TABOR ELECTRONICS

LUCID SERIES

Lucid Series RF Analog Signal Generator Desktop Model User Manual

Rev. 1.4

For more information or to schedule a demo contact info@tabor.co.il | www.taborelec.com

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Document Revision History

Revision	Date	Description	Author
1.4	15-Oct-2024	• Updated document format. • 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. • 1.2 Related Documentation – New. • 2.1 Unpacking – Updated. • Chapter 3 "SPI Programming" — Moved to "Lucid Programming Manual". • 6 Appendix A. Lucid SPI Interface — Added host setup.	Jakob Apelblat
1.3	04-May-2021	• Release supporting Lucid SW Ver. 1.8.15, FPGA Ver. 18111215 for HW Ver. D, 221220 for HW Ver. E and Ver. 221220 for HW Ver. F, and SPI & SCPI Commands List Summary Rev. 1.17. • 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 3.3 Set Frequency – Changed Min Value from 100 kHz to 9 kHz. • Table 3.64 Set Sweep Start Frequency – Changed Min Value from 100 kHz to 9 kHz. • Table 3.66 Set Sweep Stop Frequency – Changed Min Value from 100 kHz to 9 kHz. • Table 3.5 Set Output Power – Changed Min Value and Max Value from "-90 to +15" to "-100 dBm to +20dBm". • Table 3.76 Set Sweep Start Power, page 44 – Changed Min Value and Max Value from "-90 to +15" to "-100 dBm to +20dBm". • Table 3.9 Set Run Mode – Changed values, and added Gate (set and query). • Table 3.11 Set Trigger Source – New value SPI (set and query). • Table 3.21 Set Trigger Timer – Changed Min Value from 100 µs to 1 µs. • Table 3.99 Query Firmware – Changed Query Code from CB to EC. • Table 5.4 Modulation Specification – Changed Sweep Dwell Time from "10 µs to 1,000 s" to "100 µs to 1,000 s".	Jakob Apelblat
1.2	6-Aug-2020	• Minor typos. • 5 Lucid Desktop Specifications – Updated.	Jakob Apelblat
1.1	23-Jun-2020	• Supporting Lucid. 1.2.x SW version. • Updated formatting, corrected typos, etc. • Figure 2.3 Rear Panel – New photo.	Jakob Apelblat

		• Figure 2.2 Front Panel – New photo. • 2.3 Rear Panel Connectors – EXT IO removed, SYNC OUT changed to SYNC IN. • Figure 3.4 CW & Modulation Tab, page 28 – The status bar has a thermometer. • 3 SPI Programming – Updated according to SPI & SCPI Commands List Summary Rev. 1.14 • 4 SPI Programming – Updated according to SPI & SCPI Commands List Summary Rev. 1.14 • 4.1.2 USB Device Driver Manual Installation (Windows 7) – Updated step 10.	
1.0	26-Feb-2020	• First edition supporting Lucid 1.1.0 SW version.	Jonathan Netzer

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
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

Contents

Figures

Tables

1 General

1.1 Scope

The scope of this manual is to describe the setup and operating procedures of the Lucid Desktop User Manual. This covers the following models listed in the ordering information.

Table 1.1 Ordering Information

Model	Description
LS3081D	3 GHz, 1 channel, desktop RF analog signal generator
LS6081D	6 GHz, 1 channel, desktop RF analog signal generator
LS1291D	12 GHz, 1 channel, desktop RF analog signal generator
Options	
PLS	Pulse modulation
PAT	Pattern modulation
LP	Low power to -90 dBm
FS	Fast switching 100 µs
EMU	Emulator for Keysight, R&S, Anapico & Holzworth

Figure 1.1 LS1291D – 12 GHz, 1 Channel, Desktop 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 comes on a CD supplied with the device. It 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 specified for this manual 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.

