

## COM-4410 [70 MHz – 2.2 GHz] 4-CHANNEL QUADRATURE RF MODULATORS

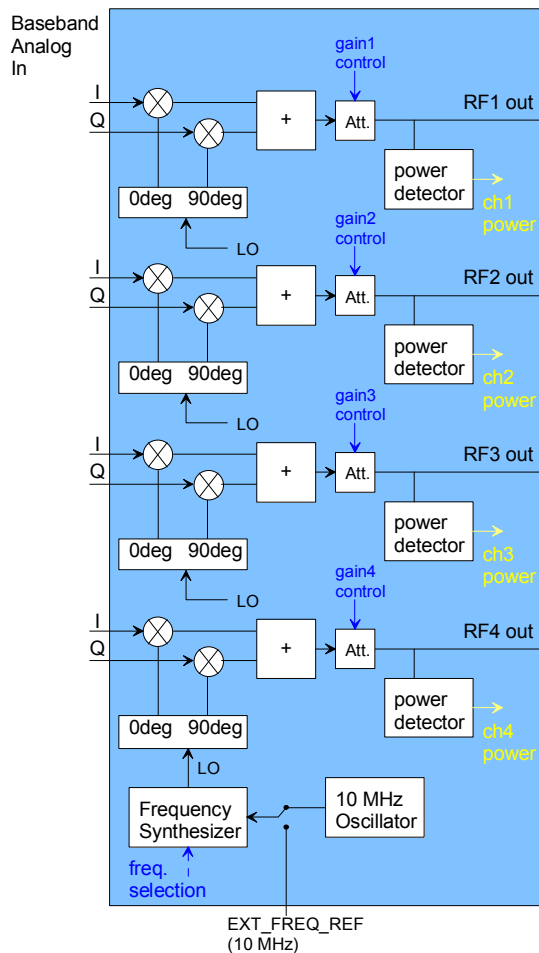
### Key Features

- Four wideband quadrature modulators share a common low-phase-noise RF frequency synthesizer.
- Software tunable in the range 70 MHz – 2.2GHz by steps of 2.5 KHz or less.
- Wideband modulation bandwidth:  
50 MHz (0.1 dB)  
500 MHz (1 dB)  
Designed for MIMO applications.
- Built-in output power detector for each channel.
- Software-based calibration to equalize gains or output power levels on all four channels.
- 8 preset frequencies for fast (<500μs) frequency hopping.
- RF frequency synthesizer is locked onto an internal or higher-stability external 10 MHz frequency reference. Automatic internal/external frequency reference selection.
- USB Monitoring & Control Interface
- Single +5V<sub>DC</sub> supply.
- Connectorized 3" x 3" module for ease of prototyping
- SMA output connectors

**Keywords:** MIMO, RF modulators, multi-channel, ADL5386, ADF4350

For the latest data sheet, please refer to the **ComBlock** web site: [comblock.com/com4410.html](http://comblock.com/com4410.html).  
These specifications are subject to change without notice.

For an up-to-date list of **ComBlock** modules, please refer to [http://www.comblock.com/product\\_list.html](http://www.comblock.com/product_list.html).



(shown without shield)

## Typical Applications

MIMO transmitter

## Electrical Interface

### Inputs / Outputs

Input Module Interface	Definition
MODx_I	Input signal, analog differential, baseband, real (I) axis. Operating maximum amplitude: 0.7Vpp on each signal (equivalent to 1.4Vpp differential). Each input signal should be DC biased from 0.4V to 0.6 (0.5V preferred for maximum AC swing). PCIe connector. The modulator index x ranges from 1 to 4.
MODx_Q	Input signal, analog differential, baseband, imaginary (Q) axis. Same electrical characteristics as above.
EXT_REF_CLK	Optional input. External 10 MHz frequency reference for frequency synthesis. Sinewave, clipped sinewave or squarewave. J9 SMA male connector. 50 Ohm. Minimum level: 2Vpp. Maximum level: 3.3Vpp.

