Quonset Microwave
www.quonsetmicrowave.com

QM2010-6000
USB RF Synthesizer Module
25 MHz – 6 GHz output

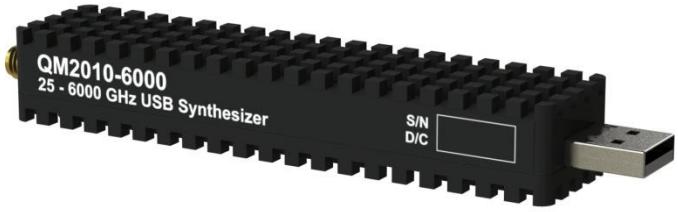
Typical Applications

- Low cost signal generators
- Test equipment
- RF System Integration
- Communication systems
- UHF/VHF systems
- Frequency conversion

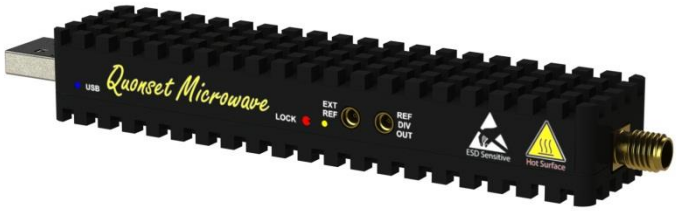
Features

- Wideband RF output, 25 MHz to 6 GHz
- Integer and Fractional operating modes
- Up to 50 dB output attenuation adjustable in 1 dB steps
- USB interface
- USBTMC VISA Compliant
- User selectable internal reference or externally applied reference

General Description



QM2010-6000 Side View
Part Number and Serial Number



QM2010-6000 Side View
USB, Lock Status, and External Reference LEDs
External Reference MMCX input, Reference Out MMCX output

Larger images in the Device Housing section

The QM2010 USB RF synthesizer series from Quonset Microwave offers a low cost solution for today's demanding RF signal generation needs.

The QM2010-6000 RF Synthesizer Module is a low-cost, wideband 25 MHz to 6 GHz frequency synthesizer ideally suited for bench top test and measurement as well as low-cost small form-factor communications systems. Its wide output frequency range, superb spurious rejection, and excellent phase noise performance provide a high-quality, low-cost alternative to conventional bench top RF signal generators. The RF synthesizer module is capable of phase locking to its internal 50 MHz reference or a user provided external reference.

The RF synthesizer module is powered and controlled directly by a host PC through USB. The QM2010-6000 is VISA compliant, enabling seamless cross-platform use. Users can control QM2010 series synthesizers through a lightweight control GUI, supported on Windows®, Macintosh®, or Linux® platforms, with SCPI compliant VISA commands, described in the QM2010 User Manual, or with third party development environments such as LabVIEW®.

The RF Synthesizer you can carry in your pocket!

Electrical Specifications

Parameter		Min.	Typ.	Max.	Units
RF Operating Frequency		25	-	6000	MHz
Reference Input Frequency (Sine)		10	50	100	MHz
Reference Input Power (Sine or square wave)		0		15	dBm
SSB RF Phase Noise:	50 MHz		-104		dBc/Hz
(100 kHz Offset	3000 MHz		-95		dBc/Hz
with Internal Ref)	6000 MHz		-86		dBc/Hz
RF Harmonics:	50 MHz (2^{nd}/3^{rd}/4^{th})		-24.66 / -10.66 / -34.5		dBc
	3000 MHz (2^{nd}/3^{rd}/4^{th})		-26.17 / -29 / -46.83		dBc
	6000 MHz (2^{nd}/3^{rd}/4^{th})		-28.5 / -47.5 / > -70		dBc
Locking Time				1	ms
Frequency Resolution:*	Integer Mode				
	Freq < 1000		12.5		MHz
	Freq = 1000-1500		25		MHz
	Freq = 1500-3000		50		MHz
	Freq > 3000		100		MHz
	Fractional Mode				kHz
Power Resolution			0.5	1	dB
Internal reference frequency			50		MHz
Internal oscillator frequency stability			±0.5		ppm

