Holzworth

Datasheet

HSM Series

RF SYNTHESIZER MODULES

Models in the range 10 MHz to 6 GHz

The Holzworth HSM Series RF synthesizer modules are stand alone, CW sources. These sources are designed as building blocks for systems integration where performance at the foundation is critical. Holzworth synthesizers provide incredible signal stability. The family includes modules spanning from 10 MHz to **1 GHz, 2 GHz, 3 GHz, 4 GHz, and 6 GHz**. When integrated as multiple units connected to the same reference signal, a phase coherent relationship is created which provides optimal unit-to-unit stability. 12 GHz and 18 GHz modules are also available. Details on these modules are included in a separate datasheet.

HSM Series RF Synthesizers

HYBRID ARCHITECTURE ENABLES BOTH LOW PHASE NOISE & FAST SWITCHING

The core architecture of the HSM Series modules is derived from Holzworth's proprietary NON-PLL design to provide the ultimate in phase / frequency stability. This direct-digital/direct-analog hybrid design was originally developed as a key building block for our phase noise analysis products. The hybrid architecture provides frequency agility & resolution, phase continuous switching, and predictable performance without compromising on spurious or phase noise performance.

The versatile HSM synthesizer modules can be controlled directly via the SPI bus, the Holzworth GUI, a preloaded lookup table, LabVIEW™, MATLAB™, C++, C#, etc. Some systems integrators have preferred the supported Linux platform over a Windows based PC. An advanced application example uses a preloaded lookup table in a multi-channel configuration further leveraging the unique non-PLL characteristics.

The attractive performance-to-price ratios available with the Holzworth HSM Series offer optimal solutions for electronics design, manufacturing test applications, and OEM systems integration.

FREQUENCY OPTIONS

HSM1001B	1 GHz RF Synthesizer Module	10 MHz to 1 GHz	-132 dBc/Hz at 1 GHz (10 kHz offset)
HSM2001B	2 GHz RF Synthesizer Module	10 MHz to 2 GHz	-126 dBc/Hz at 2 GHz (10 kHz offset)
HSM3001B	3 GHz RF Synthesizer Module	10 MHz to 3 GHz	-122 dBc/Hz at 3 GHz (10 kHz offset)
HSM4001B	4 GHz RF Synthesizer Module	10 MHz to 4 GHz	-120 dBc/Hz at 4 GHz (10 kHz offset)
HSM6001B	6.0 GHz RF Synthesizer Module	10 MHz to 6 GHz	-116 dBc/Hz at 6 GHz (10 kHz offset)

DESIGN HIGHLIGHTS

- High Amplitude Accuracy
- Agile Frequency Switching Speeds
- Pulse Modulation Burst Mode (internal pulse)
- Onboard 100 MHz Ultra-Low Noise OCXO
- 100 MHz Reference Out: -165 dBc/Hz (10 kHz offset)
- Reference Input: 10 MHz or 100 MHz
- SPI, USB or Ethernet Communications Interface
- Internal Temperature Monitor Output

HSM Series RF Synthesizers
FREQUENCY PERFORMANCE

The specified frequency performance parameters for the HSM Series RF synthesizer modules are fully verified at final performance test and 100% guaranteed for the full warranty period of the product.

PARAMETER	MIN[1]	TYPICAL[2]	MAX[1]	COMMENTS
Frequency Range				
Model HSM1001B	10 MHz		1 GHz	Settable from 5 MHz to 1.024 GHz
Model HSM2001B	10 MHz		2 GHz	Settable from 5 MHz to 2.048 GHz
Model HSM3001B	10 MHz		3 GHz	Settable from 5 MHz to 3.072 GHz
Model HSM4001B	10 MHz		4 GHz	Settable from 5 MHz to 4.096 GHz
Model HSM6001B	10 MHz		6.0 GHz	Settable from 5 MHz to 6.720 GHz
Frequency Step Size		0.001 Hz		
Phase Offset Resolution				**Offset Accuracy:**
10 MHz – 512 MHz		0.1 deg		±0.05 deg
512 MHz – 1.024 GHz		0.2 deg		±0.10 deg
1.024 GHz – 2.048 GHz		0.4 deg		±0.20 deg
2.048 GHz – 4.096 GHz		0.8 deg		±0.40 deg
4.096 GHz – 6.000 GHz		1.6 deg		±0.80 deg
Switching Speed (Frequency)				No additional frequency settling time
SPI Mode (ASCII)		350us		
SPI Mode (Binary)		200us		
List/Step Sweep Mode (WB)		70us		Wideband Mode (full bandwidth)
List/Step Sweep Mode (NB)		6us		Narrowband Mode (≤9% bandwidth) [3]
Internal Time Base Reference (Oscillator Aging Rate)		± 1 ppm/yr		1st year. ±0.5 ppm/yr each subsequent year
Temperature Effects		± 1 ppm		0 to 55 °C
Line Voltage Effects (12V)		± 0.1 ppm		±5%
Reference Output				
Frequency		100 MHz		
Amplitude	+2 dBm		+6 dBm	Nominal
Impedance		50 Ω		Nominal
External Reference Input				
Input Frequency		10 / 100 MHz		Software Select 10 MHz, 100 MHz or No Ext. Ref.
10 MHz Lock Range		± 4 ppm	± 1 ppm	20 Hz Locking BW, Internal OCXO remains on
10 MHz External Amplitude	0 dBm		+10 dBm	20 Hz Locking BW, Internal OCXO remains on, (nom)
100 MHz External Amplitude	+2 dBm		+6 dBm	Internal OXCO shuts off, (nom)
Impedance		50 Ω		50 Ω (nom)
Waveform				Sine
Digital Sweep Modes				
Operating Modes				Step sweep (linear, internal) List Sweep (arbitrary list of frequency steps) Simultaneous Amplitude sweep (list)
Sweep Range	10 MHz		6.4 GHz	Limited to max frequency of model number
Dwell Time Wideband/Sweep	100 µs		10 s	1 µs increments
Dwell Time Narrowband	6 us		10s	1 µs increments
Number of Points (STEP)	2		65535	
Number of Points (LIST)	2		3232	
Triggering				Free Run, External Trigger

