

# Lucid-X Series RF Analog Signal Generator PXIe Module User Manual

## *Preliminary*

Rev. 1.0

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## Document Revision History

Revision	Date	Description	Author
1.0	23-Oct-2023	<ul style="list-style-type: none"><li>• Original preliminary release.</li><li>• Release supporting Lucid Control Panel Ver. 1.3.400 and TE Update Tool Ver. 1.1.212, LS4091M SPI_SCPI Commands Rev 1.0, TEG SPI_SCPI Commands Rev 1.18, Lucid FPGA version 03092023 and Lucid-X FPGA version 03092023 or higher.</li></ul>	Jakob Apelblat

## Acronyms & Abbreviations

Acronym	Description
μs or us	Microseconds
ADC	Analog to Digital Converter
AM	Amplitude Modulation
ASIC	Application-Specific Integrated Circuit
ATE	Automatic Test Equipment
AWG	Arbitrary Waveform Generators
AWT	Arbitrary Waveform Transceiver
BNC	Bayonet Neill–Concelm (coax connector)
BW	Bandwidth
CW	Carrier Wave
DAC	Digital to Analog Converter
dBc	dB/carrier. The power ratio of a signal to a carrier signal, expressed in decibels
dBm	Decibel-Milliwatts. E.g., 0 dBm equals 1.0 mW.
DDC	Digital Down-Converter
DHCP	Dynamic Host Configuration Protocol
DSO	Digital Storage Oscilloscope
DUC	Digital Up-Converter
ENoB	Effective Number of Bits
ESD	Electrostatic Discharge
EVM	Error Vector Magnitude
FPGA	Field-Programmable Gate Arrays
GHz	Gigahertz
GPIO	General Purpose Interface Bus
GS/s	Giga Samples per Second
GUI	Graphical User Interface
HP	Horizontal Pitch (PXIe module horizontal width, 1 HP = 5.08mm)
Hz	Hertz
IF	Intermediate Frequency
I/O	Input / Output

Acronym	Description
IP	Internet Protocol
IQ	In-phase Quadrature
IVI	Interchangeable Virtual Instrument
JSON	JavaScript Object Notation
kHz	Kilohertz
LCD	Liquid Crystal Display
LO	Local Oscillator
MAC	Media Access Control (address)
MDR	Mini D Ribbon (connector)
MHz	Megahertz
ms	Milliseconds
NCO	Numerically Controlled Oscillator
ns	Nanoseconds
PC	Personal Computer
PCAP	Projected Capacitive Touch Panel
PCB	Printed Circuit Board
PCI	Peripheral Component Interconnect
PXI	PCI eXtension for Instrumentation
PXIe	PCI Express eXtension for Instrumentation
QC	Quantum Computing
Qubits	Quantum bits
R&D	Research & Development
RF	Radio Frequency
RT-DSO	Real-Time Digital Oscilloscope
s	Seconds
SA	Spectrum Analyzer
SCPI	Standard Commands for Programmable Instruments
SFDR	Spurious Free Dynamic Range
SFP	Software Front Panel
SMA	Subminiature version A connector
SMP	Subminiature Push-on connector

Acronym	Description
SPI	Serial Peripheral Interface
SRAM	Static Random-Access Memory
TFT	Thin Film Transistor
T&M	Test and Measurement
TPS	Test Program Sets
UART	Universal Asynchronous Receiver-Transmitter
USB	Universal Serial Bus
VCP	Virtual COM Port
Vdc	Volts, Direct Current
V p-p	Volts, Peak-to-Peak
VSA	Vector Signal Analyzer
VSG	Vector Signal Generator
WDS	Wave Design Studio

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# 1 General

## 1.1 Scope

The scope of this manual is to describe the setup and operating procedures of the Lucid-X series RF analog signal generator PXIe module. This covers the following models listed in the ordering information.

**Table 1.1 Ordering Information**

Model	Description
LSX8081X	8 GHz, 1 channel, PXIe module microwave signal generator
LSX2091X	20 GHz, 1 channel, PXIe module microwave signal generator
LSX4091X	40 GHz, 1 channel, PXIe module microwave signal generator
Options	
PLS	Pulse modulation
PAT	Pattern modulation
LP	Low power to -90 dBm
FS	Fast switching 100 $\mu$ s
EMU	Emulator for Keysight, R&S, Anapico & Holzworth
PXE21100	21 slot PXIe chassis



Figure 1.1 LSX4091X – 40 GHz, 1 channel, PXIe Module Microwave Signal Generator

## 1.2 Related Documentation

- Lucid Control Panel User Manual
- TE Update Tool User Manual

- Lucid Lucid-X Programming Manual
- Tabor Lucid Multi-Channel RF Signal Generators White Paper
- Lucid Series Performance Verification Manual

## 1.3 Software Support

The **Lucid Control Panel** is a software package that enables full control and programming of your Tabor Electronics Lucid series RF analog signal generators via a user-friendly graphical user interface. The **TE Update Tool** is a utility for updating the Lucid device FPGA. The **Lucid Programming Manual** lists and describes the set of SCPI-compatible (Standard Commands for Programmable Instruments) remote commands used to operate the Lucid devices.

The programs and the user manuals can be downloaded from the Tabor Electronics website at <http://www.taborelec.com/downloads>.

## 1.4 Document Conventions

Convention	Description	Example
Bold Writing	Indicates an item/message in the User Interface.	Click the <b>On</b> button.
<Angled and Bolded Brackets>	Indicates a physical key on the keyboard.	Press <Ctrl>+<B>.

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### Caution!

A Caution indicates instructions, which, if not followed, may result in damage to the equipment or to the loss of data.

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### Note

A Note provides additional information to help obtain optimal equipment performance.

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### Idea

An Idea provides an alternate procedure to obtain the same results.

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## 1.5 Safety

To avoid electrical shock, fire or personal injury:

- Use only the proper power cord specified for the device and certified for the country of use.
- This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, the grounding conductor must be connected to the ground. Before connecting to the power input or output, ensure that the product is properly grounded.
- Do not operate this product with removed covers or panels.

- Observe all the ratings and markings on the product. Search this manual for further rating information, before connecting to it. Do not apply potential that is higher than the maximum rating.
- Do not operate in dark or wet conditions.
- Do not operate in an explosive environment. Keep the product clean and dry.

