PTX-0350
RF UPCONVERTER, 300 – 5000 MHz

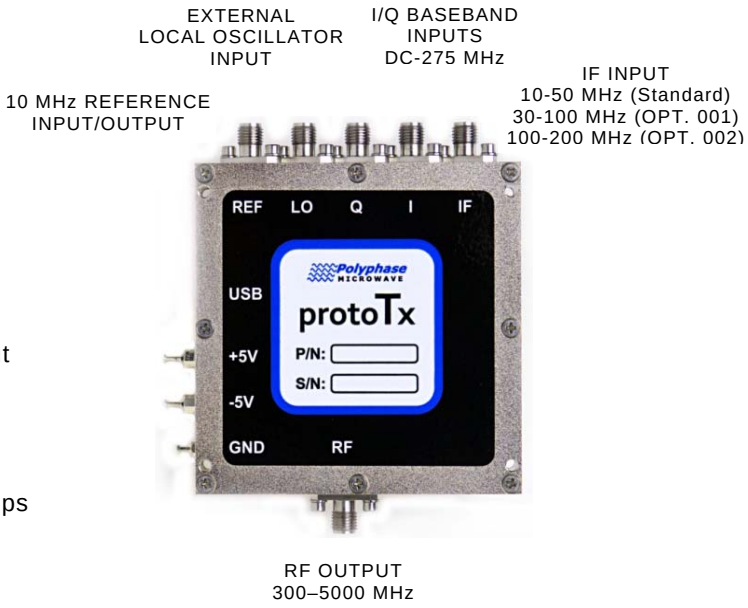
protoTx

OPERATING MODES

- I/Q upconverter
- RF = LO + IF upconverter
- RF = LO - IF upconverter
- Synthesizer

FEATURES

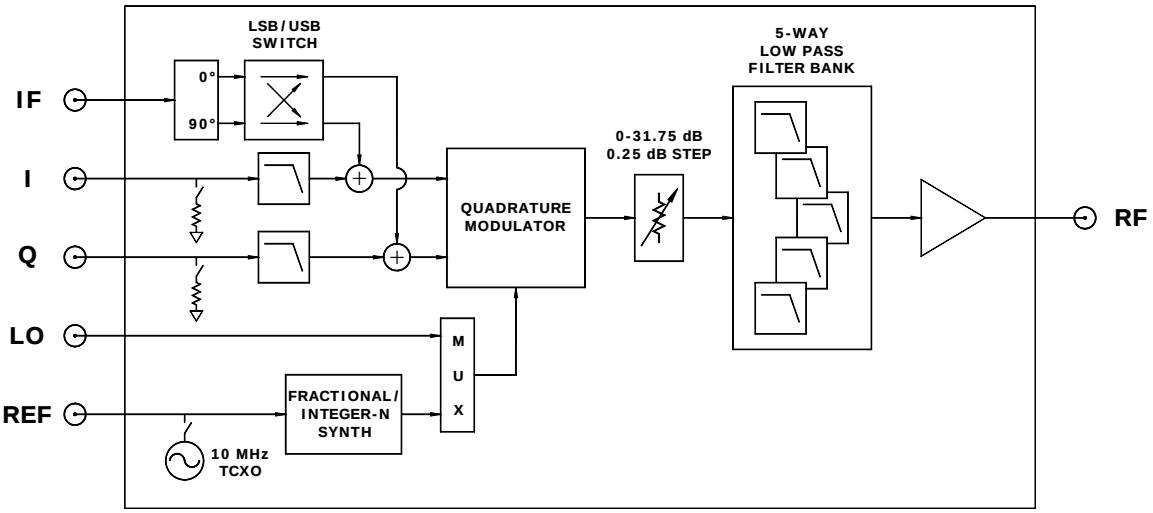
- USB 2.0 programmable
- Internal LO synthesizer or external LO input
- 1 Hz step size
- LO nulling control
- 5-way switched RF filter bank
- RF attenuator, 0 to 31.75 dB in 0.25 dB steps
- +22 dBm RF output power
- Compact size: 3”x3”x0.6”



DESCRIPTION

The protoTx PTX-0350 is a user-programmable I/Q to RF upconverter and IF to RF upconverter with internal LO synthesizer. The PTX-0350 is programmed over USB 2.0 with a Windows-based soft front panel. User settings are stored in non-volatile memory and recalled at power-up, enabling applications in target systems without USB control. The internal LO synthesizer has excellent spectral purity and can be locked to an external 10 MHz reference or the internal TCXO. For ultra-low phase noise or fast-switching LO applications, an external LO signal can be provided by the user. Programmable settings include operating mode, internal LO frequency, internal/external LO, internal/external reference, DC offsets for LO nulling control, RF filter select, RF step attenuator level, output enable/disable, and user/factory preset mode.

RF FUNCTIONAL DIAGRAM



Polyphase Microwave Inc.
1111 W. 17th St Suite 200
Bloomington, IN 47404-3004
USA

Tel: +1 (812) 323-8708
Fax: +1 (812) 323-8709
Web: www.polyphasemicrowave.com

SPECIFICATIONS

FREQUENCY

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
LO/RF Frequency Range		300		5000	MHz
I/Q Baseband Bandwidth	<1 dB Flatness	DC		275	MHz
I/Q Baseband Stop Band	>25 dB Rejection	450		7000	MHz
IF Input Frequency Range		10	30	50	MHz
IF Input Frequency Range	Option 001	30	70	100	MHz
IF Input Frequency Range	Option 002	100	150	200	MHz

RF OUTPUT

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Output P1dB[1]	All Upconverter Modes	+20	+22		dBm
Output IP3[1]	All Upconverter Modes	+28	+32		dBm
Leveled Output Power Range[1]	Synthesizer Mode	-5		+20	dBm
Power Accuracy	Synthesizer Mode	-2	±0.5	+2	dB
Output Noise (maximum gain)	RF Attenuator 0 dB		-132		dBm/Hz
Output Noise (minimum gain)	RF Attenuator 31.75 dB		-158		dBm/Hz
RF Port Return Loss			15		dB

Note 1: Output power specifications decrease 4 dB above 4500 MHz.

