

# RC6508

## QAM IF Downconverter

### Features

- Integrated IF Down Converter
- IF bandwidth from 30 MHz to 80 MHz
- Operating range between 8.5V to 13.2V
- 63dB peak conversion gain from IF to baseband
- 40dB minimum AGC range
- Simple interface to SAW filter and A/D converter
- Gain control minimizes noise figure and distortion
- Tuner control feature interfaces with variety of tuners
- Industry standard 24 Lead SSOP package

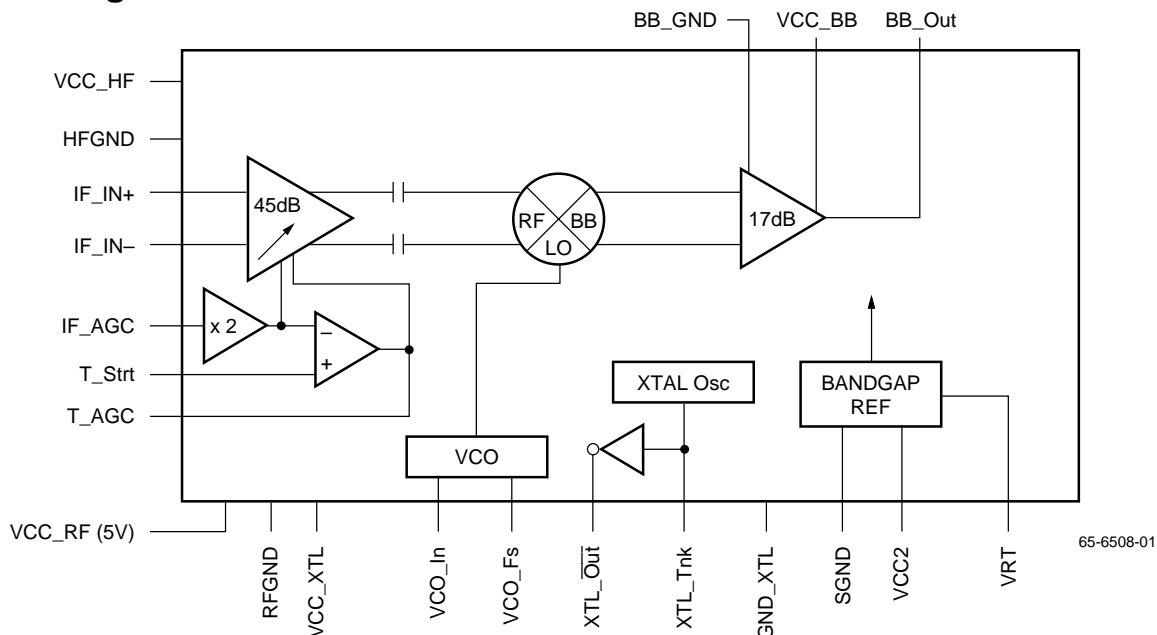
### Applications

- Digital Set-top Receivers
- Cable Modems

### Description

The RC6508 simplifies the front-end design of cable modem and set-top receivers. It is a cost-effective solution, since it integrates IF amplifier, AGC, mixer, amplifier, tuner AGC, VCO, XTAL OSC, and bandgap reference on a single chip. The RC6508 downconverts the IF signal to baseband signal for cable modem and set top receivers. The baseband signal can be digitized and decoded with an external A/D converter and a custom DSP demodulator. The input can directly interface to a SAW filter and maintain a low noise figure. The gain can be controlled over a 40dB range through an external analog input signal. The gain reduction is done in two stages with minimum noise figure and signal distortion. The IF output is then down converted and filtered using a double balanced mixer. The output can be further filtered with an external filter prior to A/D conversion. The RC6508 has an added feature that it provides an optimum tuner AGC control voltage which is used to control the front end tuner gain. The IF and Mixer section works at 9V and the oscillator works on 5V supply. The RC6508 is available in a 24 Lead SSOP package.

