



Q3500 Series of Voltage Controlled Oscillators

FEATURES

- Wide-Band Frequency Synthesis: Octave and near-octave bandwidths
- Robust Performance. No moding, dropout, or subharmonic pumping over temperature (any phase into a 12 dB return loss)
- Modulation Sensitivity (K_v) optimized for PLL gain normalization for improved stability, phase noise, and settling time
- Low tuning Voltage Range reduces power supply constraints

APPLICATIONS

- VSAT (Very Small Aperture Terminals)
- DBS (Direct Broadcast Systems)
- GPS (Global Positioning Systems)
- Digital Radios and Modems
- Mobile/Airborne Communications Systems
- High Performance Synthesizer Instrumentation
- Wide-Band Frequency Synthesizers
- Spread Spectrum Systems
- Wireless Communications



INTRODUCTION

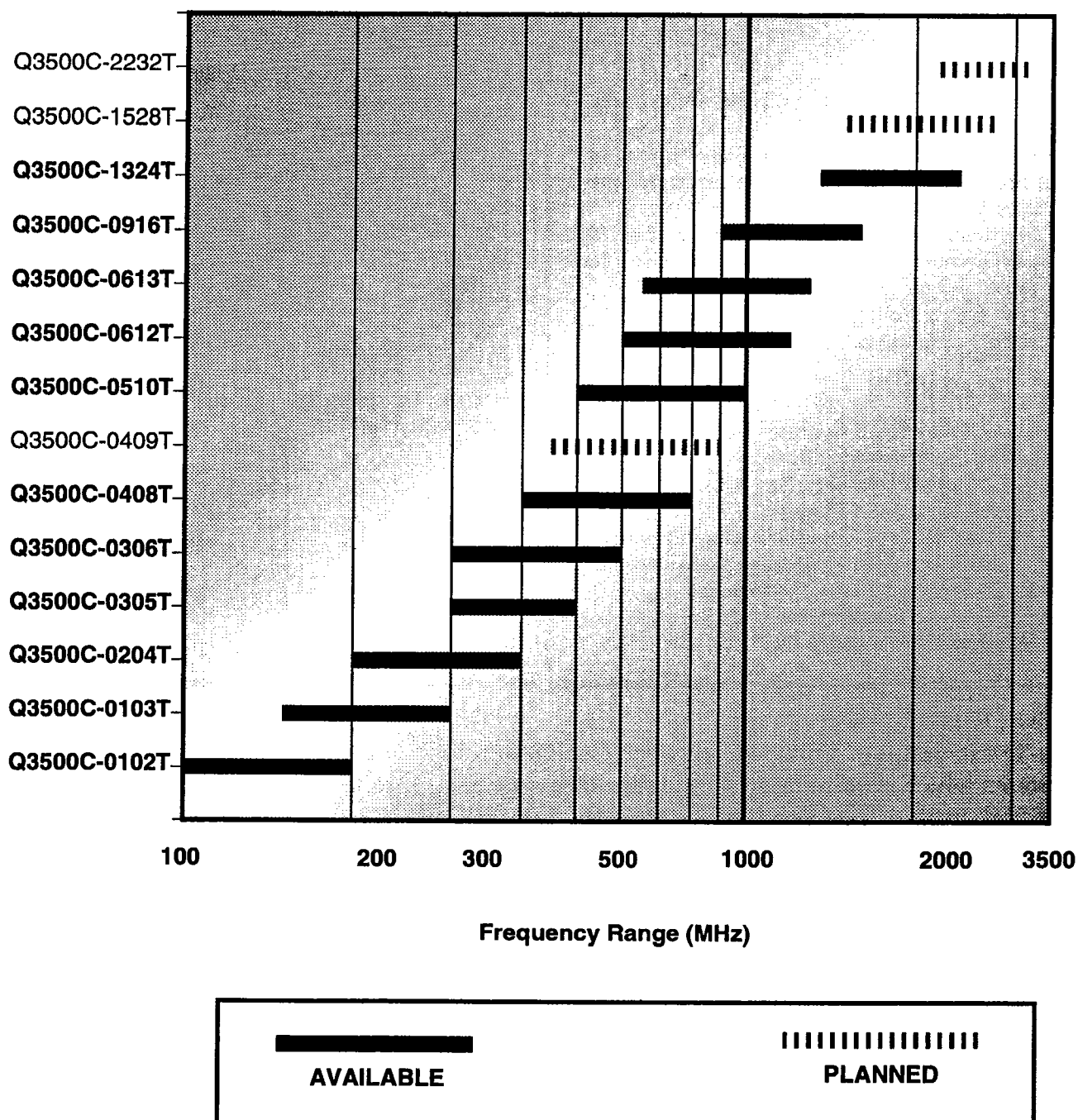
The Q3500 series of Voltage Controlled Oscillators (VCO's) is ideal for cost sensitive systems which require frequency synthesis over a wide frequency range with excellent spectral purity. The Q3500 VCO's are also ideal for operation with the QUALCOMM Q3036 Phase-Locked Loop Frequency Synthesizer (PLLFS). The combination of the Q3036 PLLFS and Q3500 VCO results in a high performance synthesizer which provides wide-band frequency synthesis and exceptional spectral purity.

This Q3500 VCO family provides robust and dependable performance. QUALCOMM engineered the Q3500 VCOs to eliminate moding, dropout and subharmonic pumping over the full temperature range. The QUALCOMM Q3500 family of VCO's uses a proprietary hyper-abrupt varactor-based design technology which provides wide-band output frequency generation with a low tuning voltage range.

The Q3500 Series collectively covers the frequency range of 100-2400 MHz. Other versions in development will extend this range from 100-3300 MHz.

Figure 1 shows the available and planned versions of the Q3500.

Tables 1A-G show the absolute Maximum/Minimum, Guaranteed and Typical performance characteristics.

**Figure 1. Q3500 VCO Product Selection Guide**

[Contact QUALCOMM if you have specific VCO frequency requirements not directly covered by this chart]

Q3500 Series of Voltage Controlled Oscillators**3****Table 1A. Q3500C-0102T (100-200 MHz) VCO Technical Specification****ABSOLUTE MAXIMUM / MINIMUM RATINGS**

PARAMETER	RATING
Maximum Supply Voltage	+15.0 V
Tuning Voltage MIN/MAX	0/20 V

TYPICAL PERFORMANCE (0 - 70°C)

PARAMETER	DATA
Nominal Supply Voltage	+12 V
Power Output (50 Ω)	+14 dBm
Typical Current	27 mA
Tuning Voltage	1.3-12.9 V
FM (Phase) Noise:	
1 KHz Offset	-85 dBc/Hz
10 KHz Offset	< -102 dBc/Hz
100 KHz Offset	< -118 dBc/Hz
1 MHz Offset	< -130 dBc/Hz
Frequency Pushing	0.2 MHz/V for 12 ± 1 V
Frequency Pulling (12dB Rtn Loss)	3 MHz peak-peak
Harmonic Spurious (Avg)	-4 dBc

GUARANTEED PERFORMANCE (0 - 70°C)

PARAMETER	DATA
Power Dissipation	480 mW max (40 mA @ +12 V)
Frequency Tuning Range	100 to 200 MHz min
Power Output (50 Ω)	11 dBm min

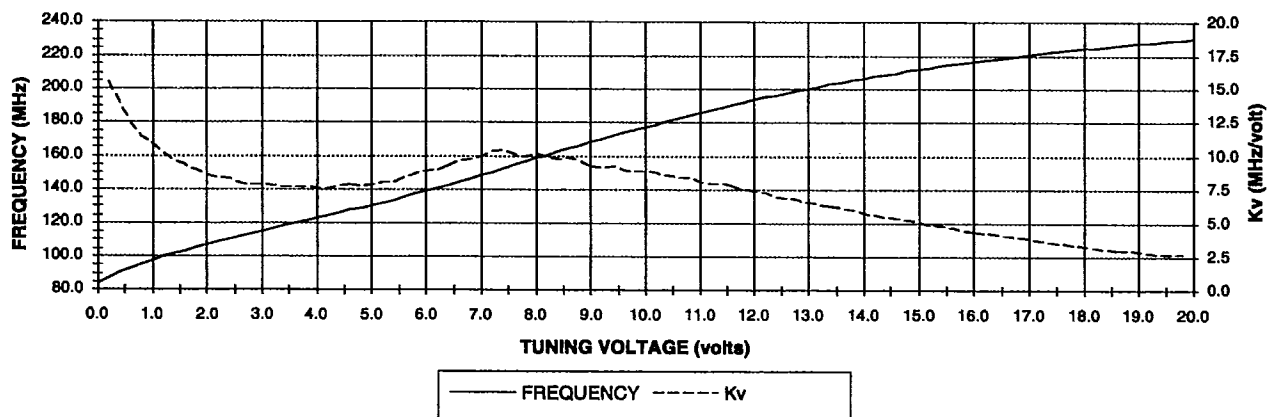
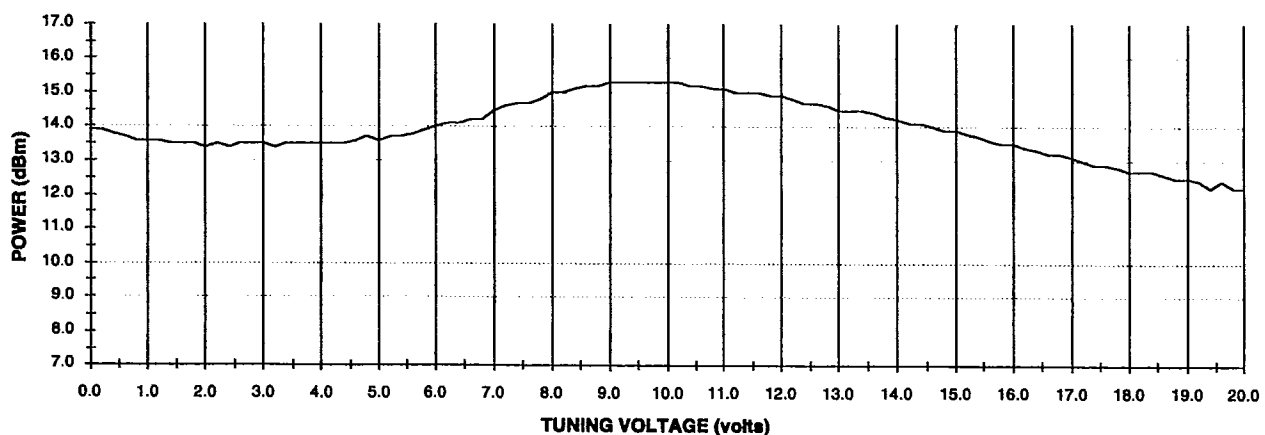
Figure 2A. Performance Curves for Q3500C-0102T**100-200 MHz VCO TYPICAL OUTPUT FREQUENCY/MODULATION SENSITIVITY VERSUS TUNING VOLTAGE****100-200 MHz VCO TYPICAL OUTPUT POWER VERSUS TUNING VOLTAGE**