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

2 Introduction

The Lucid series desktop models feature 3, 6, and 12 GHz single channel generator versions, all sharing the very same industry leading highlighted features, in a compact, small footprint module. Featuring extremely fast switching speed, superior signal integrity and purity, all the necessary modulated signals for analog communication systems, with built in SPI and micro-USB interface. The Lucid Series is designed to meet today's most demanding requirements 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 desktop model instrument is supplied with:

- Lucid power supply. Input 90 – 264 V AC, 1 A, 47-63 Hz. Output 12.0 V DC, 3.0 A, 36 W,
  

- Power cord with a plug according to customer country standard
- Lucid: USB to Micro 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.

Figure 2.1 Package and Contents of Lucid Desktop Model

2.2 Front Panel Connector Lucid

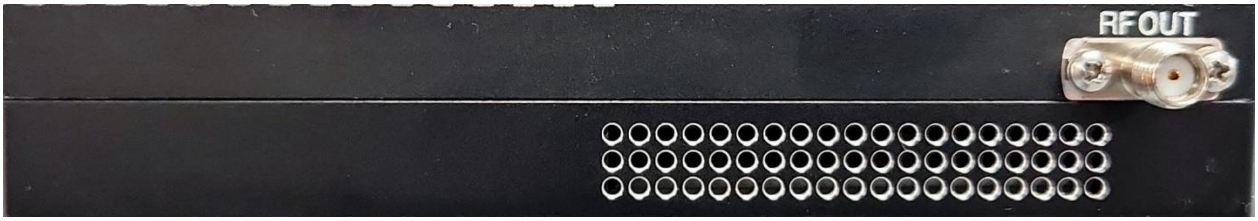


Figure 2.2 Front Panel Lucid

- RF OUT – SMA type connector for RF signal output

2.3 Rear Panel Connectors Lucid

Figure 2.3 Rear Panel Lucid

- PULSE/TRIG IN – MMCX type connector for pulse modulation or for trigger input

- AM IN – MMCX type connector for amplitude modulation input
- FM IN – MMCX type connector for frequency modulation input
- SYNC IN – MMCX type connector for Tabor Electronics factory use only
- Micro-USB – USB Micro-B interface for remote connection to PC
- SPI connector – SPI interface for remote connection to PC
- 10/100MHz IN – SMA type connector for 10 MHz or 100 MHz signal input
- 10 MHz OUT – SMA type connector for 10MHz signal output
- 100 MHz OUT – SMA type connector for 100MHz signal output
- Power – 12V power supply connector

Notes

For a detailed description of the SPI connector please refer to 6 Appendix A. Lucid SPI Interface.

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

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-X using the supplied USB Cable.
5. Double click the LCP icon on your desktop.
6. The Communications tab will be displayed.

