

## FEATURES

- 30MHz to 90MHz Tunability
- 240 Frequency Steps
- Constant Q, Two-pole Butterworth Bandpass
- 1W Power Handling
- 30 $\mu$ s Tuning Speed
- Serial/Parallel Modes
- -40C to +85C



## DESCRIPTION

The TS5010 series of TeraTune™ digitally programmable bandpass filters are available in various frequency ranges and bandwidths to help solve your CoSite receiver problems. They feature 1W power handling, low insertion loss, and frequency agility. The TS5010 is offered in both board-mounted and standalone SMA connectorized versions for ease of installation.

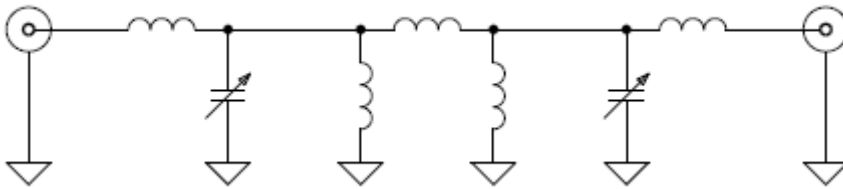


Figure 1: Equivalent Circuit

The TS5010 offers performance upgrades in an industry standard footprint. Designed from the ground up, these filters present a cost-effective alternative with enhanced features.

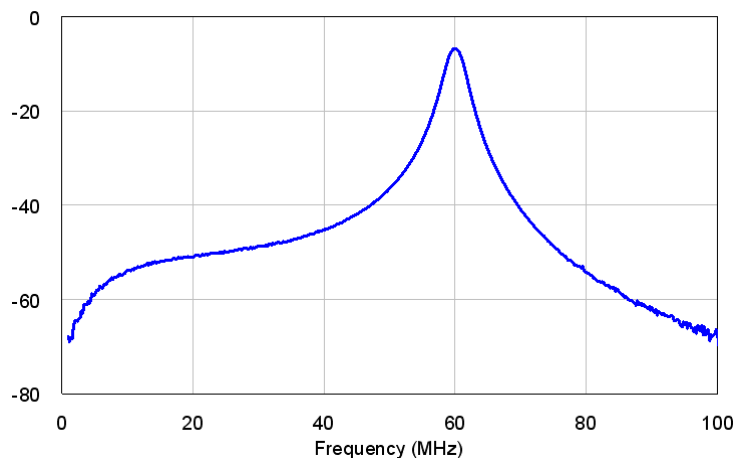


Figure 2: Typical Frequency Response

## PART NUMBERING

| TS | - | Series | - | Range | - | Steps      | - | BW          | - | Control     | - | Options |
|----|---|--------|---|-------|---|------------|---|-------------|---|-------------|---|---------|
| TS | - | 5010   | - | 30-90 | - | 240<br>250 | - | 5<br>4<br>3 | - | P<br>S<br>R | - | C       |

P = Parallel

S = SPI

R = Asynchronous Serial (RS-232)

C = Connectorized Package (SMA)

## RF PERFORMANCE

| Parameter                               | BW                | Symbol   | Min            | Typ               | Max               | Units    |
|---|-------------------|----------|----------------|-------------------|-------------------|----------|
| Input Impedance                         |                   | $Z_0$    |                | 50                |                   | $\Omega$ |
| In-Band 3 <sup>rd</sup> Order Intercept |                   | IP3      | 40             |                   |                   | dBm      |
| In-Band Power                           | 5.0<br>4.0<br>3.3 | $P_{IB}$ |                | 32<br>31<br>30    |                   | dBm      |
| Out-of-Band Power                       |                   | $P_{OB}$ | 36             |                   |                   | dBm      |
| Insertion Loss                          | 5.0<br>4.0<br>3.3 | S21      |                | 5.0<br>6.0<br>8.0 | 6.5<br>7.5<br>9.5 | dB       |
| Shape Factor (30dB/3dB)                 |                   | SF       |                | 6                 | 7                 |          |
| High Frequency Loss ( $2 \times f_0$ )  | 5.0<br>4.0<br>3.3 | HFL      | 60<br>65<br>70 |                   |                   | dB       |
| Bandwidth Variation                     |                   | BWV      | -1             | 0                 | +1                | %        |
| Center Frequency Drift                  |                   | $F_D$    |                |                   | 100               | ppm/C    |

## POWER SUPPLY

| Parameter                       | Symbol   | Min | Typ | Max | Units |
|---------------------------------|----------|-----|-----|-----|-------|
| Power Supply Voltage            | $V_{CC}$ | 4.5 | 5.0 | 5.5 | V     |
| Power Supply Current            | $I_{CC}$ | 10  |     | 350 | mA    |
| Bias Supply Voltage             | $V_{BB}$ | 10  |     | 100 | V     |
| Bias Supply Current (quiescent) | $I_{BB}$ |     | 4   | 5   | mA    |