** Under default conditions – a 50 MHz reference input with a reference divider of 1. See "Integer and Fractional Modes of Operation" for more information*

Programming Interface

The QM2010 series of RF synthesizers can be controlled using any computer with a USB port running Windows®, Macintosh®, or Linux® operating systems. Other configurations may be possible since the synthesizer uses the USB Test and Measurement Device (USBTMC) class standard to emulate a GPIB bus. This allows for easy integration into existing test setups. A Windows® compatible USBTMC driver is supplied with the module. Most distributions of Linux® already have USBTMC drivers included in the kernel, and Macintosh® users will need to obtain drivers from a third party. Installation of drivers is not necessary if you already have a compliant VISA runtime installation, such as one provided by National Instruments or Agilent. A lightweight GUI using the VISA runtime is provided with the module.

The synthesizer is controlled by delivering SCPI 1999.0 compliant text-based commands through the USB interface. For command structure information and a full command list, see the USB Programming manual (QM2010-99-2).

Integer and Fractional Modes of Operation

The QM2010 RF Synthesizer Module is capable of operating in integer or fractional mode. In integer mode, the frequency resolution of the QM2010-6000 is dependent on the frequency range of operation. This is due to the design topology of the QM2010-6000, which has a fundamental frequency range of 1500 MHz to 3000 MHz from which all other tuned frequencies are derived. When operating in this fundamental frequency range in integer mode, the frequency resolution is equal to $fres = \frac{reference}{ref\ divider}$. For frequencies above 3000 MHz, a doubler is applied to the fundamental, doubling the frequency resolution to $fres = \frac{reference}{ref\ divider} * 2$. For frequencies below 1500 MHz, a divider is applied to the output frequency, lowering the frequency resolution to $fres = \frac{reference}{ref\ divider} * \frac{1}{freq\ divider}$. The frequency divider can be any even integer value between 2 and 62, dependent on the output frequency. All frequency divider and doubler calculations take place in synthesizer firmware automatically when a frequency is set.

For example, in integer mode, tuning to an output frequency of 25 MHz requires a fundamental frequency of 1550 MHz divided by 62. We can check the feasibility of this request by first checking if the fundamental frequency divided by the reference frequency is an integer value → $N_{int} = \frac{freq_{fundamental}}{ref} = \frac{1550e6}{20e6} = 77.5$. Since the fundamental frequency is not a tunable integer value, we cannot tune to exactly 25 MHz in integer mode. The previous integer step is not a tunable frequency → $\frac{N_{int}*ref}{62} = \frac{77*20e6}{62} = 24.838\ MHz$, so we must use the next integer step → $\frac{N_{int}*ref}{62} = \frac{78*20e6}{62} = 25.161\ MHz$. If we multiply the tuning frequency by the frequency divider→ $25.161\ MHz * 62 \approx 1560\ MHz$, which will get rounded down to 1550 MHz with a reference of 50 MHz and a reference divider of 1.

If the synthesizer is unable to tune to the exact frequency in integer mode, it will tune to the closest tunable frequency. For example, 1555 MHz is not a tunable frequency in integer mode with a 50 MHz reference. The synthesizer will therefore tune to 1550 MHz.

Fractional mode will allow for a frequency step size of 1 kHz. When operating in fractional mode, it is recommended that the reference divider value always be set to 1.

Table 1 – Integer vs. Fractional Mode Comparison

Parameter	Integer Mode	Fractional Mode
Phase Noise	• Comparable to fractional mode phase noise at offset frequencies ≤ 100 kHz, *if* the reference divider value is ≤ 2 • Degrades as reference divider increases	• Comparable to integer mode at offset frequencies ≤ 100 kHz, *if* the reference divider value = 1 (should always be 1 for best performance).
Spurious Content	• Better spurious performance	• Additional spurs present at frequency offsets ≤ 5 MHz
Recommendation	• Use whenever possible for best performance	• Use when fine frequency resolution is required

Figures 1 and 2 illustrate the performance difference between integer and fractional mode when tuning to 3 GHz with a 50 MHz reference. In order to tune to 3 GHz with a 50 MHz reference, the user can either operate in integer mode with a reference divider of 1, or in fractional mode. Figure 1 depicts the phase noise differences between 3 GHz in fractional mode vs. integer mode with a reference divider of 2, whereas Figure 2 shows the spurious content difference in a 50 MHz span between the two modes of operation.