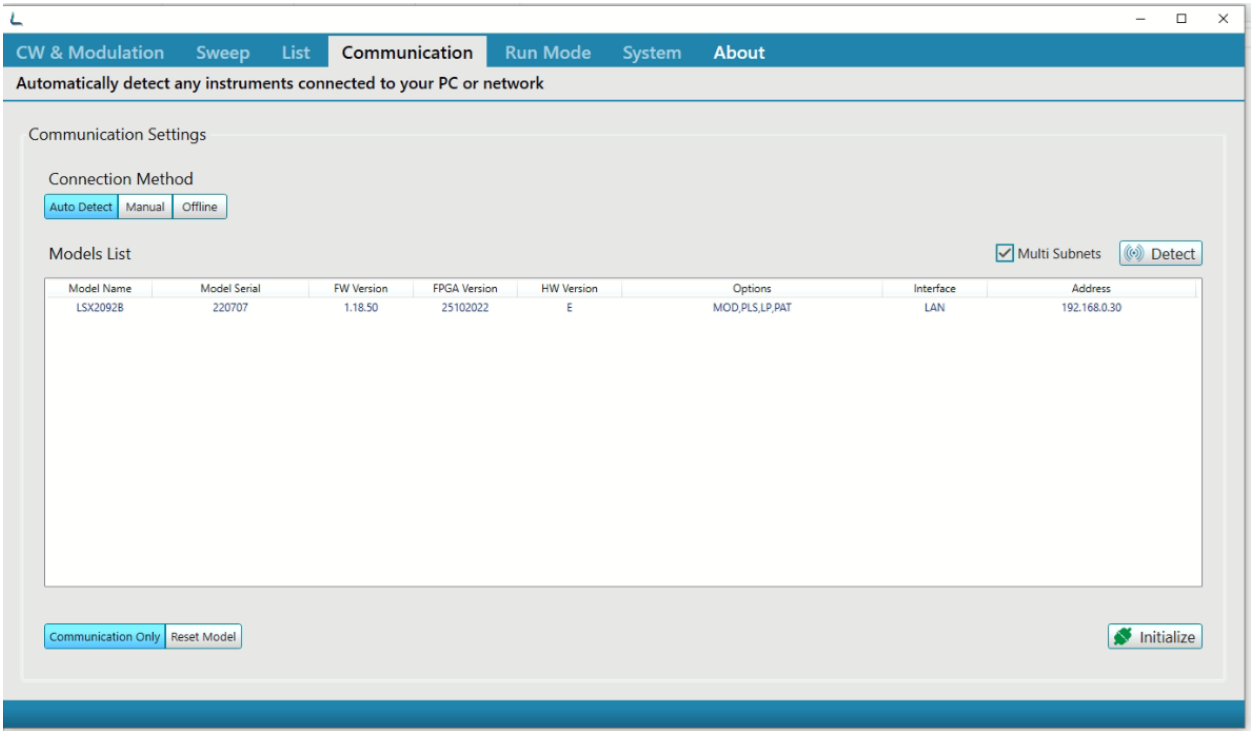


Figure 3.1 Lucid Control Panel CW & Communication Tab

7. LCP will detect your instrument, click on it and then press "Initialize".
8. The “CW & Modulation” tab will be displayed.