Table 1B. Q3500C-0103T (150-300 MHz) VCO Technical Specification

ABSOLUTE MAXIMUM / MINIMUM RATINGS

PARAMETER	RATING
Maximum Supply Voltage	+15.0 V
Tuning Voltage MIN/MAX	0/20 V

TYPICAL PERFORMANCE (0 - 70°C)

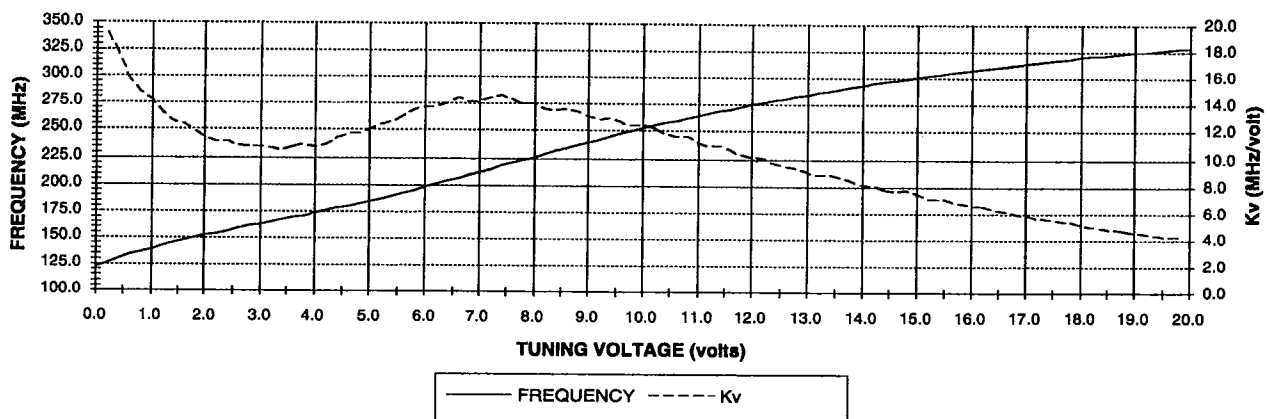
PARAMETER	DATA
Nominal Supply Voltage	+12 V
Power Output (50 Ω)	+12 dBm
Typical Current	26 mA
Tuning Voltage	1.7-14.4 V
FM (Phase) Noise:	
1 KHz Offset	-82 dBc/Hz
10 KHz Offset	< -102 dBc/Hz
100 KHz Offset	< -118 dBc/Hz
1 MHz Offset	< -130 dBc/Hz
Frequency Pushing	0.4 MHz/V for $12 \pm 1V$
Frequency Pulling (12dB Rtn Loss)	4 MHz peak-peak
Harmonic Spurious (Avg)	-4 dBc

GUARANTEED PERFORMANCE (0 - 70°C)

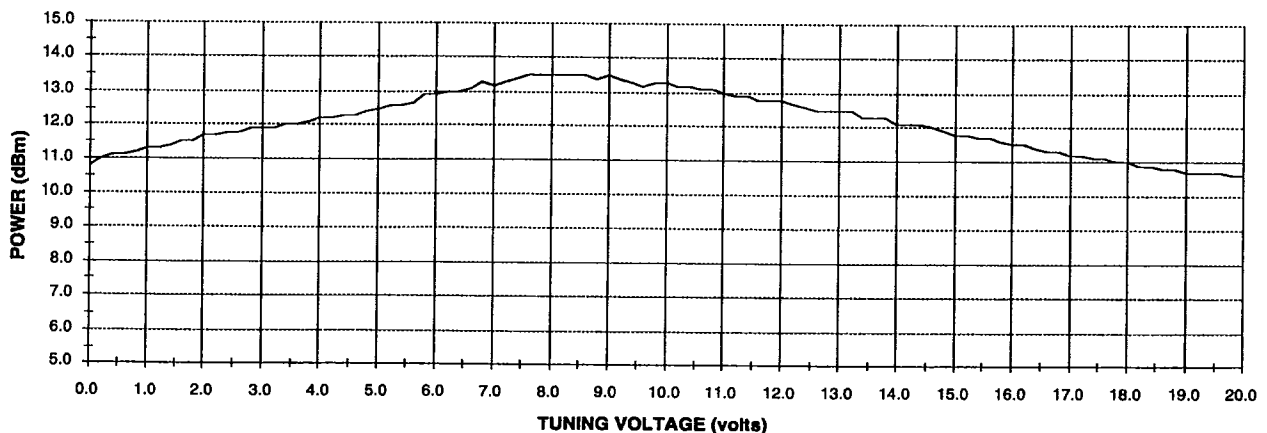
PARAMETER	DATA
Power Dissipation	420 mW max (35 mA @ +12 V)
Frequency Tuning Range	150 to 300 MHz min
Power Output (50 Ω)	9 dBm min

Figure 2B. Performance Curves for Q3500C-0103T

150-300 MHz VCO TYPICAL OUTPUT FREQUENCY/MODULATION SENSITIVITY VERSUS TUNING VOLTAGE



150-300MHz TYPICAL OUTPUT POWER VS TUNING VOLTAGE



Q3500 Series of Voltage Controlled Oscillators

5

Table 1C. Q3500C-0204T (200-400 MHz) VCO Technical Specification

ABSOLUTE MAXIMUM / MINIMUM RATINGS

PARAMETER	RATING
Maximum Supply Voltage	+14.5 V
Tuning Voltage MIN/MAX	0/20 V

TYPICAL PERFORMANCE (0 - 70°C)

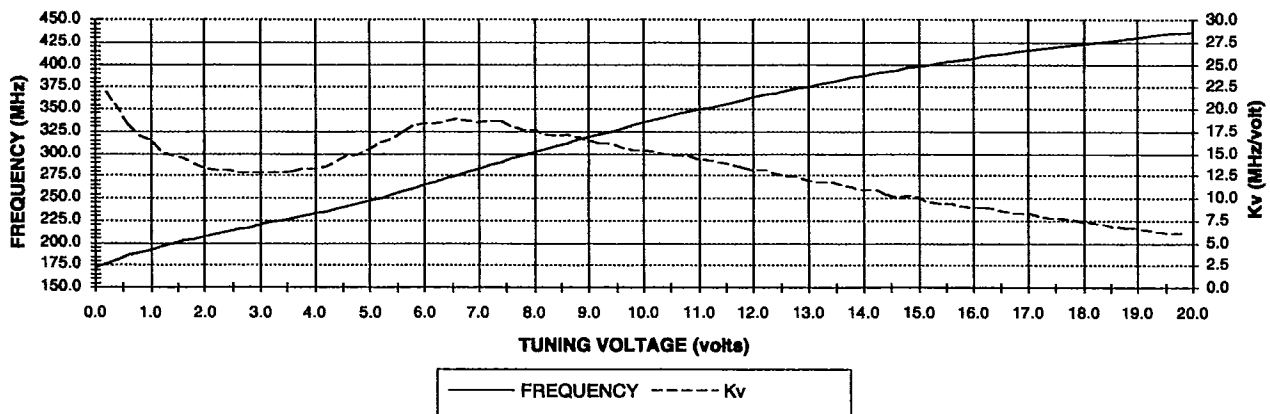
PARAMETER	DATA
Nominal Supply Voltage	+12 V
Power Output (50 Ω)	+12.5 dBm
Typical Current	26 mA
Tuning Voltage	1.6-15.4 V
FM (Phase) Noise:	
1 KHz Offset	-80 dBc/Hz
10 KHz Offset	-101 dBc/Hz
100 KHz Offset	< -118 dBc/Hz
1 MHz Offset	< -130 dBc/Hz
Frequency Pushing	0.3 MHz/V for 12 ± 1 V
Frequency Pulling (12dB Rtn Loss)	5 MHz peak-peak
Harmonic Spurious (Avg)	-4.5 dBc

GUARANTEED PERFORMANCE (0 - 70°C)

PARAMETER	DATA
Power Dissipation	420 mW max (35 mA @ +12 V)
Frequency Tuning Range	200 to 400 MHz min
Power Output (50 Ω)	10 dBm min