## ENVIRONMENTAL

| Parameter             | Symbol | Min | Typ | Max | Units |
|-----------------------|--------|-----|-----|-----|-------|
| Operating Temperature | $T_O$  | -40 | 25  | 85  | C     |
| Storage Temperature   | $T_S$  | -55 |     | 100 | C     |
| Relative Humidity     | RH     | 0   |     | 95  | %     |

## CONTROL INPUTS

| Parameter                       | Symbol          | Min                | Typ             | Max                   | Units |
|---------------------------------|-----------------|--------------------|-----------------|-----------------------|-------|
| Input Low Voltage               | V <sub>IL</sub> | -0.3               | 0               | 0.3V <sub>CC</sub>    | V     |
| Input High Voltage              | V <sub>IH</sub> | 0.7V <sub>CC</sub> | V <sub>CC</sub> | V <sub>CC</sub> + 0.3 | V     |
| Output Low Voltage (I = 10mA)   | V <sub>OL</sub> | 0                  |                 | 0.3V <sub>CC</sub>    | V     |
| Output High Voltage (I = -10mA) | V <sub>OH</sub> | 0.7V <sub>CC</sub> |                 | V <sub>CC</sub>       | V     |

## TUNECODE

The frequency band is divided into equal steps with the TuneCode defined by the following formula. TuneCodes above 250 are reserved for special operations. Power save mode shuts off all PIN diodes for lowest power consumption.

$$TuneCode = Steps \cdot \left( \frac{f_{desired} - f_{min}}{f_{max} - f_{min}} \right)$$

| Code    | Operation       |
|---------|-----------------|
| 0 - 250 | TuneCode        |
| 251     | <reserved>      |
| 252     | <reserved>      |
| 253     | <reserved>      |
| 254     | <reserved>      |
| 255     | Power Save Mode |

## PARALLEL MODE

In parallel mode, the TuneCode is specified per the input pins when the /STB line goes low. Once strobed, an internal processor looks up the required PIN diode control words and sets them accordingly. The PIN diode switch drivers take another ten microseconds to slew on or off, and the resulting bandpass is indeterminate during this time.

| Parameter                         | Symbol           | Min | Typ | Max | Units |
|-----------------------------------|------------------|-----|-----|-----|-------|
| Setup Time                        | t <sub>S</sub>   | 0   |     |     | ns    |
| Hold Time                         | t <sub>H</sub>   | 100 |     |     | ns    |
| Strobe Pulse Width                | t <sub>W</sub>   | 25  |     |     | ns    |
| Access time from Strobe to +10dBm | t <sub>ACC</sub> |     |     | 30  | μs    |
| Dwell Time                        | t <sub>DW</sub>  | 250 |     |     | μs    |

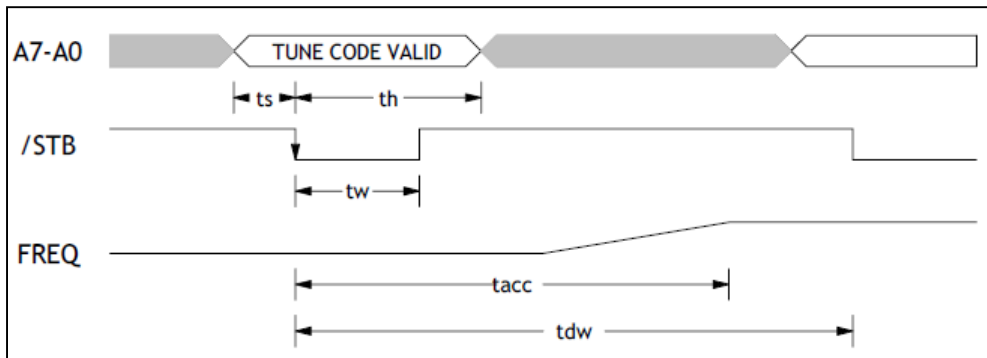


Figure 3: Parallel Mode Timing

### SERIAL (SPI) MODE

The TuneCode is clocked in serially one bit at a time, MSB first. Timing is synchronous and can be at any rate under the maximum clock rate of 5MHz. To start a sequence, the chip select line (/SS) is pulled low. Once /SS goes high, the internal processor begins the decoding process and sets the new frequency.

| Parameter                         | Symbol    | Min | Typ | Max | Units   |
|-----------------------------------|-----------|-----|-----|-----|---------|
| Select Setup Time                 | $t_{CS}$  | 100 |     |     | ns      |
| Data Setup Time                   | $t_{DS}$  | 50  |     |     | ns      |
| Data Hold Time                    | $t_{DH}$  | 50  |     |     | ns      |
| Clock High Time                   | $t_{CH}$  | 100 |     |     | ns      |
| Clock Low Time                    | $t_{CL}$  | 100 |     |     | ns      |
| Access Time from Select to +10dBm | $t_{ACC}$ |     |     | 30  | $\mu s$ |
| Dwell Time                        | $t_{DW}$  | 250 |     |     | $\mu s$ |