Analog Output Signals	Definition
RF_OUTx	Modulated RF outputs. 70 MHz – 2.2GHz. Maximum output level: +4 dBm. Impedance: 50 Ohms. SMA female connectors
Control Lines	Definition
ENABLE	Low-voltage TTL input control. Used to turn all outputs on/off. Level signal: 3.3V = ON, 0V = OFF. Response time 200 µsec. On/Off rejection > 60 dB. Connector J8 Pin B3. Pulled high by default.
PLL_STROBE	Low-voltage (3.3V / 0V) TTL input control. Pulled low by default.  A short '1' pulse will cause the COM-4410 TO to jump to the next frequency by incrementing the modulo- $N_{freq}$ frequency pointer (where $N_{freq}$ is defined in control Register 35) RF frequency 0 -> RF frequency 1 -> RF frequency 2 -> RF frequency 0 > etc... Rising-edge triggered. Minimum pulse width: 10 µsec. The signal must be returned to zero as soon as possible as it impedes the module's communication ability. Connector J8 Pin A3.
<b>USB Monitoring &amp; Control</b>	Mini-USB connector (type AB); Full speed / Low Speed
<b>Power Interface</b>	4.9 – 5.5VDC. Terminal block. Power consumption is 1120mA. (245mA per enabled channel + 140mA)

## Absolute Maximum Ratings

Supply voltage	-12V min, +8V max
12-pin connector digital inputs	-0.3V min, +5.0V max
EXT_REF_CLK	-0.3V min, +3.6V max
MODx_I, MODx_Q	0V min, +2.0V max



## Configuration

Complete ComBlock assemblies can be monitored and controlled centrally over a single USB connection using the **ComBlock Control Center** software. A mini USB cable is required.

The COM-4410 can also be monitored and controlled through adjacent ComBlocks using LAN/TCP-IP, USB, Serial or CardBus connection.

The module configuration is stored in non-volatile memory.

### Configuration (Basic)

The easiest way to configure the COM-4410 is to use the ComBlock Control Center software supplied with the module(s). In the **ComBlock Control Center** window detect the ComBlock module(s) by clicking the  *Detect* button, next click to highlight the COM-4410 module to be configured, next click the  *Settings* button to display the *Settings* window shown below.

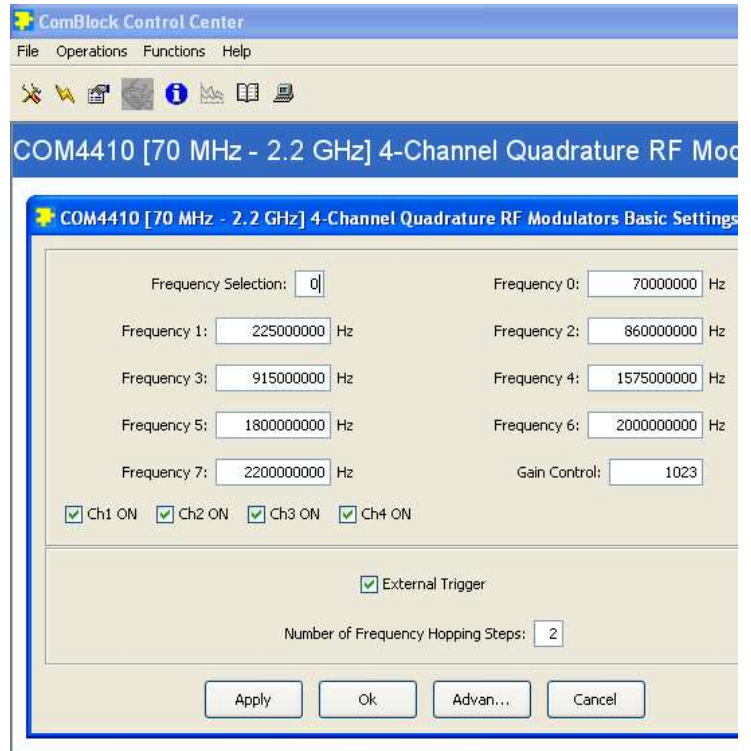
Up to eight frequencies can be stored within each module at any given time. The current frequency is selected by an index in the range 0 to 7.

Frequencies must be integer multiples of the RF synthesizer step size.

A basic frequency hopping scheme can be enabled by

- (a) enabling the external trigger
- (b) entering the number of frequency hopping steps in the round-robin arrangement.

For example, by specifying 4 steps, the modulator center frequency will follow the following index sequence: 0,1,2,3,0,1,2,3,0,1, etc., the index being incremented at the rising edge of each external PLL\_STROBE pulse.