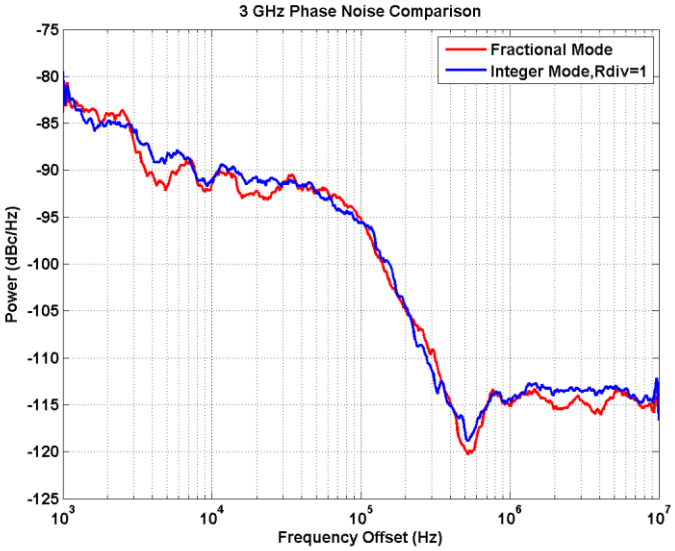


Figure 1 - Fractional vs. Integer Mode Phase Noise

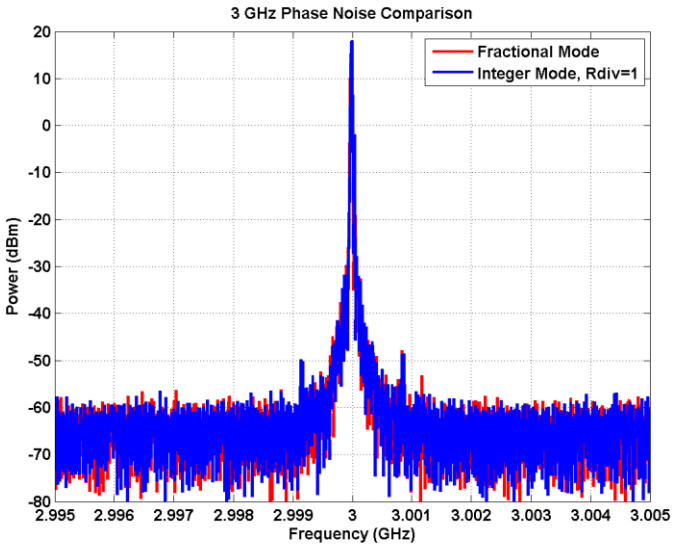


Figure 2 – Fractional vs. Integer Mode Spectrum
10 MHz span, RBW = 10 kHz, VBW = 300 Hz

Frequency Reference Consideration

Aside from reference divider selection, the phase noise performance and stability of the reference oscillator has a direct effect on QM2010 phase noise performance. The QM2010-6000 includes an on board, high precision TXCO 50 MHz reference whose phase noise parameters are outlined in Table 2. To ensure optimal QM2010 performance when an external reference is required, it is important to choose an accurate and stable oscillator with specifications equal to or better than the 50 MHz TCXO Int Ref outlined in Table 2.

Figure 3 depicts phase noise performance differences between the QM2010-6000 high precision TXCO internal reference and an ultra high precision OCXO external reference. Phase noise performance with different reference divider settings is also shown. Table 2 outlines the performance differences between reference oscillators.