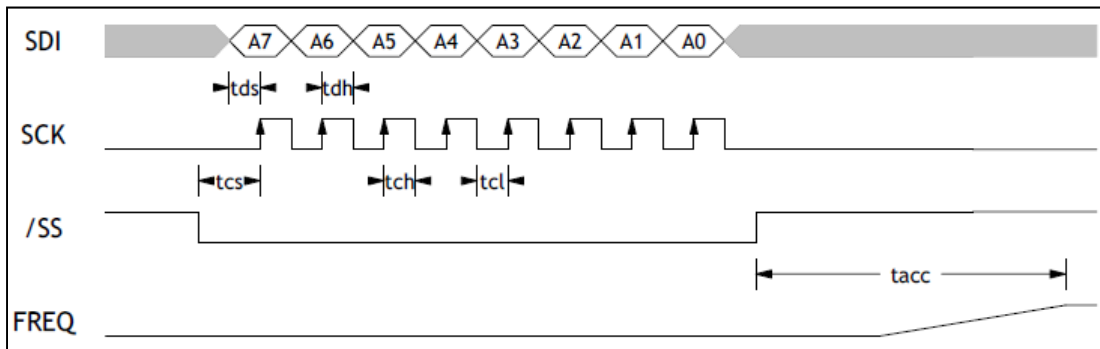


Figure 4: Serial Mode Timing

### RS-232 (ASYNC) MODE

The baud rate is fixed at 9600, 8N1. Voltage levels are TTL, with mark high, space low. Be careful not to use TuneCodes 253 and 254 as they are reserved for manufacturing and calibration purposes. Use of these codes may cause indeterminate results.

## PINOUTS

| Pin | Name   | Type | Description                    | Pin* |
|-----|--------|------|--------------------------------|------|
| 1   | RF_IN  | I/O  | RF Input and Output            |      |
| 2   | GND    |      | Ground                         |      |
| 3   | GND    |      | Ground                         |      |
| 4   | VCC    | I    | +5V Supply                     | 1    |
| 5   | GND    |      | Ground                         | 2    |
| 6   | A7     | I    | Tune Bit 7 (MSB)               | 3    |
| 7   | A6     | I    | Tune Bit 6                     | 4    |
| 8   | A5     | I    | Tune Bit 5                     | 5    |
| 9   | A4     | I    | Tune Bit 4                     | 6    |
|     | RX     |      | Receive RS-232 (Logic Levels)  |      |
| 10  | A3     | I/O  | Tune Bit 3                     | 7    |
|     | TX     |      | Transmit RS-232 (Logic Levels) |      |
| 11  | A2     | I/O  | Tune Bit 2                     | 8    |
|     | SDO    |      | Synchronous Data Out (SPI)     |      |
| 12  | A1     | I    | Tune Bit 1                     | 9    |
|     | SDI    |      | Synchronous Data In (SPI)      |      |
| 13  | A0     | I    | Tune Bit 0 (LSB)               | 10   |
|     | SCK    |      | Synchronous Clock (SPI)        |      |
| 14  | /STB   | I    | Strobe (Parallel Load)         | 11   |
|     | /SS    |      | Synchronous Select (SPI)       |      |
| 15  | GND    |      | Ground                         | 12   |
| 16  | GND    |      | Ground                         | 13   |
| 17  | VBB    | I    | +100V Bias Supply              | 14   |
| 18  | GND    |      | Ground                         | 15   |
| 19  | GND    |      | Ground                         |      |
| 20  | GND    |      | Ground                         |      |
| 21  | RF_OUT | I/O  | RF Input and Output            |      |
| 22  | GND    |      | Ground                         |      |
| 23  | NC     |      | No Connect                     |      |
| -   |        |      |                                |      |
| 41  |        |      |                                |      |
| 42  | GND    |      | Ground                         |      |