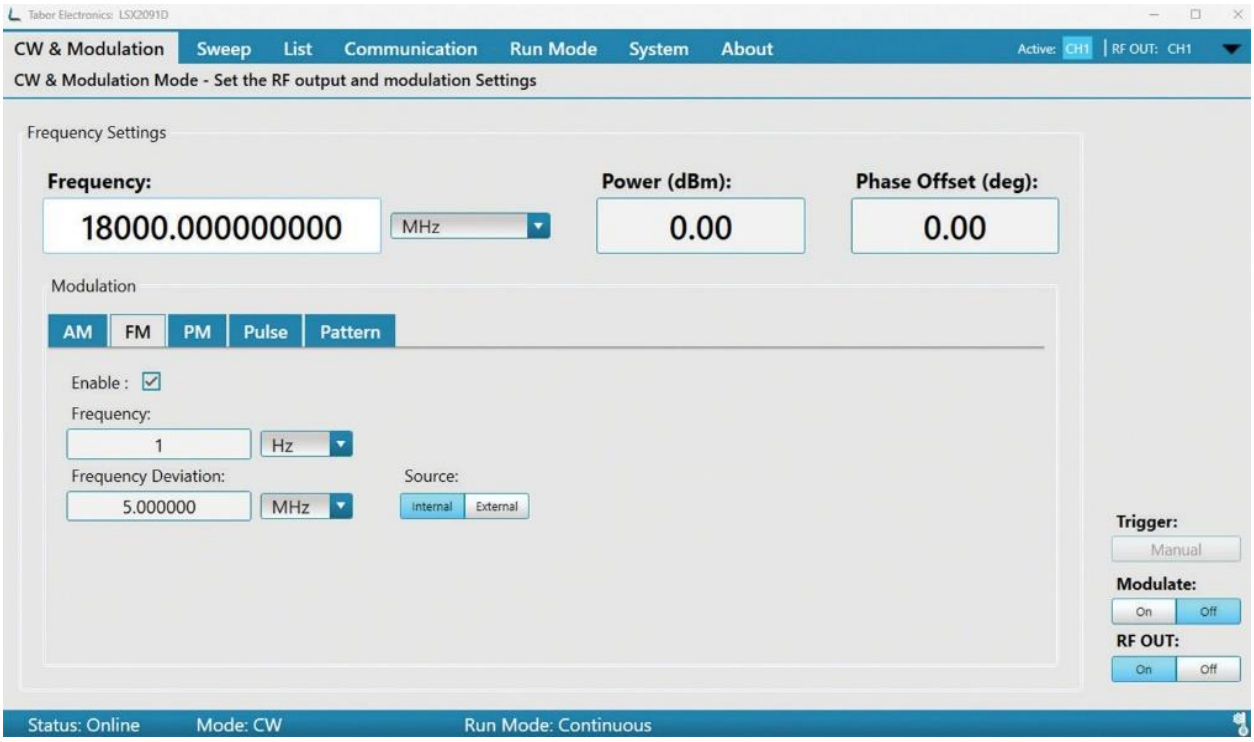


Figure 3.2 Lucid Control Panel CW & Modulation Tab

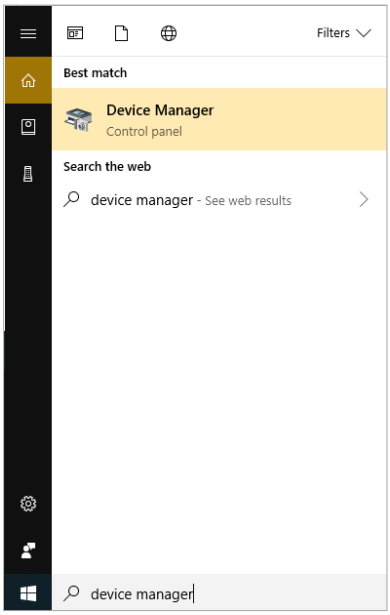
9. Enter the desired Frequency and Power (dBm) and switch "RF OUT" to "On".
10. Verify with an oscilloscope or a spectrum analyzer the generated RF signal.

4 Troubleshooting

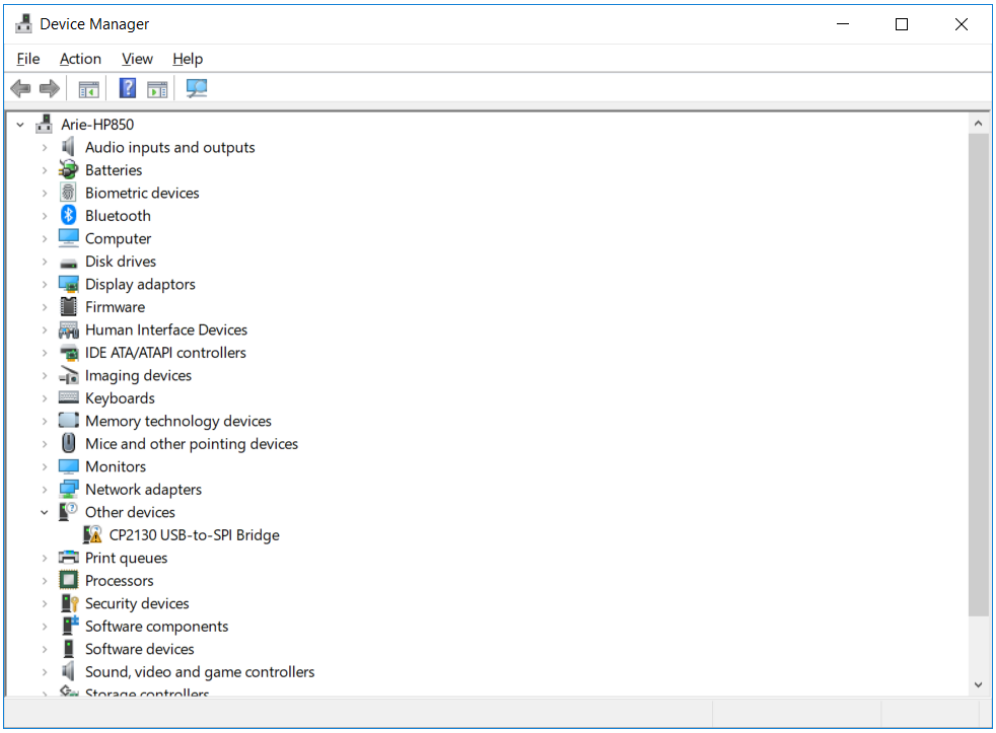
4.1 Manually Installing Instrument Drivers