Figure 2C. Performance Curves for Q3500C-0204T

200-400 MHz VCO TYPICAL OUTPUT FREQUENCY/MODULATION SENSITIVITY VERSUS TUNING VOLTAGE



200-400MHz VCO TYPICAL OUTPUT POWER VERSUS TUNING VOLTAGE

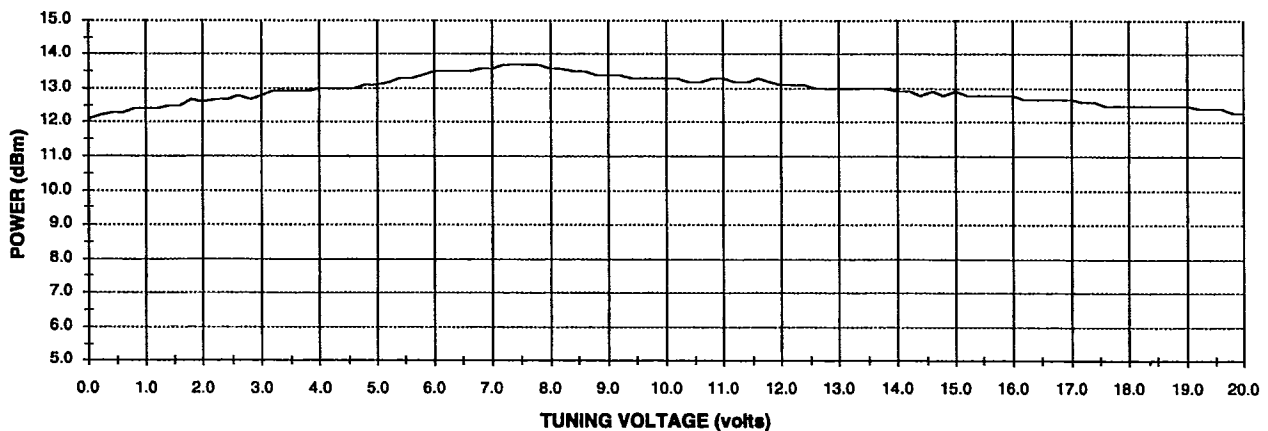


Table 1D. Q3500C-0305T (300-500 MHz) VCO Technical Specification

ABSOLUTE MAXIMUM / MINIMUM RATINGS

PARAMETER	RATING
Maximum Supply Voltage	+14.5 V
Tuning Voltage MIN/MAX	0/20 V

TYPICAL PERFORMANCE (0 - 70°C)

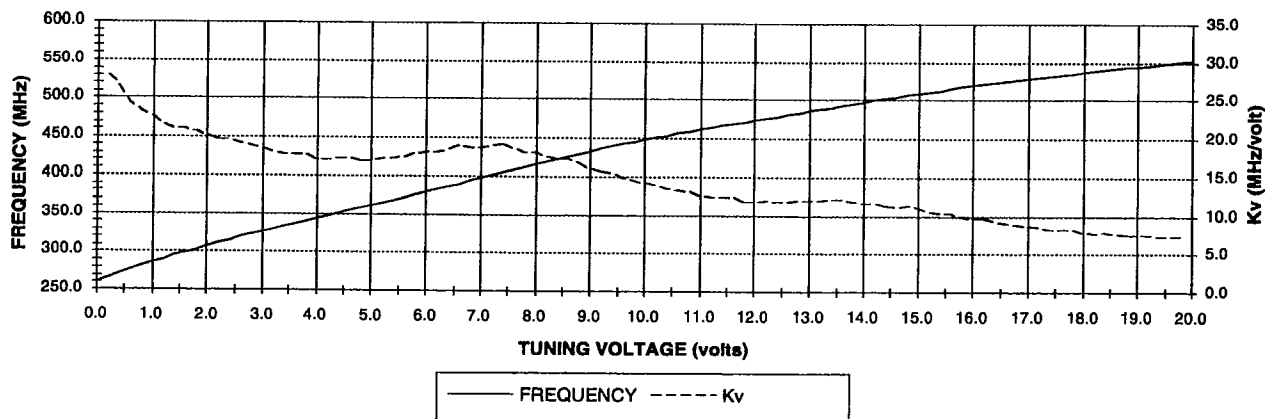
PARAMETER	DATA
Nominal Supply Voltage	+12 V
Power Output (50 Ω)	+12 dBm
Typical Current	26 mA
Tuning Voltage	1.6-14.0 V
FM (Phase) Noise:	
1 KHz Offset	-78 dBc/Hz
10 KHz Offset	-100 dBc/Hz
100 KHz Offset	< -118 dBc/Hz
1 MHz Offset	< -130 dBc/Hz
Frequency Pushing	1.5 MHz/V for 12 ± 1 V
Frequency Pulling (12dB Rtn Loss)	8 MHz peak-peak
Harmonic Spurious (Avg)	-4 dBc

GUARANTEED PERFORMANCE (0 - 70°C)

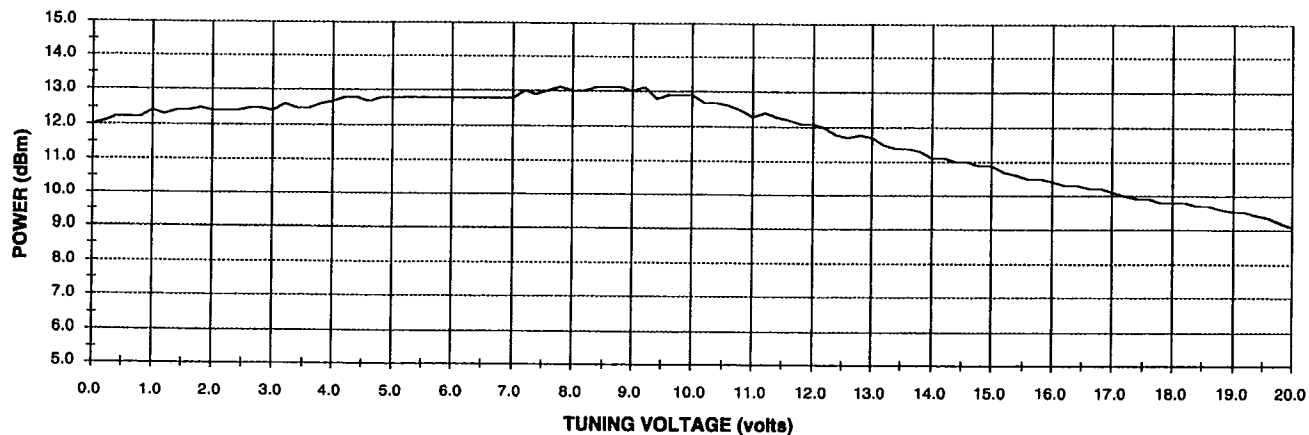
PARAMETER	DATA
Power Dissipation	360 mW max (30 mA @ +12 V)
Frequency Tuning Range	300 to 500 MHz min
Power Output (50 Ω)	9 dBm min

Figure 2D. Performance Curves for Q3500C-0305T

300-500 MHz VCO TYPICAL OUTPUT FREQUENCY/MODULATION SENSITIVITY VERSUS TUNING VOLTAGE



300-500 MHz VCO TYPICAL OUTPUT POWER VERSUS TUNING VOLTAGE



Q3500 Series of Voltage Controlled Oscillators

7

Table 1E. Q3500C-0306T (300-600 MHz) VCO Technical Specification

ABSOLUTE MAXIMUM / MINIMUM RATINGS

PARAMETER	RATING
Maximum Supply Voltage	+15 V
Tuning Voltage MIN/MAX	0/20 V

TYPICAL PERFORMANCE (0 - 70°C)

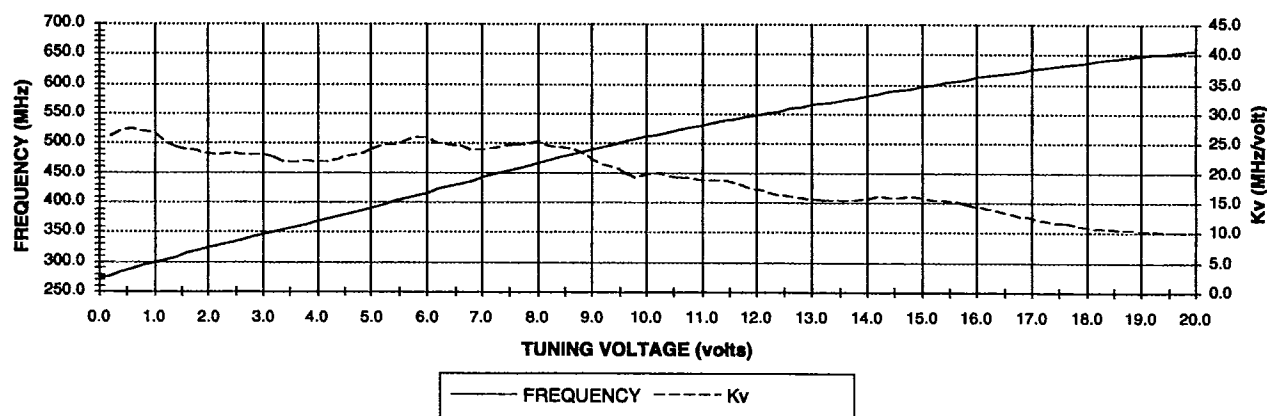
PARAMETER	DATA
Nominal Supply Voltage	+12 V
Power Output (50 Ω)	+9.5 dBm
Typical Current	26 mA
Tuning Voltage	1.0-15.2V
FM (Phase) Noise:	
1 KHz Offset	-72 dBc/Hz
10 KHz Offset	-96 dBc/Hz
100 KHz Offset	-116 dBc/Hz
1 MHz Offset	< -130 dBc/Hz
Frequency Pushing	.7 MHz/V for $12 \pm 1V$
Frequency Pulling (12dB Rtn Loss)	8 MHz peak-peak
Harmonic Spurious (Avg)	-11 dBc
Tuning Port DC Resistance	20 K Ω

GUARANTEED PERFORMANCE (0 - 70°C)

