TABOR ELECTRONICS

LUCID SERIES

Lucid Series Analog RF Signal Generator Rackmount User Manual

Rev. 1.3

Simulate, Stimulate, Test...

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Document Revision History

Table Document Revision History

Revision	Date	Description	Author
1.3	10-Dec-24	• Release supporting Lucid Control Panel Ver. 1.3.500 and TE Update Tool Ver. 1.1.212, LS4091M SPI_SCPI Commands Rev 1.0, TESG SPI_SCPI Commands Rev 1.18, Lucid FPGA version 03092023. • Removed Lucid-X that now has a separate user manual. • 5 Lucid Rackmount Specifications — Updated • Table 5.5 Modulation Specifications — Added note.	Jakob Apelblat
1.2	19-Oct-23	• Updated document format. • Added Lucid-X rackmount. • Release supporting Lucid Control Panel Ver. 1.3.400 and TE Update Tool Ver. 1.1.212, LS4091M SPI_SCPI Commands Rev 1.0, TESG SPI_SCPI Commands Rev 1.18, Lucid FPGA version 03092023 and Lucid-X FPGA version 03092023 or higher. • 1.2 Related Documentation – New. • Table 1.1 Ordering Information – Added Lucid-X series. • 2.2 Front Panel – Added "CH1…CH16 Lucid-X Up to four 2.4 mm…" • 5 Lucid Rackmount Specifications – Added Lucid-X series	Jakob Apelblat
1.1	24-Mar-21	• 1.3 Software Support – New. • Removed sections "Lucid Software Requirements", "Installation, "PC Control Software", 'Troubleshooting", and "FPGA Firmware Update" that are included in the new "Lucid Control Panel User Manual". • Removed section SCPI Programming that is included in the new "Lucid Programming Manual". • Table 5.5 Modulation Specification – Changed Sweep Dwell Time from "10 µs to 1,000 s" to "100 µs to 1,000 s".	Jakob Apelblat
1.0	6-Aug-20	• Original release supporting Lucid SW Rev. 1.2.0 and SPI & SCPI Commands List Summary Rev. 1.14.	Jakob Apelblat

Acronyms & Abbreviations

Table 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
GPIB	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

Acronym	Description
I/O	Input / Output
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

Acronym	Description
SMP	Subminiature Push-on connector
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 rackmount devices. The manual covers the following models listed in the below ordering information.

Table 1.1 Ordering Information

Model	Description
LS3081R	3 GHz, 1 channel, rackmounted analog RF signal generator
LS3082R	3 GHz, 2 channel, rackmounted analog RF signal generator
LS3084R	3 GHz, 4 channel, rackmounted analog RF signal generator
LS30816R	3 GHz, 16 channel, rackmounted analog RF signal generator
LS6081R	6 GHz, 1 channel, rackmounted analog RF signal generator
LS6082R	6 GHz, 2 channel, rackmounted analog RF signal generator
LS6084R	6 GHz, 4 channel, rackmounted analog RF signal generator
LS1291R	12 GHz, 1 channel, rackmounted analog RF signal generator
LS1292R	12 GHz, 2 channel, rackmounted analog RF signal generator
LS1294R	12 GHz, 4 channel, rackmounted analog RF signal generator
LS12916R	12 GHz, 16 channel, rackmounted analog RF signal generator
Options	
PLS	Pulse modulation
PAT	Pattern modulation
ELP	Extended low power (-150dBc)
EPR	Extended power range (-130dBc to +20dB)
FS	Fast switching 100us
SD	Removable SD memory card
W-Rack	Rackmount kit
EMU	Emulator for Keysight, R&S, Anapico, and Holzworth

Figure 1.1 LS1294R – 12 GHz 4 Channel RF Analog Signal Generator

1.2 Related Documentation

- Lucid Control Panel User Manual

- TE Update Tool User Manual

- Lucid 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 **On** button.
<Angled and Bolded Brackets>	Indicates a physical key on the keyboard.	Press <Ctrl>+<B>.

Caution!

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

Note

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

Idea

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

1.5 Safety

To avoid Electrical Shock, fire or personal injury:

- Use only the proper power cord 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 the 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 that 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.

Note

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

2 Introduction

The Lucid series rackmount platform is designed to offer maximum channel density at minimum cost of space. The rackmounted platform offers up to 4 phase coherent channels in a 19" 1U box and up to 16 phase coherent channels in a 3U, 19" box. It provides extremely fast switching speed, superior signal integrity and purity, a removable memory card for maximum security, all the necessary modulated signals for analog communication systems, and with built in LAN and USB interfaces. The Lucid Series is designed to meet today's most demanding specifications that is needed from the R&D benches to the production lines.

2.1 Unpacking

Check that the packaging is undamaged. If packaging is damaged, notify the carrier immediately.
The Lucid benchtop model instrument is supplied with:

- Power cord with a plug according to customer country standard.

- USB cable for connecting a control PC to the instrument.

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

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.

2.2 Front Panel

Figure 2.1 Lucid LS6084R4 Front Panel

- **Power Button** POWER – Turn on or off the device.

- **SD CARD** – Removable SD card for instrument security. It is used for storing all data about used frequencies for PATTERN in the Modulation, the List, and System tabs.

  - Min capacity 4GB

  - Max capacity 16GB

  - Speed grade 10

  - Can be used with SD to micro-SD adapter

- **CH1...CH16**

  - Up to sixteen SMA type connectors for RF signal output.

2.3 Rear Panel

Figure 2.2 Lucid Rear Panel for 4 Channels

- **Reference:**

  - **10/100MHz IN** – BNC type connector for external 10 MHz or 100 MHz signal. This input is normally used for synchronizing system components to a single clock reference.

  - **10 MHz OUT** – BNC type connector for 10 MHz signal output. The output is used to synchronize other system devices to the Lucid Rackmount clock reference.

  - **100 MHz OUT** – BNC type connector for 100 MHz signal output. The output is used to synchronize other system devices to the Lucid Rackmount clock reference.