Table 2 – Reference Characteristics - Internal Reference vs. External

Parameter	50 MHz TCXO Int Ref	20 MHz OCXO Ext Ref
SSB Phase Noise at 10 Hz Offset	-70 dBc/Hz	-110 dBc/Hz
SSB Phase Noise at 100 Hz Offset	-100 dBc/Hz	-135 dBc/Hz
SSB Phase Noise at 1 kHz Offset	-122 dBc/Hz	-150 dBc/Hz
Frequency Stability at 25 °C	± 0.5 ppm	± 0.2 ppm
Frequency Stability vs. Temp	± 0.25 ppm	± .02 ppm

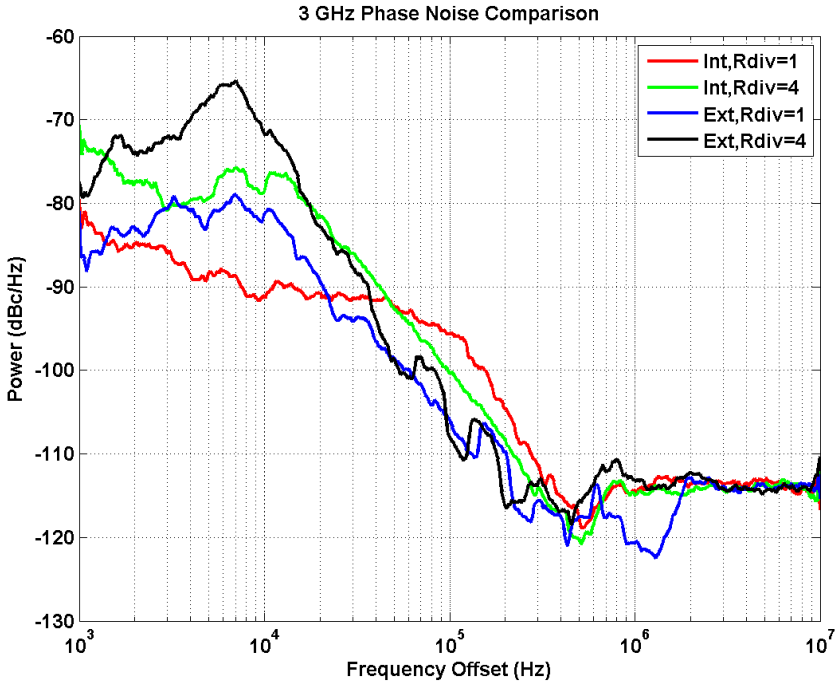


Figure 3 - Phase Noise Reference and Reference Divider Comparison

QM2010-6000 Performance Plots

Unless explicitly defined, all data was taken with the internal 50 MHz reference operating with a reference divider value of 1.

Figure 4 shows representative phase noise plots for 0.5 GHz, 1 GHz, 3 GHz and 6 GHz carrier outputs.

Figure 5 is the maximum and minimum power output vs. tuning frequency.

Figures 6-13 show the representative spectral plots at several frequencies.

Power Calibration

The QM2010 series of USB Stick Synthesizers feature output power control tunable to within ± 1 dB of a desired power level.

If the selected power level exceeds the maximum or minimum output power levels shown in Figure 5, the QM2010 will set the power level to the closest possible value.