\* SMA version

**MECHANICAL**

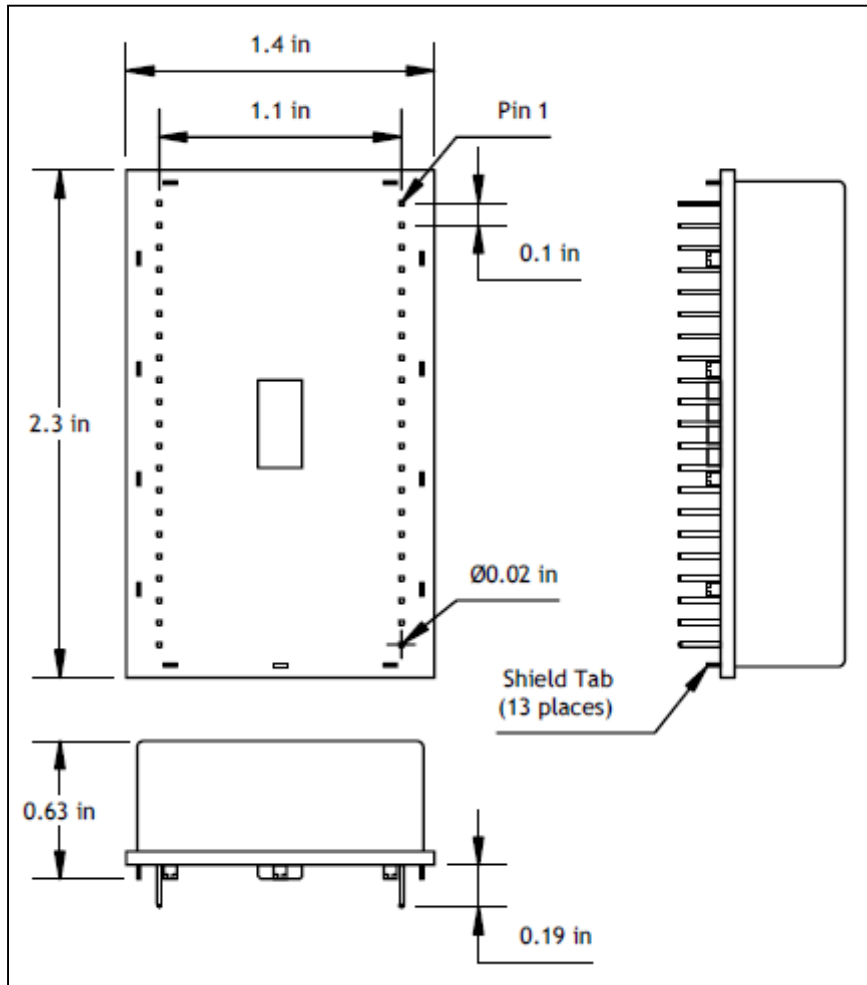


Figure 5: Package Dimensions, Bottom and Side Views

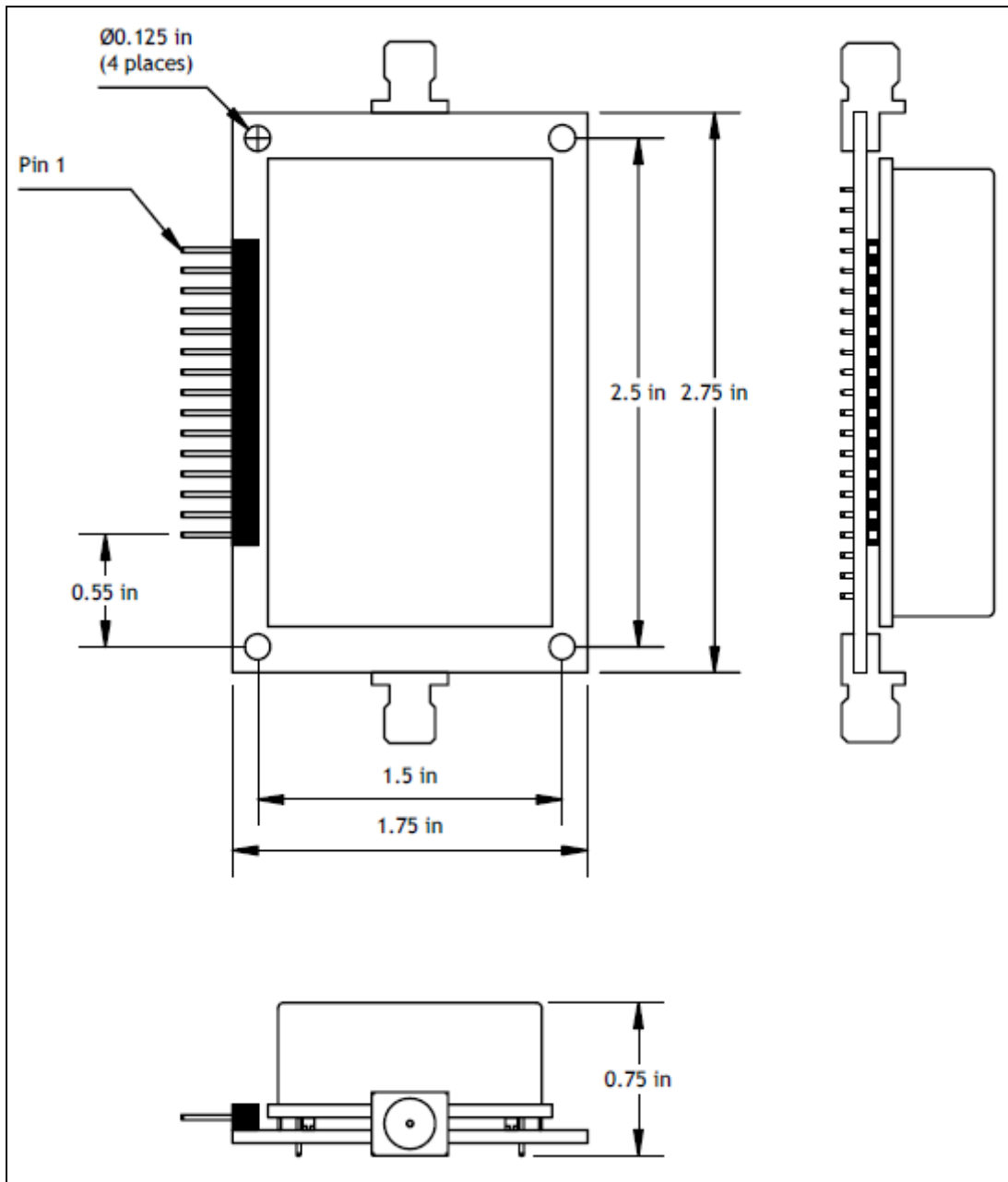


Figure 6: Connectorized SMA Package Dimensions, Top and Side Views

## APPLICATION INFORMATION

The power handling capability of the filter is dependent on VSWR, bandwidth, and bias voltage. Lower levels of bias voltage, all the way down to +10V