- **MODULATION IN** – Up to four BNC type connectors, one for each channel, for an input from an external amplitude modulation source.

- **TRIGGER IN** – Up to four BNC type connectors, one for each channel, for an input from an external trigger source.

- **LAN + USB HOST** –

  - **RJ45** – 100BaseT Ethernet connector for connecting a control PC via the LAN.

  - **USB Type A** – USB 2 Type A interface for connecting a USB device such as a memory device for storing and recalling instrument setups, keyboard or mouse.

- **USB DEVICE** – USB 2 Type B connector for connecting a control PC.

- **POWER FUSE T6.3A/250V** – Fuse glass 6.3 A 250 VAC 5X20 mm Slo-Blo.

- **AC Power Socket**– 3 Pins IEC320 C14 Inlet Power Plug Socket.

Note

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

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3 Getting Started

Refer to the "Lucid Control Panel User Manual" for a detailed description of operating the instrument. Here follows a short description how to get started.

1. You can download the latest Lucid Control Panel (LCP) from the Tabor Electronics website at http://www.taborelec.com/downloads to your control PC.
2. Double-click the "te_lucid_control_panel_x.y.zzz" installation file to install LCP.
3. Follow the instructions.
4. Connect your control PC to Lucid using the supplied USB Cable.
5. Double click the LCP icon ∟ on your desktop.
6. The Communications tab will be displayed.
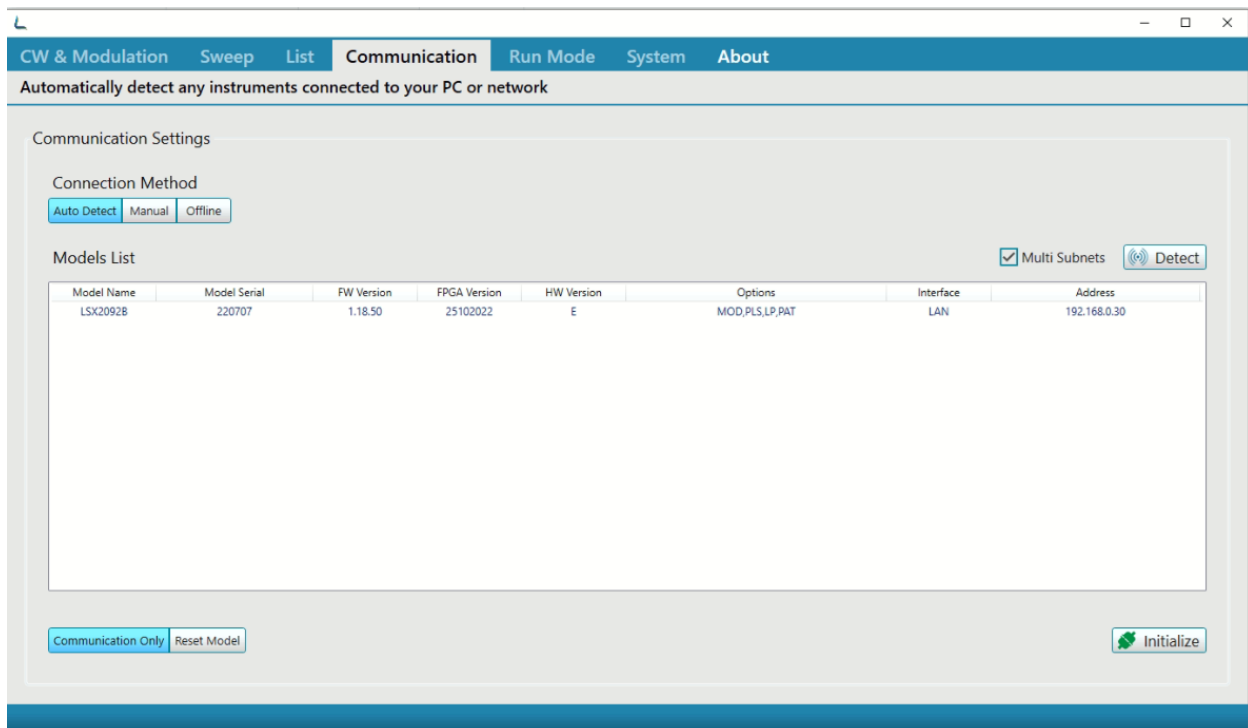
Figure 3.1 Lucid Control Panel CW & Communication Tab

7. LCP will detect your instrument, click on it and then press "Initialize".
8. The "CW & Modulation" tab will be displayed.
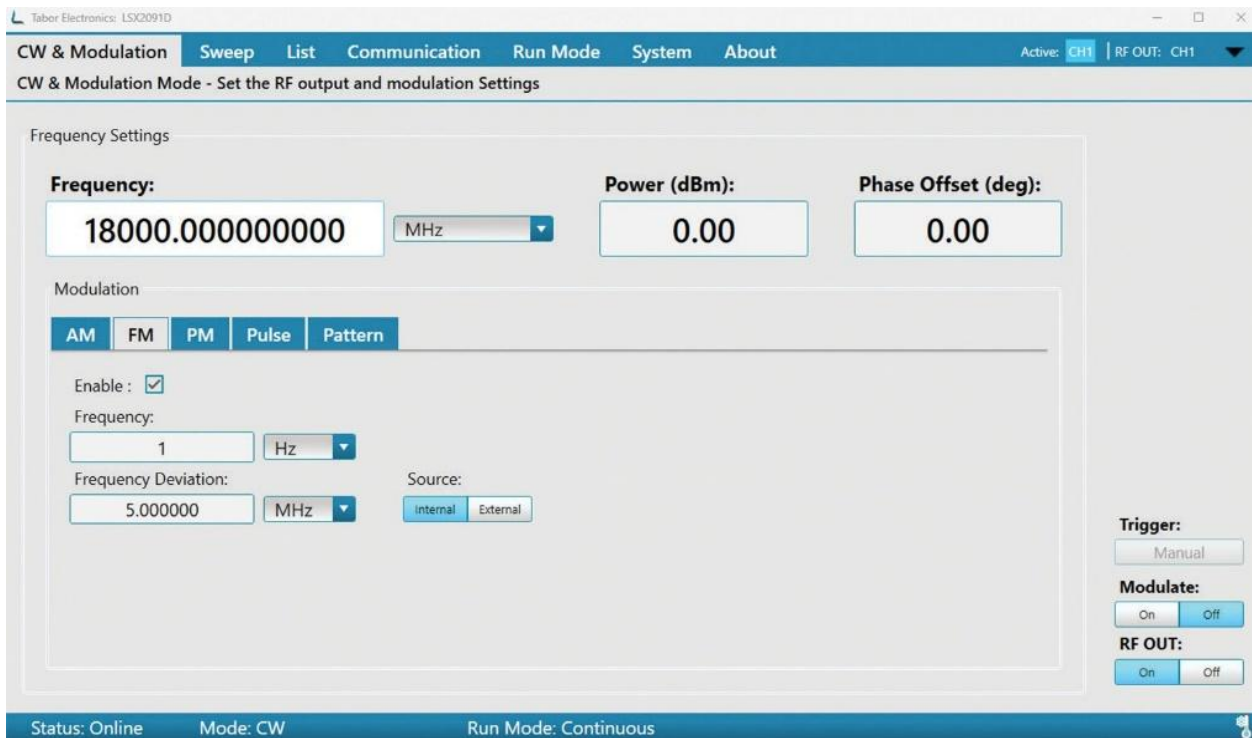
Figure 3.2 Lucid Control Panel CW & Modulation Tab