SPECTRAL PURITY

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Harmonics	Synthesizer Mode		-35		dBc
Non-Harmonic Spurious	Synthesizer Mode		-75	-45	dBc
Internal LO Phase Noise @ 500 MHz	100 Hz Offset 1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset 10 MHz Offset		-92 -97 -102 -116 -139 -150	-86 -91 -96 -110 -133 -144	dBc/Hz
Internal LO Phase Noise @ 1000 MHz	100 Hz Offset 1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset 10 MHz Offset		-89 -93 -95 -110 -137 -150	-83 -87 -89 -104 -131 -144	dBc/Hz
Internal LO Phase Noise @ 2000 MHz	100 Hz Offset 1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset 10 MHz Offset		-86 -87 -89 -105 -132 -148	-80 -81 -83 -99 -131 -142	dBc/Hz
Internal LO Phase Noise @ 4000 MHz	100 Hz Offset 1 kHz Offset 10 kHz Offset 100 kHz Offset 1 MHz Offset 10 MHz Offset		-80 -82 -82 -100 -126 -142	-74 -76 -76 -94 -120 -136	dBc/Hz

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UPCONVERSION

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
I/Q to RF Conversion Gain[2]	RF Attenuator = 0 dB	+13	+17		dB
IF to RF Conversion Gain[2]	RF Attenuator = 0 dB	+13	+17		dB
External LO Input Power	All Upconverter Modes	-8	-5	-2	dBm
I/Q Amplitude Imbalance	I/Q Upconverter Mode	-0.2	±0.05	+0.2	dB
I/Q Phase Error, Internal LO[2]	I/Q Upconverter Mode	-2	±0.5	+2	°
I/Q Phase Error, External LO	I/Q Upconverter Mode	-6	±1	+6	°
Unadjusted LO Leakage, Internal LO[3]	RF Attenuator 0 dB		-40	-25	dBm
Unadjusted LO Leakage, External LO[3]	RF Attenuator 0 dB		-20	-5	dBm
Sideband Suppression[2,4]	RF=LO+IF Mode		-35	-25	dBc
Sideband Suppression[2,4]	RF=LO-IF Mode		-35	-25	dBc

Note 2: Specified from 300 MHz to 4000 MHz.
Note 3: User adjustment of LO nulling achieves -60 dBm typical LO leakage.
Note 4: Option 002 sideband suppression is -30 dBc typical, -20 dBc maximum.

REFERENCE

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Internal TCXO Frequency	Internal Reference		10		MHz
Internal TCXO Stability	Internal Reference		±2.0		ppm
Output Level into 50 Ω	Internal Reference		1.0		Vp-p
Input Level into 50 Ω	External Reference	0.5	1.0	1.5	Vp-p

ELECTRICAL

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Positive Supply Voltage		+4.95	+5.0	+5.2	V
Positive Supply Current			570	650	mA
Negative Supply Voltage		-5.2	-5.0	-4.95	V
Negative Supply Current			45	60	mA

GENERAL

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Operating Temperature Range		-40		+55	°C
Non-Operating Temperature Range		-40		+85	°C
Warm-Up Time			5		seconds
Supply Voltage w/o Damage		-12		12	V
External LO Input Power w/o Damage				+10	dBm
External IF Input Power w/o Damage				+18	dBm
External I/Q Input Voltage w/o Damage		-2.5		+2.5	V