are possible, as long as RF signal levels remain appropriately low. Power levels should be reduced to below 0dBm during switching.

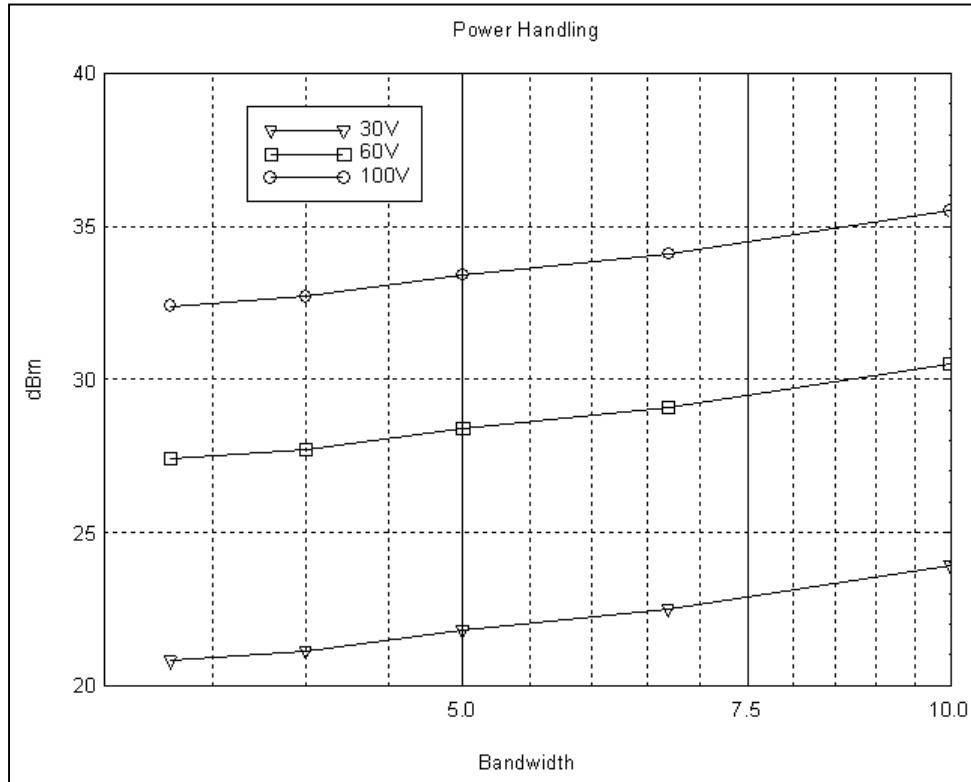


Figure 7: Power Handling versus Bias and Bandwidth

### SOLDERING

The TS-5010 should be hand soldered. Wave solder or IR reflow may cause parts on the internal circuit boards to loosen or shift position. The use of sockets is acceptable.