9. Enter the desired Frequency and Power (dBm) and switch "RF OUT" to "On".
10. Verify with an oscilloscope or a spectrum analyzer the generated RF signal.

4 Troubleshooting

4.1 Manually Installing Instrument Drivers

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

1. Download the latest Lucid series USB device driver from www.taborelec.com/downloads.

1. Using the supplied USB cable, connect the Lucid benchtop model to the PC.

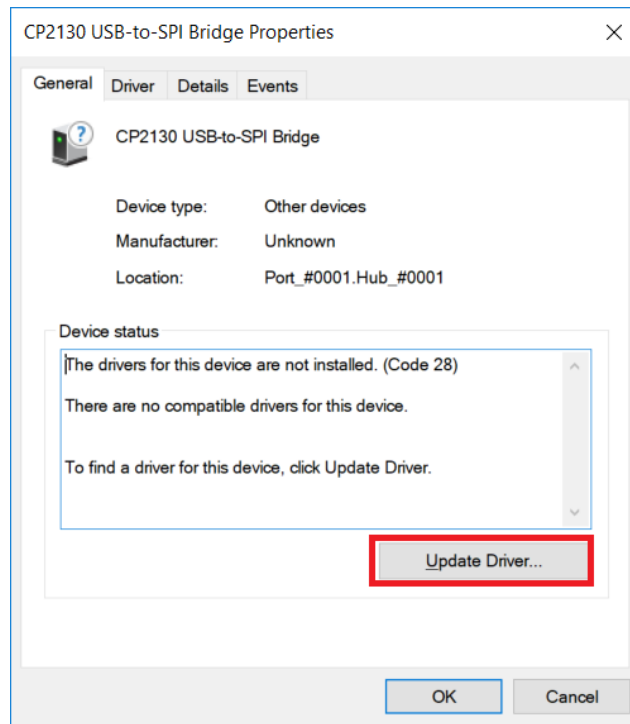2. Open the **Start** menu, and in the search field, type **Device Manager**.