4.1.1 USB Device Driver Manual Installation (Windows 10)

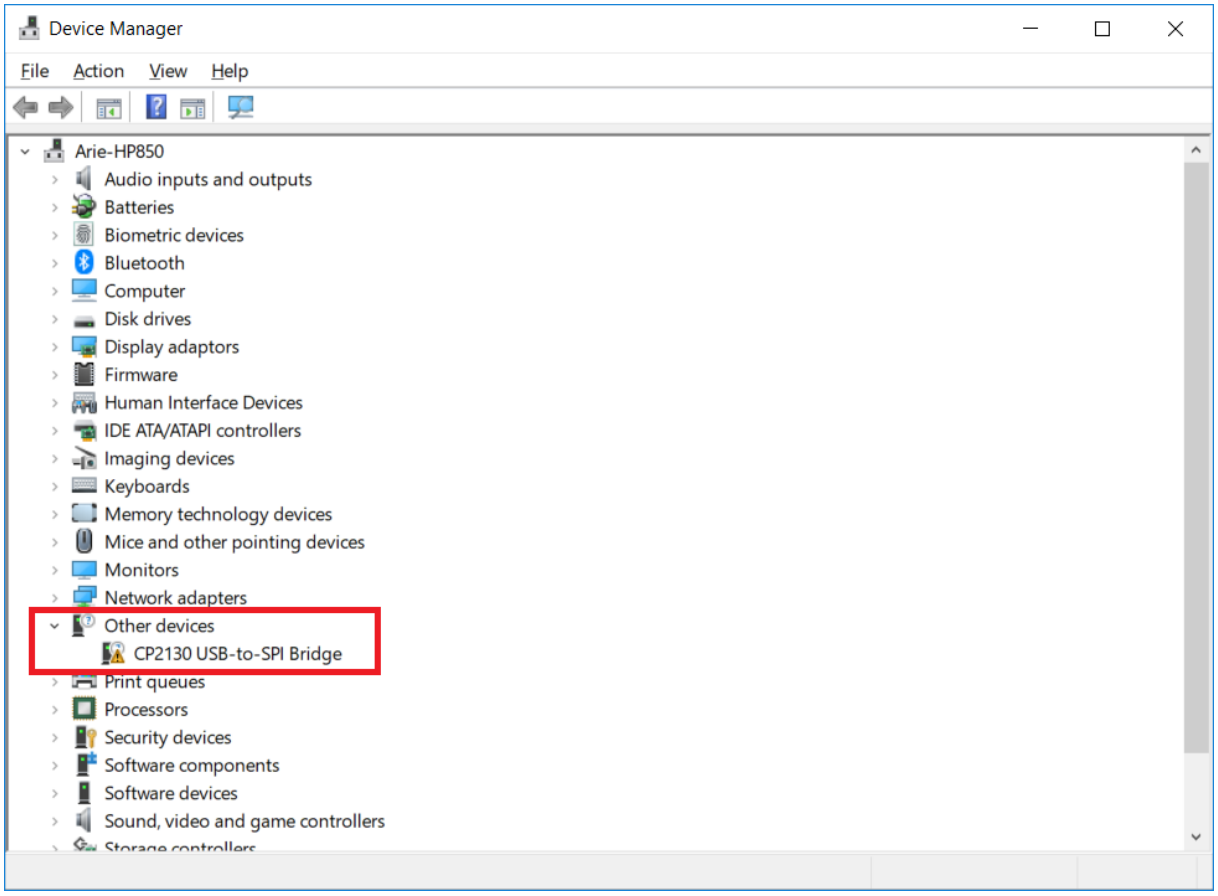
11. Download the latest Lucid series USB device driver from www.taborelec.com/downloads. Using the supplied USB cable, connect the Lucid desktop model to the PC.
12. Open the **Start** menu, and in the search field, type Device Manager.