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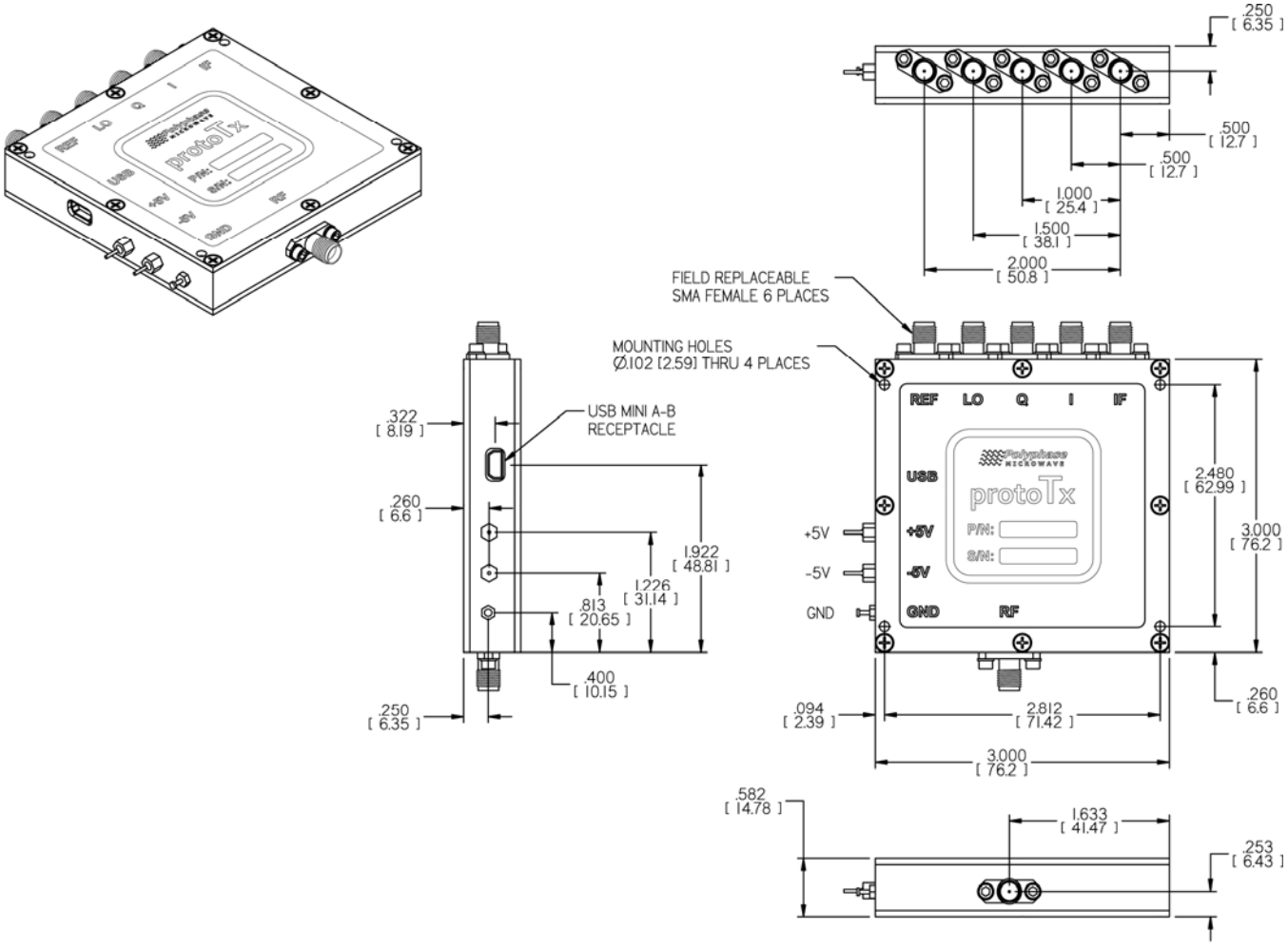

PORT DESCRIPTIONS

NAME	TYPE	DESCRIPTION
REF	Input/Output	10 MHz Reference, 1 Vp-p Nominal into 50Ω, AC Coupled
LO	Input	External Local Oscillator Input, 200 - 5500 MHz, High Impedance, AC-Coupled
Q	Input	Q Baseband Input, DC – 275 MHz, 50Ω, DC-Coupled, ±2.5 VDC max.
I	Input	I Baseband Input, DC – 275 MHz, 50Ω, DC-Coupled, ±2.5 VDC max.
IF	Input	Intermediate Frequency Input, 10-50 MHz (Standard), 50Ω, AC-Coupled
RF	Output	RF Output, 200 – 5500 MHz, 50Ω, AC-Coupled
USB	Input/Output	USB 2.0 Interface, Non-Bus Powered
+5V	Input	+5.0 V DC Supply Input, 570 mA Typical
-5V	Input	-5.0 V DC Supply Input, 45 mA Typical
GND	Input/Output	DC Ground Return

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TYPICAL PERFORMANCE

PHASE NOISE
SYNTHESIZER MODE

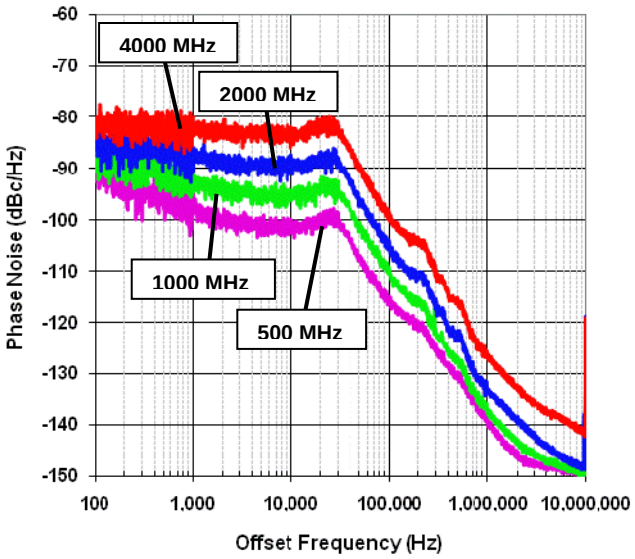

Figure 1.

MODULATED RF OUTPUT SPECTRUM
I/Q UPCONVERTER MODE

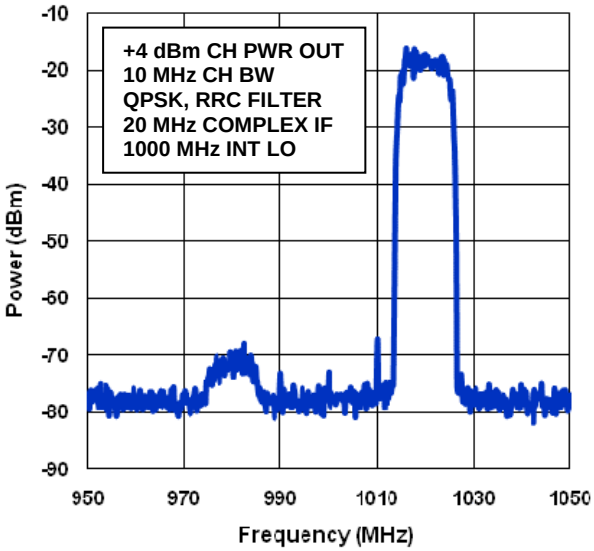

Figure 2.