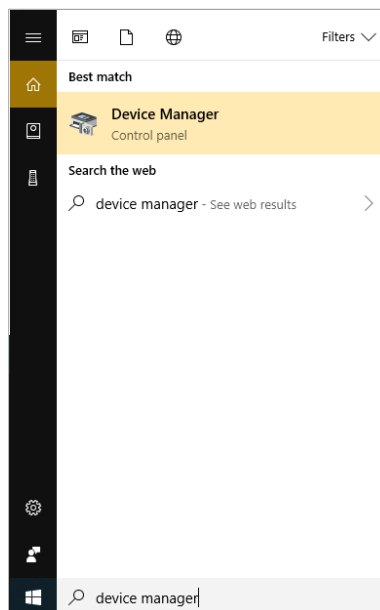
3. In the search results list, select **Device Manager**.
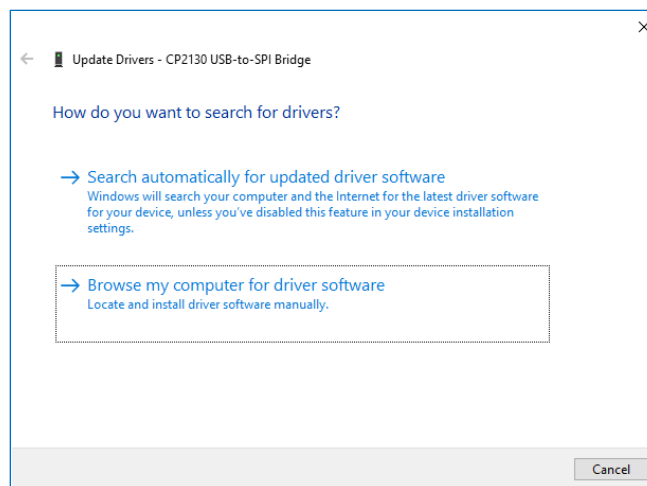   The **Device Manager** window opens.
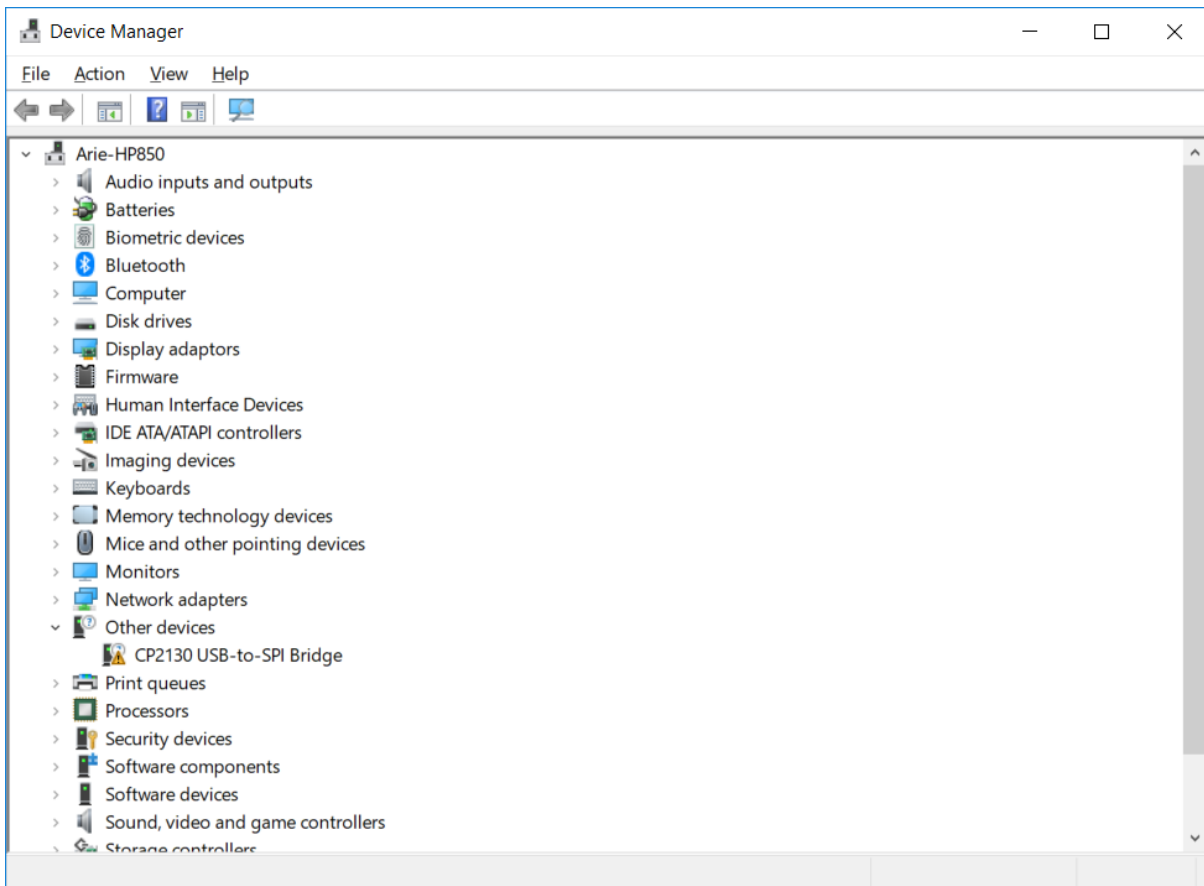
4. In the navigation tree, expand **Other devices** and double click on **CP2130 USB-to-SPI Bridge**.
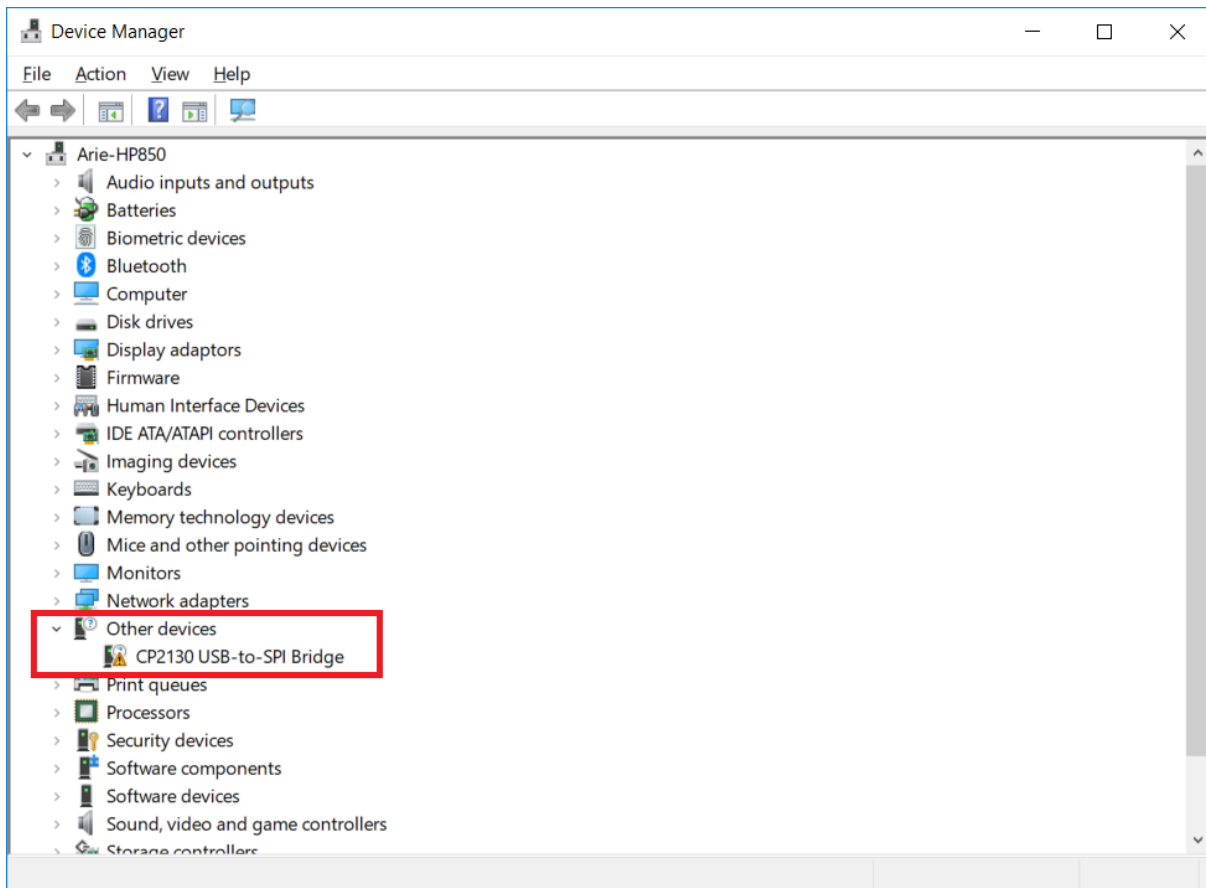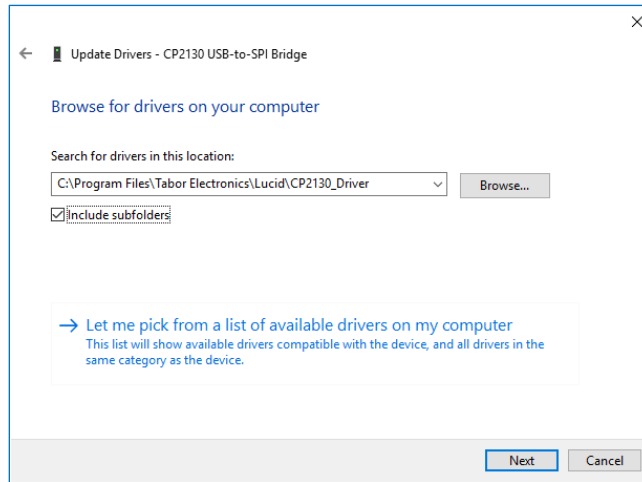
5. The **CP2130 USB-to-SPI Bridge Properties** window opens.
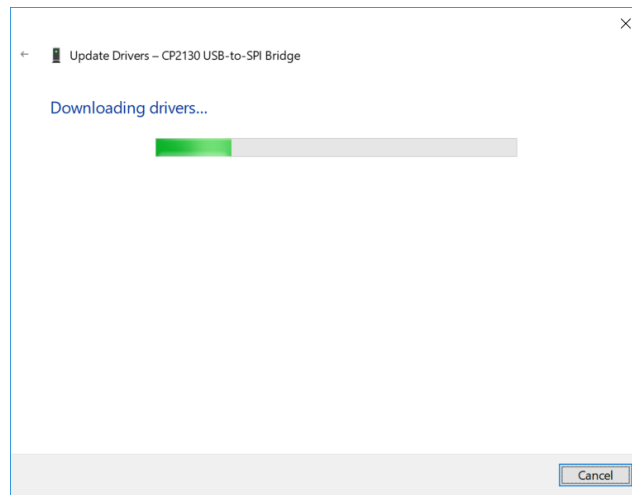   Click **Update Driver**.