PARAMETER	DATA
Power Dissipation	360 mW max (30 mA @ +12 V)
Frequency Tuning Range	300 to 600 MHz min
Power Output (50 Ω)	9.5 dBm min

Figure 2E. Performance Curves for Q3500C-0306T

300-600 MHz VCO TYPICAL OUTPUT FREQUENCY/MODULATION SENSITIVITY VERSUS TUNING VOLTAGE



300-600 MHz VCO TYPICAL OUTPUT POWER VERSUS TUNING VOLTAGE

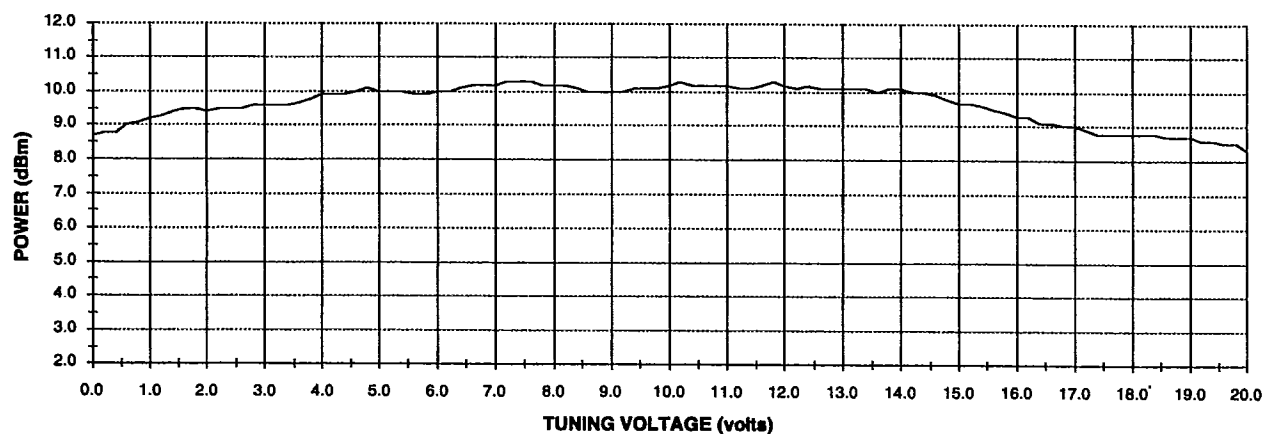


Table 1F. Q3500C-0408T (400-800 MHz) VCO Technical Specification

ABSOLUTE MAXIMUM / MINIMUM RATINGS

PARAMETER	RATING
Maximum Supply Voltage	+15 V
Tuning Voltage MIN/MAX	0/20 V

TYPICAL PERFORMANCE (0 - 70°C)

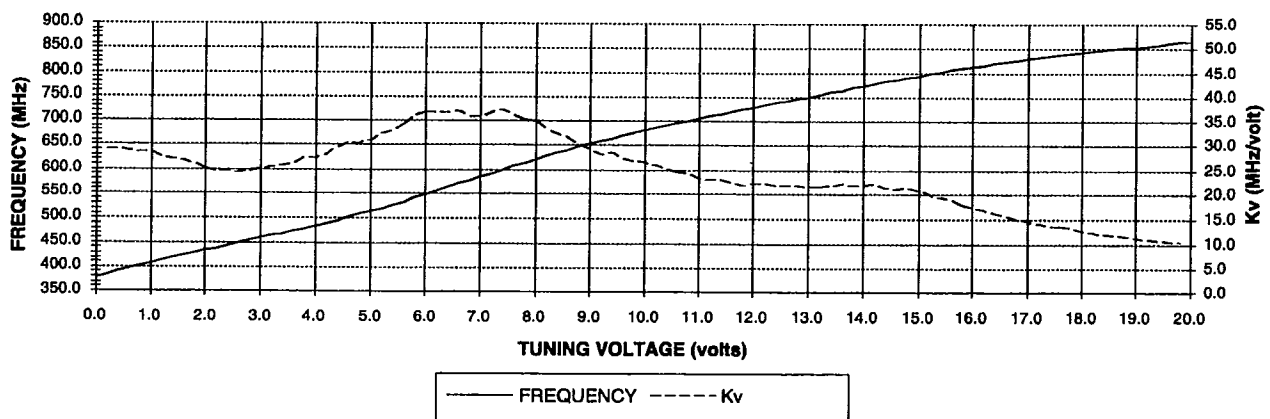
PARAMETER	DATA
Nominal Supply Voltage	+12 V
Power Output (50 Ω)	+10 dBm
Typical Current	26 mA
Tuning Voltage	0.9-15.6 V
FM (Phase) Noise:	
1 KHz Offset	-73 dBc/Hz
10 KHz Offset	-95 dBc/Hz
100 KHz Offset	-114 dBc/Hz
1 MHz Offset	< -129 dBc/Hz
Frequency Pushing	1 MHz/V for 12 ± 1 V
Frequency Pulling (12dB Rtn Loss)	10 MHz peak-peak
Harmonic Spurious (Avg)	-12 dBc
Tuning Port DC Resistance	20 K Ω

GUARANTEED PERFORMANCE (0 - 70°C)

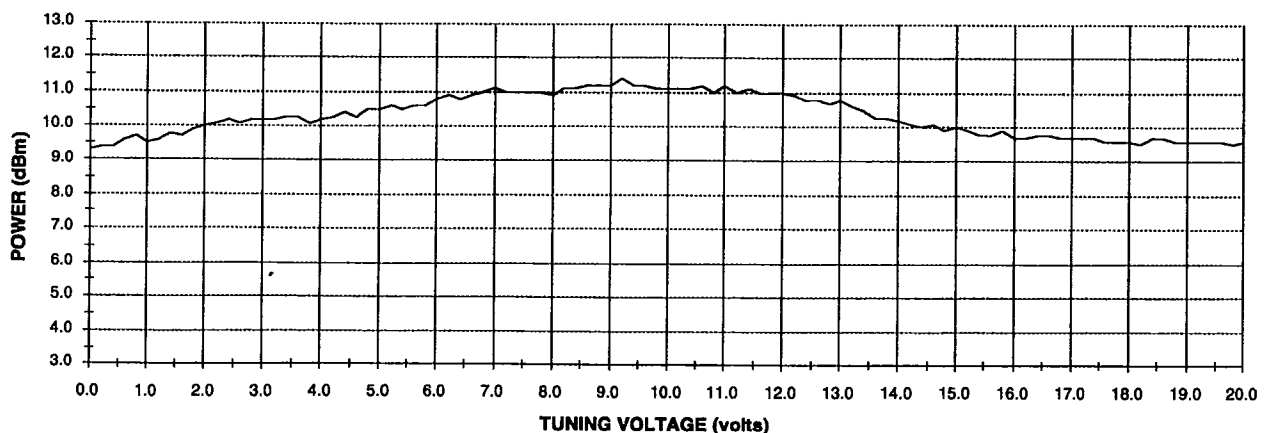
PARAMETER	DATA
Power Dissipation	360 mW max (30 mA @ +12 V)
Frequency Tuning Range	400 to 800 MHz min
Power Output (50 Ω)	10 dBm min

Figure 2F. Performance Curves for Q3500C-0408T

400-800 MHz VCO TYPICAL OUTPUT FREQUENCY/MODULATION SENSITIVITY VERSUS TUNING VOLTAGE



400-800 MHz VCO TYPICAL OUTPUT POWER VERSUS TUNING VOLTAGE



Q3500 Series of Voltage Controlled Oscillators

9

Table 1G. Q3500C-0510T (500-1000 MHz) VCO Technical Specification

ABSOLUTE MAXIMUM / MINIMUM RATINGS

PARAMETER	RATING
Maximum Supply Voltage	+15 V
Tuning Voltage MIN/MAX	0/20 V

TYPICAL PERFORMANCE (0 - 70°C)

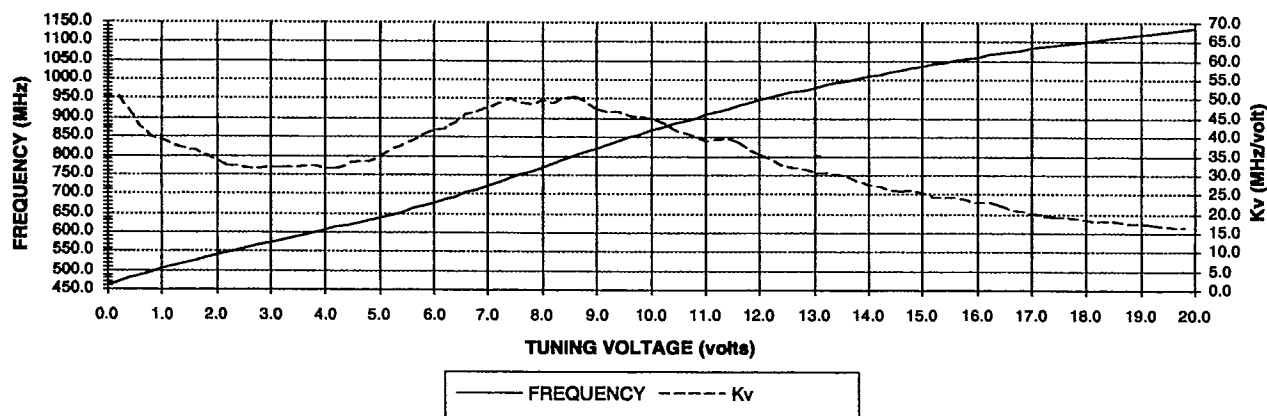
PARAMETER	DATA
Nominal Supply Voltage	+12 V
Power Output (50 Ω)	+12.5 dBm
Typical Current	33 mA
Tuning Voltage	0.8-13.5 V
FM (Phase) Noise:	
1 KHz Offset	-72 dBc/Hz
10 KHz Offset	-94 dBc/Hz
100 KHz Offset	-114 dBc/Hz
1 MHz Offset	<-128 dBc/Hz
Frequency Pushing	0.6 MHz/V for 12 ± 1 V
Frequency Pulling (12dB Rtn Loss)	10 MHz peak-peak
Harmonic Spurious (Avg)	-11 dBc