MODULATED RF OUTPUT SPECTRUM
RF = LO + IF UPCONVERTER MODE

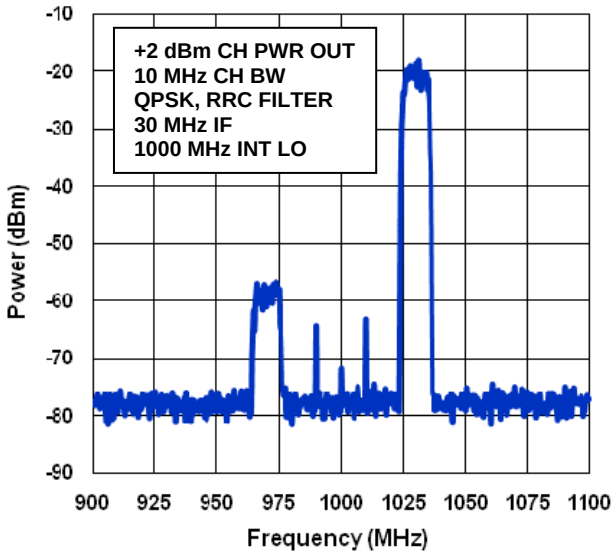

Figure 3.

MODULATED RF OUTPUT SPECTRUM
RF = LO - IF UPCONVERTER MODE

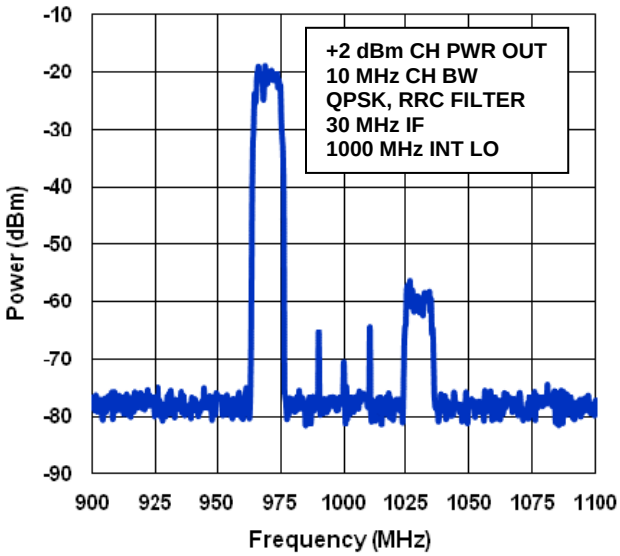

Figure 4.

Polyphase Microwave Inc.
1111 W. 17th St Suite 200
Bloomington, IN 47404-3004
USA

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TYPICAL PERFORMANCE

POWER FLATNESS
SYNTHESIZER MODE

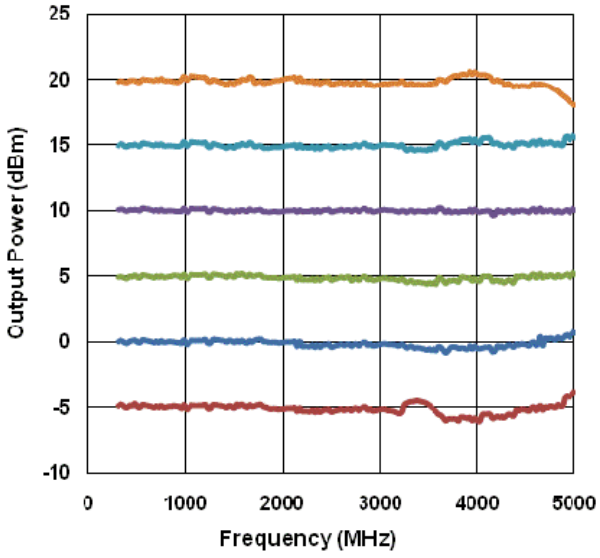

Figure 5.

HARMONICS @ 500 MHz
SYNTHESIZER MODE

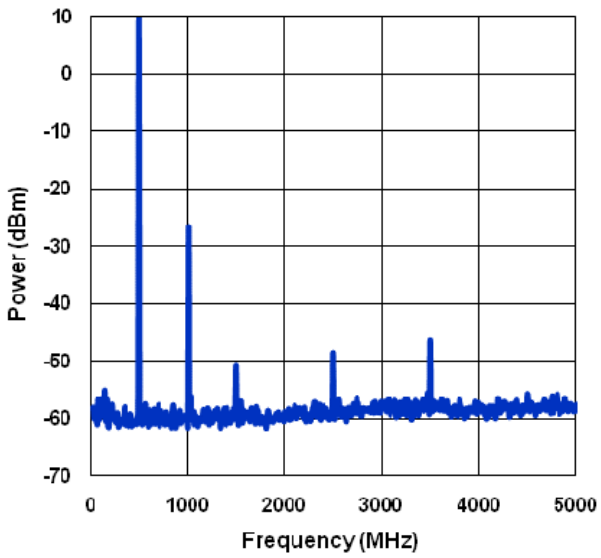

Figure 6.