## 1.6 Maintenance

### 1.6.1 Preventive Maintenance

There are no hardware adjustments within Lucid Generators. Tabor Electronics Ltd., recommends that the Lucid Generator is calibrated every 12 months or whenever a problem is suspected. The specific calibration interval depends upon the accuracy required. No periodic preventive maintenance is required.

### 1.6.2 Long Term Storage or Repackaging For Shipment

If the instrument is to be stored for a long period of time or shipped immediately, proceed as directed below. If you have any questions, contact your local Tabor Electronics representative or the Tabor Electronics Customer Service Department.

1. Repack the instrument using the wrappings, packing material and accessories originally shipped with the unit. If the original container is not available, purchase replacement materials.
2. Be sure the carton is well sealed with strong tape or metal straps.
3. Mark the carton with the model and serial number. If it is to be shipped, show sending and return address on two sides of the box.
4. If the instrument is to be shipped for service or repair, the following information must be included with the shipment:
  - Name and address of the owner.
  - Record the model and serial number of the instrument, options, and firmware version.
  - Note the problem and symptoms – detailed information will help in verifying the problem
    - What was the instrument setup?
    - Did the unit work; then fail?
    - What other equipment was connected to the generator when the problem occurred?
  - The name and telephone number of someone familiar with the problem who can be contacted by Tabor Electronics if any further information is required.
  - Show the returned authorization order number (RMA) as well as the date and method of shipment.

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#### Note

Always obtain a return authorization number from the factory before shipping the instrument to Tabor Electronics.

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## 2 Introduction

The Lucid-X series PXIe models feature 8, 20 and 40 GHz single channel generator versions, all sharing the very same industry leading highlighted features, in a compact, small footprint PXIe (PCI Express eXtension for Instrumentation). It features extremely fast switching speed, superior signal integrity and purity, all the necessary modulated signals for analog communication systems. The Lucid Series is designed to meet today's most demanding requirements that is needed from the R&D benches to the production lines. The module shall be plugged into a standard PXIe chassis such as the Tabor PXE21 21 slot PXIe chassis.

### 2.1 Unpacking

Check that the packaging is undamaged. If packaging is damaged, notify the carrier immediately.

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#### Note

Lucid software, user manual and instrument drivers can be downloaded from <https://www.taborelec.com/Downloads>.

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#### Caution!

The Lucid Series RF Signal Generator ships in an antistatic package to prevent damage from electrostatic discharge (ESD). When storing the unit, use the antistatic case.

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## 2.2 Lucid-X PXIe Module Rear



Figure 2.1 Lucid-X PXIe Module Rear

## 2.3 Lucid-X Module Front Panel



**Figure 2.2 Front Panel**

- RF OUT – 2.4 mm type connector for RF signal output
- Status – LED
  - On – RF OUT port is active
  - Off – RF OUT port is not active



- REF OUT 10/100MHz – SMA type connector for 10/100 MHz signal output
- PULSE/TRIG – SMP type connector for pulse modulation or for trigger input
- REF IN 10/100MHz – SMA type connector for 10 MHz or 100 MHz signal input
- FM – SMP type connector for frequency modulation input
- CLK IN – SMA type connector for 3 GHz signal input
- AM – SMP type connector for amplitude modulation input
- CLK OUT 3GHz – SMA type connector for 3 GHz signal output

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**Note**

The Lucid generator will automatically revert to external reference when a signal is detected at its input.

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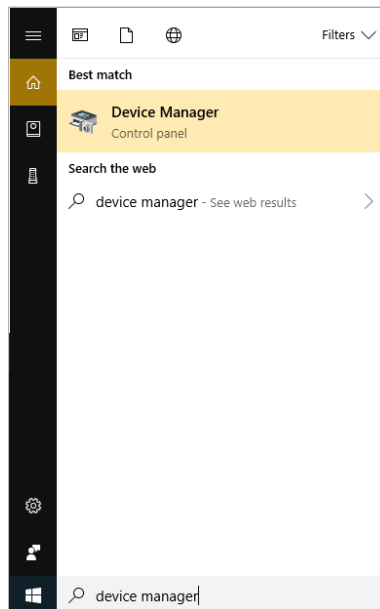
## 2.4 Multi-Instrument Synchronization Operation TBD

## 3 Troubleshooting

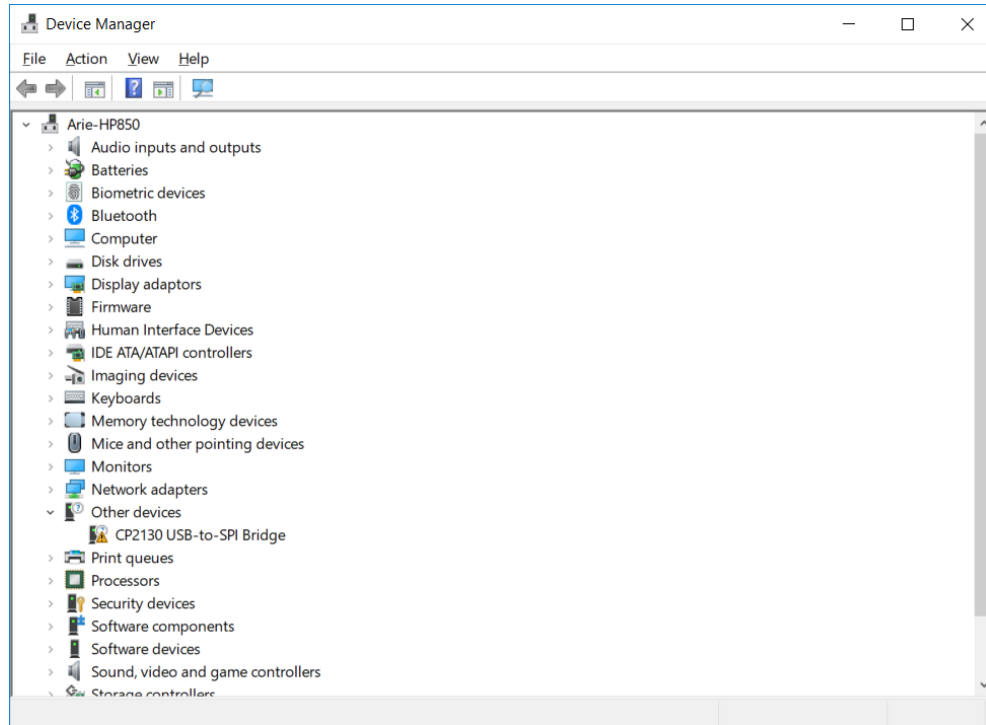
### 3.1 Manually Installing Instrument Drivers