## Configuration (Advanced)

Alternatively, users can access the full set of configuration features by specifying 8-bit control registers as listed below. These control registers can be set manually through the ComBlock Control Center or by software using the ComBlock API (see [www.comblock.com/download/M&C\\_reference.pdf](http://www.comblock.com/download/M&C_reference.pdf))

All control registers are read/write.

Undefined control registers or register bits are for backward software compatibility and/or future use. They are ignored in the current firmware version.

Programmers developing custom applications (using the [ComBlock API](#) instead of the supplied ComBlock control center graphical user interface) should know that frequency changes are enacted upon (re-)writing to the last register (REG39).

Parameters	Configuration
RF frequency 0	Preselected frequency 0. Range 70 MHz - 2.2GHz, expressed in Hz. REG0: bit 7:0 (LSB) REG1: bit 15:8 REG2: bit 23:16 REG3: bit 31:24 (MSB)
Output power	10-bit control.  REG4: bit 7-0 (LSB) REG5: bit 1-0 (MSB)
Modulator on/off	Individual ON/OFF control for each channel. 0 = OFF, 1 = ON  Another method to turn all modulators on/off simultaneously is to use the ENABLE external control on the J8 connector.  REG5 bit 4: channel 1 on/off REG5 bit 5: channel 2 on/off REG5 bit 6: channel 3 on/off REG5 bit 7: channel 4 on/off
External controls enabled/disabled	Enable or disable the PLL_STROBE and ENABLE external controls on the J8 connector. 0 = external controls disabled 1 = external controls enabled REG6: bit 1

Frequency selection	Use to switch local oscillator frequency among preselected values. Note: the external PLL_STROBE control may override this selection. Range 0 through 7 REG6 bits 7-5.
RF frequency 1	Preselected frequency 1. Same format as RF frequency 0. REG7: bits 7:0 (LSB) REG8: bits 15:8 REG9: bits 23:16 REG10: bits 31:24 (MSB)
RF frequency 2	Preselected frequency 2. Same format as RF frequency 0. REG11: bits 7:0 (LSB) REG12: bits 15:8 REG13: bits 23:16 REG14: bits 31:24 (MSB)
RF frequency 3	Preselected frequency 3. Same format as RF frequency 0. REG15: bits 7:0 (LSB) REG16: bits 15:8 REG17: bits 23:16 REG18: bits 31:24 (MSB)
RF frequency 4	Preselected frequency 4. Same format as RF frequency 0. REG19: bits 7:0 (LSB) REG20: bits 15:8 REG21: bits 23:16 REG22: bits 31:24 (MSB)
RF frequency 5	Preselected frequency 5. Same format as RF frequency 0. REG23: bits 7:0 (LSB) REG24: bits 15:8 REG25: bits 23:16 REG26: bits 31:24 (MSB)
RF frequency 6	Preselected frequency 6. Same format as RF frequency 0. REG27: bits 7:0 (LSB) REG28: bits 15:8 REG29: bits 23:16 REG30: bits 31:24 (MSB)
RF frequency 7	Preselected frequency 7. Same format as RF frequency 0. REG31: bits 7:0 (LSB) REG32: bits 15:8 REG33: bits 23:16 REG34: bits 31:24 (MSB)

Number of RF frequencies Nfreq in the scanning list	Each time a PLL_STROBE pulse is received, the frequency pointer increments modulo Nfreq. Nfreq is in the range 1 – 8. REG35: bits 7:0.
Channel 1 output power correction	Channel 1 output power correction factor used for fine manual calibration. The correction is a signed number expressed in steps of 0.05 dB. For example 0 = 0 dB correction 1 = +0.05 dB correction 255 = -1 = -0.05 dB correction REG36: bits 7:0
Channel 2 output power correction	Same format as above. REG37: bits 7:0
Channel 3 output power correction	Same format as above. REG38: bits 7:0
Channel 4 output power correction	Same format as above. REG39: bits 7:0