GUARANTEED PERFORMANCE (0 - 70°C)

PARAMETER	DATA
Power Dissipation	480 mW max (40 mA @ +12 V)
Frequency Tuning Range	500 to 1000 MHz min
Power Output (50 Ω)	9.5 dBm min

Figure 2G. Performance Curves for Q3500C-0510T

500-1000 MHz VCO TYPICAL OUTPUT FREQUENCY/MODULATION SENSITIVITY VERSUS TUNING VOLTAGE



500-1000MHz VCO TYPICAL OUTPUT POWER VERSUS TUNING VOLTAGE

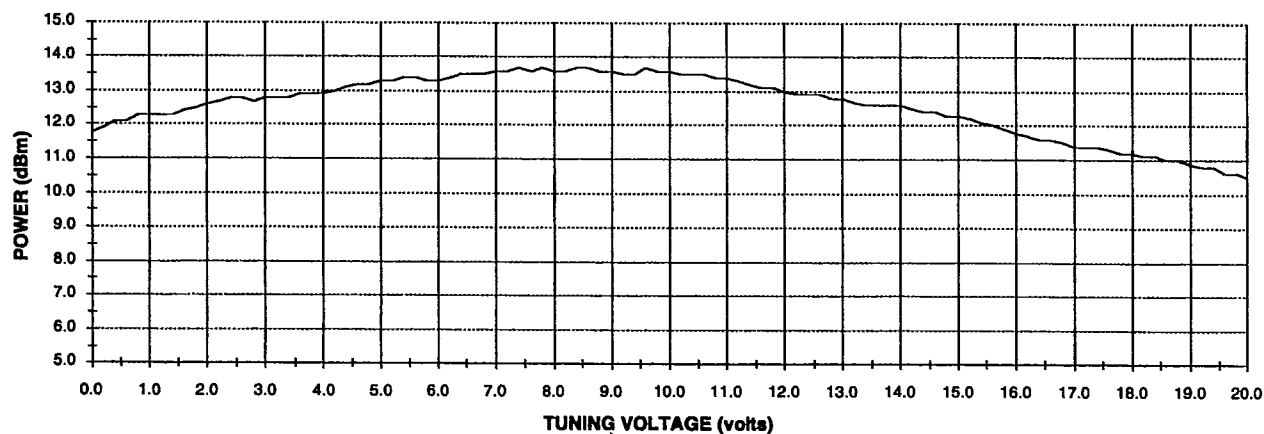


Table 1H. Q3500C-0612T (600-1200 MHz) VCO Technical Specification

ABSOLUTE MAXIMUM / MINIMUM RATINGS

PARAMETER	RATING
Maximum Supply Voltage	+15 V
Tuning Voltage MIN/MAX	0/20 V

TYPICAL PERFORMANCE (0 - 70°C)

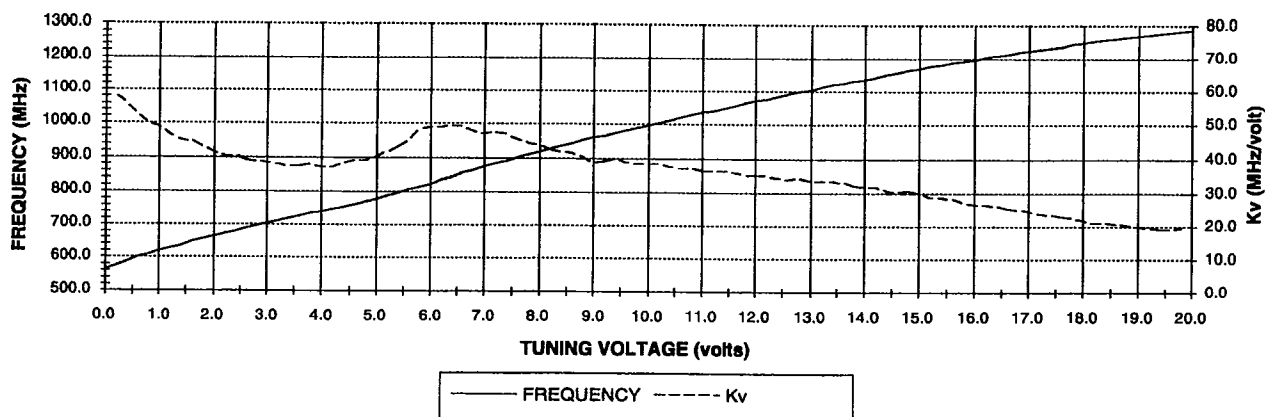
PARAMETER	DATA
Nominal Supply Voltage	+12 V
Power Output (50 Ω)	+8 dBm
Typical Current	22 mA
Tuning Voltage	0.6-15.4 V
FM (Phase) Noise:	
1 KHz Offset	-72 dBc/Hz
10 KHz Offset	-94 dBc/Hz
100 KHz Offset	-114 dBc/Hz
1 MHz Offset	-127 dBc/Hz
Frequency Pushing	1.0 MHz/V for 12 ± 1 V
Frequency Pulling (12dB Rtn Loss)	13 MHz peak~peak
Harmonic Spurious (Avg)	-10 dBc

GUARANTEED PERFORMANCE (0 - 70°C)

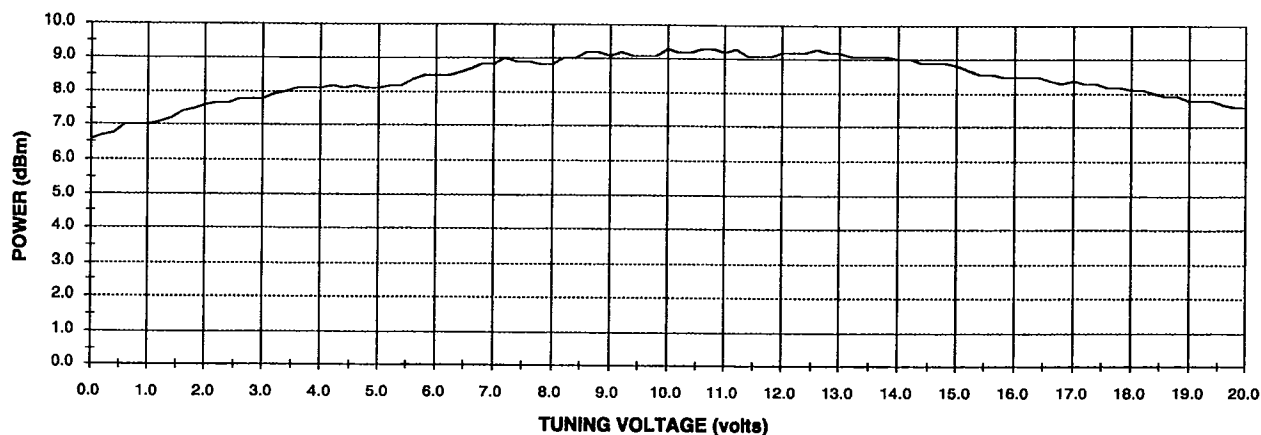
PARAMETER	DATA
Power Dissipation	300 mW max (25 mA @ +12 V)
Frequency Tuning Range	600 to 1200 MHz min
Power Output (50 Ω)	8 dBm min

Figure 2H. Performance Curves for Q3500C-0612T

600-1200 MHz VCO TYPICAL OUTPUT FREQUENCY/MODULATION SENSITIVITY VERSUS TUNING VOLTAGE



600-1200MHz VCO TYPICAL OUTPUT POWER VERSUS TUNING VOLTAGE



Q3500 Series of Voltage Controlled Oscillators

11

Table 1I. Q3500C-0613T (650-1300 MHz) VCO Technical Specification

ABSOLUTE MAXIMUM / MINIMUM RATINGS

PARAMETER	RATING
Maximum Supply Voltage	+15 V
Tuning Voltage MIN/MAX	0/20 V

TYPICAL PERFORMANCE (0 - 70°C)

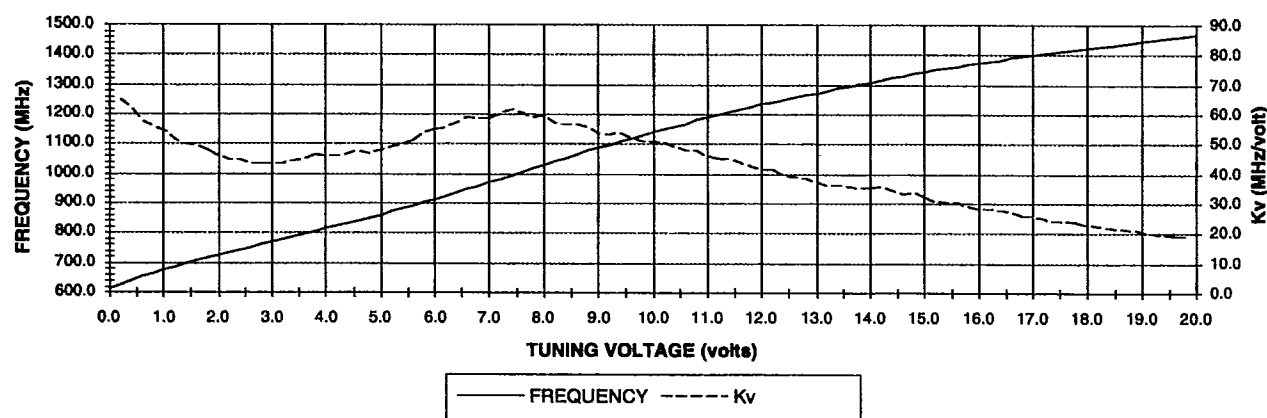
PARAMETER	DATA
Nominal Supply Voltage	+12 V
Power Output (50 Ω)	+8 dBm
Typical Current	22 mA
Tuning Voltage	0.5 - 13.6 V
FM (Phase) Noise:	
1 KHz Offset	-69 dBc/Hz
10 KHz Offset	-92 dBc/Hz
100 KHz Offset	-112 dBc/Hz
1 MHz Offset	-125 dBc/Hz
Frequency Pushing	1.5 MHz/V for 12 ± 1 V
Frequency Pulling (12dB Rtn Loss)	15 MHz peak-peak
Harmonic Spurious (Avg)	-11 dBc