### Block Diagram



## Functional Description

The RC6508 shown in the block diagram performs all the IF and baseband signal conversion with the minimal external components. It consists of three general sections:

- IF Gain Section
- IF Down Conversion and Frequency Synthesis
- Reference Voltage

### IF Gain Section

This is the first stage of the IF-to-Baseband conversion. The IF input signal is fed into a variable gain control amplifier that is capacitively coupled to the subsequent stages. The gain control amplifier has stabilized gain over temperature and supply variations. The amplifier gain is directly proportional to the IF\_AGC voltage. The gain in various stages is not reduced at the same time in order to minimize the noise figure degradation. The transition point is set by the voltage on T\_Strt pin. T\_strt sets the T\_AGC trigger to control the front end tuner gain.

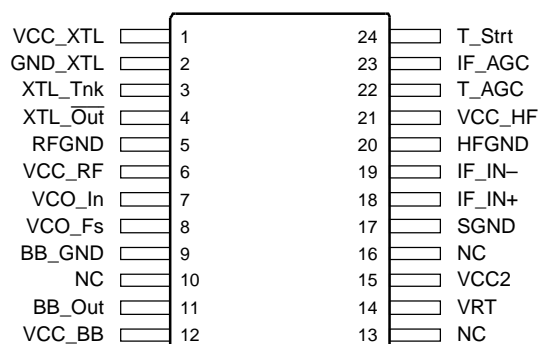
### IF Down Conversion and Frequency Synthesis

This is the second stage of the IF-to-Baseband conversion. It consists of a double balanced linear mixer. The output of the front end gain stage is capacitively coupled to the input (RF port) of the mixer. The LO signal for the mixer can be directly driven or synthesized with the Voltage Controlled Oscillator (VCO). This section has also a crystal oscillator that can be used to generate a master clock for the frequency synthesis. The mixer translates the signal to a second IF frequency equal to the symbol rate and passes through an amplifier. The final output is a baseband signal, BB\_Out. This signal can be further filtered externally before connecting it to an external ADC and QAM demodulator.

### Reference Voltage

The RC6508 has a built-in 2.0V reference with capability of driving 10mA load and can be used to set up A/D reference.

## Pin Assignments



65-6508-02

## Pin Descriptions

| Pin Name      | Pin Number | Pin Function Description                                      |
|---------------|------------|---|
| BB_GND        | 9          | Ground Connection.  |
| BB_Out        | 11         | Baseband Voltage output.                                      |
| GND_XTL       | 2          | Crystal Oscillator Ground.                                    |
| HFGND         | 20         | Analog Ground Connection.                                     |
| IF_AGC        | 23         | Input Voltage for IF Front End Gain Control.                  |
| IF_IN+,IF_IN- | 18,19      | IF inputs.  |
| NC            | 10,13,16   | No Connection.  |
| RFGND         | 5          | Ground Connection for High Frequency Mixed Signal Sections.   |
| SGND          | 17         | Analog Ground Connection.                                     |
| T_AGC         | 22         | Output Voltage for Tuner Gain Control.                        |
| T_Strt        | 24         | Threshold Voltage Input for Starting Tuner Gain Control.      |
| VCC_BB        | 12         | Baseband Supply Voltage, typically 9V.                        |
| VCC2          | 15         | Analog Supply Voltage (9V).                                   |
| VCC_HF        | 21         | Analog Supply Voltage (9V).                                   |
| VCC_RF        | 6          | Supply Voltage (5V) for High Frequency Mixed Signal Sections. |
| VCC_XTL       | 1          | Supply Voltage for Crystal Oscillator.                        |
| VCO_Fs        | 8          | VCO External Frequency Select Circuit Connection.             |
| VCO_In        | 7          | VCO Input, can be used for directly feeding external LO.      |
| VRT           | 14         | Output reference voltage for top of A/D input range.          |
| XTL_Out       | 4          | Crystal Oscillator Output.                                    |
| XTL_Tnk       | 3          | Crystal Oscillator Frequency Select Circuit Connection.       |