## Status Registers

Parameters	Monitoring
Channel 1 power measurement	10-bit number. The higher the number, the lower the power. The power measurement linearity is shown below. SREG0(7:0): bits 7-0 (LSB) SREG1(1:0): bits 9-8 (MSB)
Channel 2 power measurement	Same format as above. SREG2(7:0): bits 7-0 (LSB) SREG3(1:0): bits 9-8 (MSB)
Channel 3 power measurement	Same format as above. SREG4(7:0): bits 7-0 (LSB) SREG5(1:0): bits 9-8 (MSB)
Channel 4 power measurement	Same format as above. SREG6(7:0): bits 7-0 (LSB) SREG7(1:0): bits 9-8 (MSB)
Temperature measurement	Temperature (°C) measured at the modulator integrated circuit. 10-bit number.  SREG8(7:0): bits 7-0 (LSB) SREG9(1:0): bits 9-8 (MSB)
PLL lock status	A persistent '1' indicates that the frequency synthesizer is locked to the frequency reference. SREG10(0)
Power supply faults	Returns 0 when all internal supply voltages are within nominal range. SREG11(7:0)

## Test Points

Test points are provided for easy access by an oscilloscope probe.

Test Point	Definition
PLL_REF (TP2)	Internal / External 10 MHz frequency reference clock
PLL_LOCK (TP1)	Frequency synthesizer PLL lock status. Active high: '1' when locked. This information is also available in status register SREG10

## Operations

### Internal vs External Frequency Reference

An external 10 MHz frequency reference can be used when the user application requires high frequency stability. In this case, simply connect a 10 MHz sinewave, clipped sinewave or square wave to the J9 EXT-REF SMA connector. Detection is automatic, thus no configuration change is needed. Upon removal of the external 10 MHz frequency reference signal, the COM-4410 automatically reverts to the internal frequency reference.

### Tuning Step Size

The frequency translation is user programmable in the range of 70 MHz to 2.2 GHz. The step size depends on the selected frequency as listed below:

Tuning frequency	Step size
1.1 to 2.2 GHz	2.5 KHz
550 MHz to 1.1 GHz	1.25 KHz
275 MHz to 550 MHz	625 Hz
137.5 MHz to 275 MHz	312.5 Hz
68.75 MHz to 137.5 MHz	156.25 Hz

### Gain / Output Power Calibration

The COM-4410 includes a software-based gain calibration mode which adjusts each channel gain so that the output levels on all four channels are equal to the user-specified output power level.

This gain calibration is performed when the user changes the output power. The calibration takes **TBD** msec. The channel gains are fixed thereafter.

This mechanism can be used to calibrate gains or calibrate output power levels. To calibrate gain, the user should make sure that identical input signals are supplied at the input.

The absolute power measurement accuracy is better than  $\pm 0.5$  dB over the nominal operating conditions (frequency, temperature, output level range of +5 to -30 dBm). In order to achieve better accuracy, channel-specific manual corrections can be entered by the user in control registers REG36 through REG39.

Note: the power measurement is implemented using logarithmic amplifiers. This implementation is sufficient to meet the main requirement of normalizing output powers when similar waveforms are used all four channel. However, the log amplifier fundamentally responds to voltage, whereas its power response depends on the actual signal waveform. Therefore caution should be used when using the absolute measurement. A waveform-dependent correction should be added to the raw power measurement. The COM-4410 is calibrated for a sinusoidal (CW) waveform.

## Schematics

The schematics are available on the ComBlock CD shipped with every module (in the “Hardware schematics” folder).

## Performance

### Internal Clock Reference

The internal crystal performance is as follows:

- tolerance: [-5 to +15] ppm max @25°C
- temperature stability (-10°C to +60°C):  $\pm 50$  ppm max
- aging:  $\pm 5$  ppm/year max (1<sup>st</sup> year) @25°C

## Modulation

LO leakage (Carrier feedthrough) at output, maximum tx gain:

< -31 dBc over all operating conditions

-38 dBc @ 350 MHz, 25°C, typ.

-35 dBc @ 860 MHz, 25°C, typ.

Significantly better performance is obtained after using the nulling feature of the external DACs.

Sideband suppression:

< -28 dBc over all operating conditions

-49 dBc @ 350 MHz, typ.

-37 dBc @ 860 MHz, typ.

Significantly better performance is obtained after using the nulling feature of the external DACs.