GUARANTEED PERFORMANCE (0 - 70°C)

PARAMETER	DATA
Power Dissipation	300 mW max (25 mA @ +12 V)
Frequency Tuning Range	650 to 1300 MHz min
Power Output (50 Ω)	5 dBm min

Figure 2I. Performance Curves for Q3500C-0613T

650-1300 MHz VCO TYPICAL OUTPUT FREQUENCY/MODULATION SENSITIVITY VERSUS TUNING VOLTAGE



650-1300 MHz VCO TYPICAL OUTPUT POWER VERSUS TUNING VOLTAGE

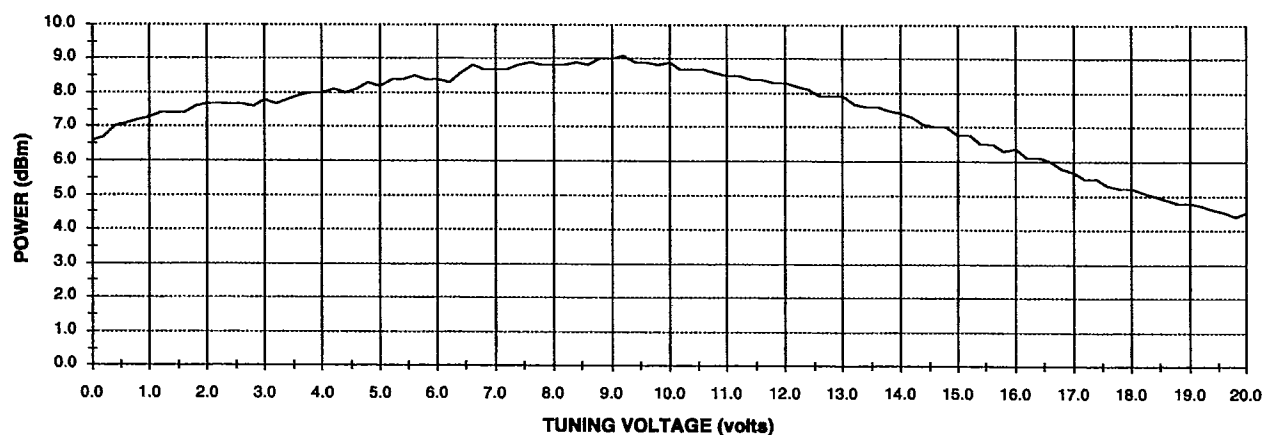


Table 1J. Q3500C-0916T (900-1600 MHz) VCO Technical Specification

ABSOLUTE MAXIMUM / MINIMUM RATINGS

PARAMETER	RATING
Maximum Supply Voltage	+15 V
Tuning Voltage MIN/MAX	0/20 V (Note 1 below)

TYPICAL PERFORMANCE (0 - 70°C)

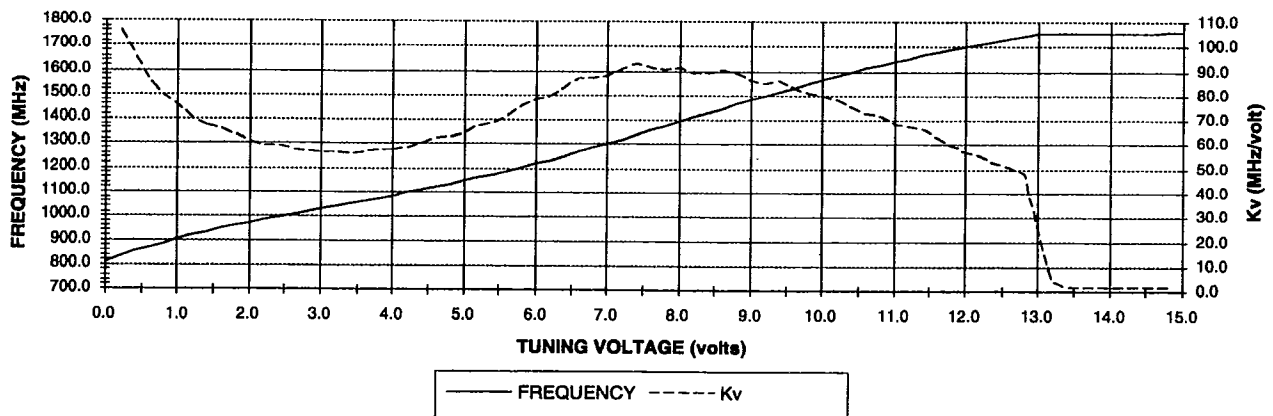
PARAMETER	DATA
Nominal Supply Voltage	+12 V
Power Output (50 Ω)	+7 dBm
Typical Current	22 mA
Tuning Voltage	1.0 - 10.5 V
FM (Phase) Noise:	
1 KHz Offset	-66 dBc/Hz
10 KHz Offset	-90 dBc/Hz
100 KHz Offset	-110 dBc/Hz
1 MHz Offset	-124 dBc/Hz
Frequency Pushing	1.5 MHz/V for 12 ± 1 V
Frequency Pulling (12dB Rtn Loss)	16 MHz peak-peak
Harmonic Spurious (Avg)	-12 dBc

GUARANTEED PERFORMANCE (0 - 70°C)

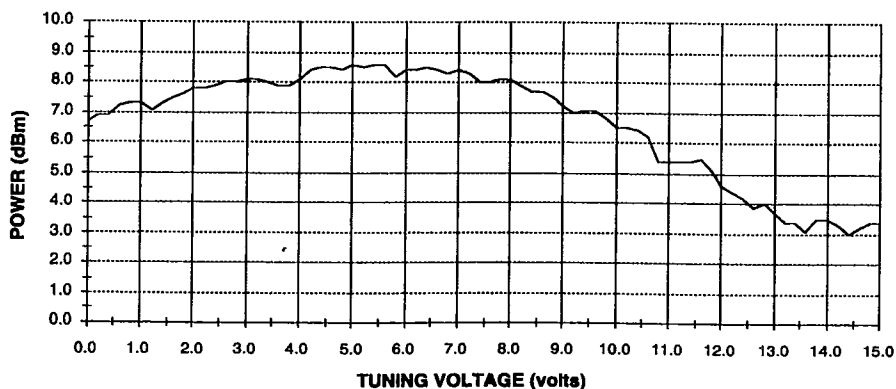
PARAMETER	DATA
Power Dissipation	300 mW max (25 mA @ +12 V)
Frequency Tuning Range	900 to 1600 MHz min
Power Output (50 Ω)	5 dBm min

Figure 2J. Performance Curves for Q3500C-0916T

900-1600 MHz VCO TYPICAL OUTPUT FREQUENCY/MODULATION SENSITIVITY VERSUS TUNING VOLTAGE



900-1600MHz VCO TYPICAL OUTPUT POWER VERSUS TUNING VOLTAGE



NOTE 1

This VCO version has an internal zener diode that limits the input voltage V_T to approximately 13 V. See section on Input Voltage Limiting (Page 14) which discusses design precautions.

Table 1K. Q3500C-1324T (1350-2400 MHz) VCO Technical Specification

ABSOLUTE MAXIMUM / MINIMUM RATINGS

PARAMETER	RATING
Maximum Supply Voltage	+15 V
Tuning Voltage MIN/MAX	0/20 V

TYPICAL PERFORMANCE (0 - 70°C)

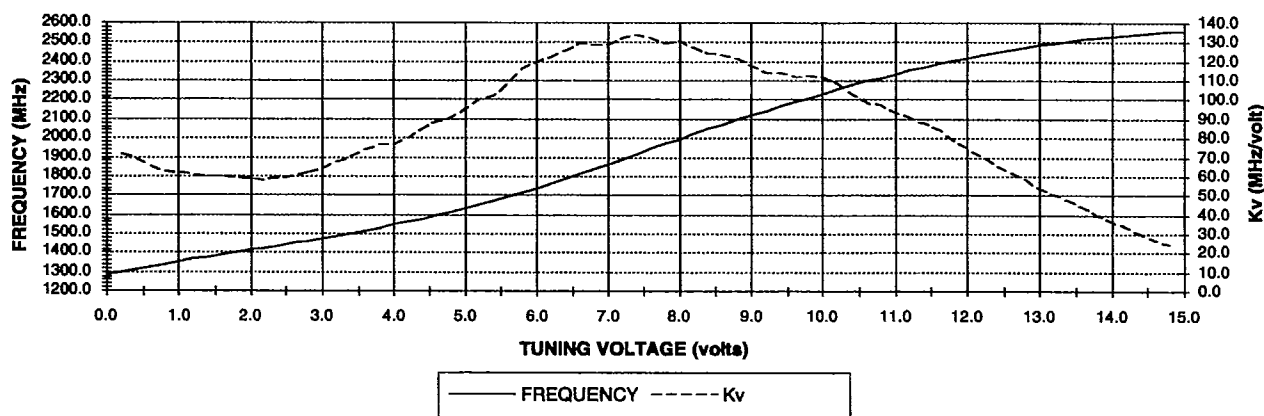
PARAMETER	DATA
Nominal Supply Voltage	+12 V
Power Output (50 Ω)	+7 dBm
Typical Current	20 mA
Tuning Voltage	1 - 12 V
FM (Phase) Noise:	
10 KHz Offset	-90 dBc/Hz
100 KHz Offset	-110 dBc/Hz
1 MHz Offset	-124 dBc/Hz
Frequency Pushing	4 MHz/V for 12 ± 1 V
Frequency Pulling (12dB Rtn Loss)	34 MHz peak~peak
Harmonic Spurious (Avg)	-12 dBc