## Absolute Maximum Ratings

| Parameter                                   |                        | Min.      | Typ. | Max.      | Units |
|---|------------------------|-----------|------|-----------|-------|
| IF_IN+, IF_IN-,<br>IF_AGC, T_Strt           | Input Voltages         | GND – 0.3 |      | VCC + 0.3 | V     |
| VCC_RF, VCC_BB,<br>VCC_HF, VCC2,<br>VCC_XTL | Analog Supply Voltages |           |      | 13.5      | V     |
| Tstg  | Storage Temperature    | -40       |      | 125       | °C    |

## Operating Conditions

| Parameter |                                   | Min. | Typ. | Max. | Units |
|-----------|-----------------------------------|------|------|------|-------|
| VCC       | Analog Supply Voltage             | 8.5  | 9    | 13.2 | V     |
| VCC_RF    | Supply Voltage for IF and Mixer   | 4.75 | 5    | 5.25 | V     |
| VCC_XTL   | Supply Voltage for XTLOSC and VCO |      |      |      |       |
| T         | Temperature                       | 0    |      | 70   | °C    |

## DC Electrical Characteristics

VCC\_RF, VCC\_XTL = 5V; VCC\_HF, VCC\_BB, VCC2 = 9V; T<sub>A</sub> = 0 to 70°C, unless otherwise specified.

| Parameter         | Conditions                 | Min.        | Typ. | Max. | Units |                 |
|-------------------|----------------------------|-------------|------|------|-------|-----------------|
| PWIF              | Power Consumption in IF    |             | 0.4  | 0.5  | W     |                 |
| ICCHF             | Front End Supply Current   | 9V Supply   | 20   | 25   | mA    |                 |
|                   |                            | 12V Supply  | 27   | 35   |       |                 |
| ICCBB             | Back and Baseband Current  | 9V Supply   | 21   | 25   | mA    |                 |
| ICCRF             | RF Supply Current          | 5V Supply   | 6    | 10   | mA    |                 |
| VRT               | Reference Output Voltage   |             | 1.95 | 2.05 | 2.15  | V               |
| ΔVBB <sub>o</sub> | Baseband DC Output Swing   |             | 3.5  |      |       | V <sub>pp</sub> |
| Tagc_hi           | Tuner AGC for Maximum Gain | IF_AGC = 5V |      | 7.5  |       | V               |
| Tagc_lo           | Tuner AGC for Minimum Gain | IF_AGC = 2V |      | 2    |       | V               |

**AC Electrical Characteristics** VCC\_XTL, VCC\_RF = 5V; VCC\_HF, VCC\_BB = 9V; IF\_AGC = 2V; T<sub>sr</sub> = 5V; T<sub>A</sub> = 0 to 70°C, unless otherwise specified.

| Parameter          | Conditions                        | Min.   | Typ. | Max.  | Units |        |
|--------------------|-----------------------------------|--|------|-------|-------|--------|
| ZIFin              | AC Input Impedance                | @43.75MHz  | 2    |       | KΩ    |        |
| CIFin              | AC Equivalent Input Cap           | IF_IN±   |      | 6     | pF    |        |
| Vis                | Input Sensitivity at Maximum Gain | V <sub>agc</sub> =2.5V   |      | 250   | μV    |        |
| IMD3               | Two Tone Intermodulation          | f1/f2 = 43.75/42.75 MHz,<br>IF_IN = -16dBm,<br>VCO_IN = 0.1V <sub>pp</sub> ,<br>LO = 38.75MHz <sup>1</sup> |      | 45    |       | dB     |
| G                  | IF to Baseband Gain               | IF_AGC = 2V  | 35   | 40    |       | dB     |
| NF                 | Noise Figure (Maximum Gain)       |  |      | 9     |       | dB     |
| Ragc               | AGC Gain Range                    | IF_AGC = 0V-4V   | 40   | 43    |       | dB     |
| Sagc               | AGC Sensitivity Average Slope     | T_Strt = 5V,<br>F_AGC = 0.8V-4V  |      | 10    |       | dB/V   |
| BW_IF              | IF Bandwidth                      | 0.1dB for 10MHz bands  | 30   | 43.75 | 75    | MHz    |
|                    |                                   | 0.1dB for 5MHz bands   | 30   |       | 80    |        |
| fLO                | Down Conversion Frequency         | VCO-IN=0.1V <sub>pp</sub>  |      |       | 100   | MHz    |
| Φ <sub>n</sub> LO  | VCO Phase Noise                   | @ ±10KHz offset  |      |       | -80   | dBc/Hz |
| Φ <sub>n</sub> XTL | XTAL OSC Phase Noise              | @ ±3KHz offset   |      |       | -80   | dBc/Hz |