#### 3.1.1 USB Device Driver Manual Installation (Windows 10)

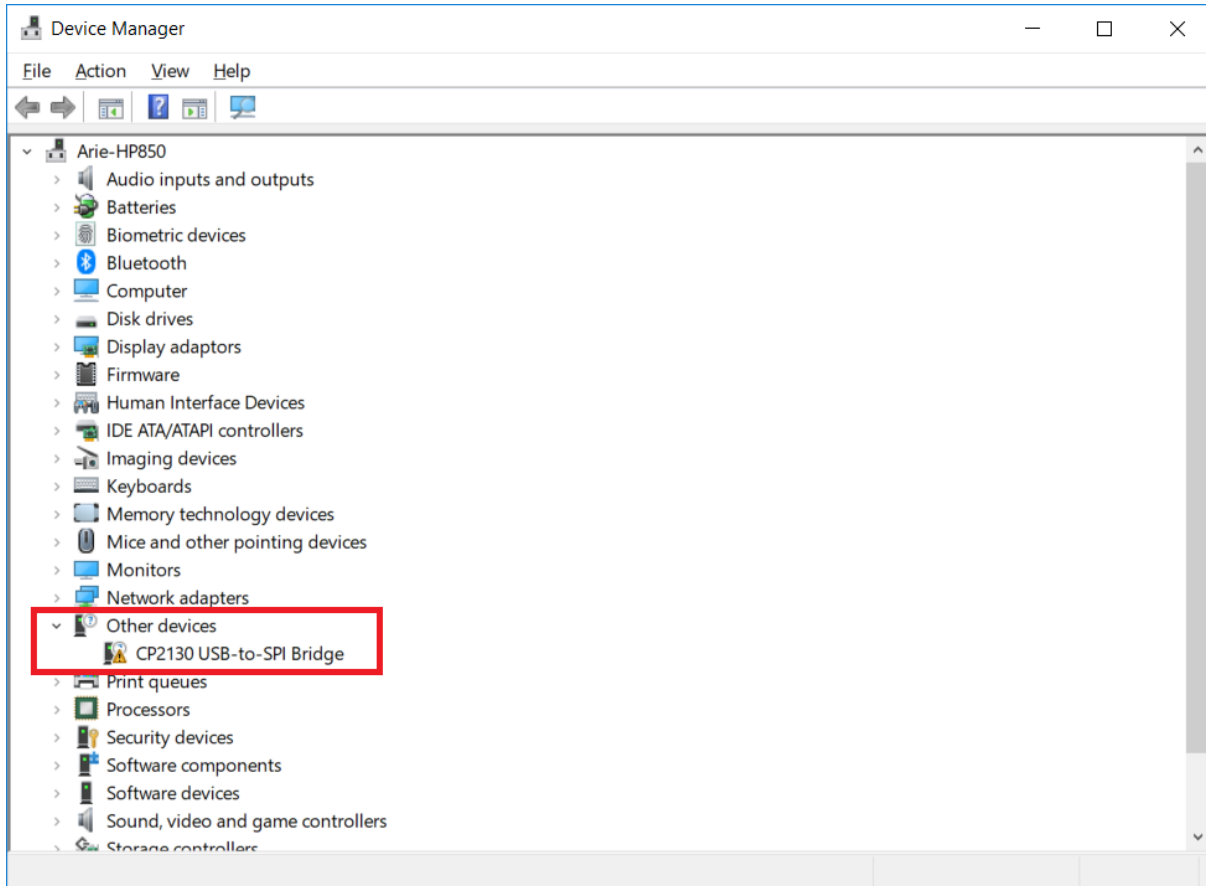
5. Download the latest Lucid series USB device driver from [www.taborelec.com/downloads](http://www.taborelec.com/downloads). Using the supplied USB cable, connect the Lucid desktop model to the PC.
6. Open the **Start** menu, and in the search field, type Device Manager.



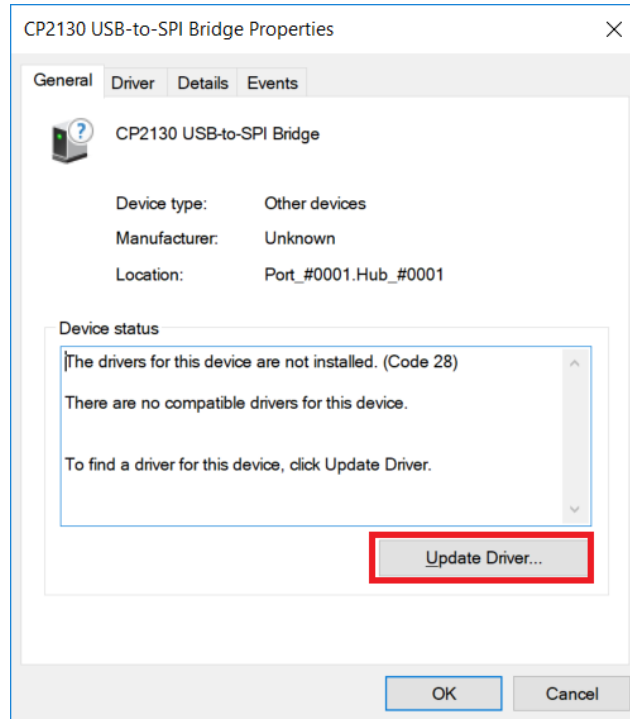
7. In the search results list, select Device Manager.  
The Device Manager window opens.