Modulation bandwidth:

$\pm 50$  MHz @0.1dB

$\pm 500$  MHz @1dB

$\pm 600$  MHz @2dB

$\pm 700$  MHz @3dB

**Insert chart**

*Output spectrum 0 – 2.2GHz. 10 KHz resolution bandwidth. 1.5 GHz modulated output.*

**Insert chart**

*Maximum output power vs tuning frequency. 1Vpp baseband input. Gain settings 1023*

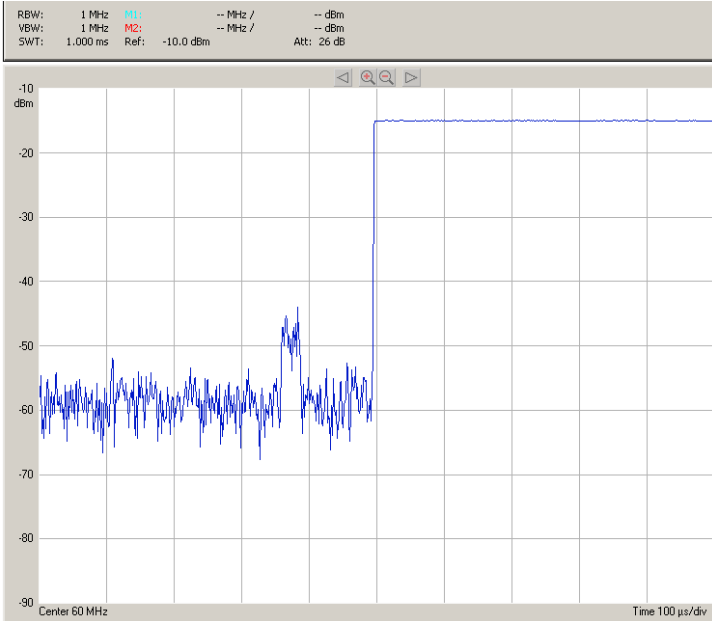
**Insert chart**

*Minimum output power vs tuning frequency. 1Vpp baseband input. Gain settings 0.*

# Frequency Synthesizer

LO frequency switching time using the PLL\_STROBE signal: < 500µs

LO frequency switching time using control registers: < 10ms



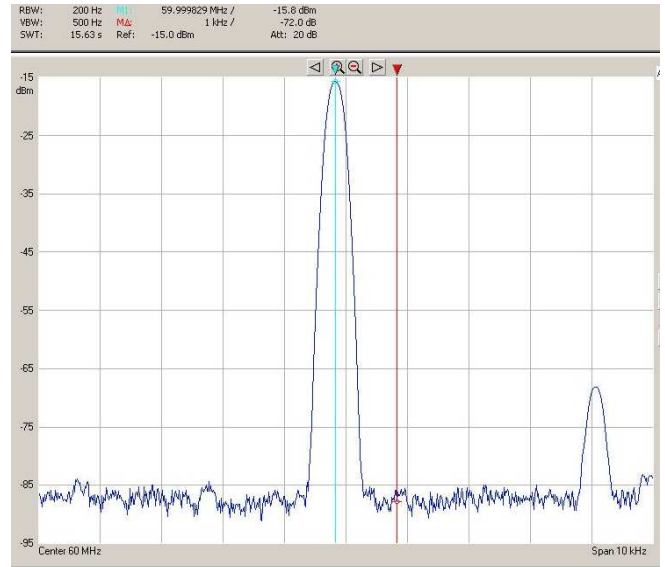
*Frequency hop using the PLL\_STROBE signal*

## Phase noise @ 70 MHz

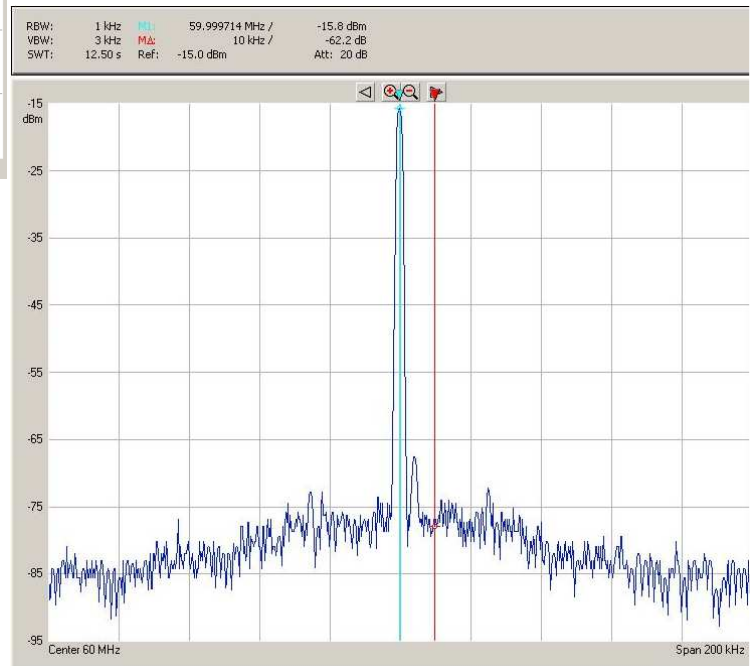
- < -95 dBc @ 1 KHz
- < -91 dBc @ 10 KHz
- < -98 dBc @ 100 KHz

