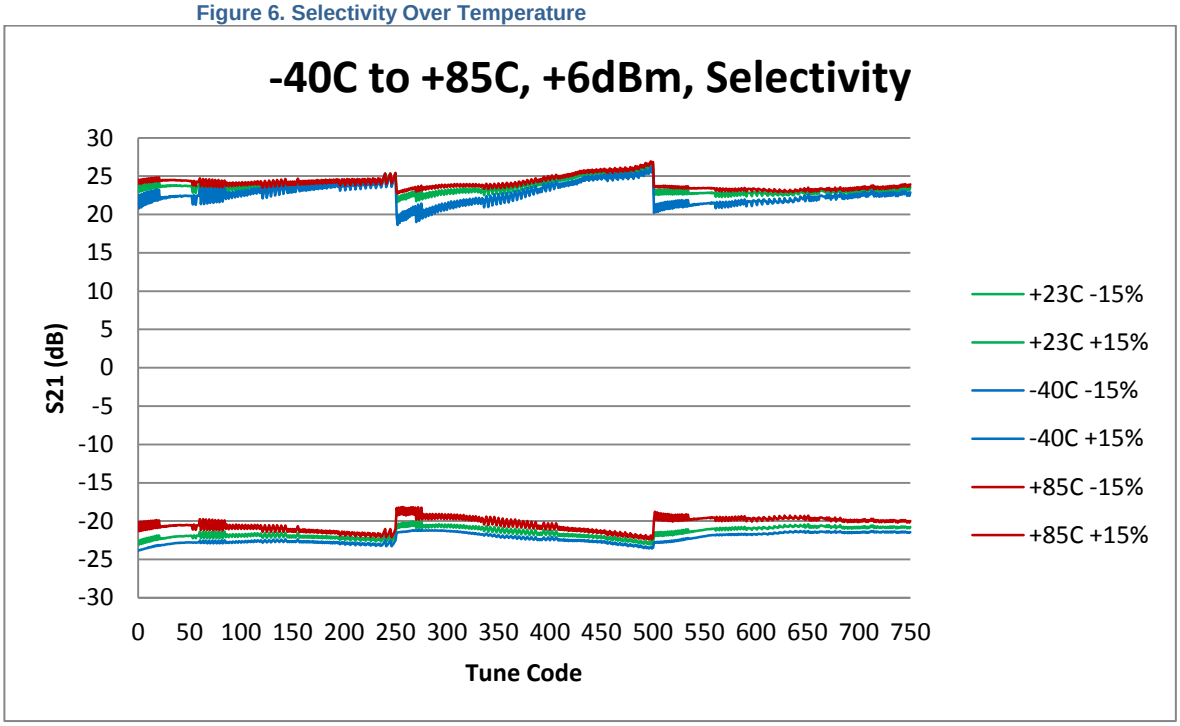


Figure 7. Insertion Loss Over Temperature

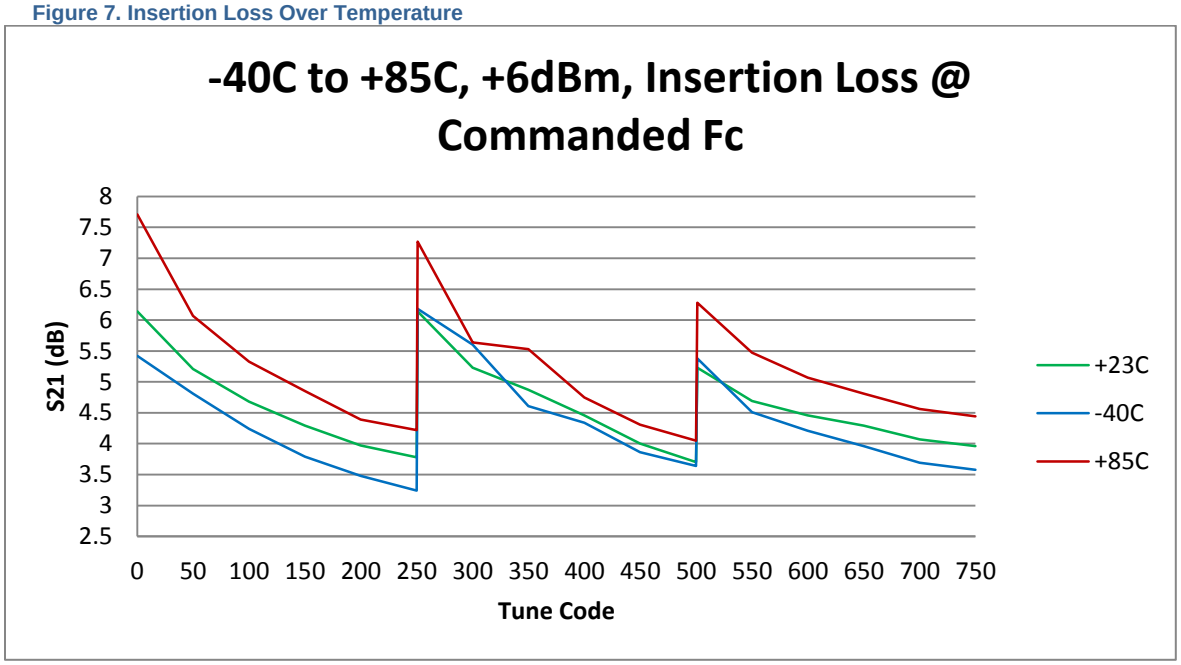