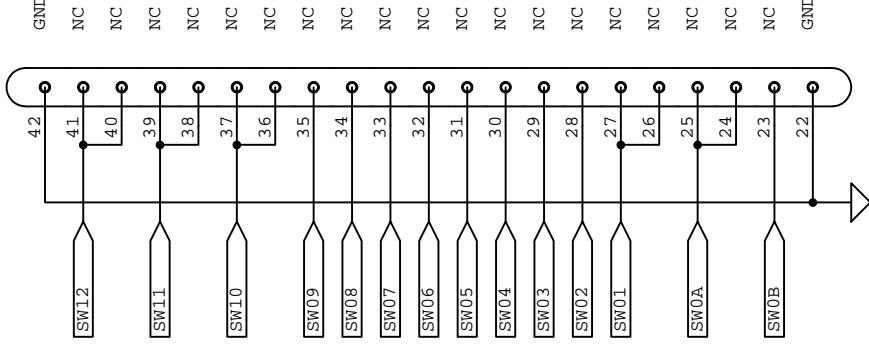
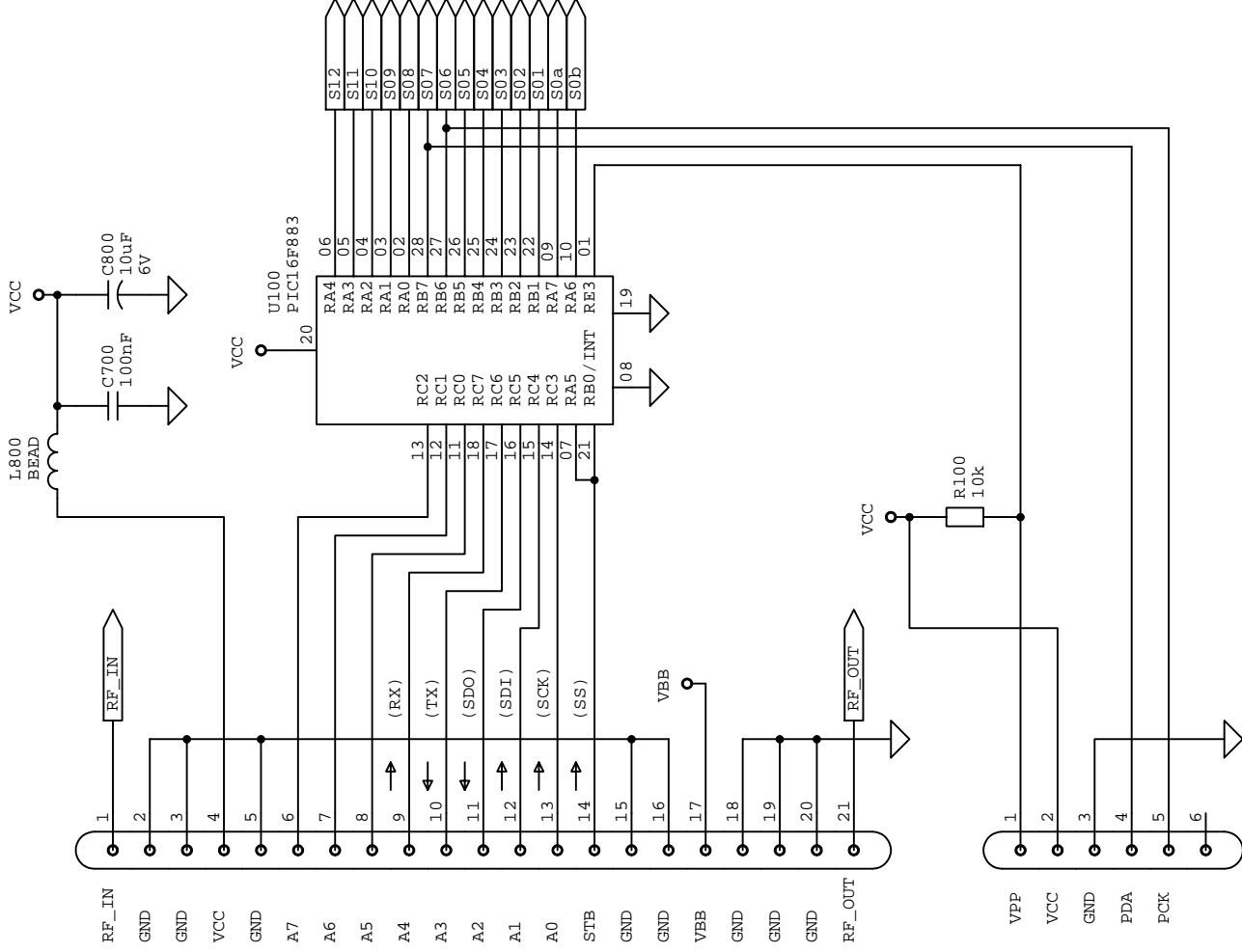
### NC PINS

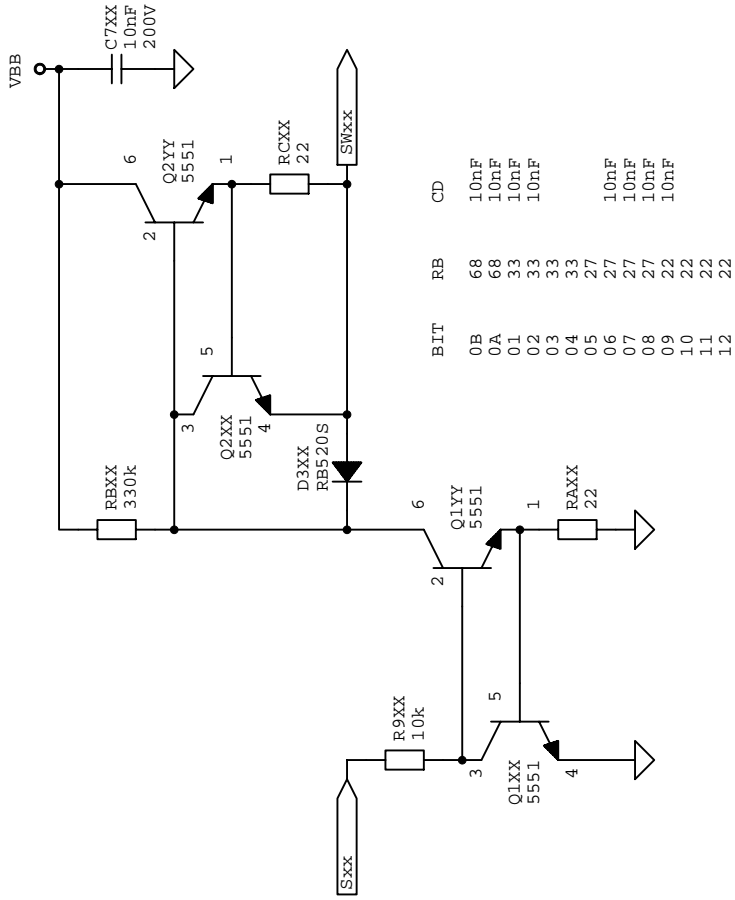
Do not connect anything to the NC (no connect) pins. They are used for internal signaling (PIN diode drive voltages).