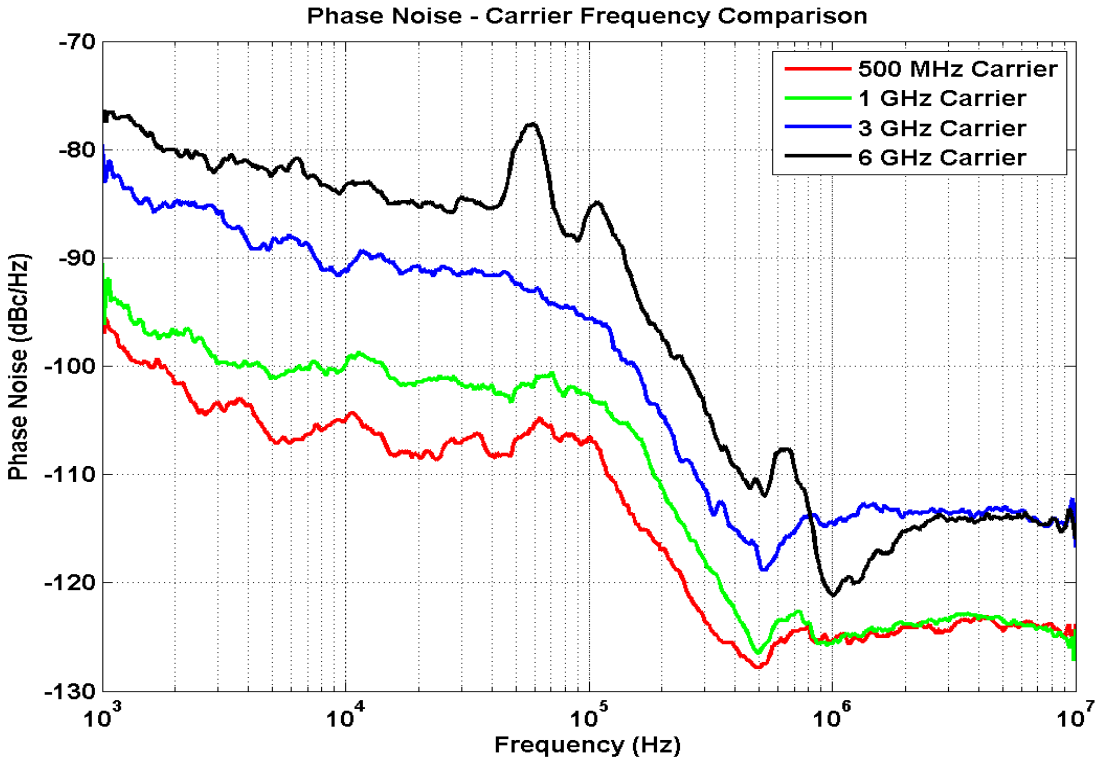


Figure 2 - Representative Phase Noise Plots

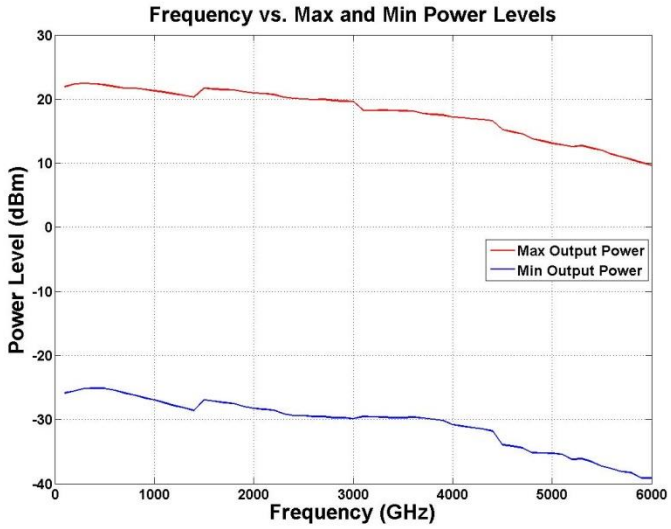


Figure 5 – Frequency vs. Max and Min Power Levels

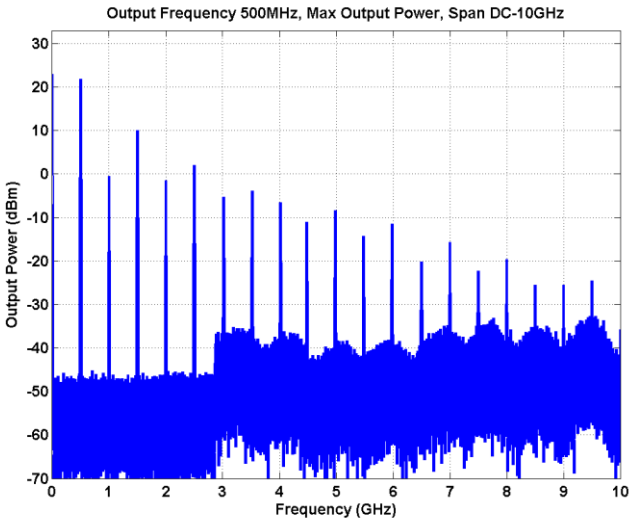


Figure 6 – 0.5 GHz Output, DC-10 GHz, VBW/RBW = 100 kHz

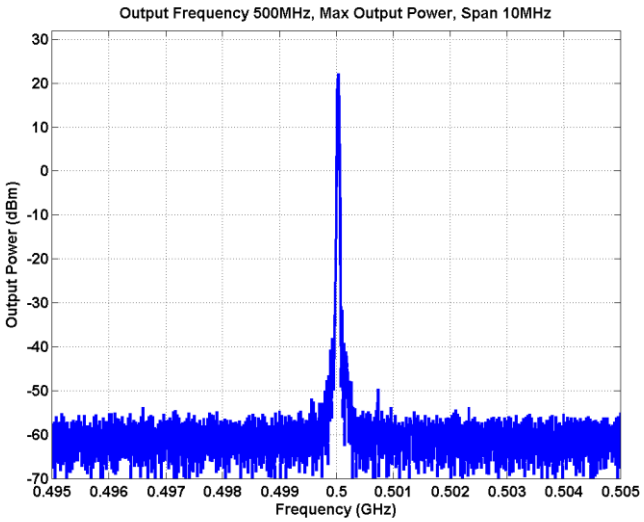


Figure 7 – 0.5 GHz Output, 10 MHz span, VBW/RBW = 3 kHz

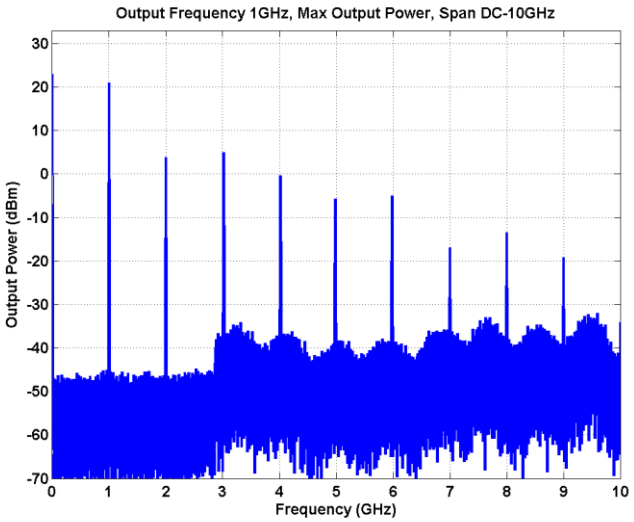


Figure 8 - 1 GHz Output, DC-10 GHz, VBW/RBW = 100 kHz

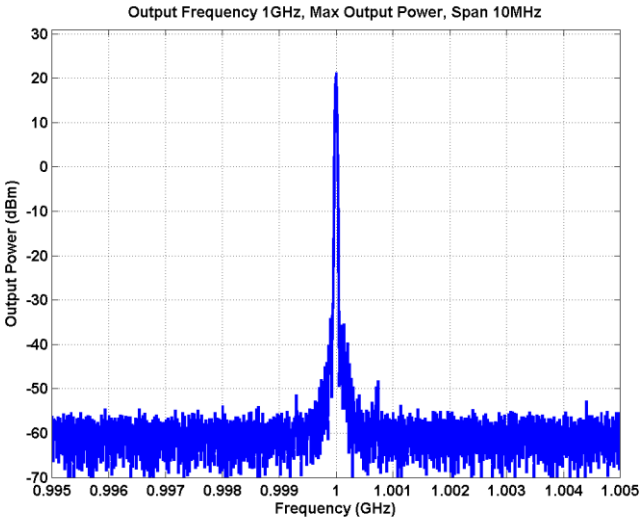


Figure 9 – 1 GHz Output, 10 MHz span, VBW/RBW = 3 kHz

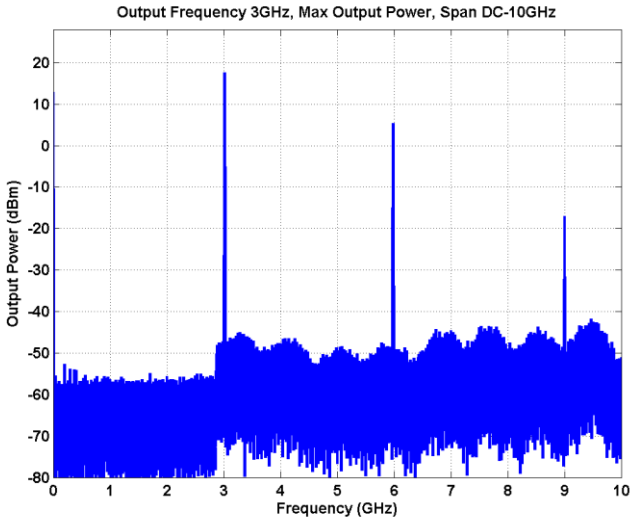


Figure 10 – 3 GHz Output, DC-10 GHz, VBW/RBW = 100 kHz

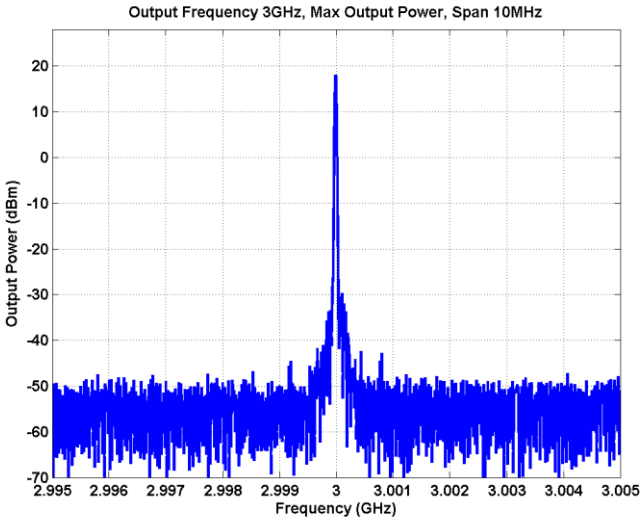


Figure 11 – 3 GHz Output, 10 MHz span, VBW/RBW = 3 kHz

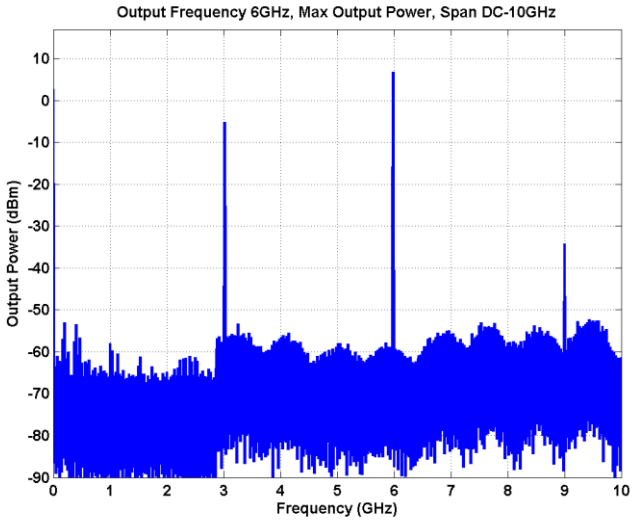


Figure 12 – 6 GHz Output, DC-10 GHz, VBW/RBW = 100 kHz

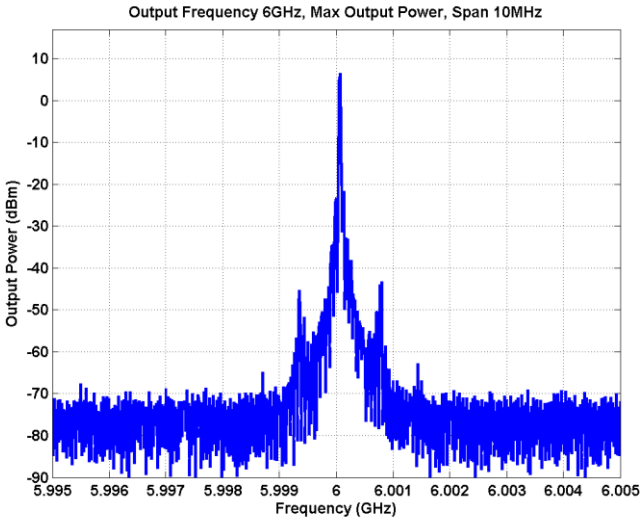


Figure 13 – 6 GHz Output, 10 MHz span, VBW/RBW = 3 kHz

Device Housing