Figure 8. Return Loss Over Temperature

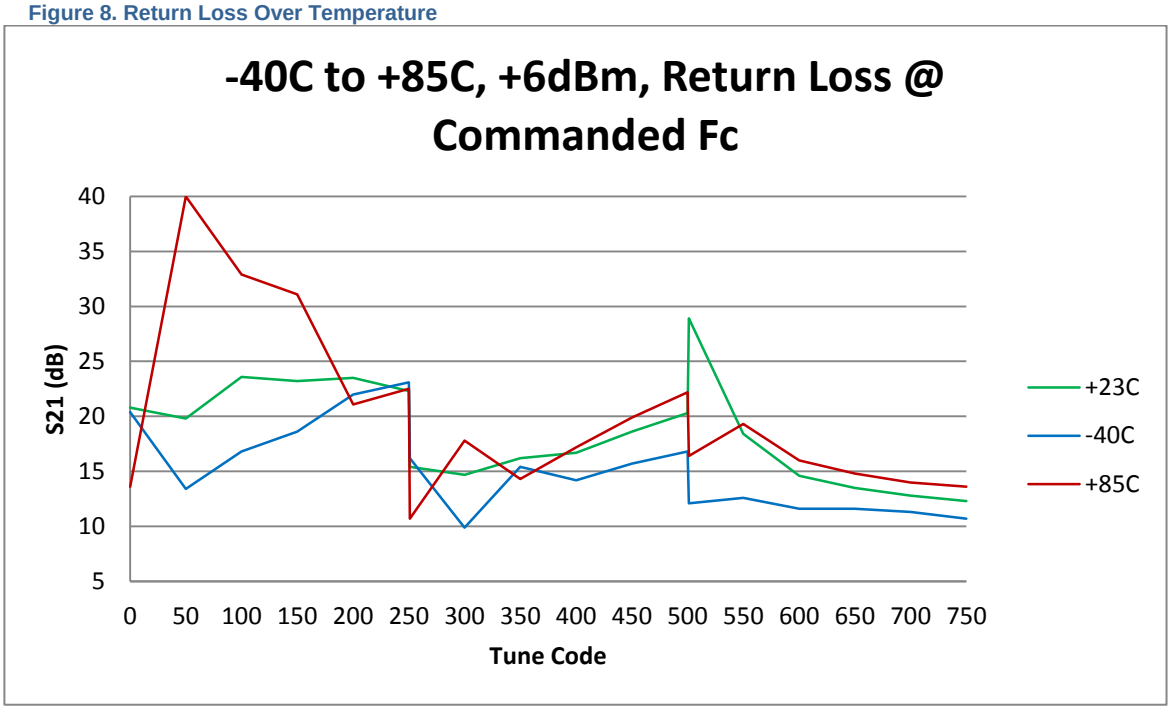
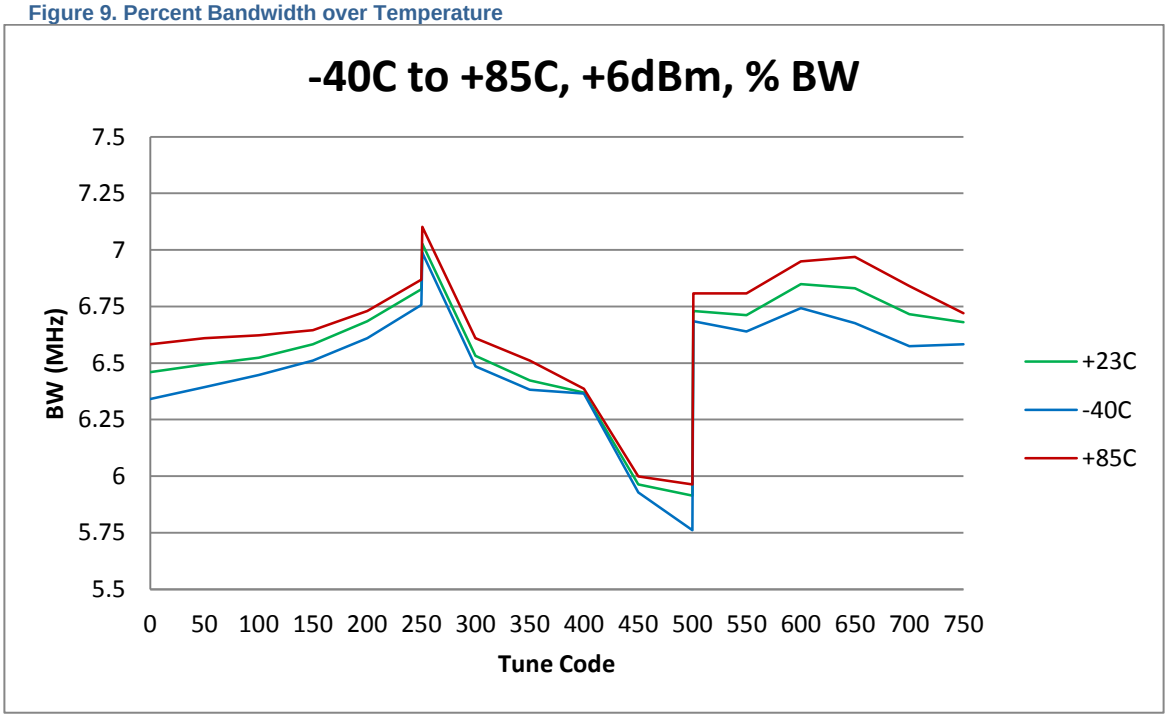


Figure 9. Percent Bandwidth over Temperature



4.7 Timing Requirements

4.7.1 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.