**Note:**

1. With the application of antialiasing filter as load.

### Typical Performance Characteristics

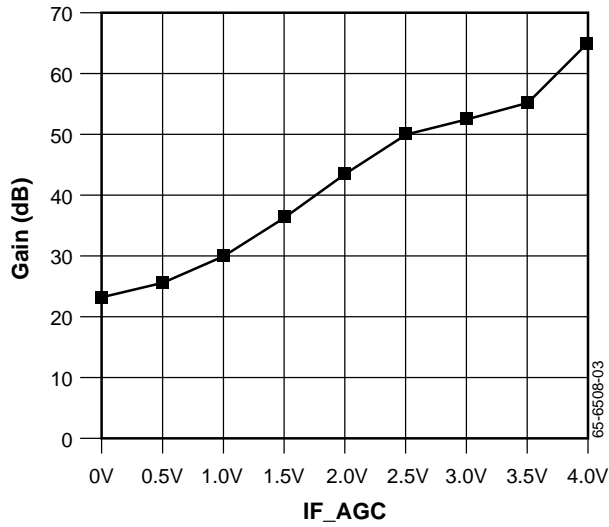


Figure 1. Typical IF\_AGC Control Characteristics

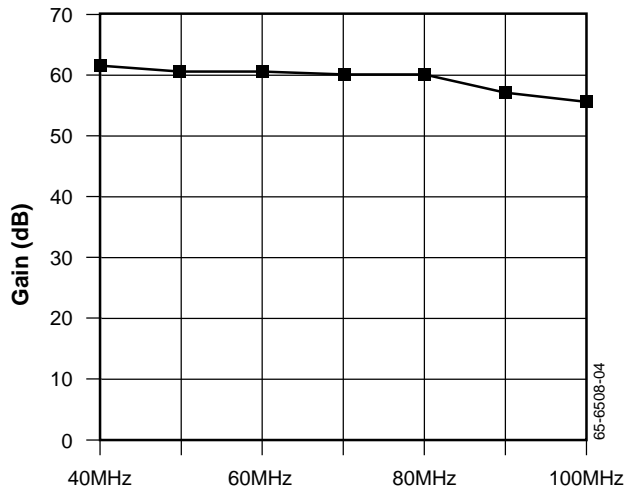


Figure 2. IF Input Bandwidth

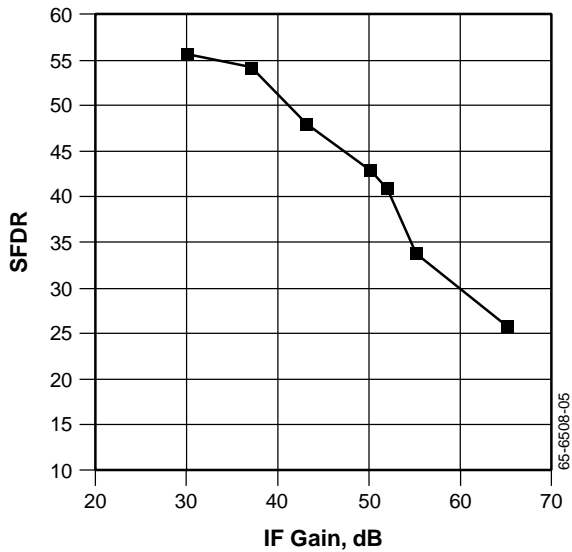


Figure 3. SFDR vs. RC6508/TMC1175AM7C40 (Raytheon Demo Board with 64 QAM demodulator)