The QM2010 housing is a doubled sided pin fin heat sink constructed of anodized aluminum as shown in Figures 14 and 15. This creates an extremely rugged package that provides adequate surface area for natural convection cooling and EMI protection for the sensitive electronics housed within. The device should be kept clean and unobstructed in order to promote air circulation. Because the device is cooled through natural convection, a case temperature rise of +20 ^{o}C over ambient conditions can be expected. If this product is used outside of a lab environment (+30 ^{o}C ambient conditions) users are urged to exhibit care while handling the device, such as wearing heat resistant gloves or applying forced air cooling with an external fan.

Table 3 - QM2010 USB RF Synthesizer Module Physical Parameters

Dimensions	4.1” x 0.9” x 0.645”
Weight	0.2 lbs

Figure 3 – QM2010-6000 Side View, Part Number and Device Name

Figure 4 – QM2010-6000 Side View, Status LEDs and External Reference Input

Figure 15 shows the status LED locations on the QM2010 series of USB stick synthesizers. The blue LED to the left of the “USB” text will illuminate when the device is enumerated by a host PC. The “LOCK” LED will be green when the device is phase locked or red if the device is unlocked or has RF power disabled. The “EXT REF” LED should illuminate yellow when the device is set to lock to an external reference. When locking to the internal 50 MHz reference, the EXT REF LED should be off.

Interface Connections

I/O Connector	Connector Type	Description
EXT REF	MMCX-F	External Reference input (10 MHz to 100 MHz)
REF DIV OUT	MMCX-F	Reference divider out – not used in normal operation
RF out	SMA-F	RF output: 25-6000 MHz
USB	USB Type A – Male	USB signal and power

Accessories

A USB A Extension Cable, 3 feet is included. It is recommended that any non-supplied USB A Extension Cable have power strands less than or equal to 24 AWG and be as short as possible. The additional voltage drop inherent in long or high gauge USB cabling will negatively affect QM2010 performance.

Associated Manuals