WIDEBAND SPURIOUS
SYNTHESIZER MODE

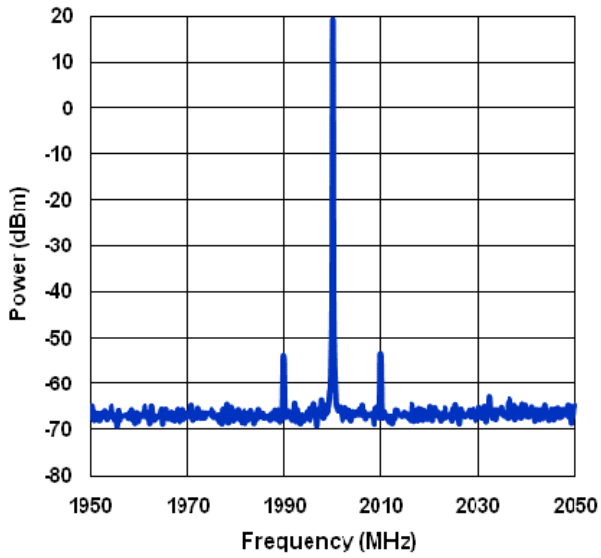

Figure 7.

NARROWBAND SPURIOUS
SYNTHESIZER MODE

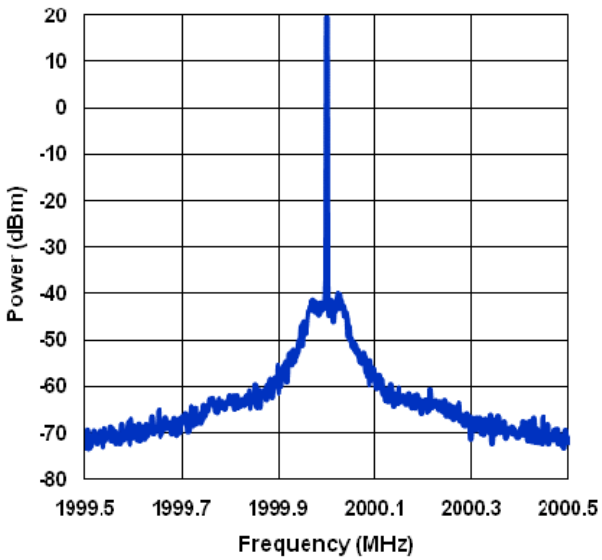

Figure 8.

Polyphase Microwave Inc.
1111 W. 17th St Suite 200
Bloomington, IN 47404-3004
USA

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TYPICAL PERFORMANCE

CONVERSION GAIN

I/Q UPCONVERTER MODE

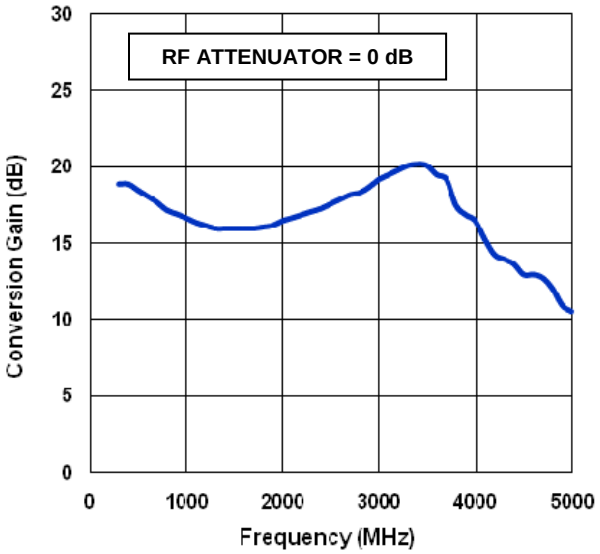

Figure 9.

CONVERSION GAIN

RF = LO ± IF UPCONVERTER MODES

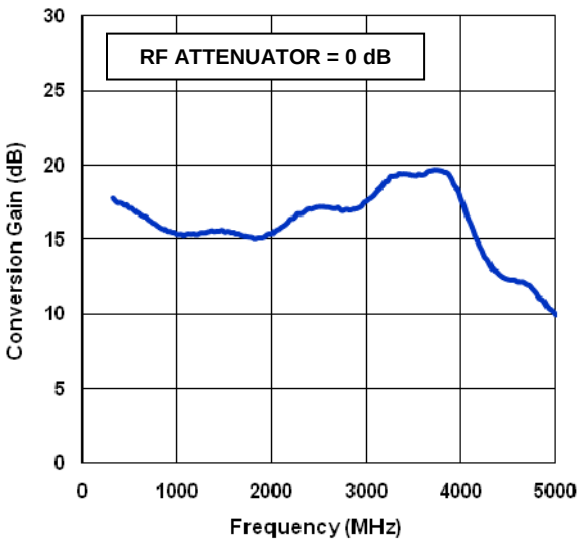

Figure 10.

RF FILTER BANK GAIN RESPONSE

ALL UPCONVERTER MODES

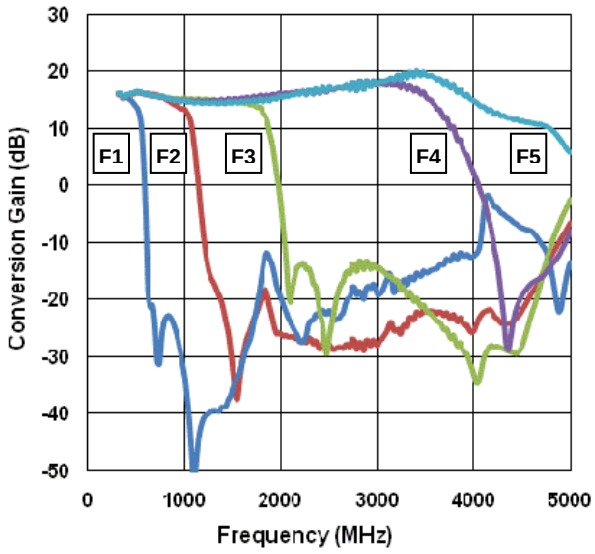

Figure 11.