## Phase noise @ 2.2 GHz

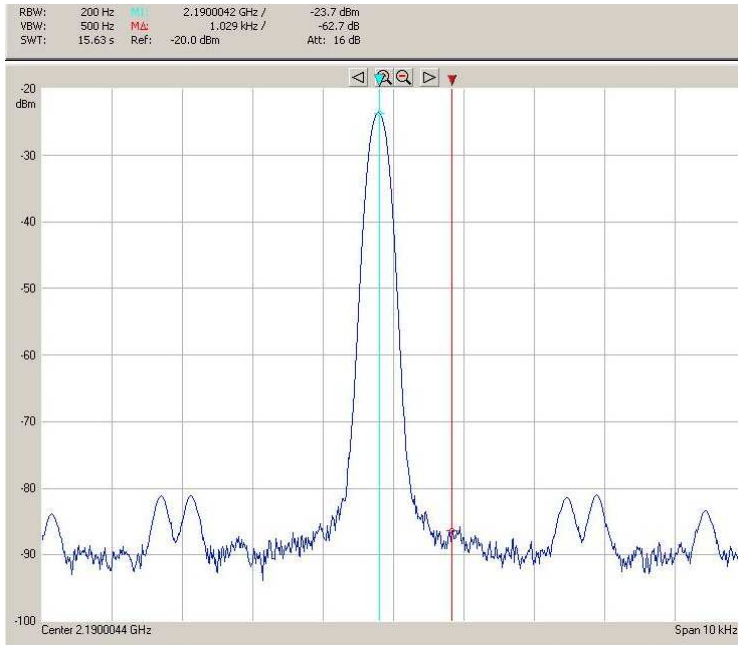
- < -85 dBc @ 1 KHz
- < -84 dBc @ 10 KHz
- < -93 dBc @ 100 KHz



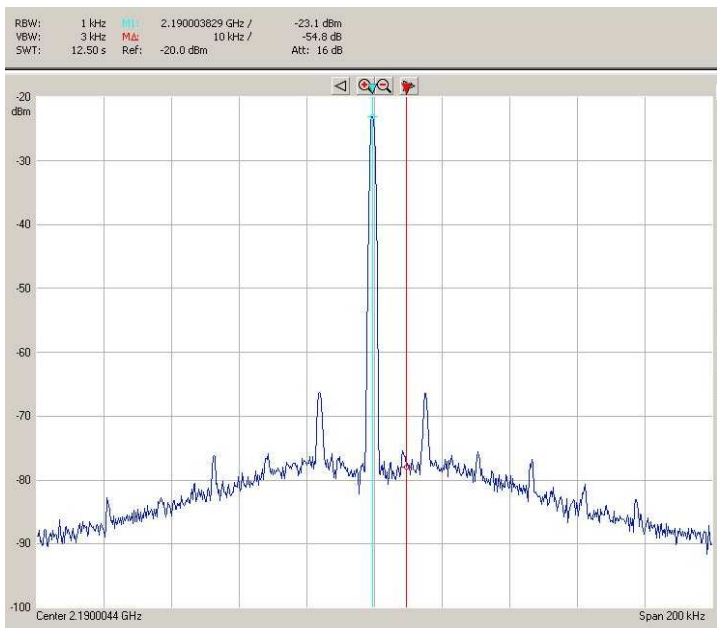
*Close-in phase noise @ 70 MHz.  
 10 KHz span, 200 Hz resolution bandwidth,  
 -10 MHz complex input.*



*Wideband phase noise @ 70 MHz.  
 200 KHz span, 1KHz resolution bandwidth,  
 -10 MHz complex input.*