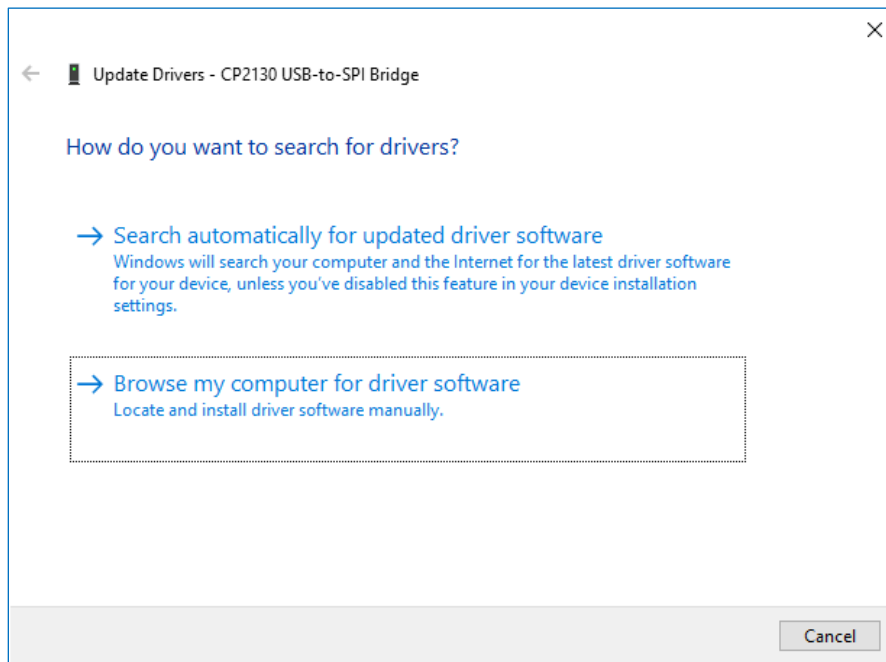
8. In the navigation tree, expand Other devices and double click on CP2130 USB-to-SPI Bridge.



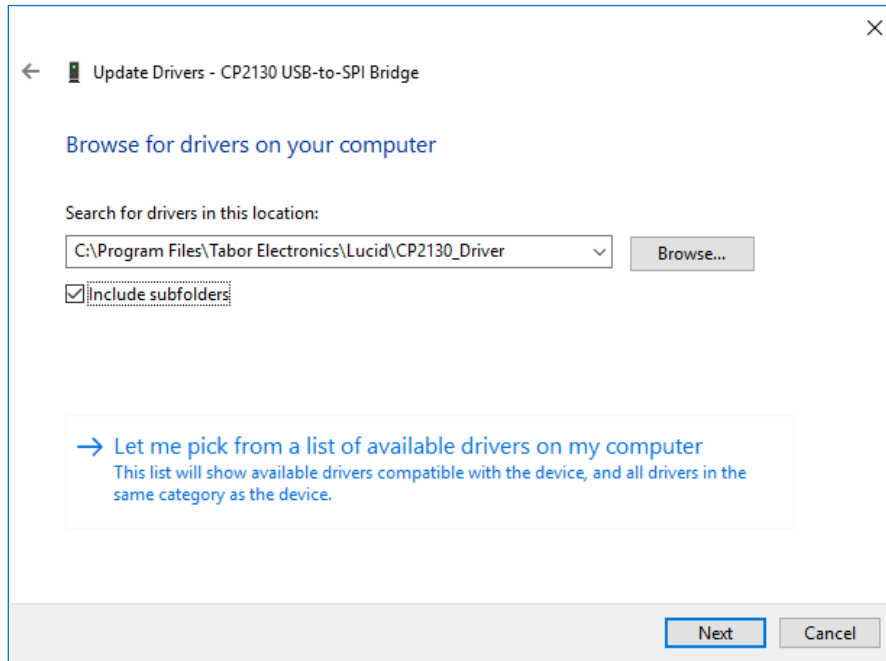
9. The CP2130 USB-to-SPI Bridge Properties window opens.  
Click Update Driver.



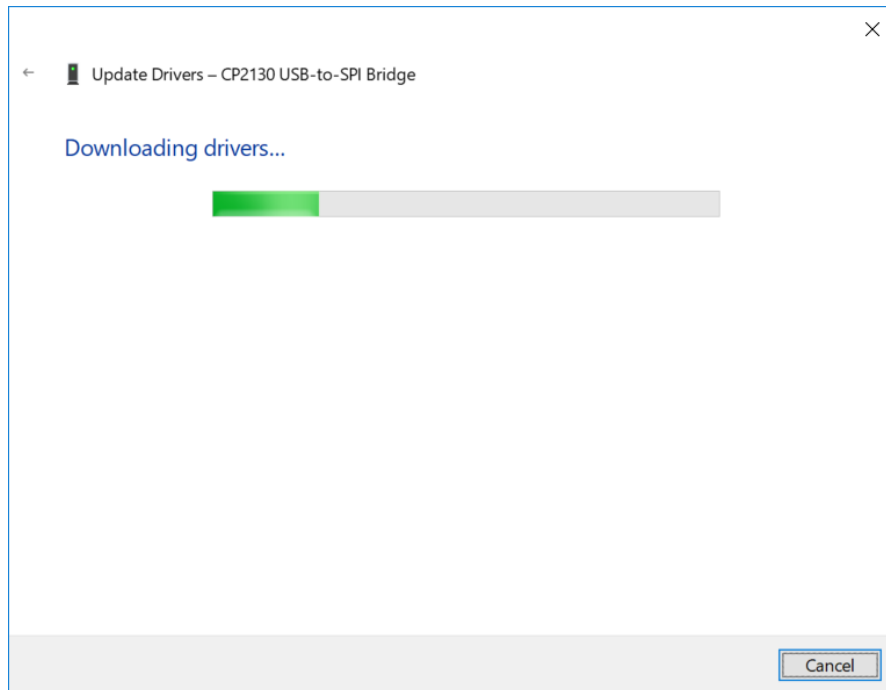
10. In the Update Drivers - CP2130 USB-to-SPI Bridge window, select Browse my computer for driver software.