RF PORT RETURN LOSS

ALL MODES

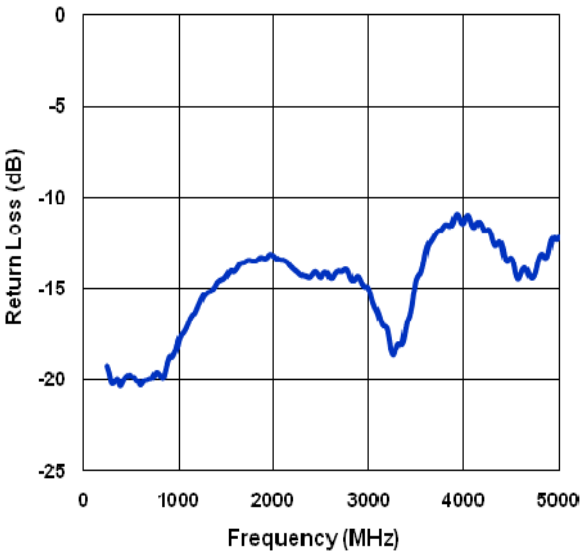

Figure 12.

Polyphase Microwave Inc.
1111 W. 17th St Suite 200
Bloomington, IN 47404-3004
USA

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Fax: +1 (812) 323-8709
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TYPICAL PERFORMANCE

OUTPUT P1dB COMPRESSION
ALL UPCONVERTER MODES

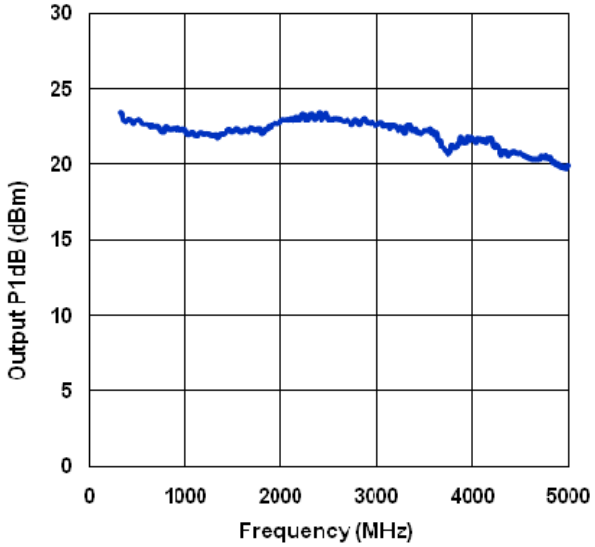

Figure 13.

OUTPUT IP3
ALL UPCONVERTER MODES

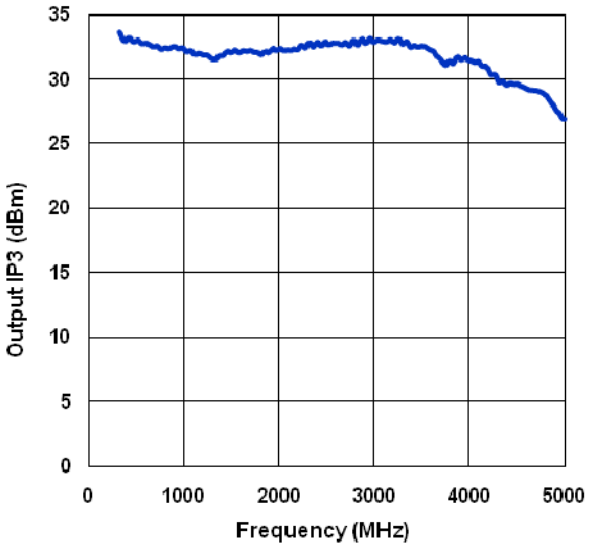

Figure 14.

LO LEAKAGE (UNADJUSTED)
ALL UPCONVERTER MODES

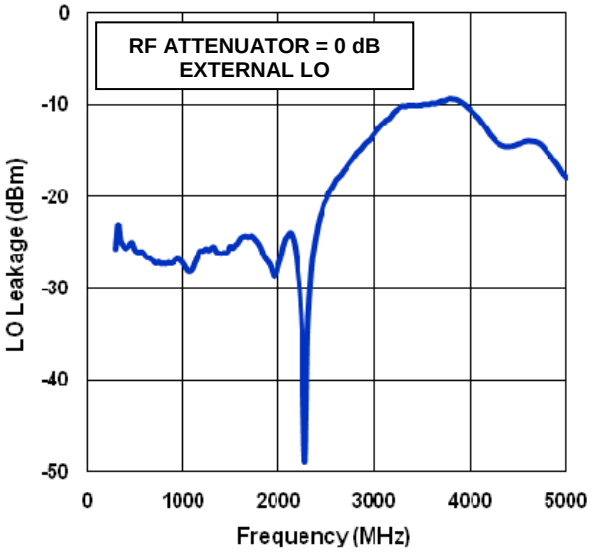

Figure 15.