1 All MIN/ MAX performance parameters are guaranteed and 100% verified during final performance test, unless noted otherwise.
2 Typical performance is "by design" and consistent with field performance data
3 Narrowband List mode frequency limits are defined as: FCENTER ± ((FCENTER x 0.09) / 2)

HSM Series RF Synthesizers
AMPLITUDE PERFORMANCE

The specified amplitude based parameters for the HSM Series RF synthesizer modules are fully verified at final performance test and 100% guaranteed for the full warranty period of the product.

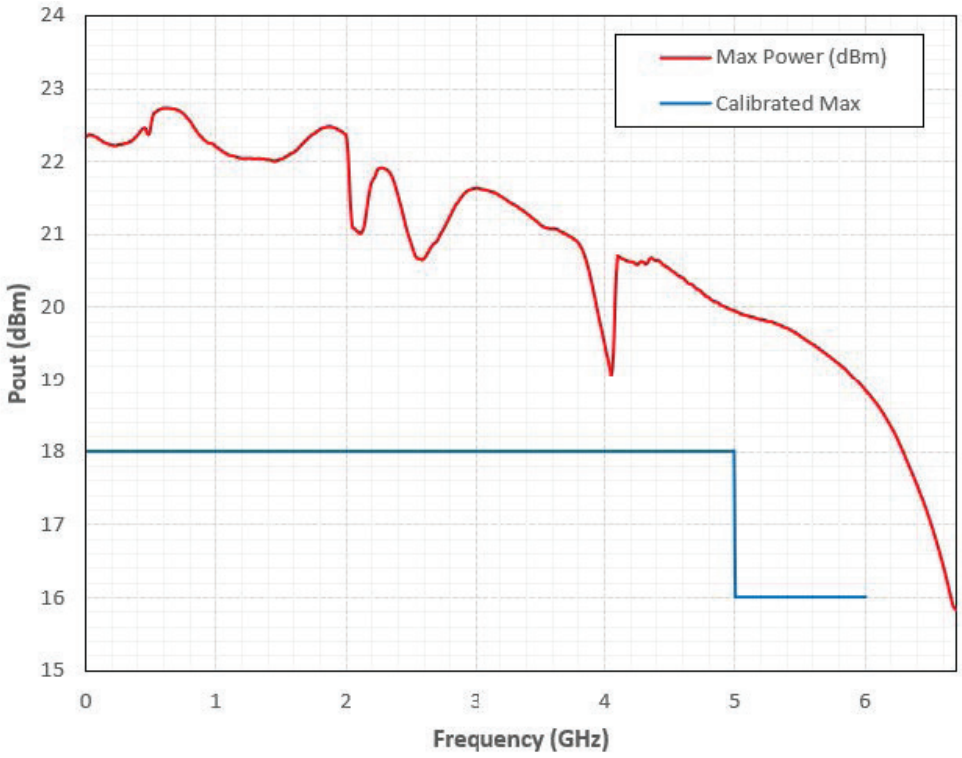
PARAMETER	MIN[1]	TYPICAL[2]	MAX[1]	COMMENTS
Output Power (Calibrated)				Refer to typical data. Page 5
10 MHz ≤ f ≤ 5 GHz	-50 dBm		+18 dBm	Settable from -90 dBm to +25 dBm
5 GHz < f ≤ 6.0 GHz	-50 dBm		+16 dBm	Settable from -90 dBm to +25 dBm
Absolute Level Accuracy				25 °C to 35 °C (case temperature)
10 MHz ≤ f ≤ 6.0 GHz +18 to +15 dBm		± 0. 35 dB	± 1.00 dB	
10 MHz ≤ f ≤ 6.0 GHz +15 to -10 dBm		± 0. 25 dB	± 0.65 dB	
10 MHz ≤ f ≤ 6.0 GHz -10 to -50 dBm		± 0.50 dB	± 1.50 dB	
Resolution		0.01 dB		
Connector		50 Ω		SMA
VSWR (S_{22})				
10 MHz to 2 GHz		1.33 (-17 dB)		Measured
2 GHz to 4.1 GHz		1.57 (-13 dB)		Measured
4.1- 6.0 GHz		2.32 (-8 dB)		Measured
Maximum Reverse Power	*** Some applications may require reverse power protection.			
Max DC Voltage	25 VDC maximum by design.			
> 10 MHz	10 mW (+16dBm) max by design.			
Switching Speed (Amplitude)				Settled within 10% of set value
SPI Mode		200 µs		
List / Step Sweep Mode		1 µs		
SSB Phase Noise				Refer to typical data: Page 6
100 MHz, 10 kHz offset		≤ -147 dBc/Hz	≤ -141 dBc/Hz	
500 MHz, 10 kHz offset		≤ -138 dBc/Hz	≤ -132 dBc/Hz	
1.0 GHz, 10 kHz offset		≤ -132 dBc/Hz	≤ -126 dBc/Hz	
2.0 GHz, 10 kHz offset		≤ -126 dBc/Hz	≤ -120 dBc/Hz	
3.0 GHz, 10 kHz offset		≤ -122 dBc/Hz	≤ -116 dBc/Hz	
4.0 GHz, 10 kHz offset		≤ -120 dBc/Hz	≤ -114 dBc/Hz	
6.0 GHz, 10 kHz offset		≤ -116 dBc/Hz	≤ -110 dBc/Hz	
Harmonics (CW mode)		**(2ND / 3RD)**	**(All)**	Refer to typical data: Page 7
100 MHz to 1.024 GHz		-42 / -60 dBc	-30 dBc	@ 0 dBm
>1.024 GHz to 4.096 GHz		-45 / -75 dBc	-30 dBc	@ 0 dBm
>4.096 GHz to 6.0 GHz		-50 / -65 dBc	-40 dBc	@ 0 dBm
Sub-Harmonics (CW mode)		**($^1/_2$ / $^3/_2$)**	**(All)**	Refer to typical data: Page 7
10 MHz to 1.024 GHz		-90 / -75 dBc	-60 dBc	@ 0 dBm
>1.024 GHz to 4.096 GHz		-75 / -60 dBc	-45 dBc	@ 0 dBm
>4.096 GHz to 6.0 GHz		-65 / -80 dBc	-50 dBc	@ 0 dBm
Non-Harmonics/Broadband Spurious (CW mode)				Refer to typical data: Page 8
10 MHz to 2 GHz		-70 dBc	-60 dBc	@ +10 dBm
>2 GHz to 4.096 GHz		-65 dBc	-50 dBc	@ +10 dBm
>4.096 GHz to 6.0 GHz		-60 dBc	-45 dBc	@ +10 dBm