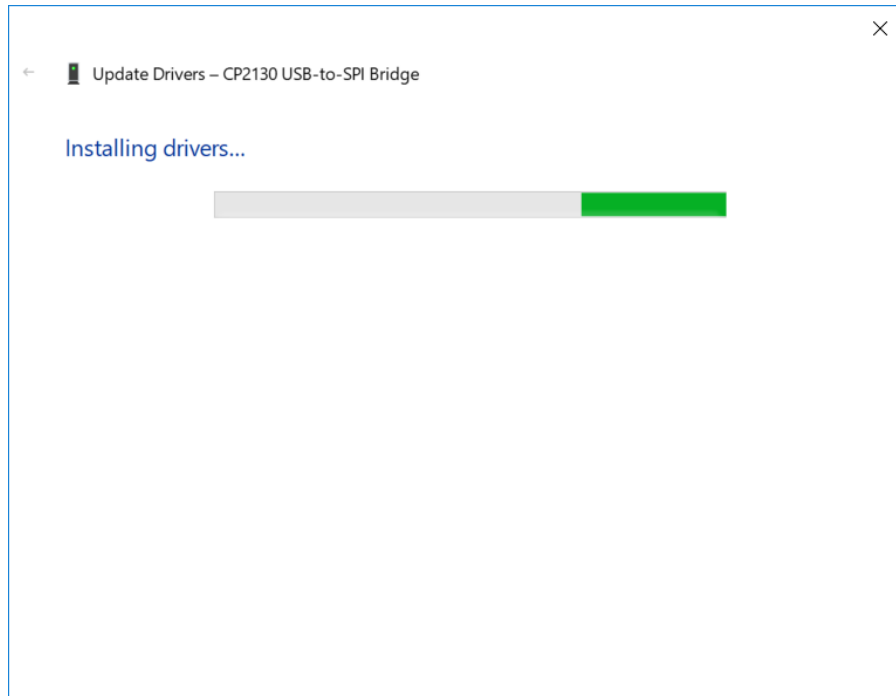
11. Browse to the driver software location on PC, select the file and click OK.



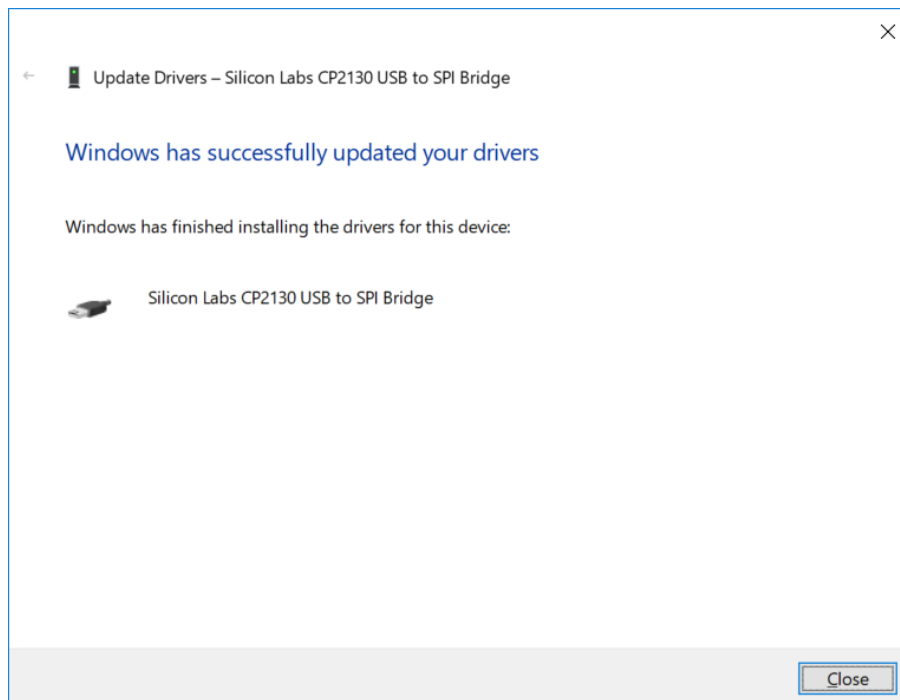
## 12. Driver download begins.



13. After the download is complete, the driver installation begins.

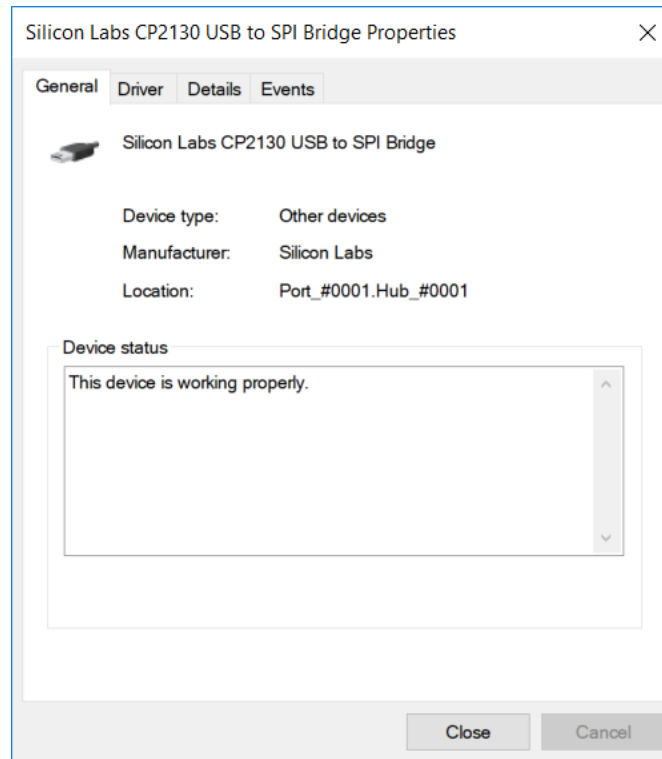


14. After the installation is complete, the following success message is displayed:



15. Click Close to close the Update Drivers window and to proceed.

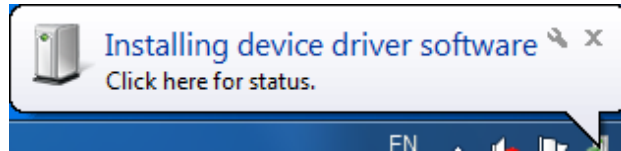
16. In the CP2130 USB-to-SPI Bridge Properties window the displayed device status should be: **The device is working properly.**