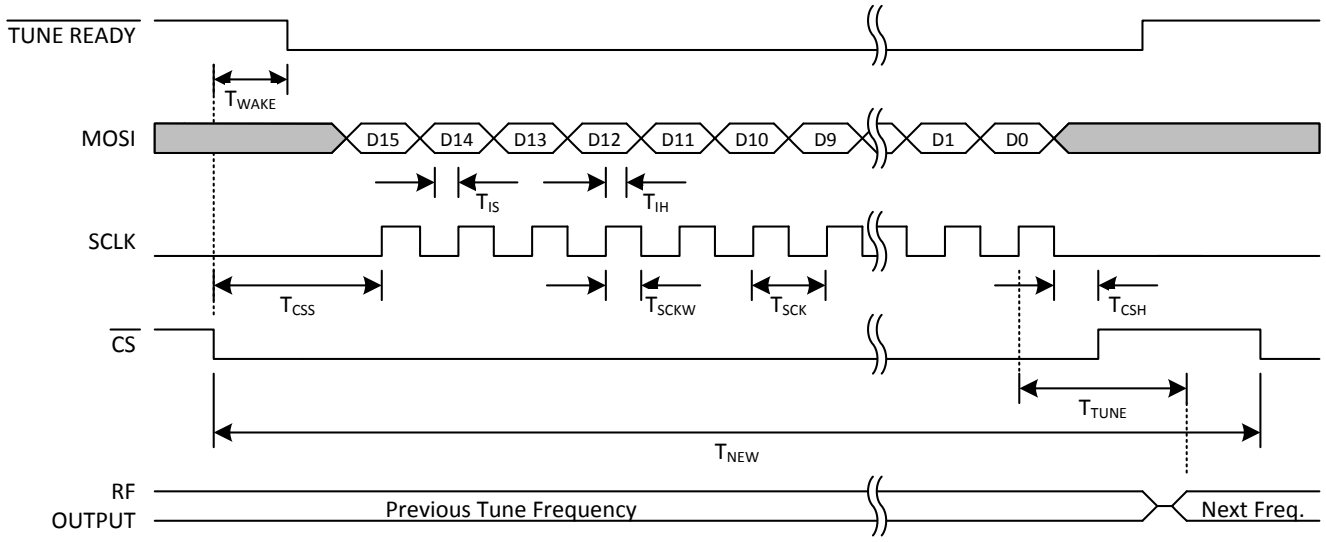


Figure 10. Serial Timing Diagram

Table 4. SPI Timing Characteristics

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

Parameter	Parameter	Min.	Max.	Unit
T_{WAKE}	Wakeup Time – The amount of time from $\overline{CS}$ transitioning low until $\overline{TUNE\ READY}$ transitions low.	-	6.5	µs
T_{CSS}	$\overline{CS}$ Setup Time – The amount of time needed from when $\overline{CS}$ transitions low until the first rising edge of SCLK.	6.8	-	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_{SCK}	SCLK Period	143	-	ns
T_{SCKW}	SCLK Duty Cycle	$\frac{T_{SCLK}}{2}$	-	ns
T_{SCLKF}	SCLK Fall Time (Not shown)	-	1.6	µs
T_{SCLKR}	SCLK Rise Time (Not shown)	-	1.6	µs
T_{CSH}	$\overline{CS}$ Hold Time – The amount of time $\overline{CS}$ 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 $\overline{CS}$. 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%.	-	35[8]	µs

[8] Refer to section 7.0 for measurements.

5.0 Functional Description

5.1 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. The tune command is formatted the same for both SPI and parallel interface modes.

Table 5. Tune Command Properties

Symbol	Band	Value	Description
f_{MIN}	VHFL	30 MHz	Minimum Tunable Frequency. f_{MIN} is the absolute minimum frequency that the filter is capable of tuning to for the respective band.
	VHFH	89.52 MHz	
	UHF	220.204 MHz	
f_{MAX}	VHFL	89 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.
	VHFH	219 MHz	
	UHF	520 MHz	
f_{STEP}	VHFL	0.236 MHz	Tune step size. f_{STEP} is the minimum spacing between adjacent tune commands.
	VHFH	0.52 MHz	
	UHF	1.204 MHz	
f_{COM}	-	$round\left(\frac{(f_{DESIRED} - f_{MIN})}{f_{STEP}}\right)$	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 6. 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
NN-30-520-X-S06	30	520		0[9]	0	0	0	0	0	Band Bits		Commanded Frequency							

6.0 Detailed Description

6.1 Digital Interface

Table 7. Band Bit Selection

Band Bits			
Bit 9	Bit 8	Selected Band	Band Range (MHz)
0	0	VHFL	30 - 89
0	1	VHFH	89.52 - 219
1	0	UHF	220.204 - 520
1	1	Unsupported, Do not Select	-

[9] Bits represented as zero must be set to zero for all tune positions.