1 All MIN/ MAX performance parameters are guaranteed and 100% verified during final performance test, unless noted otherwise.
2 Typical performance is "by design" and consistent with field performance data

The data contained in this section demonstrates the typical output power performance of the HSM Series.

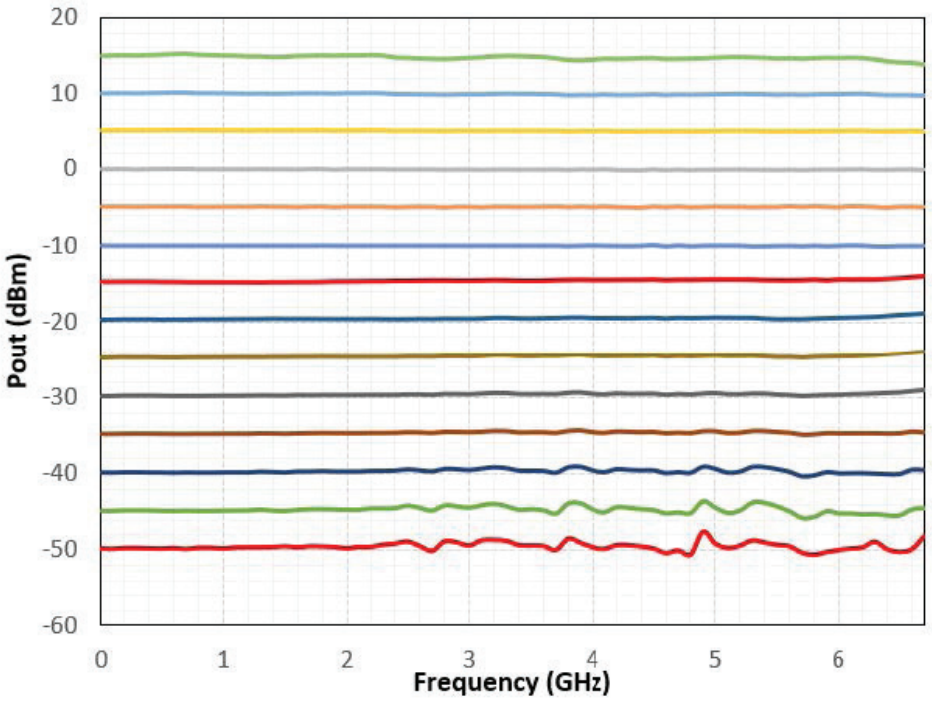
MAXIMUM (UNLEVELED) OUTPUT POWER

Figure 1:
- Maximum Output Power
- 25 dBm Setting
- 10 MHz - 6.0 GHz



CALIBRATED OUTPUT POWER

Figure 2:
- Calibrated Output Power
- -50 dBm to +15 dBm
- 10 MHz - 6.0 GHz



The raw data contained in this section demonstrates the typical phase noise performance of the HSM Series.