Description	Link
QM2010 USB Synthesizer Stick Quick Start Manual	http://www.quonsetmicrowave.com/v/vspfiles/Manuals/QM2010_Quick_Start.pdf
QM2010 USB Stick Synthesizer User Manual	http://www.quonsetmicrowave.com/v/vspfiles/Manuals/QM2010_User_Manual.pdf

Associated Products

Product Number	Description
QM2010-4400	35 MHz to 4400 MHz USB Synthesizer
QM2010-5-10	5 GHz to 10 GHz USB Synthesizer
QM2010-10-20	10 GHz to 20 GHz USB Synthesizer
QM2010-21-24	21 GHz to 24 GHz USB Synthesizer
QM2010-24-27	24 GHz to 27 GHz USB Synthesizer
QM1002 Series	1U 19” Rack-mountable Single or Dual Channel RF Upconverters
QM1003 Series	1U 19” Rack-mountable Single or Dual Channel RF Downconverters
QM1004 Series	1U 19” Rack-mountable RF Up-Downconverter Module
QM1007 Series	1U 19” Rack-mountable RF Up-Downconverter Module

Absolute Maximums

Ref input power	+20 dBm
Vcc	+5.5 Vdc
Operating Temperature	0 to +55 ºC
Storage Temperature	-50 to +100 ºC

ELECTROSTATIC SENSITIVE DEVICE
OBSERVE HANDLING PRECAUTIONS

Ordering Information

QM2010-6000