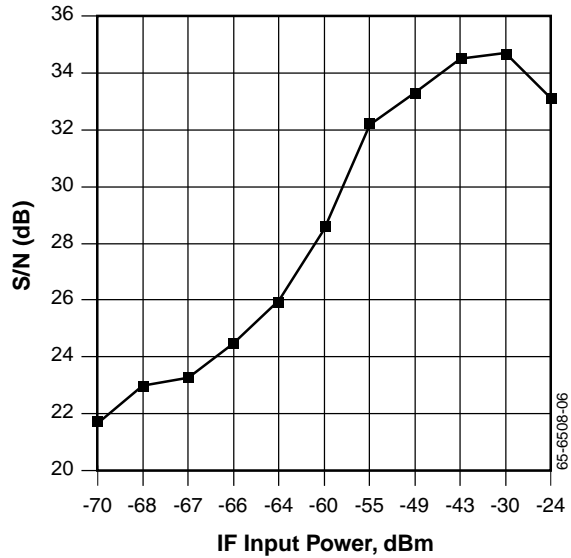


Figure 4. S/N vs. IF Input Power RC6508/TMC1175AM7C40 (A/D IN = 2Vpp) (Raytheon Demo Board with 64 QAM demodulator)

# Applications

The RC6508 is designed to down convert QAM IF signals. It interfaces easily with Raytheon Electronic's TMC1175A A/D converter and a DSP.