*Close-in phase noise @ 2.2 GHz.  
 10 KHz span, 200 Hz resolution bandwidth,  
 -10 MHz complex input.*



*Wideband phase noise @ 2.2 GHz.  
 200 KHz span, 1KHz resolution bandwidth,  
 -10 MHz complex input.*

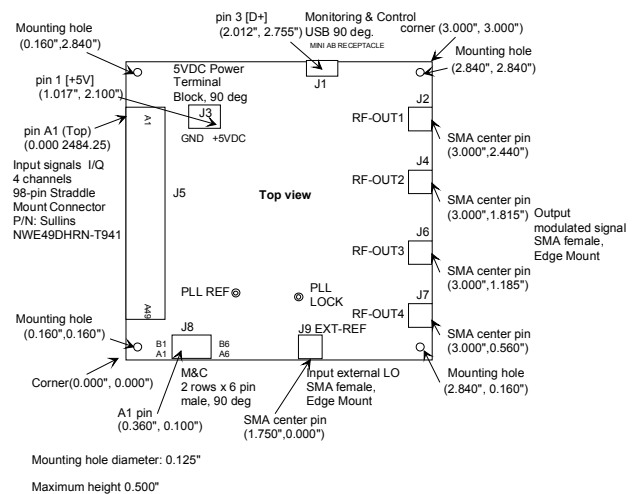
Similar phase noise performance are obtained with internal and external frequency references.

## Harmonics

### Power measurement

Accuracy (no correction, unmodulated CW carrier):  
 $\pm 0.5$  dB  
 Video bandwidth: 3.5 MHz

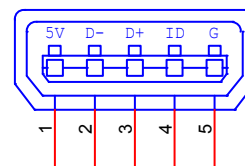
### Mechanical Interface



### Pinout

#### Mini USB Connector J1

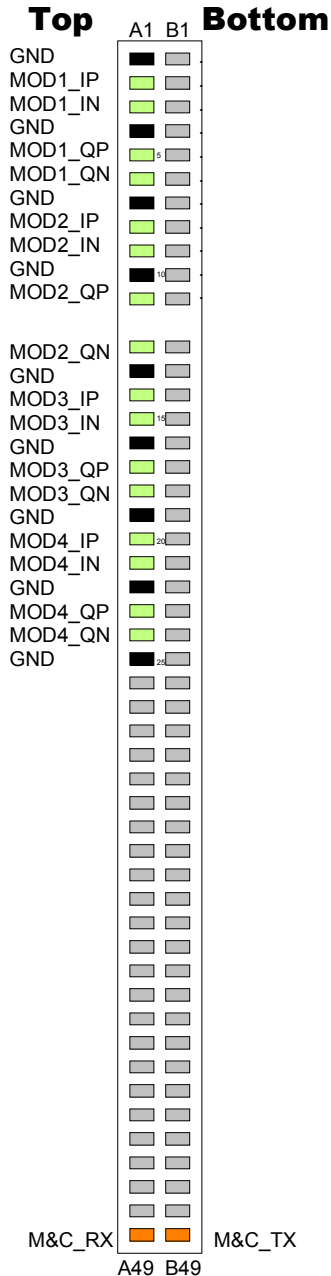
The COM-4410 is a USB device with a mini type AB connector. (G = GND)



## Input Connector J5

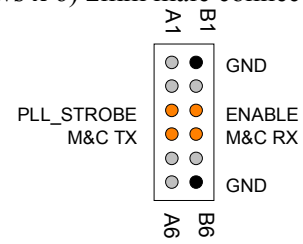
98-pin Female Connector.

This module is designed for direct connection to the COM-2802 8-channel baseband digital-to-analog conversion module.



## Connector J8

12-pin (2 rows x 6) 2mm male connector.



## I/O Compatibility List

(not an exhaustive list)

Input
<a href="#">COM-2802</a> Synchronized Channel 900MS/s Digital-to-Analog Conversion
<a href="#">COM-9105</a> PCIe adapter

## ComBlock Ordering Information

COM-4410      [70 MHz – 2.2 GHz] 4-CHANNEL QUADRATURE MODULATORS

MSS • 18221-A Flower Hill Way •  
Gaithersburg, Maryland 20879 • U.S.A.  
Telephone: (240) 631-1111  
Facsimile: (240) 631-1676  
E-mail: sales@comblock.com