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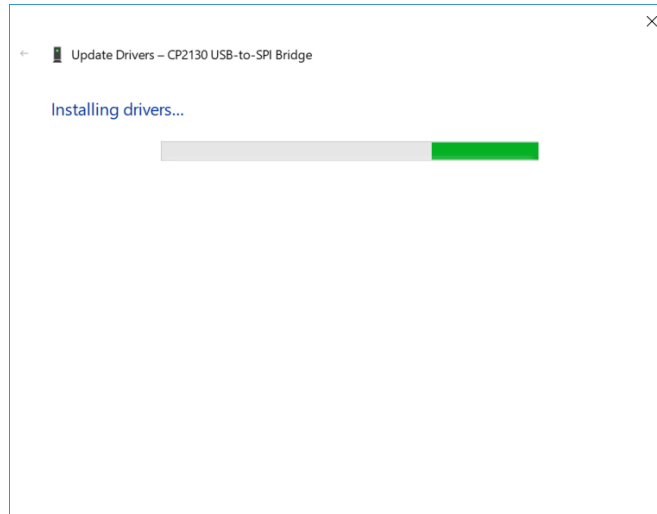

7. Browse to the driver software location on PC, select its folder and click **OK**.
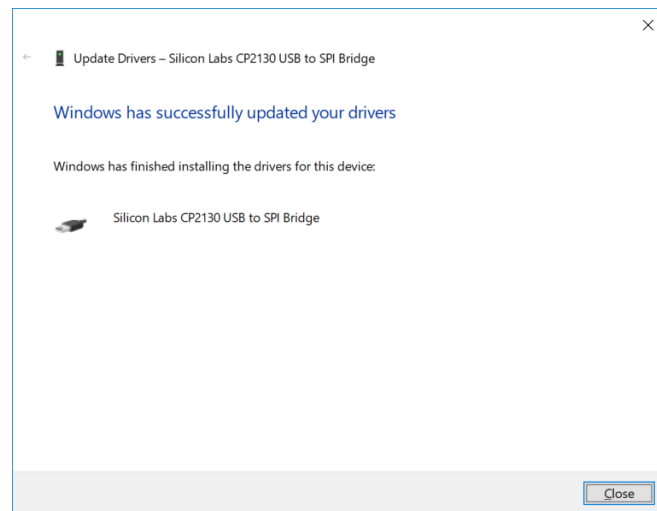
8. Driver download begins.

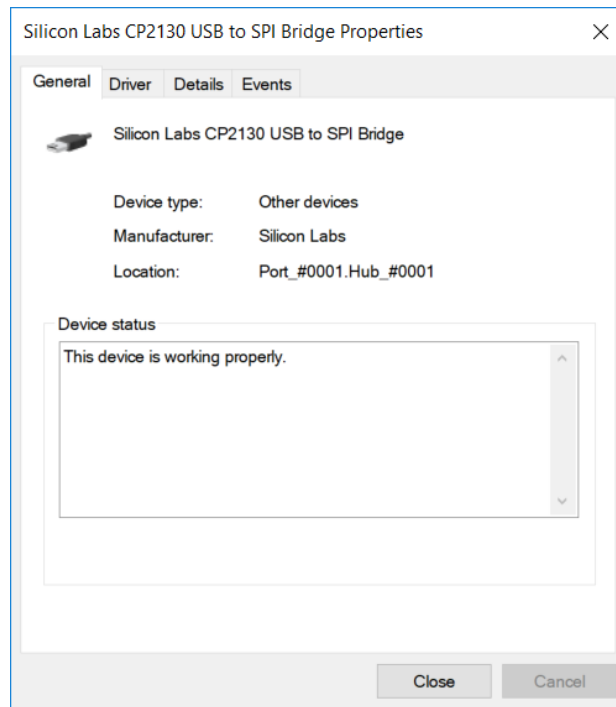9. After the download is complete, the driver installation begins.