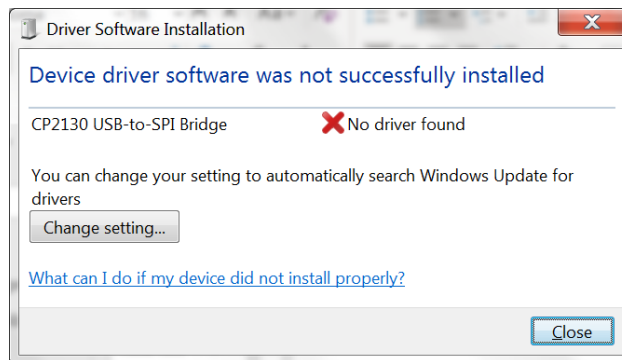
### 3.1.2 USB Device Driver Manual Installation (Windows 7)

1. Download the latest Lucid series USB device driver from the Tabor Electronics Ltd., website. Device drivers are available at [www.taborelec.com/downloads](http://www.taborelec.com/downloads)
2. Connect the Lucid Generator to the PC using the supplied USB Cable.

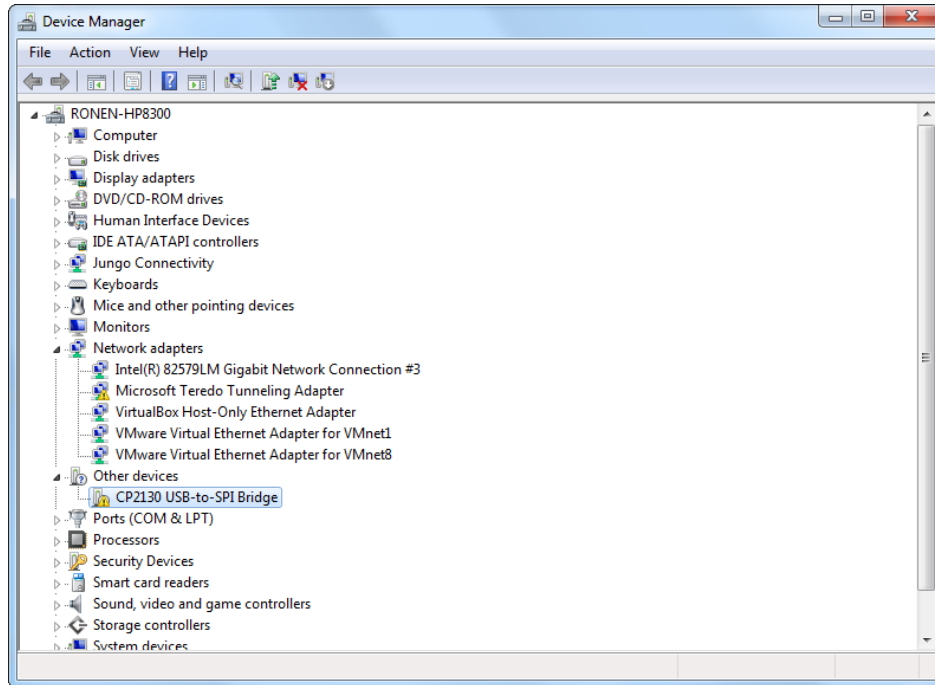


The Installing Device Driver Software message is displayed at the lower-right part of the screen.

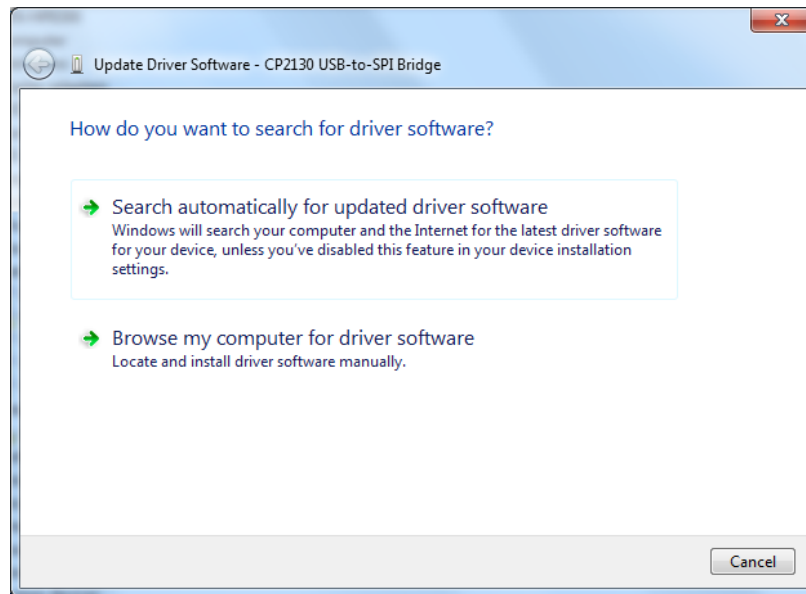
3. Wait for the following messages to appear:



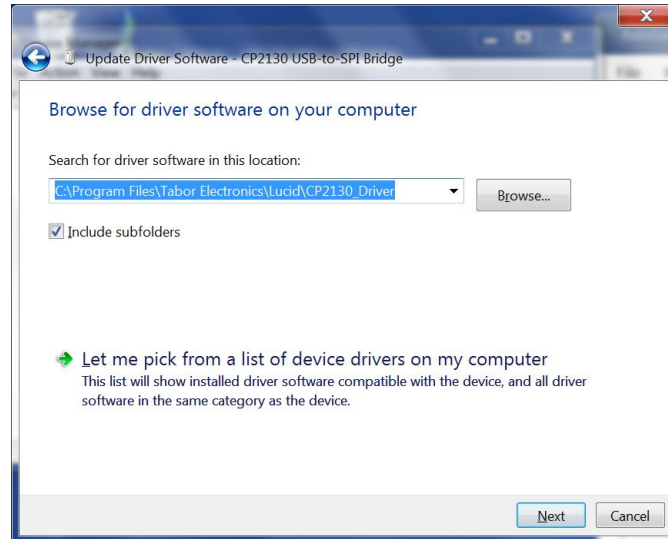
4. Click **Close**.
5. Open the **Start** menu, and in the search field, type Device Manager.
6. In the search results list, select Device Manager. The Device Manager window opens.
7. In the navigation tree, expand Other devices and select CP2130 USB-to-SPI Bridge.