GUARANTEED PERFORMANCE (0 - 70°C)

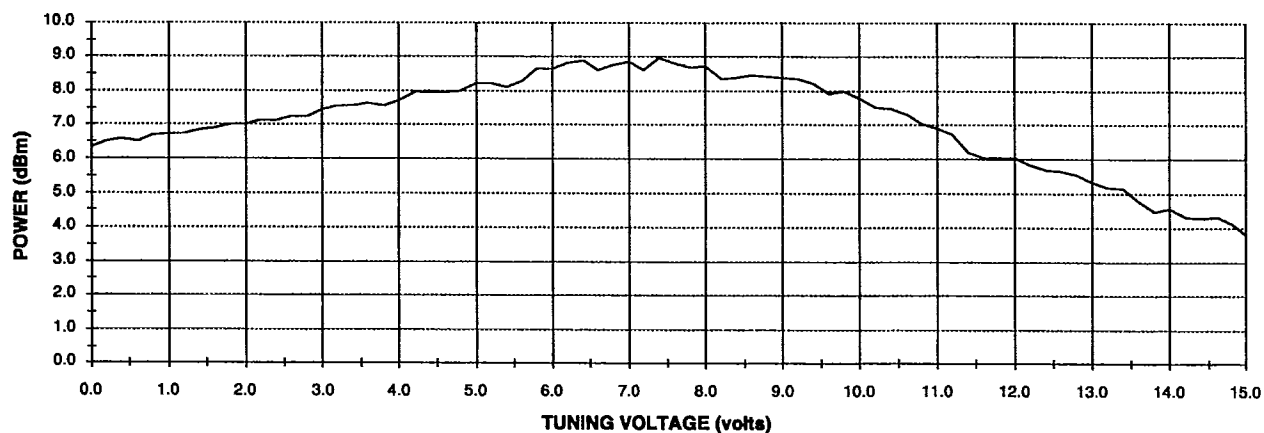
PARAMETER	DATA
Power Dissipation	300 mW max (25 mA@ +12 V)
Frequency Tuning Range	1350 to 2400 MHz min
Power Output (50 Ω)	5 dBm min

Figure 2K. Performance Curves for Q3500C-1324T

1350-2400 MHz VCO TYPICAL OUTPUT FREQUENCY/MODULATION SENSITIVITY VERSUS TUNING VOLTAGE



1350-2400 MHz VCO TYPICAL OUTPUT POWER VERSUS TUNING VOLTAGE



INPUT VOLTAGE LIMITING

The Q3500C-0916T uses an input zener diode to clamp the input voltage at 13V. This guarantees that the VCO always has an output at high tune voltages.

QUALCOMM recommends that an input resistor be used in designs where the input tune line voltage may be larger than 13V in order to limit the current flow through the zener diode. See Figure 3 and Table 2 (below) for suggested R_{TUNE} values versus the maximum tune voltage.

The Q3500C-0916T is the only version that requires input voltage limiting.

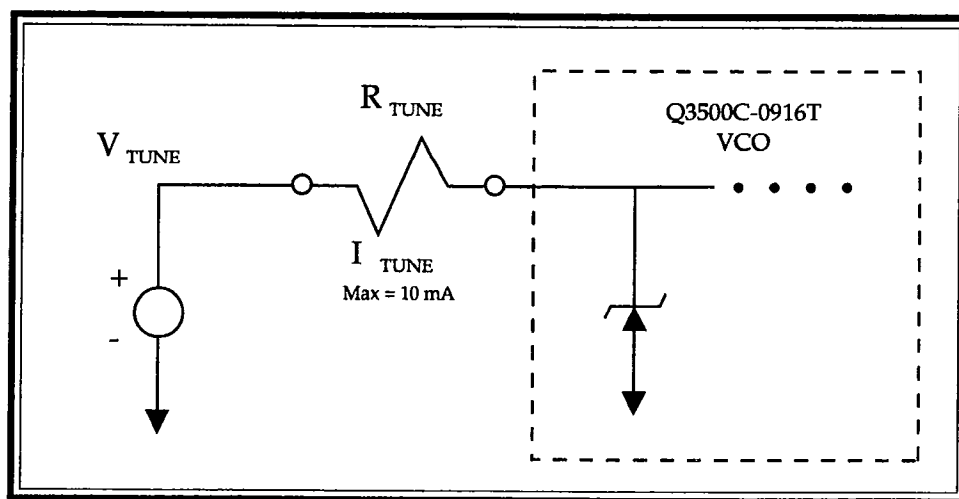


Figure 3. Input Resistor Requirement

V_{TUNE}	$R_{TUNE} (I_{TUNE} = 10 \text{ mA})$
13V	0Ω
15V	200Ω
20V	700Ω

Table 2. R_{TUNE} Versus Maximum Tune Voltage

TEST METHODOLOGY

Test configurations 1, 2 & 3 (Figures 4, 5 & 6) illustrate the actual test methods used for collecting the test data for all Q3500 VCO versions.

The performance curves of Figures 2 A-K were generated using test configuration 1. (Figure 4) The frequency vs. voltage curve values are used to compute modulation sensitivity. The frequency pushing value is determined by collecting the frequency vs. voltage curves at the nominal supply voltage values ± 1 VDC and extracting the typical frequency variation shown in tables 1 A-K.

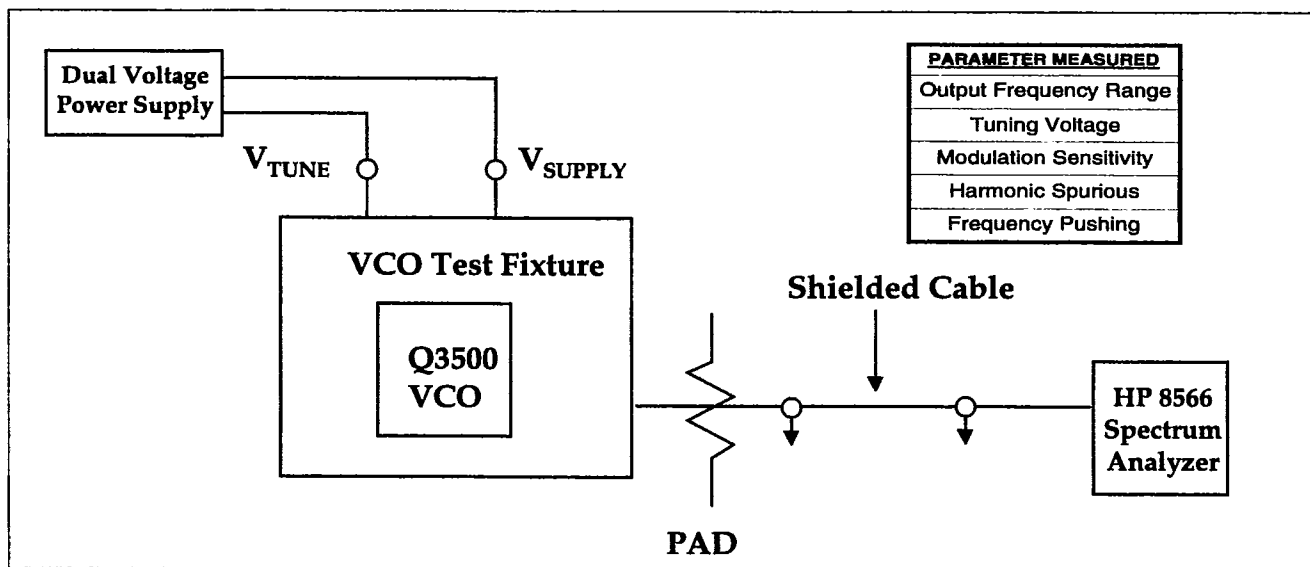


Figure 4. Test Configuration (#1)

As tables 1 A-K indicate, the Q3500 series has low phase noise. However, overall system phase noise is more subtle than just the sum of the VCO, reference, loop filter, and phase detector's individual phase noise contributions.

At different offsets from the carrier, one part of the loop will dominate in contributing phase noise. This depends on the loop's natural frequency, which in turn depends on K_v , the VCO modulation sensitivity (measured in MHz/V). If K_v were linear, then loop design and phase noise analysis would be straight-forward. Unfortunately, based on extensive testing, QUALCOMM has found that a typical VCO's K_v is non-linear, with K_v decreasing with increasing frequencies.

QUALCOMM has specifically engineered the Q3500 series to optimize K_v . This greatly eases PLL gain normalization over the full tuning range for improved stability, settling time, and improved close-in system phase noise.

As a result, the PLL loop bandwidth (ideally, the frequency where VCO phase noise and the multiplied-up reference phase noise are equal) *in a synthesizer using the Q3500 will be more constant and will have a lower overall system phase noise than the same system with a VCO whose K_v behaves differently.*

The frequency pulling values are collected using test configuration 2. (Figure 5) The Sliding line was shifted through 0-360° through the full output frequency range of each VCO version. The typical peak-to-peak variations are shown in Tables 1 A-K.