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

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

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

4.1.2 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

2. Connect the Lucid Generator to the PC using the supplied USB Cable.
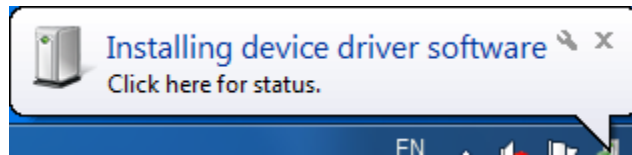
The **Installing Device Driver Software** message is displayed at the lower-right part of the screen.

3. Wait for the following messages to appear:
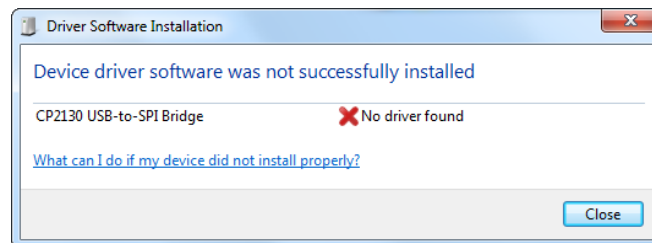
4. Click **Close**.

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**.
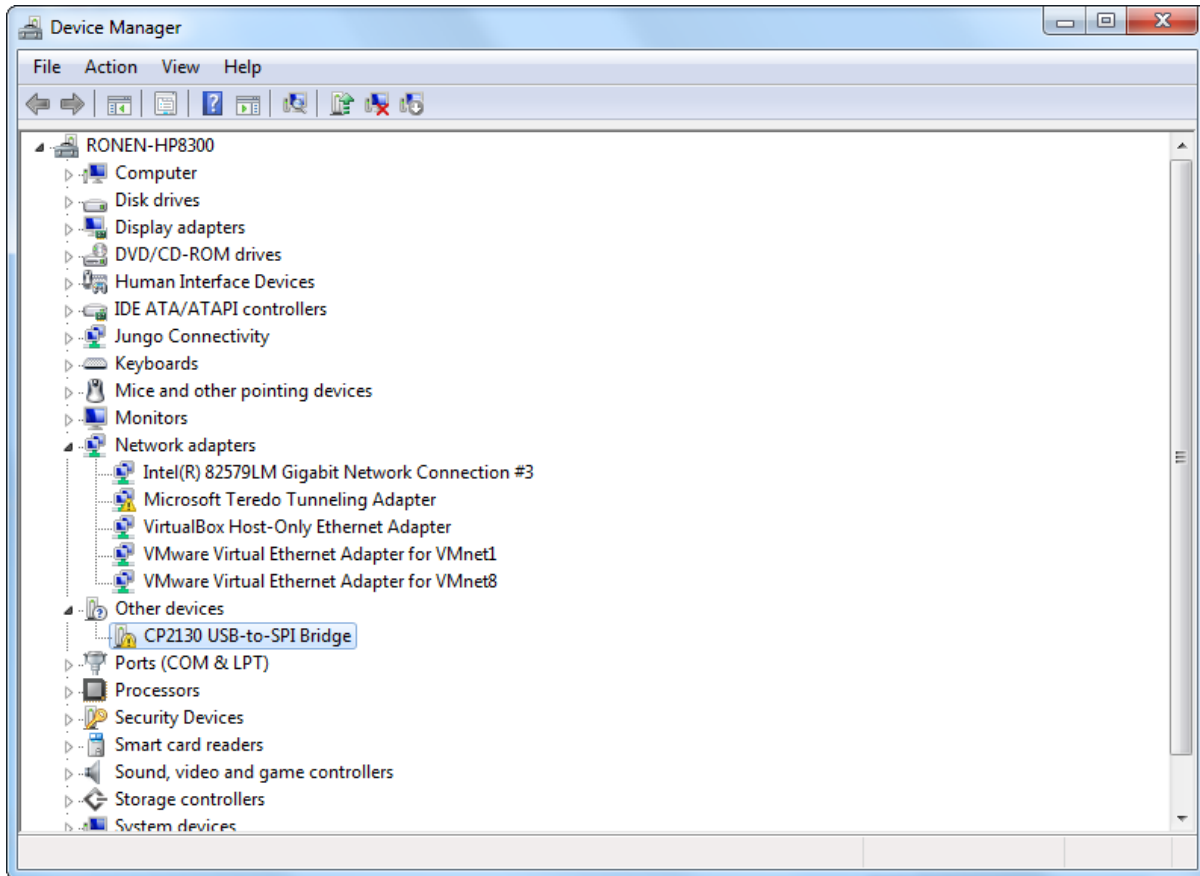
8. In the U**pdate Drivers** - **CP2130 USB-to-SPI Bridge** window, select **Browse my computer for driver software**.