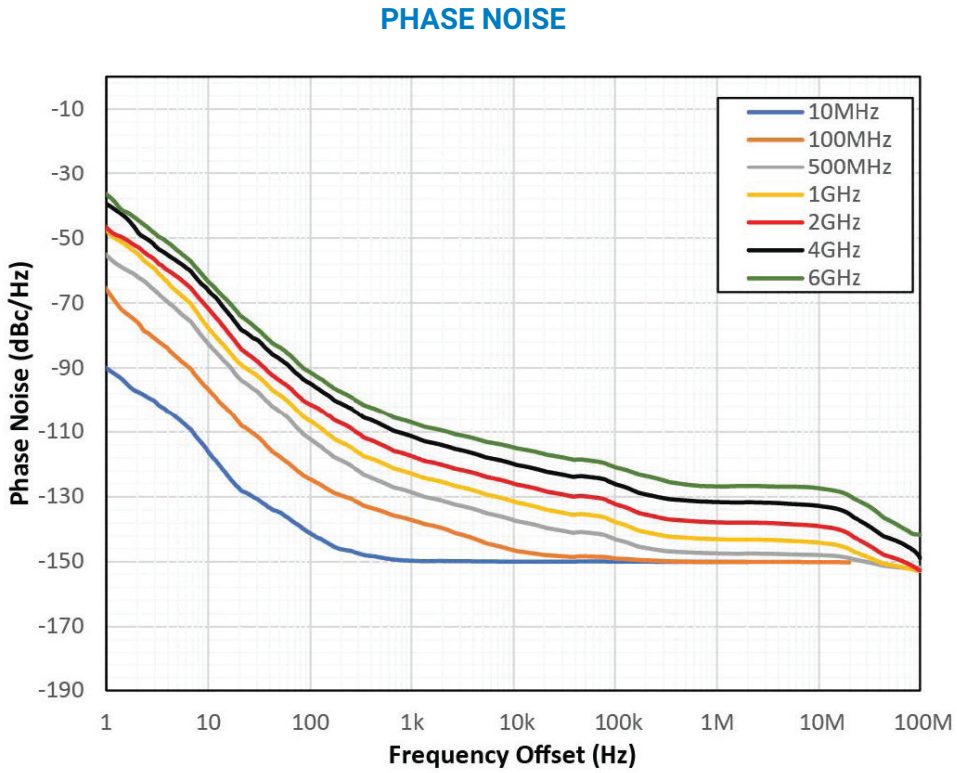


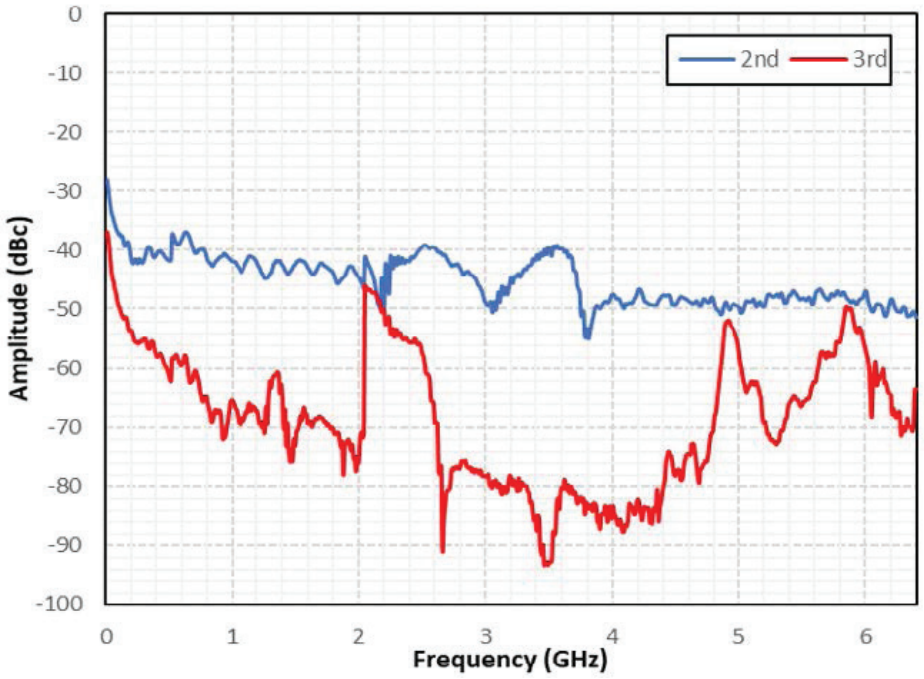
Figure 3:

- Typical Phase Noise Performance Data
- 10 MHz - 6 GHz
- POUT Setting: +10 dBm

The data contained in this section demonstrates the typical spectral purity performance of the HSM Series designs.

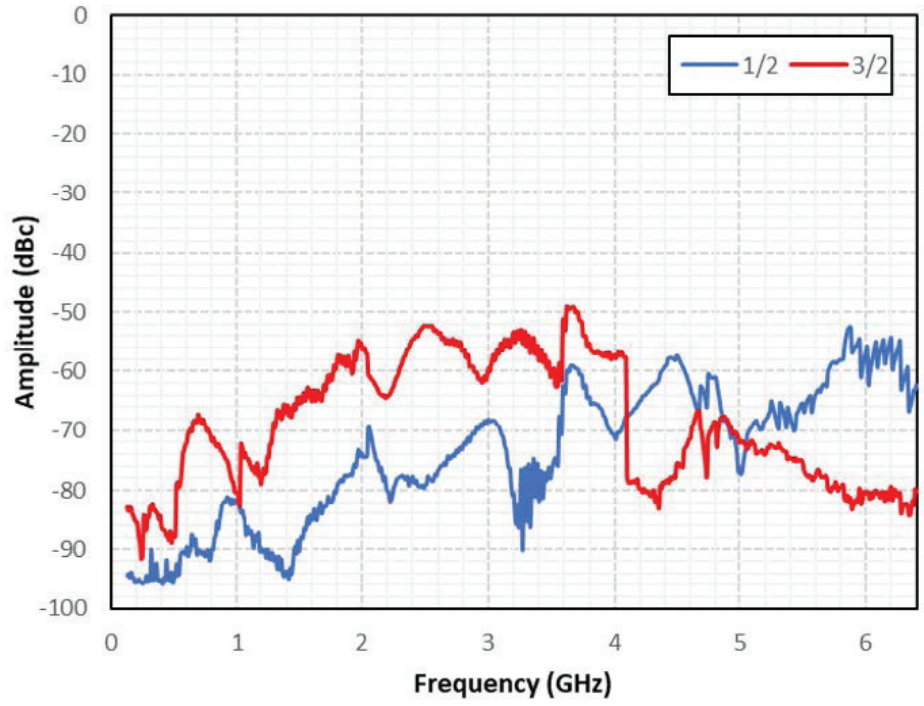
HARMONICS

Figure 4:
- Harmonics
- Typical Performance
- 10 MHz - 6.0 GHz
- POUT Setting: 0 dBm



SUB-HARMONICS

Figure 5:
- Sub-Harmonics
- Typical Performance
- 10 MHz - 6.0 GHz
- POUT Setting: 0 dBm



The data contained in this section demonstrates the typical spurious performance of the HSM Series designs.