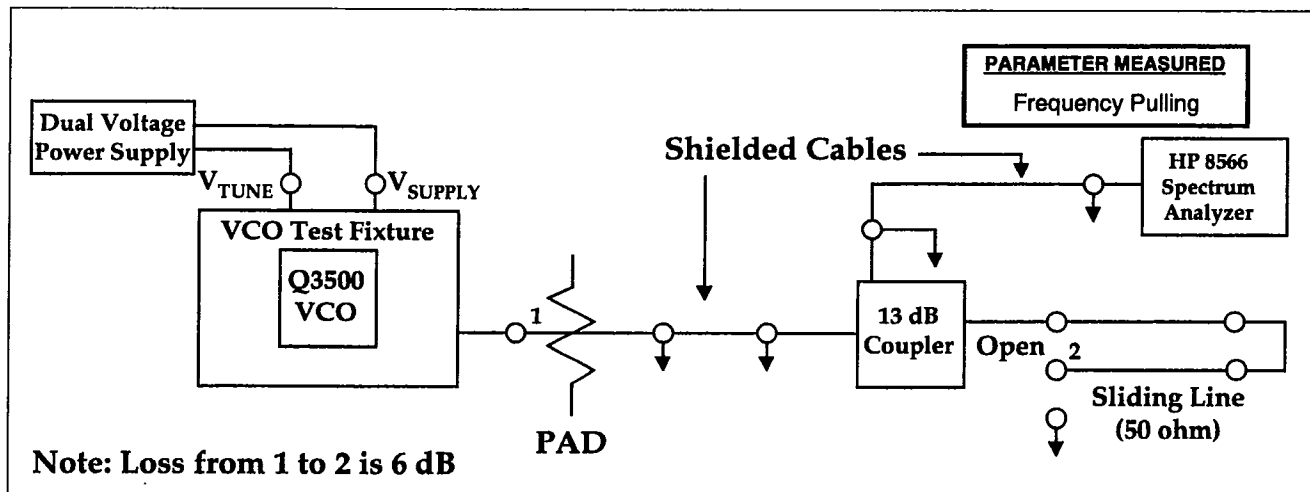


Figure 5. Frequency Pulling Test Configuration (#2)

The Phase Noise performance was determined by measurement of the output spectrum of the VCO in a very narrow band Phase Locked Loop Custom Prototyping Kit (Q0410-2) using test configuration 3. (Figure 6) The values of phase noise at offsets of 1, 10, 100 & 1000 kHz are shown in Tables 1 A-K.

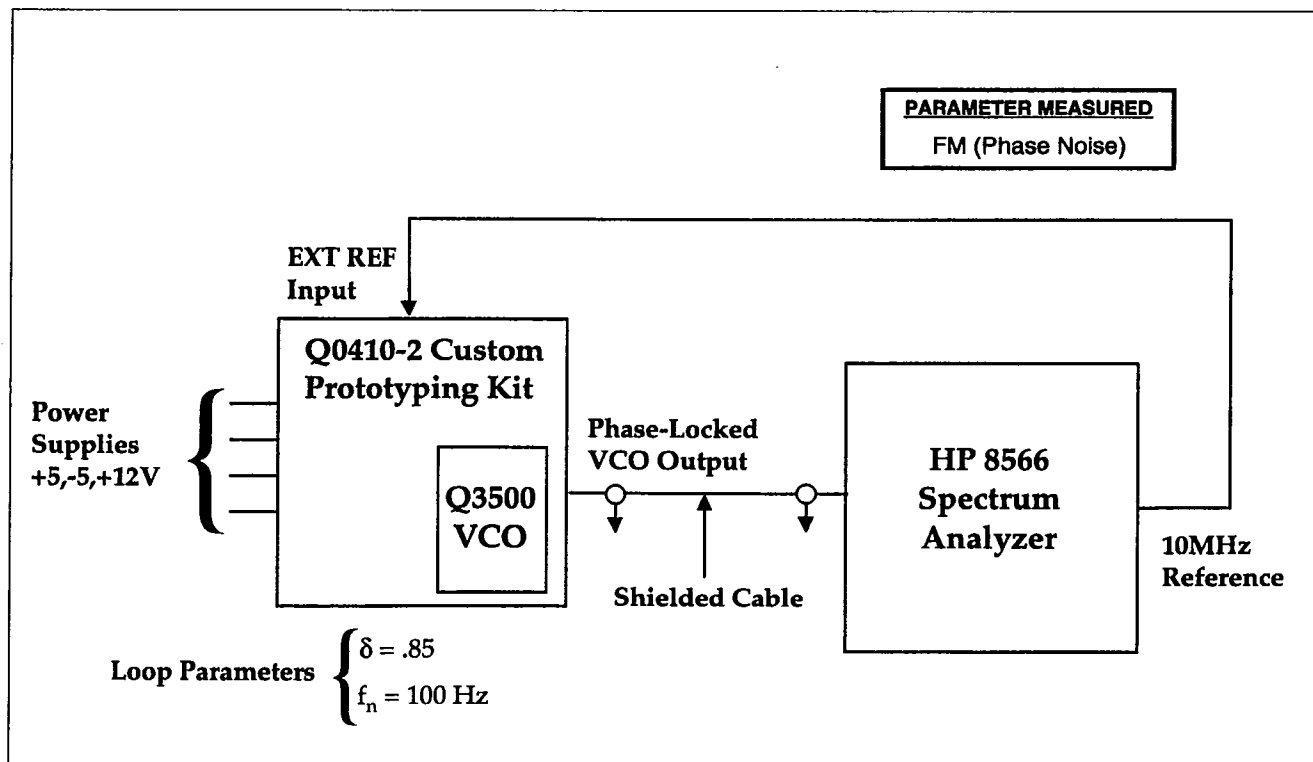


Figure 6. Phase Noise Test Configuration (#3)

Note: Pins 1,2,3 and 4 are press or interference fit. This allows the device to be installed and removed without damage to the device or migration of the pins.

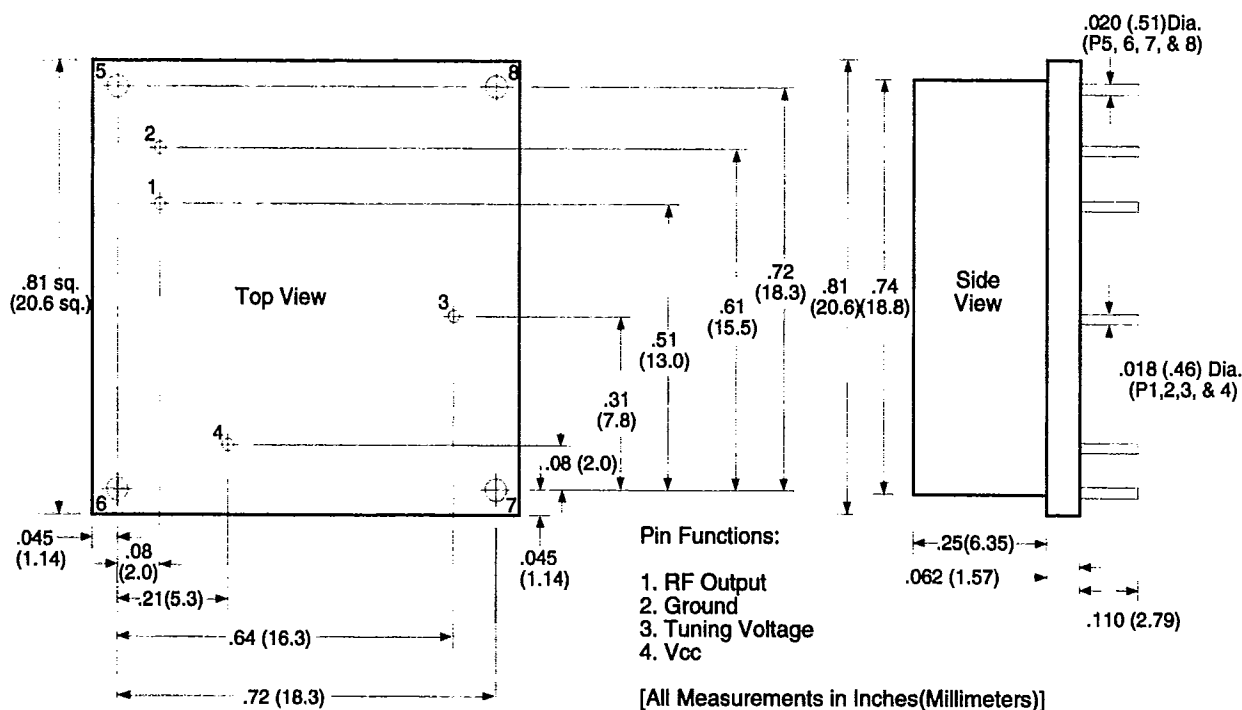


Figure 7. VCO Package Outline

OTHER QUALCOMM SYNTHESIZER PRODUCTS

QUALCOMM offers several Phase-Locked Loop Evaluation boards (Q0410-1 & -2) which are based on the QUALCOMM Q3036 Phase-Locked Loop Frequency Synthesizer (PLLFS) integrated circuit.

The Q0410 PLL boards shorten your evaluation and design time. The Q0410-1 PLO Synthesizer system is a turn-key synthesizer which includes a Q3500C-0916T VCO and tunes from 900-1600 MHz in 1.25 MHz steps.

The Q0410-2 PLL Custom Prototyping Kit allows designers to install any Q3500 VCO or TO-8 VCO and quickly develop a custom synthesizer.

The Q0710-1 DDS - driven PLL is a turnkey synthesizer which tunes from 900-1600 MHz in approximately 1 Hz steps. The Q0710-1 includes the Q3500C-0916T VCO, Q3036 PLL IC and Q2334 Direct Digital Synthesizer IC.