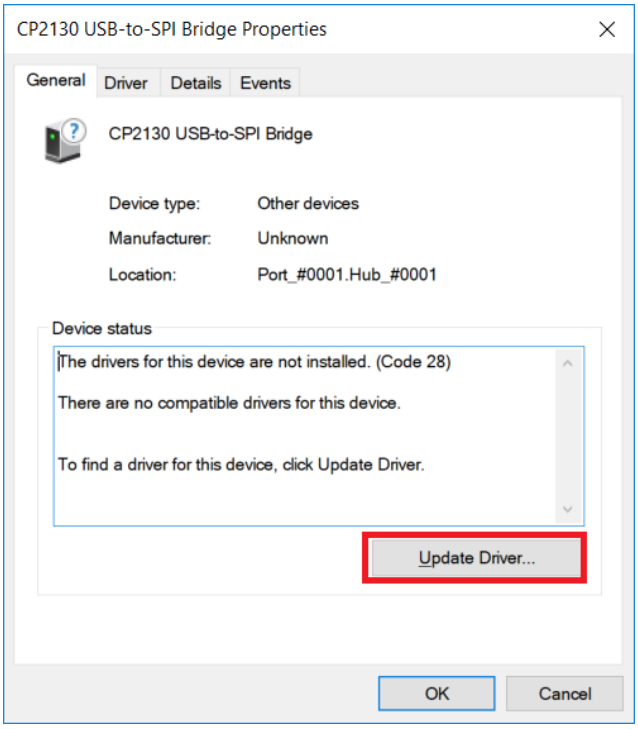
13. In the search results list, select Device Manager.
    The Device Manager window opens.



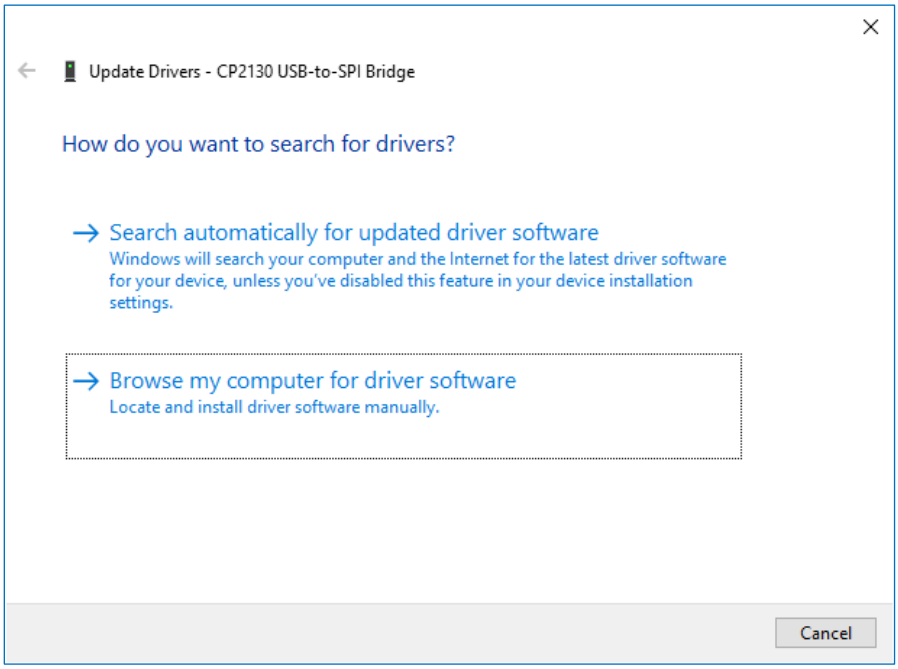
14. In the navigation tree, expand Other devices and double click on CP2130 USB-to-SPI Bridge.