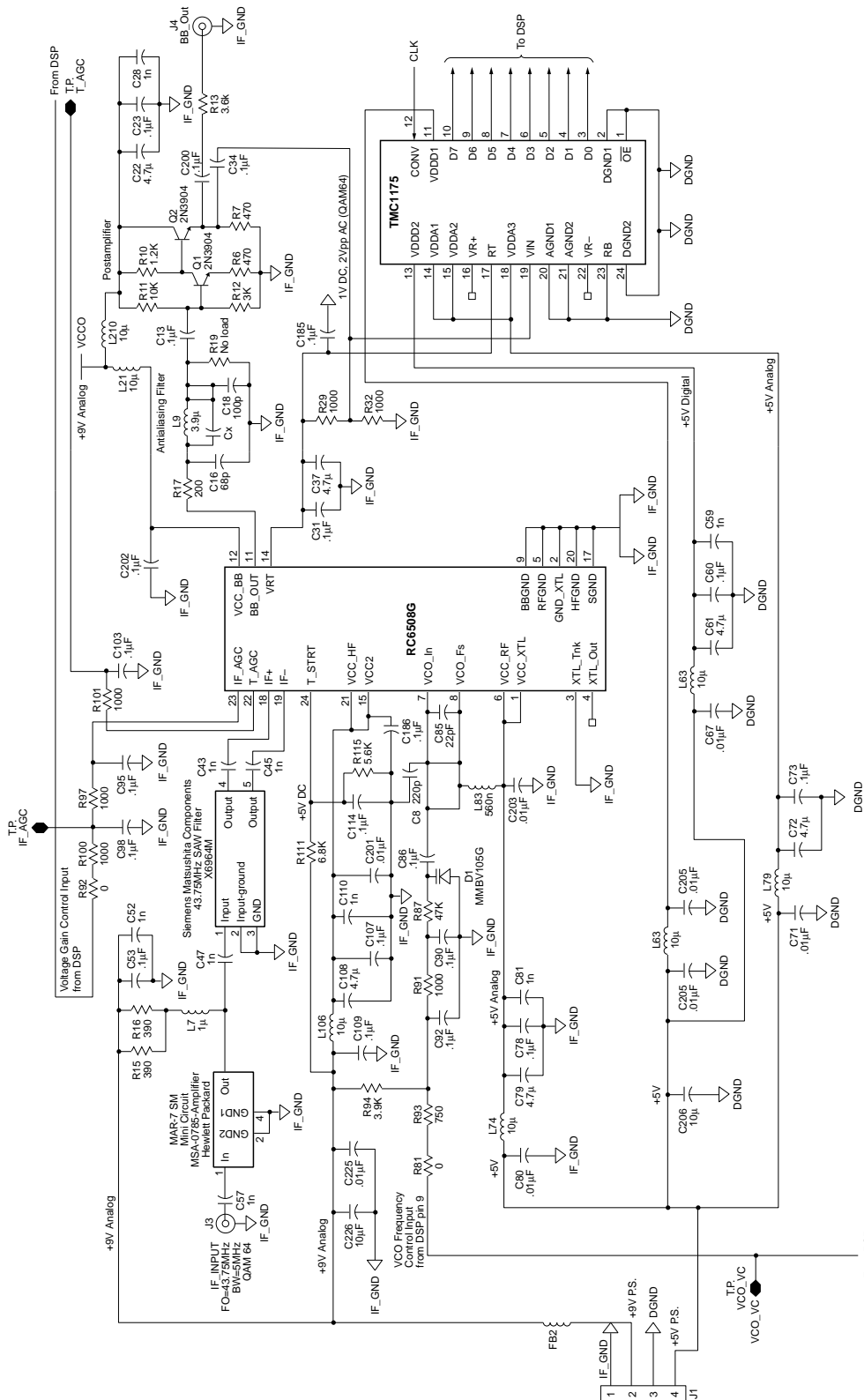
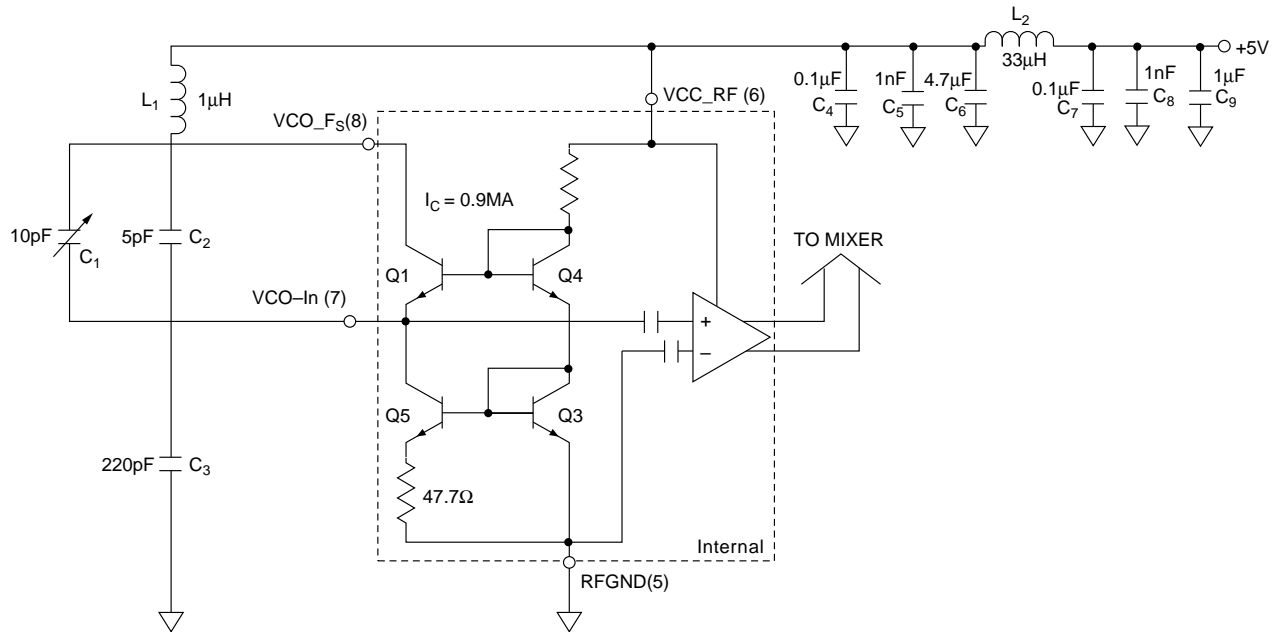