6.2 Example Tune Commands

Table 8. 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)
30.00	VHFL	0x00	30	0.236	$round\left(\frac{(30.00 - 30.00)}{0.236}\right)$	0	0x00	0x0000
49.00	VHFL	0x00	30	0.236	$round\left(\frac{(49.00 - 30.00)}{0.236}\right)$	81	0x51	0x0051
89.00	VHFL	0x00	30	0.236	$round\left(\frac{(89.00 - 30.00)}{0.236}\right)$	250	0xFA	0x00FA
89.52	VHFH	0x01	89.52	0.52	$round\left(\frac{(89.52 - 89.52)}{0.52}\right)$	0	0x00	0x0100
126.48	VHFH	0x01	89.52	0.52	$round\left(\frac{(126.48 - 89.52)}{0.52}\right)$	71	0x47	0x0147
219	VHFH	0x01	89.52	0.52	$round\left(\frac{(219.00 - 89.52)}{0.52}\right)$	249	0xF9	0x01F9
220.204	UHF	0x02	220.204	1.204	$round\left(\frac{(220.204 - 220.204)}{1.204}\right)$	0	0x00	0x0200
389.90	UHF	0x02	220.204	1.204	$round\left(\frac{(389.90 - 220.204)}{1.204}\right)$	141	0x8D	0x028D
520.00	UHF	0x02	220.204	1.204	$round\left(\frac{(520.00 - 220.204)}{1.204}\right)$	249	0xF9	0x02F9

6.3 Additional Interface Detail

Table 9. Additional Pin Information

Pin Name	Description
$\overline{\text{TUNE READY}}$	The $\overline{\text{TUNE READY}}$ indicator is a driven digital output. Do not connect any other push-pull output directly to this pin. The function of $\overline{\text{TUNE READY}}$ is to indicate the status of the digital interface during and after tune events. The normal logic state of the pin is high at power up. In this condition the filter is waiting on a new tune command. When a new tune command is initiated by transmitting logic '0' to $\overline{\text{CS}}$, $\overline{\text{TUNE READY}}$ will transition low 1 µs before the filter is ready to start receiving data on the SPI interface. The external control circuit must monitor $\overline{\text{TUNE READY}}$ to determine when it transitions low or alternatively, delay for the minimum control circuit setup time before loading the digital data. Once the filter has received the valid tune command and has finished processing all tune functions, $\overline{\text{TUNE READY}}$ will return to a logic high state.

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 -10 dBm is considered to be “hot switching” of the filter. The data taken in “Table 10. Typical RF Tune Times” was taken with 0dBm input but this does not imply that tuning operation of the filter with that level can be done reliably. It is recommended that RF is less than -10 dBm during a tune event.