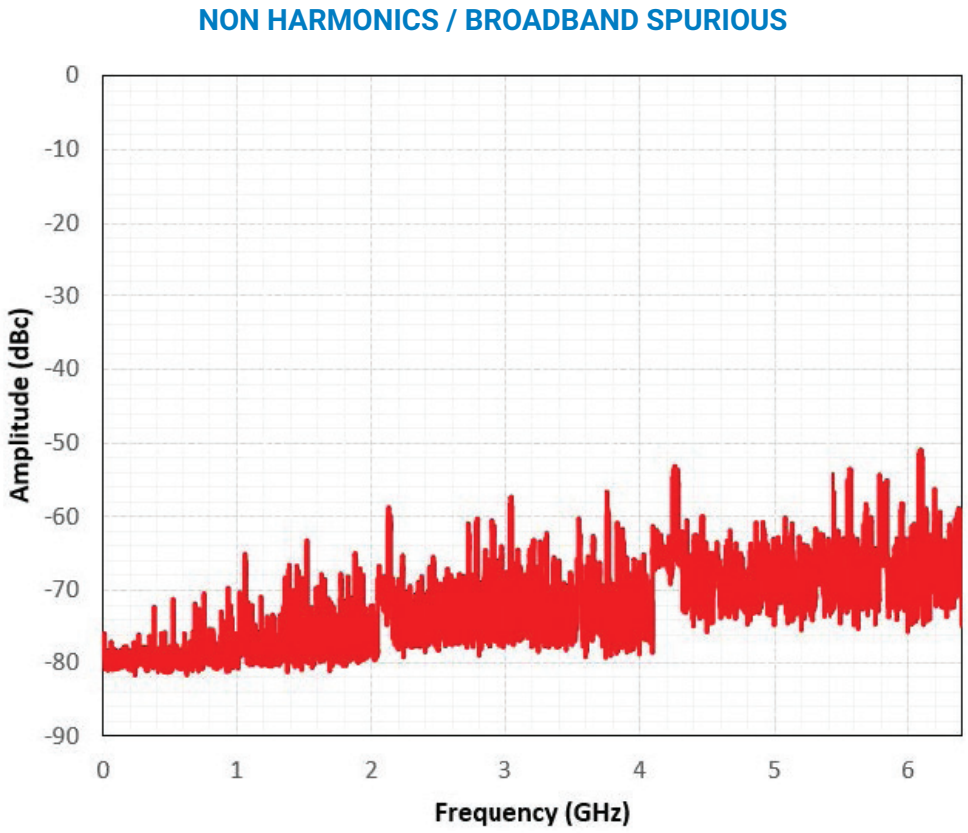


Figure 6:

- Non-Harmonic Spurious, Typical Performance
- 10 MHz - 6.0 GHz
- POUT Setting: +10 dBm
- Spectrum Analyzer Bandwidth Settings: 10 MHz Span, 10 kHz Bandwidth

HSM Series RF Synthesizers
MODULATION PERFORMANCE (External Stimulus)

The modulation parameters listed here are based on modulation functions as related to the use of an external modulation stimulus. Internal "self pulse" functions are available with the current revision of the HSM series RF synthesizers.

PARAMETER	PERFORMANCE [1]	COMMENTS
FREQUENCY MODULATION (Analog)		
Maximum Deviation	100 kHz	
Resolution	0.01% or 1 mHz, whichever is greater	
Modulation Freq. Response	DC to 20 kHz (-3 dB)	DC Coupled
Sensitivity when using Ext. Input	± 1V peak into 50 Ω	+ 1V: Maximum Positive Deviation 0V: Zero Deviation from Carrier - 1V: Maximum Negative Deviation
PHASE MODULATION (Analog)		
Modulation Deviation	±1.6 deg to ±180 deg	
Frequency Response	DC to 20 kHz (-3 dB)	DC Coupled
Resolution	Frequency Dependent	See Phase Offset Specification
Sensitivity when using Ext. Input	± 1V peak into 50 Ω	+ 1V: Maximum Positive Deviation 0V: Zero Deviation from Carrier - 1V: Maximum Negative Deviation
AMPLITUDE MODULATION (Analog)		
AM Depth Type	Linear	
Depth Maximum Resolution Depth Accuracy	 5% to 75% <3% of Maximum Depth 5% of Maximum Depth	 0.45 dB to 12 dB
Modulation Rate	DC to 10 kHz (-3 dB)	DC Coupled
Sensitivity when using Ext. Input	± 1V peak for indicated Depth (into 50 Ω)	+ 1V: Maximum Positive Deviation 0V: Zero Deviation from Carrier - 1V: Maximum Negative Deviation
PULSE MODULATION (Analog)		
Risetime (T_r)	<50 ns	
Falltime (T_f)	<50 ns	
On/Off Ratio	> 70 dB	
Minimum Pulse Width	<100 ns	
ALC Loop Deviation (ALC disabled)	1 dB difference from ALC enabled	

[1] Nominal

PARAMETER	PERFORMANCE [1]	COMMENTS
External Trigger Threshold	+1.2 V	±5% into 50 Ω

[1] Nominal

HSM Series RF Synthesizers
MODULATION PERFORMANCE (Self Pulse)

HSM Series synthesizers are capable of operating in self pulse modulation mode, which does not require an external stimulus signal.

PARAMETER	PERFORMANCE [1]	COMMENTS
PULSE MODULATION (Analog)		
Risetime (T_r) fc < 512 MHz fc > 512 MHz	10 ns 35 ns	
Falltime (T_f) fc < 512 MHz fc > 512 MHz	8 ns 10 ns	
On/Off Ratio	> 70 dB	
Minimum Pulse Width	50 ns	
ALC Loop Deviation (ALC disabled)	1 dB difference from ALC enabled	

[1] Nominal

ENVIRONMENTAL SPECIFICATIONS

THIS MODULE IS DESIGNED FOR INDOOR USE ONLY

Environmental specifications are based on component margins, thermal verification testing and current draw tests.