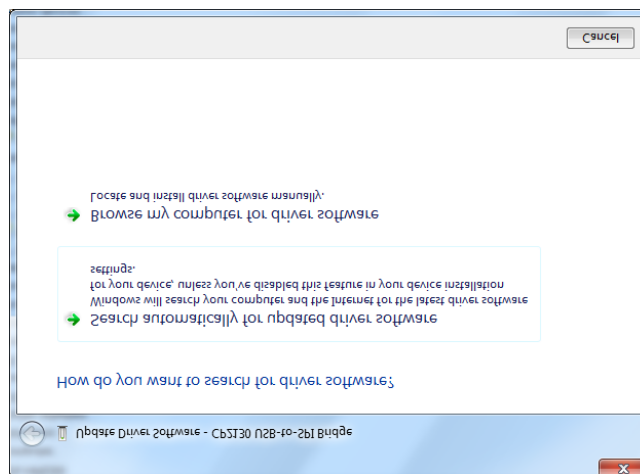
9. Browse to the driver software location on PC, select the folder and click **Next**.
   Driver installation begins.
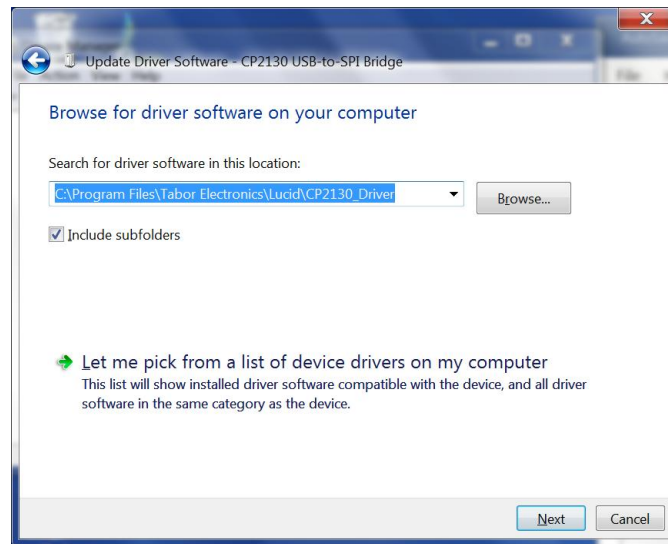
10. After the driver software installation is complete, click **Close**.
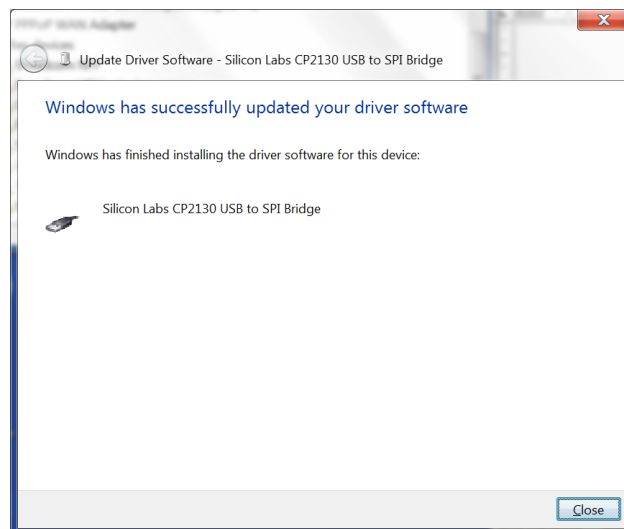
11. In the Device Manager, under Silicon Labs USB Devices, click **Silicon Labs CP2130 USB to SPI Bridge**.
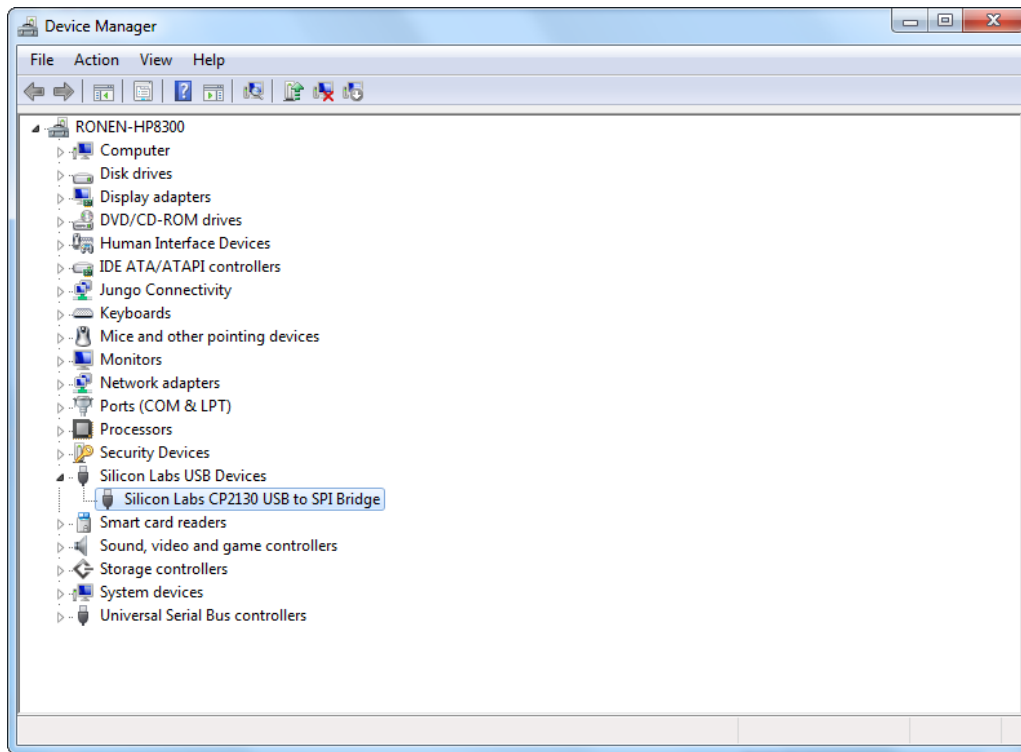
12. In the **CP2130 USB-to-SPI Bridge Properties** window the device status should indicate the device is working properly.
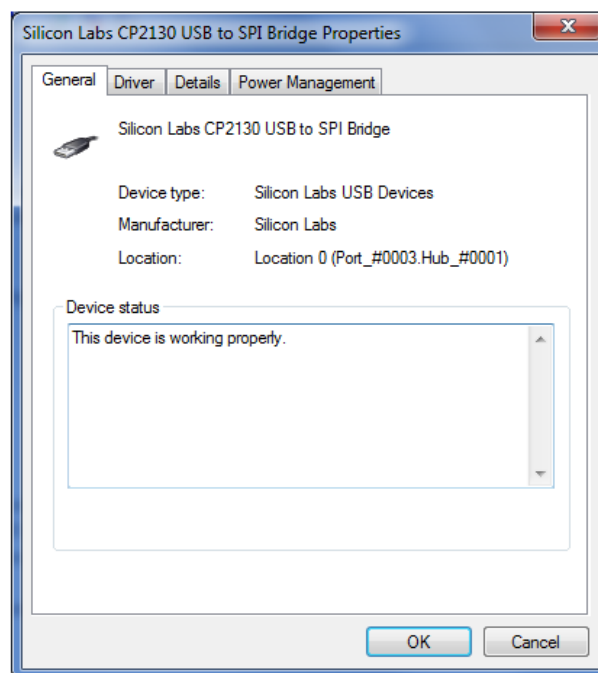
5 Lucid Rackmount Specifications