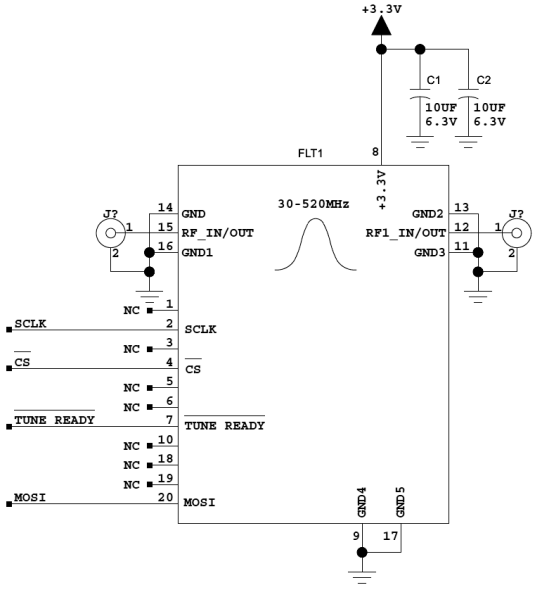
Table 10. Typical RF Tune Times

Previously Commanded Frequency (MHz)[10]	New Commanded Frequency (MHz)[11]	Typical Tune Time (µs)
30 (Low End of Band 1)	89 (High End of Band 1)	29
30 (Low End of Band 1)	219 (High End of Band 2)	27.7
30 (Low End of Band 1)	520 (High End of Band 3)	25.7
89 (High End of Band 1)	30 (Low End of Band 1)	24.3
89.52 (Low End of Band 2)	89 (High End of Band 1)	29.4
89.52 (Low End of Band 2)	219 (High End of Band 2)	28.7
89.52 (Low End of Band 2)	520 (High End of Band 3)	26.4
219 (High End of Band 2)	89.52 (Low End of Band 2)	26.9
220.204 (Low End of Band 3)	89 (High End of Band 1)	29.8
220.204 (Low End of Band 3)	219 (High End of Band 2)	28.7
220.204 (Low End of Band 3)	520 (High End of Band 3)	26.8
520 (High End of Band 3)	220.204 (Low End of Band 3)	23.7
520 (High End of Band 3)	30 (Low End of Band 1)	24.8

8.0 Application Information

8.1 Application Circuit (note: for device with option “C086”, +25VDC needs to be supplied at pin 10)

Figure 12. Serial Application Circuit[12]



[10] The frequency that the NN-30-520-X-S06 is tuned to when the tune command occurs.

[11] The frequency that the NN-30-520-X-S06 is tuned to for the tune time measurement.

[12] DC Blocking capacitors for RF I/O pins are internal to filter.