PARAMETER	MIN[1]	TYPICAL[2]	MAX[1]	COMMENTS
Power Consumption[3]		9 W	12 W	12 W during warm-up
Warm-Up Time[4]	2 min	5 min		20 °C (ambient temp. dependent)
Temperature Monitor Range	-40 °C		+85 °C	

1 All MIN/ MAX performance parameters are guaranteed and 100% verified during final performance test, unless noted otherwise.
2 Typical performance is "by design" and consistent with field performance data
3 See PINOUT CONFIGURATION table on page 15 for volt/amp ratings per pin.
4 Warmup time 2 minutes for internal reference accuracy.

REGULATORY COMPLIANCE	CE compliance with the following European Union directives Low Voltage Directive EU 2014/35 Electromagnetic Compatibility Directive (EMC) EU 2014/30 RoHS Directive EU 2015/863, WEEE Directive EU 2012/19

STEP 1: SELECT MODULE FREQUENCY

FREQUENCY RANGE	MODEL NUMBER
10 MHz to 1 GHz	HSM1001B
10 MHz to 2 GHz	HSM2001B
10 MHz to 3 GHz	HSM3001B
10 MHz to 4 GHz	HSM4001B
10 MHz to 6 GHz	HSM6001B

STEP 2: SELECT ADDITIONAL OPTIONS

The options listed in this section are available for the multi-channel platform to comply with application specific requirements.

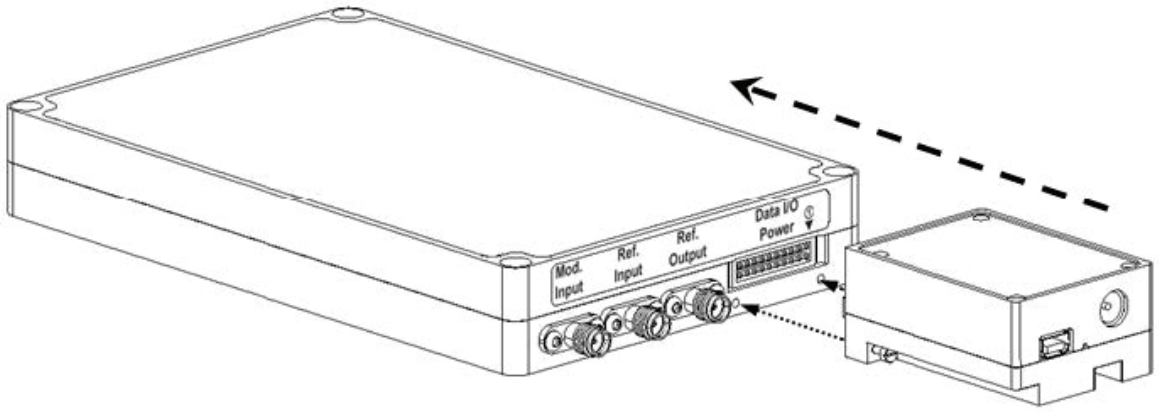
OPTION	DESCRIPTION
SECURE	Secure option that wipes user settings when powered off. Model numbers ending in “S”

COMMUNICATION MODULES

Communications modules are also made available for ease of integration or simply to match legacy laboratory communications requirements. USB, Ethernet, etc. modules can be purchased directly from Holzworth.

HCM Communications Module Installation

The HCM Communication Module is an SPI to USB (or Ethernet) adapter that also includes a power supply adapter allowing the user to connect the RF synthesizer to standard AC power. The selected HCM Module creates a USB (or Ethernet) connection to a PC so that the Holzworth GUI, LabVIEW™, MATLAB™, etc. can be utilized to control the source. No drivers are required to run the Holzworth GUI.



HCM1 USB Communications Module with power supply
HCM3 Ethernet Communications Module with power supply