LO LEAKAGE (FACTORY NULLED)
ALL UPCONVERTER MODES

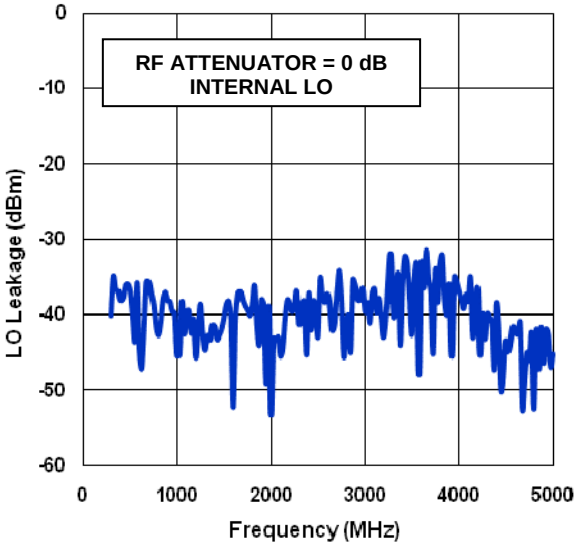

Figure 16.

Polyphase Microwave Inc.
1111 W. 17th St Suite 200
Bloomington, IN 47404-3004
USA

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TYPICAL PERFORMANCE

SIDEBAND SUPPRESSION
RF = LO ± IF MODES, INTERNAL LO

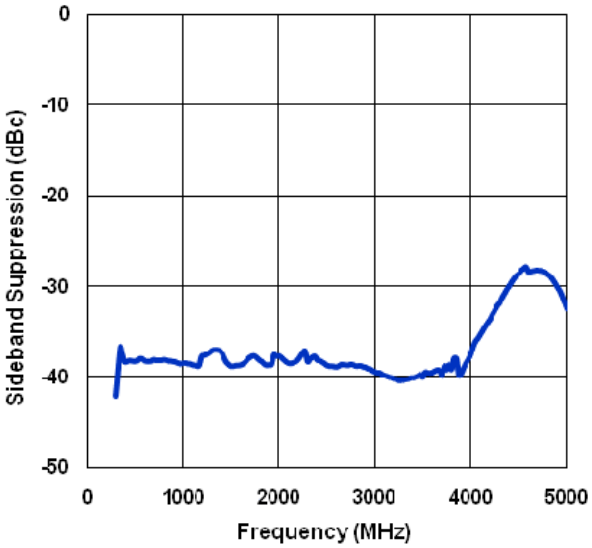

Figure 17.

SIDEBAND SUPPRESSION
RF = LO ± IF MODES, EXTERNAL LO

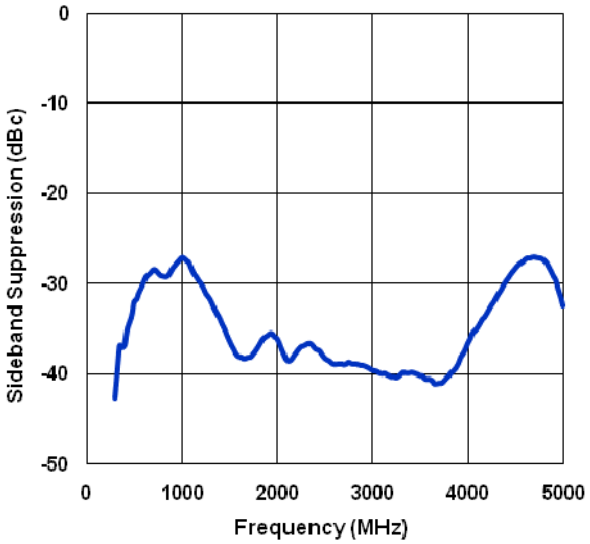

Figure 18.

SIDEBAND SUPPRESSION
I/Q UPCONVERTER MODE, INTERNAL LO

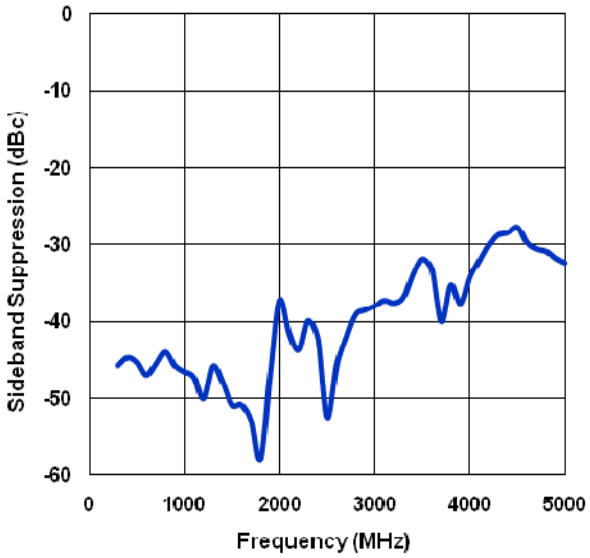

Figure 19.

SIDEBAND SUPPRESSION
I/Q UPCONVERTER MODE, EXTERNAL LO

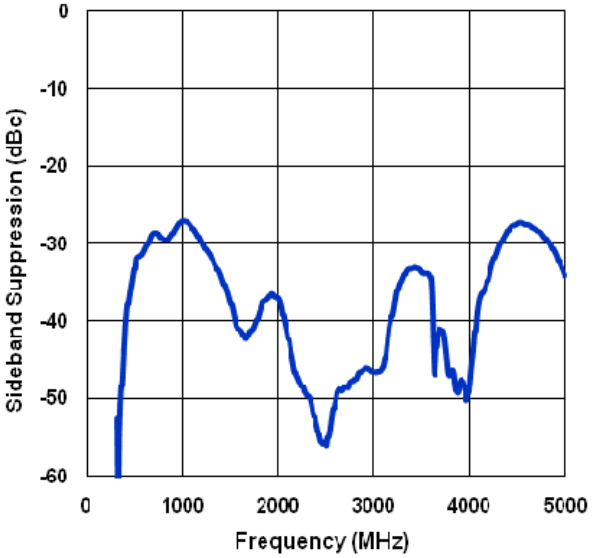

Figure 20.