9.0 Package Information

9.1 Package Detail

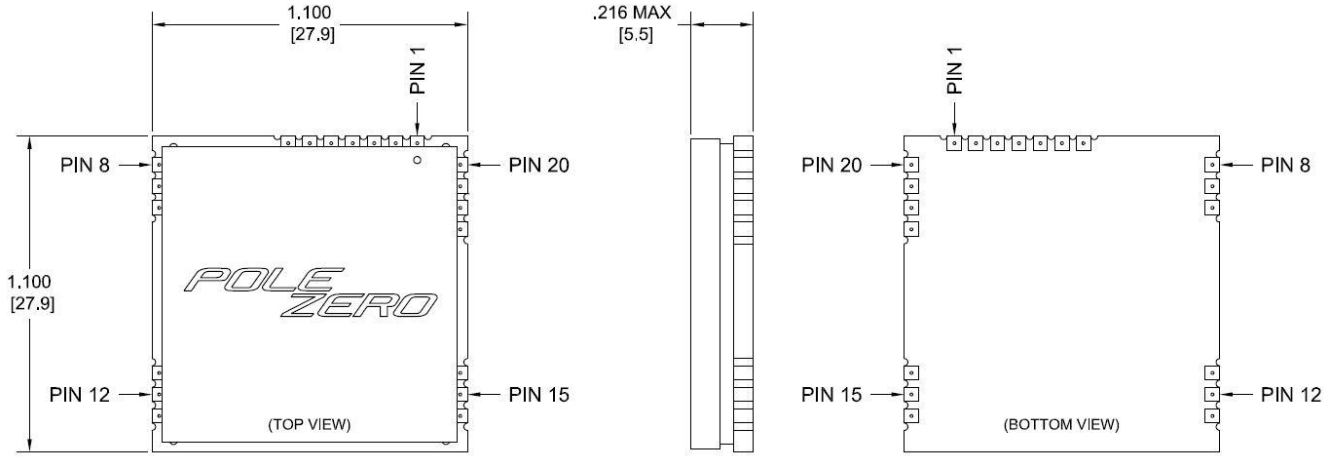


Figure 13. Package Detail

9.2 Recommended Pad Layout

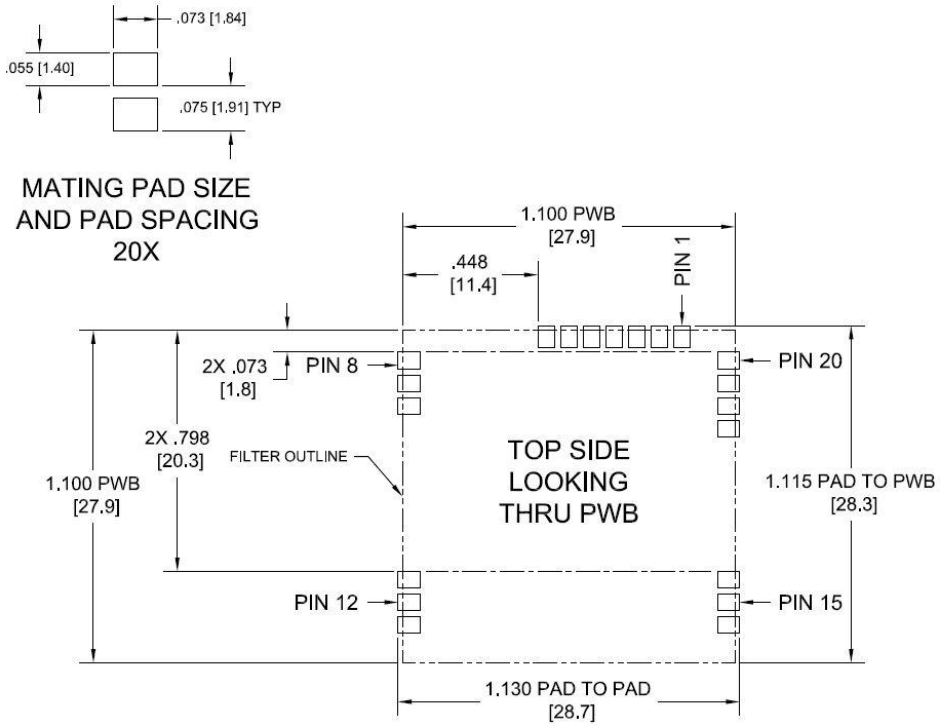


Figure 14. Recommended Pad Layout

10.0 Mounting Instructions

10.1 Solder Reflow Profile

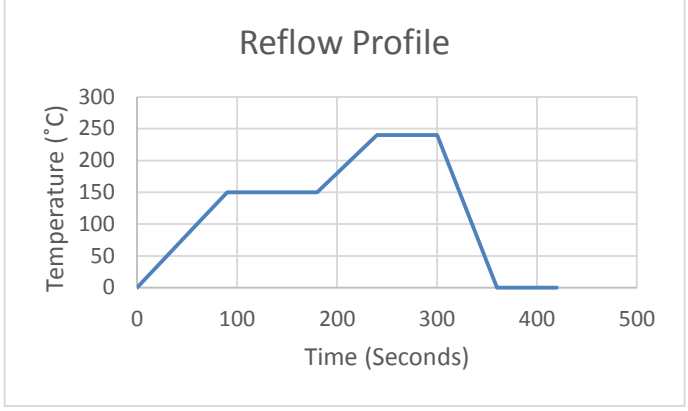


Figure 3. Recommended Solder Reflow Profile

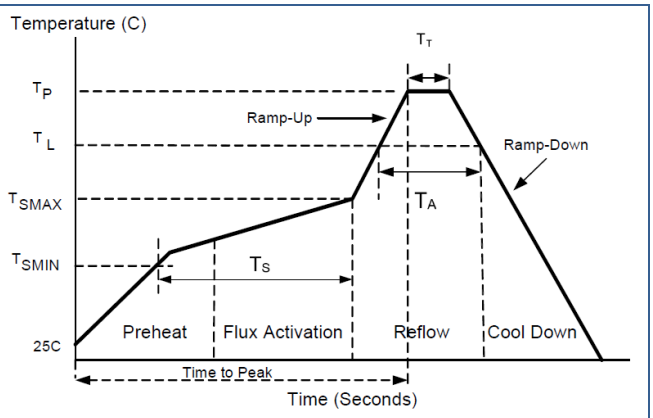


Figure 4. Reflow Profile Key

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 **Error! Reference source not found.**. 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 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.

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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14.0 Contact and Support

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