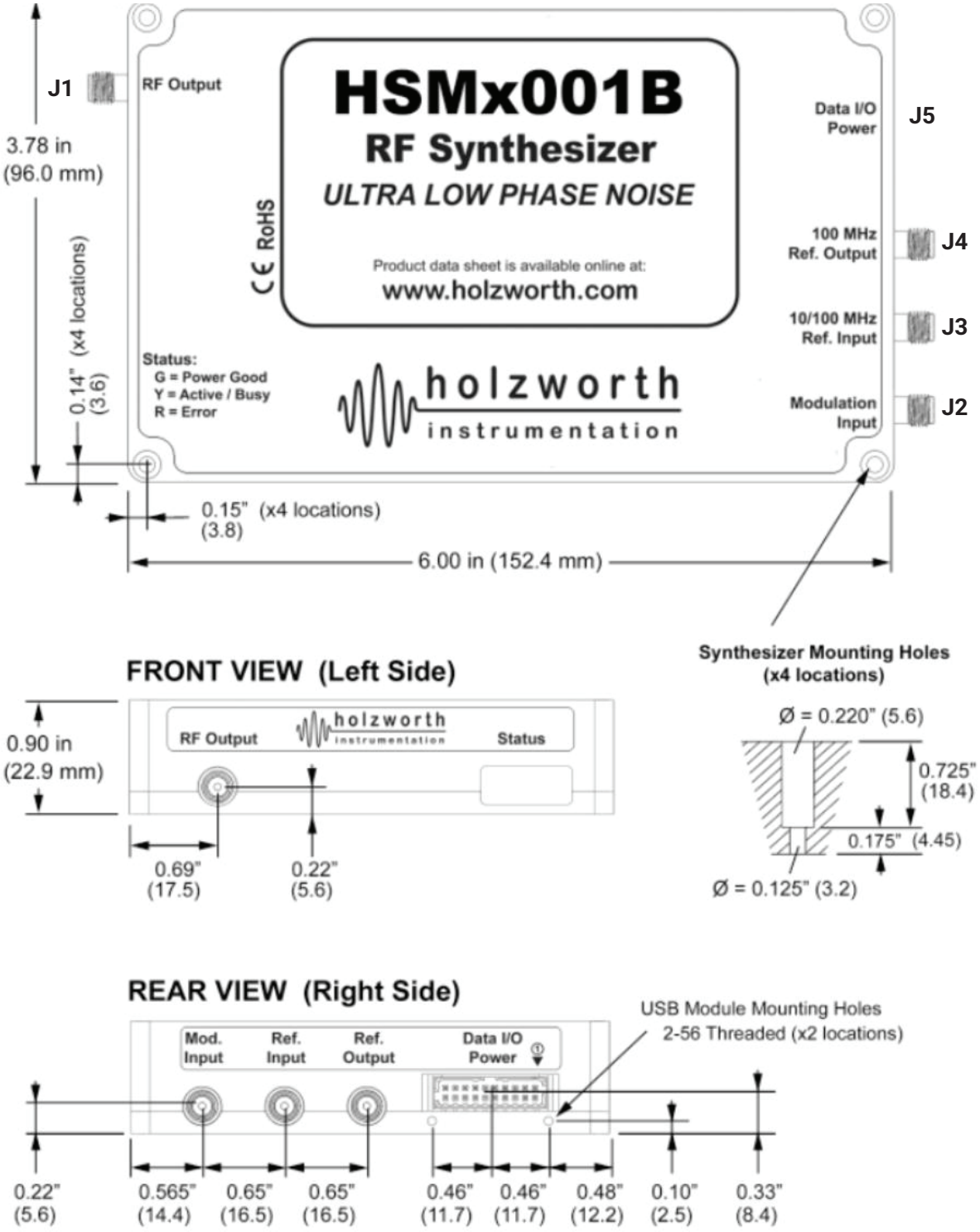
Each variation of the HCM Communications Module securely fastens to the synthesizer and comes complete with an AC power supply and the appropriate cable. HCM modules are a recommended accessory as the first step in integrating the HSM series synthesizers via the SPI bus. More information is available upon request.

Do not exceed an ambient temperature of 45 °C when using an HCM module with the HSM.

If using a power supply, other that that provided with the HCM module, use only an appropriately-rated, agency-approved +5 V DC power supply with a current rating of 5 A.

MECHANICAL CONFIGURATION

Mechanical details are in both inches and millimeters (listed inside parenthesis). All dimensions hold tolerances to within ±0.010 inches.



INTERFACE DEFINITIONS

The interfaces defined within this section are cross referenced to the mechanical configuration included in this document. Ports are labeled on the synthesizer modules, but numbers are not physically printed on the module.

J-PORT DEFINITIONS

PORT	DESCRIPTION	DESCRIPTION
J1	RF Output	SMA Jack, Multiplexed, 50 ohm Input
J2	Modulation Input	SMA Jack, Multiplexed, 50 ohm Input
J3	10/100 MHz Ref. Input	SMA Jack: 10 MHz/100MHz Reference Input (software selectable)
J4	100 MHz Ref. Output	SMA Jack: 100 MHz Reference Output
J5	Data I/O - Power	2 mm, 20 pin (2x10) Milli-grid Shrouded Pin Header (detent type) Contains Power, Ground, SPI, and Status Indicators
Display	Status	Tri-color LED Indicator Panel: GREEN = Power Good YELLOW = Communication Active / Busy / Not Ready RED = ERROR (i.e. no 10MHz PLL lock, Unleveled, etc.)

J5 PINOUT CONFIGURATION

PIN No.	Label	PIN No.	Label
1	GND	**2**	GND
3	+ 5 V, 1 A (max)	**4**	+5 V tied to pin 3
5	+12 V, 400 mA (nom), 600 mA (warm up) [1]	**6**	N.C. (reserved)
7	NC	**8**	N.C. (reserved)
9	INPUT: /RESET (10 kΩ pull-up to 3.3 V)	**10**	N.C. (reserved)
11	INPUT: /CS (Synthesizer Select)	**12**	N.C. (reserved)
13	OUTPUT: SDO (Synthesizer Data Output)	**14**	OUTPUT: Power Good (OC 47 kΩ pull-up to 3.3 V)
15	INPUT: SDI (Synthesizer Data Input)	**16**	OUTPUT: /ERROR (OC 47 kΩ pull-up to 3.3 V)
17	INPUT: SCLK (Synthesizer Clock Input)	**18**	OUTPUT: /BUSY (OC 47 kΩ pull-up to 3.3 V)
19	GND	**20**	GND

[1] Nominally 400mA draw at steady state. 600mA draw at startup for at least 5 mins for OCXO power on.