Figure 5. Application of RC6508 in Cable Modem Receivers (Raytheon Demo Board with 64 QAM Demodulator)

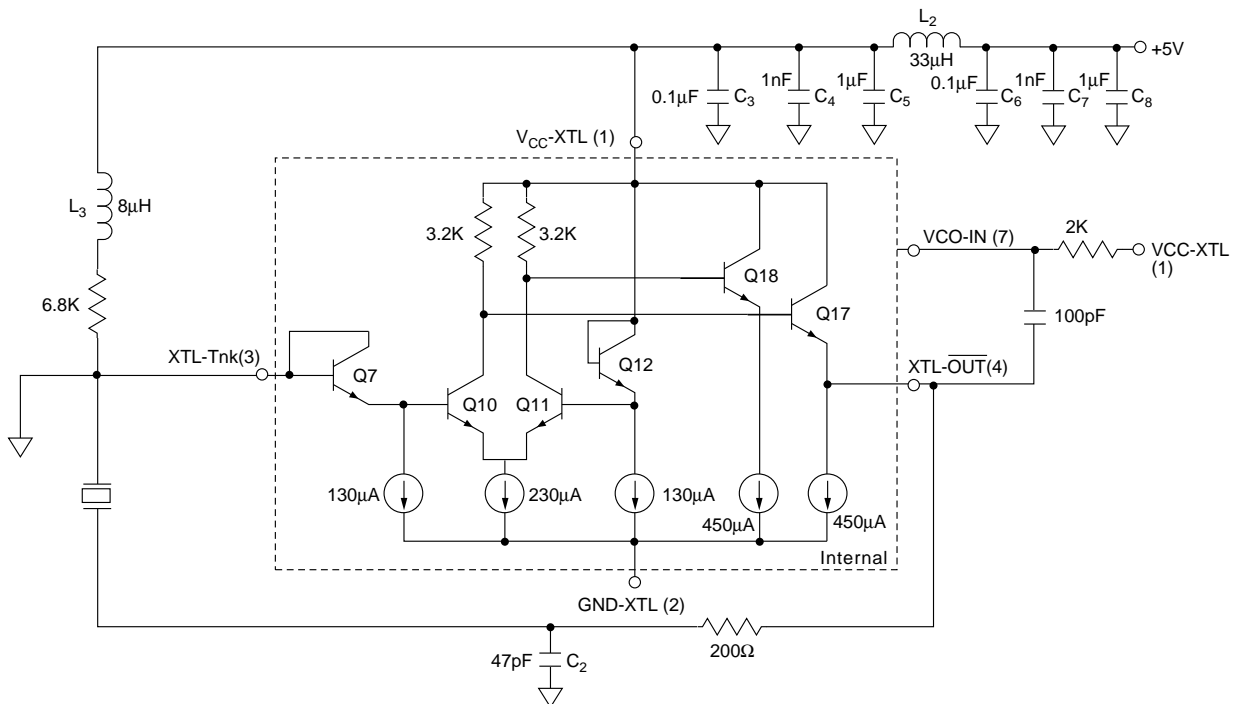
### VCO Internal Schematic



The VCO can be designed as a Colpitts oscillator. The above circuit application shows VCO with adjustable typical value of 38.75 MHz. The frequency is controlled by the external resonance circuit. The oscillating transistor is Q1 in common

base configuration. To inject signal in the mixer in place of LO, the VCO\_Fs must be open. The signal on the pin VCO\_In should be under 100mVp-p and AC coupled.