5.1 Frequency

Table 5.1 Frequency Specifications

Frequency	
Range	
LS3081R, LS3082R, LS3084R, LS30816R	9 kHz to 3 GHz
LS6081R, LS6082R, LS6084R, LS60816R	9 kHz to 6 GHz
LS1291R, LS1292R, LS1294R, LS12916R	9 kHz to 12 GHz
Resolution	0.001 Hz
Phase Offset	0.01 deg
Switching Speed	
Standard	500 µs
FS Option	100 µs

5.2 Frequency Reference

Table 5.2 Frequency Reference Specifications

| Frequency Reference	
Temperature Stability	±25 ppb max
Aging	±3 ppm max for 20 years
Warm Up time	30 min

5.3 Amplitude

Table 5.3 Amplitude Specifications

Amplitude		
Max Output Power		
Settable	+20 dBm	
Calibrated	+15 dBm[1]	
Min Output Power	Base	LP Opt.
Settable	-100 dBm	
Calibrated	-80 dBm	

Amplitude		
Resolution	0.01 dB	
Power Mute	-95 dBm	
Output Return Loss	-10 dBm	
Accuracy (dB)	-50 dBm to +15 dBm	-90 dBm to -50 dBm
Up to 100 MHz	±0.3 (typ.)	±0.5 (typ.)
100 MHz to 3 GHz	±0.4 (typ.)	±0.6 (typ.)
3 GHz to 9 GHz	±0.7 (typ.)	±0.9 (typ.)
Above 9 GHz	±1 (typ.)	±1.5 (typ.)

[1] Above 25 kHz.

5.4 Phase Noise and Harmonics

Table 5.4 Phase Noise and Harmonics Specifications

Phase Noise (dBc/Hz	
Measured @ 10 kHz Offset)	
1 GHz	-138 (typ.)
2 GHz	-133 (typ.)
3 GHz	-130 (typ.)
6 GHz	-124 (typ.)
12 GHz	-118 (typ.)
Harmonics (dBc)	
Range	
Up to 100 MHz	-30 dBc
Up to 8 GHz:	-50 dBc
100 MHz to 12 GHz	-50 dBc[2]
Sub-harmonics (dBc)	
6 to 12 GHz:	-55 dBm
Non-harmonics (dBc)	
Up to 12 GHz	-90 dBc (typ.)[3,4], -60 dBc (max.)[5]

[2] 750 MHz to 900 MHz -35dBc (typ.).

[3] -60 dBm max. @ 1 GHz, 1.5 GHz, 2.5 GHz and 3 GHz.

[4] -75 dBm max. @ -15 dBm to +15 dBm and f> 6 GHz.

[5] Boundary spurs which may appear @ -100 MHz to +100 MHz offset from CW.

5.5 Modulation

Table 5.5 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[6]	
AM Depth	
Type	Linear
Maximum Settable	90 %
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	60 dB
Rise/fall Time (10%-90%)	15 ns (typ.)
Resolution	6.4 ns
Minimum Width	32 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	32 ns to 20 days
Sweep	
Range	Same as frequency range
Modes	Frequency and amplitude step, list
Dwell Time	100 µs to 1,000 s

Modulation	
Resolution	1 µs
Number of Points	
List	2 to 4,096
Step	2 to 65,535
Step Change	Linear
Trigger	Free run, External, Bus, Timer

[6] Specified for CW>100MHz

5.6 Inputs

Table 5.6 Inputs Specifications

Inputs	
Reference 10/100 MHz Input	
Connector Type	BNC
Input Impedance	50 Ω
Waveform	Sine or Square
Frequency	10 MHz/100 MHz
Power	-3 dBm to +10 dBm
Absolute Maximum Level	+15 dBm
Modulation Input	
Connector Type	BNC (per channel)
Input Impedance	50 Ω
Maximum Input Voltage	±1 V
Input Damage Level	±3.5 V
Trigger Input	
Connector Type	BNC (per channel)
Input Impedance	50 Ω
Input Voltage	TTL, CMOS compatible
Threshold	1.5 V
Damage level	-0.42 V or +5.42 V

5.7 Outputs

Table 5.7 Outputs Specifications

Outputs	
CH1/CH2/CH3/CH4 RF Out	
Impedance	50 Ω
Connector Type	SMA
Number of Outputs	
LS3081R/LS6081R/LS1291R	1
LS3082R/LS6082R/LS1292R	2
LS3084R/LS6084R/LS1294R	4
LS30816R/LS60816R/LS12916R	16
10/100 MHz Output	
Impedance	50 Ω
Connector Type	2 x BNC
Frequency	10 MHz, 100 MHz
Shape	Sine
Power	3 to 7 dBm

5.8 General

Table 5.8 General Specifications

General	
Voltage Range	90 VAC to 264 VAC
Frequency Range	47 Hz to 63 Hz
Power Consumption	
1U Box	100 W
3U Box	400 W
Interface	
Host	2 x front panel USB type A 1 x rear panel USB type A
Device	1 x rear panel USB type B
LAN	1 x rear panel 1000/100/10 BASE-T
Storage	16 GB removable SD card

General	
Dimensions (WxHxD)	
1 U Box	450 x 43 x 500 mm
3 U Box	450 x 129 x 500 mm
Weight	
Without Package	
1U Box	6 kg
3U Box	12 kg
Shipping Weight	
1U Box	7 kg
3U Box	13 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