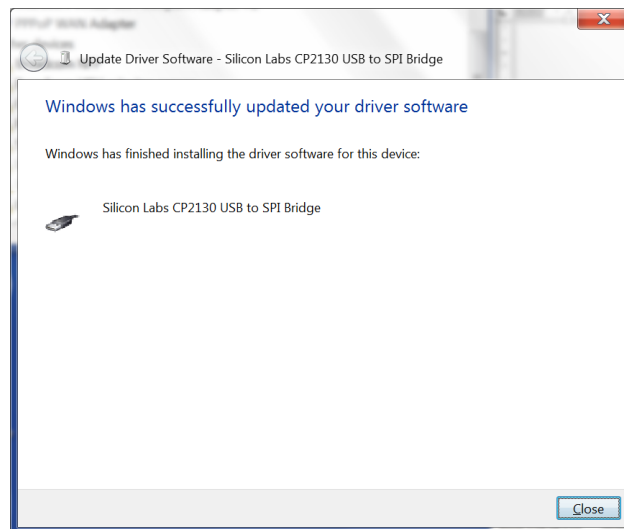
8. Right-click on CP2130 USB-to-SPI Bridge and select **Update Driver Software...** from the drop-list menu.
9. In the Update Drivers - CP2130 USB-to-SPI Bridge window, select Browse my computer for driver software.



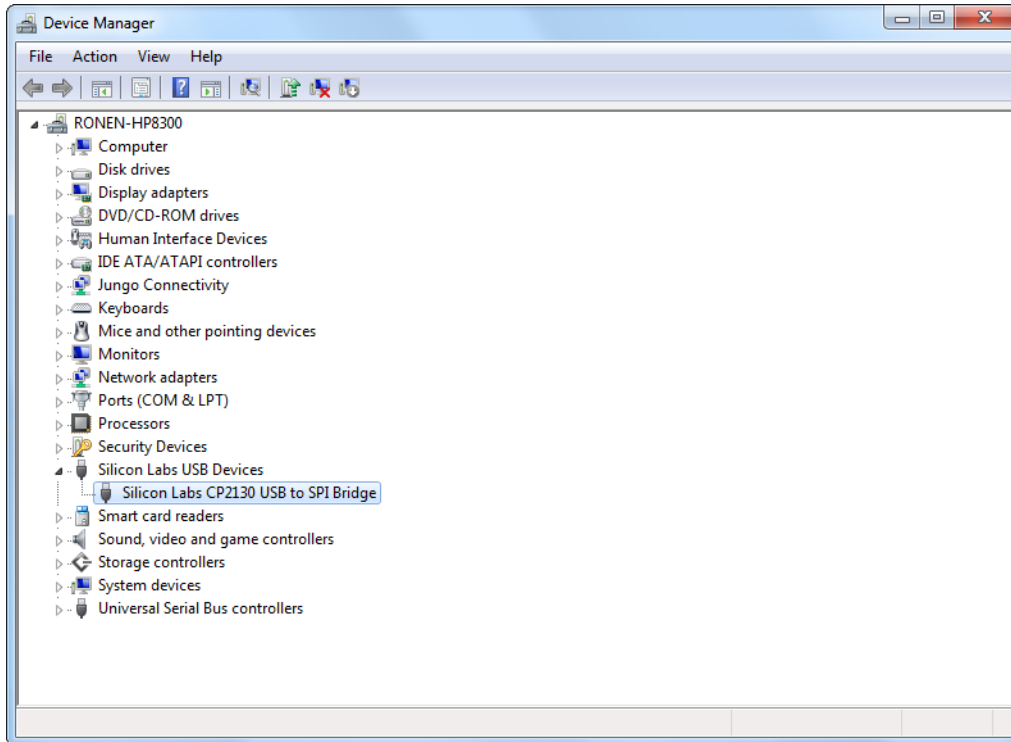
10. Browse to the driver software location on PC, select the folder and click Next. Driver installation begins.



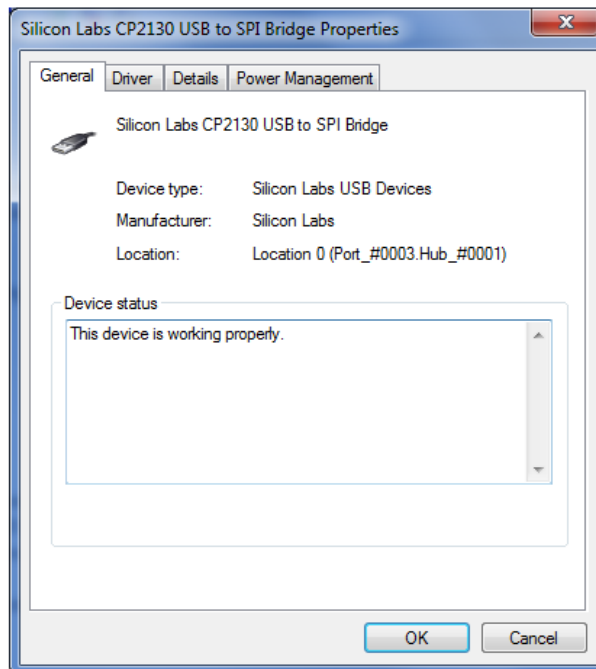
11. After the driver software installation is complete, click Close.