Polyphase Microwave Inc.
1111 W. 17th St Suite 200
Bloomington, IN 47404-3004
USA

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Fax: +1 (812) 323-8709
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APPLICATIONS

PROGRAMMING

The PTX-0350 is programmed using the protoTx Interface Software. Please refer to the *protoTx User Manual* for detailed installation and operating instructions.

protoTx INTERFACE SOFTWARE
WINDOWS XP / VISTA / 7

Figure 21.

OPERATING MODES

In **I/Q upconverter** mode, the I and Q baseband inputs are low pass filtered and input to the internal quadrature modulator where the LO signal is directly modulated. Figure 2 shows an example RF output spectrum in I/Q upconverter mode for a 10 MHz wide QPSK channel having a 20 MHz IF frequency shift. Input I/Q signals should have 50Ω input impedance with DC-coupling. The protoTx I and Q input ports have 50Ω impedance with an input voltage range of ± 2.5 V. The standard I and Q baseband bandwidth is DC – 275 MHz (-1 dB flatness). Custom I/Q bandwidths from 50 MHz to 500 MHz are available. The unused IF input should be terminated into 50Ω for the best noise performance.

When **RF = LO + IF upconverter** mode is selected, the IF input signal is processed by a 90 degree hybrid coupler to obtain quadrature IF signals. The quadrature IF signals are input to the quadrature modulator along with the LO to obtain upper sideband RF (RF = LO + IF), while the lower sideband RF (RF = LO – IF) is suppressed. See Figure 3 for an example of the RF output in RF = LO + IF upconverter mode. The standard IF port frequency range is 10 MHz to 50 MHz. Option 001 IF frequency range is 30 MHz to 100 MHz and Option 002 is 100 MHz to 200 MHz. Custom IF frequency ranges are available from 5 MHz to 250 MHz. The unused I and Q input ports should be left open for the best LO Leakage performance.

RF = LO – IF upconverter mode reverses the quadrature IF signals to obtain the lower sideband RF (Figure 4).

In **Synthesizer** mode, the internal LO synthesizer is routed through the quadrature modulator without modulation. To prevent unwanted modulations in synthesizer mode, ensure that no IF or I/Q signals are connected to the protoTx.

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LO NULLING

The PTX-0350 generates internal I and Q DC offsets using two 8-bit DACs that null (cancel) the LO leakage signal at the RF output port. Factory-calibrated DC offsets achieve -30 dBm typical LO leakage at all frequencies (Figure 16). User DC offsets can be entered to further null the LO leakage power below -60 dBm. Using a spectrum analyzer to monitor the LO leakage, first adjust the I-channel DC offset to minimize the LO leakage spur power. Then adjust the Q-channel DC offset. Repeat the process until the LO leakage is nulled. The I and Q DC offset range is 0-255 (8-bits) with a setting of 127 at the center of the range.

INTERNAL LO SYNTHESIZER

The internal LO synthesizer is based on a fractional/integer-N PLL architecture. The phase detector comparison frequency is 10 MHz. Low-level integer (10 MHz) spurs are present at the LO frequency ±10 MHz. Figure 7 shows the internal LO synthesizer's 10 MHz integer spurs at the nominal level of -75 dBc.

When the internal LO frequency is an integer multiple of 10 MHz, the synthesizer operates in integer mode. The LO frequency is an exact integer multiple of the 10 MHz reference.

For all other frequencies, the internal synthesizer operates in fractional mode. Fractional mode generates LO frequencies accurate to ± 1 Hz. Fractional spurs are generated in the synthesizer with a maximum level of -48 dBc for fractional frequencies within the PLL loop filter bandwidth of 30 kHz. The LO synthesizer's fractional frequency is the distance in Hz to the closest integer multiple of 10 MHz. As the fractional frequency increases beyond 30 kHz, the fractional spur level decreases rapidly. Figure 22 shows fractional spur level plotted vs. fractional frequency. For example, if the internal LO synthesizer is set to 999 MHz, the fractional frequency is 1 MHz, and fractional spurs will be present at 998 MHz and 1000 MHz at a level of -100 dBc.

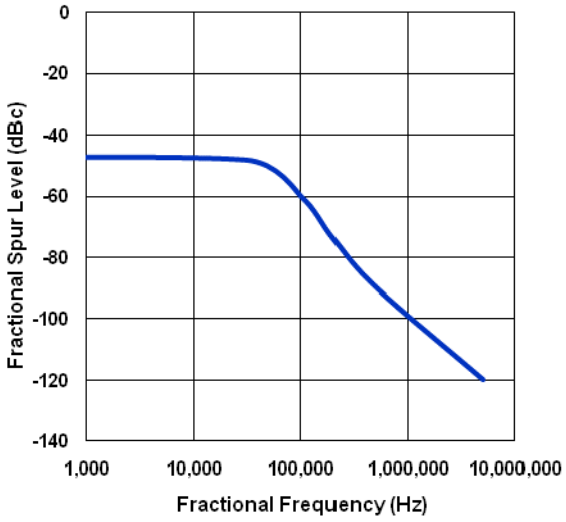

Figure 22.