### PCB EDGES

The edges of the bottom circuit board have exposed inner layer traces (GND, V<sub>CC</sub>). Care must be taken such that they do not short to adjacent components.







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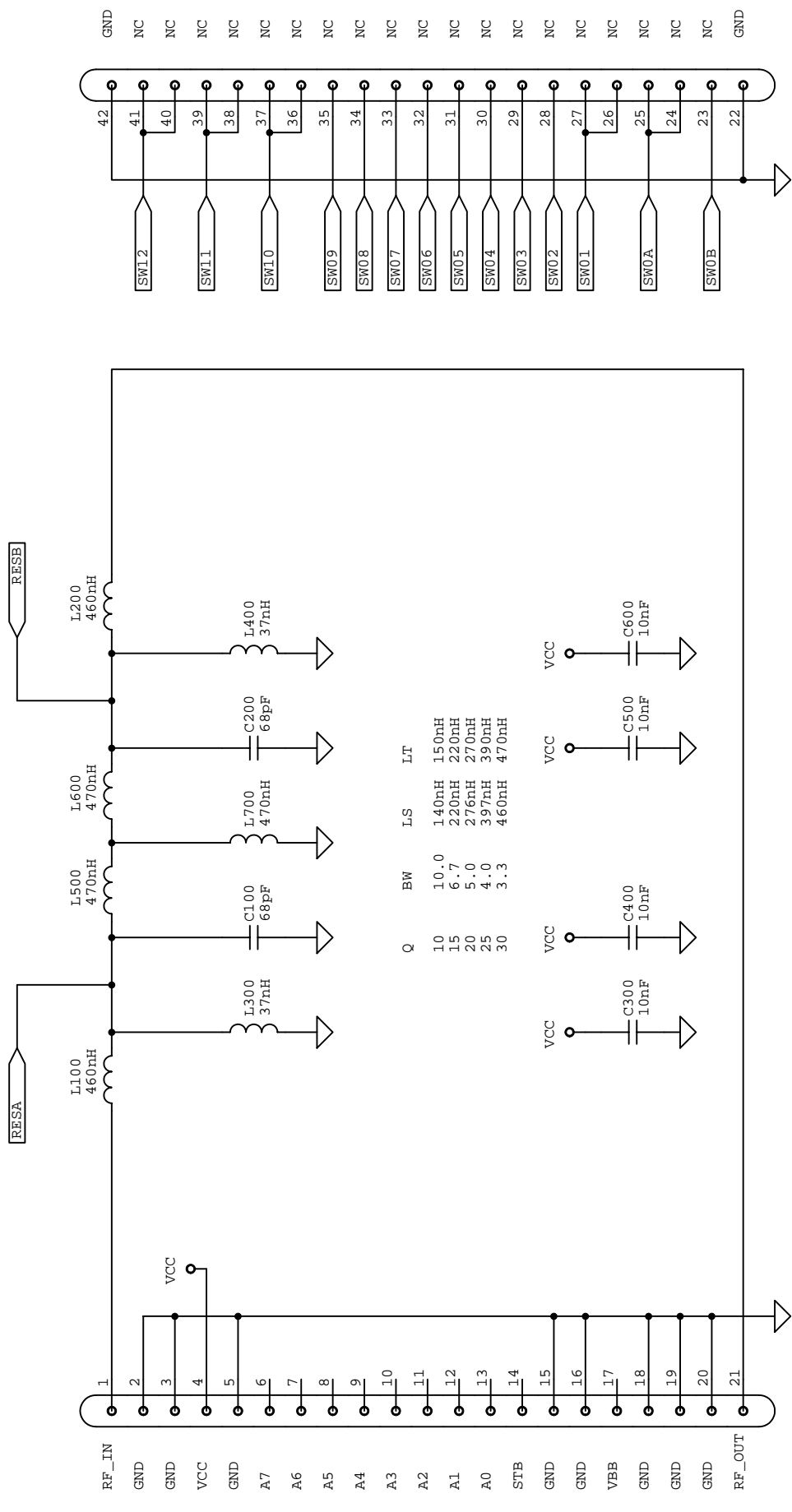
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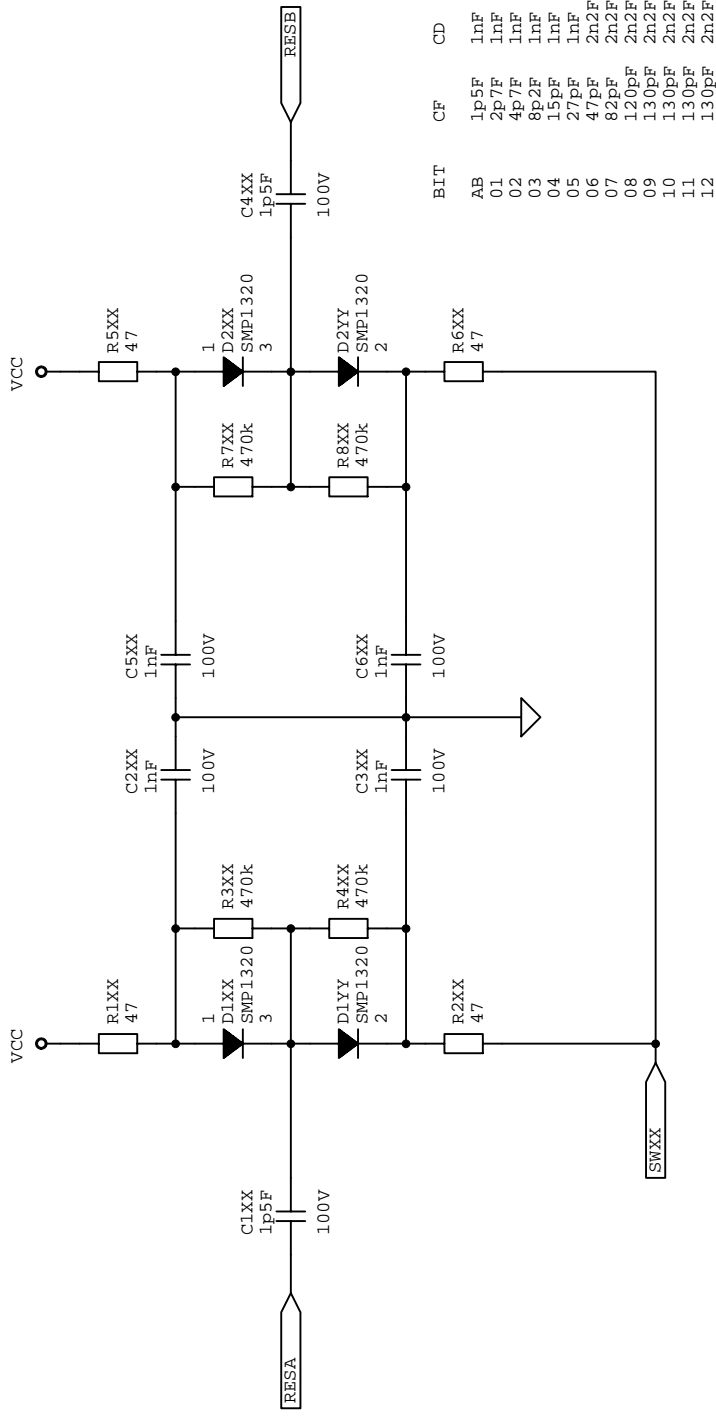
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| BIT | CF    | CD   |
|-----|-------|------|
| AB  | 1p5F  | 1nF  |
| 01  | 2p7F  | 1nF  |
| 02  | 4p7F  | 1nF  |
| 03  | 8p2F  | 1nF  |
| 04  | 15pF  | 1nF  |
| 05  | 27pF  | 1nF  |
| 06  | 47pF  | 2n2F |
| 07  | 82pF  | 2n2F |
| 08  | 120pF | 2n2F |
| 09  | 130pF | 2n2F |
| 10  | 130pF | 2n2F |
| 11  | 130pF | 2n2F |
| 12  | 130pF | 2n2F |

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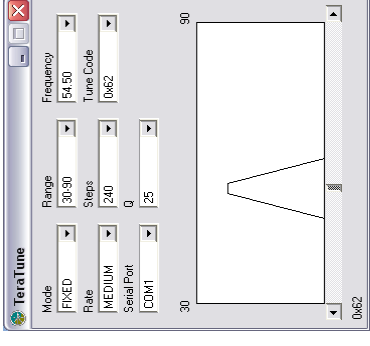
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# TeraTune Project

1300 lines of code



900 lines of code



600 lines of code

330 surface mount parts  
(26 PIN diodes)



300 lines of code



TS-5010  
Rev

12 11 10 09 08 07 06 05 04 03 02 01



Digitally Programmable Bandpass Filter