12. In the Device Manager, under Silicon Labs USB Devices, click **Silicon Labs CP2130 USB to SPI Bridge**.



13. In the CP2130 USB-to-SPI Bridge Properties window the device status should indicate the device is working properly.



## 4 Lucid PXIe Module Specifications

### 4.1 Frequency

**Table 4.1 Frequency Specifications**

Frequency	
Range	
LSX8081X	100 kHz to 8 GHz
LSX2091X	100 kHz to 20 GHz
LSX4091X	100 kHz to 40 GHz
Resolution	0.001 Hz
Phase Offset	0.01 deg
Switching Speed	
Standard	500 $\mu$ s
FS Option	100 $\mu$ s

### 4.2 Frequency Reference

**Table 4.2 Frequency Reference Specifications**

Frequency Reference	
Temperature Stability	$\pm$ 25 ppb max
Aging	$\pm$ 3 ppm max for 20 years
Warm Up time	30 min

### 4.3 Amplitude

**Table 4.3 Amplitude Specifications**

Amplitude		
Max Output Power		
Settable	+15 dBm	
Calibrated	+10 dBm	
Min Output Power	Base	LP Opt.
Settable	-70 dBm	-80 dBm
Calibrated	-50 dBm	-70 dBm
Resolution	0.01 dB	

Amplitude	
Power Mute	-70 dBm
Output Return Loss	-10 dBm
Accuracy (dB)	-50 dBm to +15 dBm
Up to 100 MHz	±0.3 (typ.)
100 MHz to 3 GHz	±0.4 (typ.)
3 GHz to 9 GHz	±0.7 (typ.)
Above 9 GHz	±1 (typ.)

## 4.4 Phase Noise and Harmonics

**Table 4.4 Phase Noise and Harmonics Specifications**

Phase Noise (dBc/Hz)		
Measured @ 10 kHz Offset)		
100 MHz	-155 (typ.)	
250 MHz	-147 (typ.)	
500 MHz	-141 (typ.)	
1 GHz	-134 (typ.)	
2 GHz	-128 (typ.)	
4 GHz	-123 (typ.)	
8 GHz	-116 (typ.)	
10 GHz	-115 (typ.)	
20 GHz	-109 (typ.)	
40 GHz	-103 (typ.)	
Harmonics (dBc)		
Range	0 dBm	+10 dBm
Up to 8 GHz:	-50 dBc	-42 dBc
8 GHz to 20 GHz	-40 dBc	-32 dBc
20 GHz to 40 GHz	-35 dBc	-28 dBc
Sub-harmonics (dBc)		
Up to 20 GHz:	-75 dBc (typ.)	
20 to 40 GHz:	-35 dBc (typ.)	
Non-harmonics (dBc)		
Up to 40 GHz	Lucid-X -90dBc (typ.) -60dBc (max.) <sup>1</sup>	

<sup>1</sup> Boundary spurs which may appear @ -100 MHz to +100 MHz offset from CW.

## 4.5 Modulation

**Table 4.5 Modulation Specifications**

Modulation	
Frequency Modulation	
Maximum Deviation	10 MHz
Resolution	0.1 % or 1 Hz (the greater)
Modulation Rate	1 MHz
Resolution	1 Hz
Amplitude Modulation	
AM Depth	
Type	Linear
Maximum Settable	100%
Resolution	0.1 % of depth
Modulation Rate	DC to 100 kHz
Phase Modulation	
Peak Deviation	360 deg
Modulation Rate	DC to 100 kHz
Pulse Modulation (PLS Option)	
On/off Ratio	70dB
Rise/fall Time (10%-90%)	15 ns (typ.)
Resolution	10 ns
Minimum Width	30 ns
Repetition Frequency	DC to 10 MHz
Pattern Modulation (PAT Option)	
Number of Steps	1 to 2,048
Step Repetitions	1 to 65,535
ON/Off Time	20 ns to 20 days
Sweep	
Range	Same as frequency range
Modes	Frequency and amplitude step, list
Dwell Time	100 $\mu$ s to 1,000 s
Resolution	1 $\mu$ s

Modulation	
Number of Points	
List	2 to 4,096
Step	2 to 65,535
Step Change	Linear
Trigger	Free run, External, Bus, Timer

## 4.6 Inputs

**Table 4.6 Inputs Specifications**

Inputs	
Pulse/Trigger	
Connector Type	SMP
Input Impedance	50 $\Omega$
Input Voltage	TTL, CMOS compatible
Threshold	1.5 V
Damage Level	-0.42 V or +5.42 V
Reference Input	
Connector Type	SMA
Input Impedance	50 $\Omega$
Waveform	Sine or Square
Frequency	10/100 MHz
Power	-3 dBm to +10 dBm
Absolute Maximum Level	+15 dBm
FM	
Connector Type	SMP
Input Impedance	50 $\Omega$
Maximum Input Voltage	$\pm 1$ V
Input Damage Level	$\pm 3.5$ V
Clock Input	
Connector Type	SMA
Input Impedance	50 $\Omega$
Waveform	Sine
Frequency	2.7 GHz/3.0 GHz/3.3 GHz



Inputs	
Power	+10 dBm
Absolute Maximum Level	+12 dBm
AM	
Connector Type	SMP
Input Impedance	50 $\Omega$
Maximum Input Voltage	$\pm 1$ V
Input Damage Level	$\pm 3.5$ V

## 4.7 Outputs

**Table 4.7 Outputs Specifications**

Outputs	
RF Out	
Impedance	50 $\Omega$
Connector Type	2.4 mm
Number of Outputs	1
Reference Out	
Impedance	50 $\Omega$
Connector Type	SMA
Frequency	10/100 MHz
Shape	Sine
Power	3 to 7 dBm
Clock Output	
Connector Type	SMA
Input Impedance	50 $\Omega$
Waveform	Sine
Frequency	2.7 GHz/3.0 GHz/3.3 GHz
Power	+10 dBm
Absolute Maximum Level	+12 dBm

## Multi-Instrument Synchronization

**Table 4.8 Multi-Instrument Synchronization Specifications TBD**

Multi-Instrument Synchronization	
Number of Ports	2
Type	SYNC I/O & SYNC X
Connector Type	MMCX
Input Impedance	50 $\Omega$

## 4.8 General

**Table 4.9 General Specification**

General	
Voltage Range	+12.0 to +12.6 VDC

Power Consumption	30 W max. per slot
Current Consumption	
+3.3 V	0.5 A max.
+12 V	5.5 A max.
Interface	PXIe Gen3 x8 Lanes
Dimensions (WxHxD)	8HP PXIe (2 Slots)
Weight	
Without Package	1.0 kg
Shipping Weight	1.5 kg
Temperature	
Operating	0°C to +40°C
Storage	-40°C to +70°C
Warm up Time	15 minutes
Humidity:	85% RH, non-condensing
Safety	CE Marked, IEC61010-1:2010
EMC	IEC 61326-1:2013
Calibration	2 years
Warranty	3 years standard