### Crystal Oscillator Internal Schematic



The crystal oscillator is an ECL inverter. It is necessary to bias the XTl-Tnk with a choke to 5V VCC\_XTL power supply. The output is about 0.7V DC lower than VCC\_XTL with

an approximate swing of 0.5Vpp at the output. If the oscillator is not used, it is good to ground XTl\_Tnk pin.

**Notes:**



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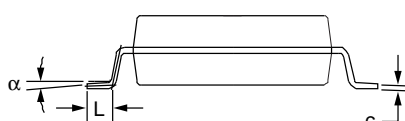
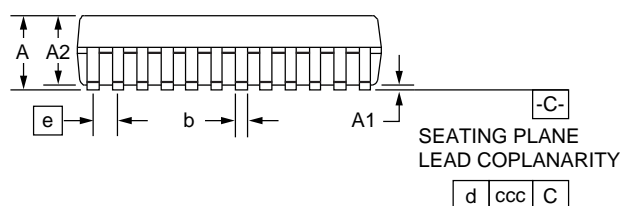
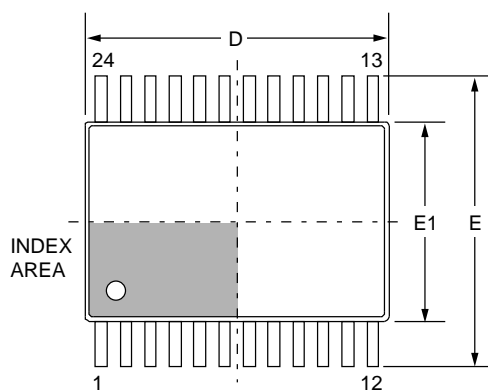
# Mechanical Dimensions

## 24 Lead SSOP Package (5.3mm Body Width)

| Symbol   | Inches   |       | Millimeters |      | Notes |
|----------|----------|-------|-------------|------|-------|
|          | Min.     | Max.  | Min.        | Max. |       |
| A        | —        | .0.78 | —           | 2.00 |       |
| A1       | .002     | —     | 0.05        | —    |       |
| A2       | .065     | .073  | 1.65        | 1.85 |       |
| b        | .010     | .015  | 0.22        | 0.38 |       |
| c        | .0035    | .010  | 0.09        | 0.25 |       |
| D        | .311     | .335  | 7.90        | 8.50 |       |
| E        | .291     | .323  | 7.40        | 8.20 |       |
| E1       | .197     | .220  | 5.00        | 5.60 |       |
| e        | .026 BSC |       | 0.65 BSC    |      |       |
| L        | .022     | .037  | 0.55        | 0.95 |       |
| N        | 24       |       | 24          |      |       |
| $\alpha$ | 0°       | 8°    | 0°          | 8°   |       |
| ccc      | —        | .004  | —           | 0.10 |       |

**Notes:**

1. Dimensioning and tolerancing per ANSI Y14.5M – 1982.
2. "D" and "E" do not include mold flash. Mold flash or protrusions shall not exceed .006 inch (0.15mm).
3. "L" is the length of terminal for soldering to a substrate.
4. Terminal numbers are shown for reference only.
5. "C" dimension does not include solder finish thickness.
6. Symbol "N" is the maximum number of terminals.



## Ordering Information

| Product Number | Temperature Range | Screening  | Package      | Package Marking |
|----------------|-------------------|------------|--------------|-----------------|
| RC6508G        | 0°C–70°C          | Commercial | 24 Lead SSOP | RC6508G         |

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Raytheon Electronics  
Semiconductor Division  
350 Ellis Street  
Mountain View CA 94043  
650.968.9211  
FAX 650.966.7742