J5 PIN LABEL DEFINITIONS

PIN No.	Label
+5V	Nominally pulls 1A from the +5V Rail. Initially at power on the draw will be 100 mA then increase as subsystems power-on. Tolerance +10% to -2%. 4.9V to 5.5V.
+12V [or +15V]	Nominally 400 mA draw at steady state. 600 mA draw at startup for at least 5 mins for OCXO power on. +15V O.K. but increases power dissipation.
NC	No Connect. Voltage supply pin. Not currently used.
/RESET	Active low on this pin put the module in reset, releasing it returns to reset operation. Module is ready 1 2 seconds after /RESET is released. 10K pullup to 3.3V in parallel to 0.01uF cap to ground.
/CS	Communications chip select, active low. 47K pullup on this line. /CS must be low for any communication to occur. Allows for multiple synthesizer modules on 1 spi bus. 3.3V logic levels, 5V tolerant.
SDO	Synthesizer (module/slave) Data Output. Connects to Master Serial Data Input (Active when chip select is low. High Z when /CS is high. 47K pulldown. 3.3V logic levels, 5V tolerant.
SDI	Synthesizer (module/slave) Data Input. Connects to Master Serial Data Output (High-Z input on module. 3.3V logic levels, 5V tolerant. 47K pulldown.
SCLK	SPI Clock (slave clock input). Idle Low, Active High. Data is transitioned into the module on a rising low to high transition. Data is transitioned out on the same edge and is valid on the falling edge of SC LK. 3.3V logic levels, 5V tolerant. 47K pulldown.
Power Good	Open collector output, 47k pullup to 3.3V. When high, power is healthy. When low, either voltages or currents are problematic. Module may not operate correctly. There is a 0.5 second delay from when power is applied to a valid PowerGood. Actual Power Good may take up to 2 seconds to go high due to some very stable internal references that are settling. This may be multiplexed with other HSM6001 synthesizers.
/ERROR	Open collector output, 47k pullup to 3.3V. Nominally high. If an error condition occurs, such as a PLL unlock or un-leveled condition, this will go active low. This can be multiplexed with other HSM6001 synthesizers.
READY or /BUSY	Open collector output, 47k pullup to 3.3V. Nominally high. After an SPI communication, if a command has been issued, then the /BUSY will go active low until that command is finished. During this time no communication may occur and SPI bus will be asleep.
N.C.	These are reserved lines for use in our communications module. They should be left floating.

J5 (SPI) MATING CONNECTOR PART NUMBERS

APPLICATION	MOLEX PART NUMER	DESCRIPTION
IDC Ribbon	Molex 87568-2093	2mm Milli-Grid, 20pin (2x10) Female, Polarization and Ramp Locking
Vertical PCB Thru Hole	Molex 79107-7009	2mm Milli-Grid, 20pin (2x10) Female, NO Polarization or Ramp Locking
Vertical PCB SMT	Molex 79109-1009	2mm Milli-Grid, 20pin (2x10) Female, NO Polarization or Ramp Locking

SPI COMMUNICATIONS

BUS OVERVIEW

The SPI bus is a byte oriented bus, sending 8 bits at a time. Any number of bytes may be sent, from 1 byte to 64 bytes while chip select is low. Bytes sent beyond 64 bytes will be ignored. The data is held in a buffer until chip select goes high, initiating the parsing of the data and execution of the commands. The maximum speed of the bus is 1.6 MHz. Data may be written to the module and data may be received from the module. After a command is sent requesting data, the next transfer sends this data out on SDO. During the read, a new command may be send and will be parsed when chip select goes high. A read is always followed by a write with a read request.

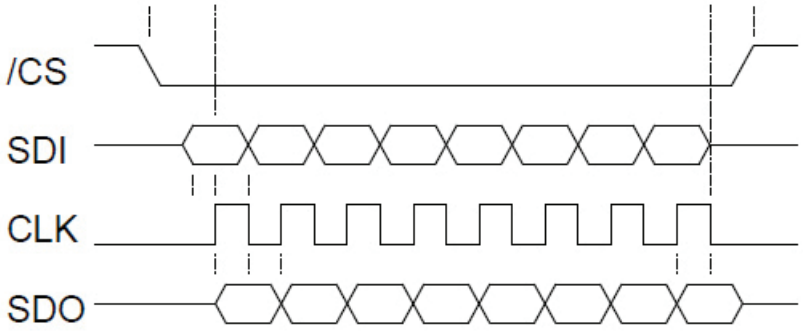
BUS HARDWARE PROTOCOL

Data is clocked into the module on the rising edge of sclk. Data is clocked out of the module on this same edge. Data output is valid on the falling edge of sclk. Data is only transferred when chip select is low. When chip select goes high, this initiates the parsing and execution of data.

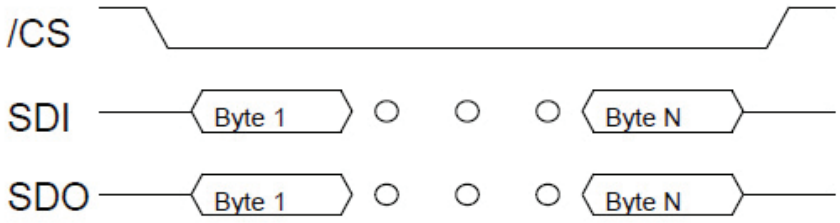
CONTROLLING MULTIPLE SYNTHESIZERS

The SPI bus may be daisy chained. The Status flags can be daisy chained as well, they are open-collector. Each synthesizer requires its own chip select in a multiple channel scenario.

SPI TIMING



The figure above demonstrates bit level timing where data is sampled into and out of the module on the rising edge of SCLK (Slave Clock). Data out is valid on the falling edge of SCLK.



The above figure displays how byte level communications occurs. Any number of bytes may be sent. After /CS goes high, the data is parsed and executed. If no data is sent, the SPI communications module simply resets itself and no parsing or execution of data occurs. If /CS goes high in the middle of a byte transfer (1-7 bits are sent instead of 8) this byte is ignored.

HSM Series RF Synthesizers
WARRANTY

All Holzworth HSM Series synthesizer modules come with a standard 3 year 100% product warranty covering manufacturing defects. All product repairs and maintenance must be performed by Holzworth Instrumentation. Holzworth reserves the right to invalidate the warranty for any products that have been tampered with or used improperly. Refer to Holzworth Terms & Conditions of Sales for more details.

Holzworth products are proudly designed and assembled in the USA.

CONTACT INFORMATION

Contact Holzworth directly for a product quotation, a product demonstration, or for technical inquiries.

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H/HSM Series/0423/EN
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