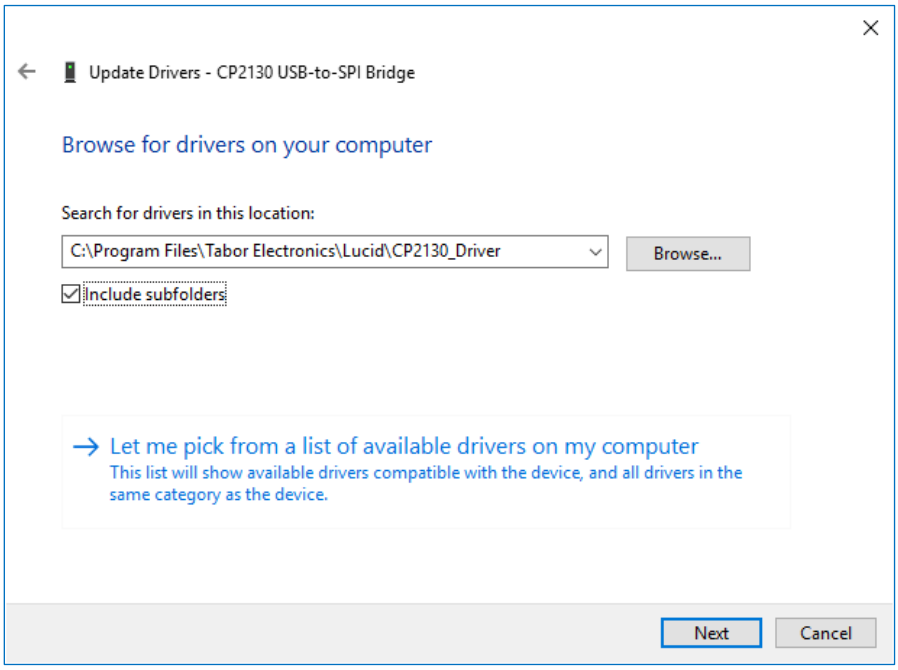
15. The CP2130 USB-to-SPI Bridge Properties window opens.
    Click Update Driver.



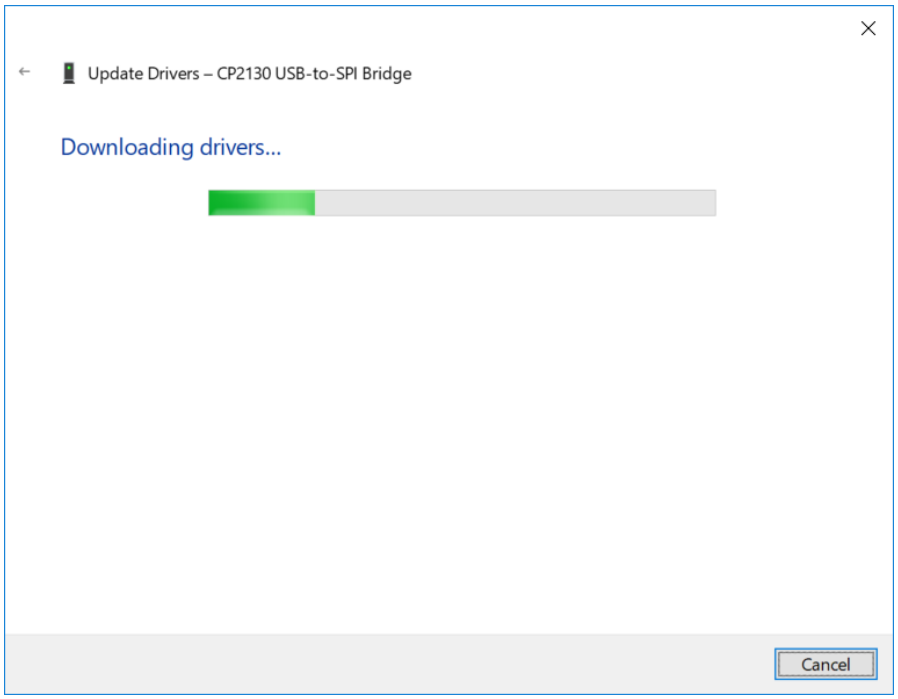
16. In the Update Drivers - CP2130 USB-to-SPI Bridge window, select Browse my computer for driver software.



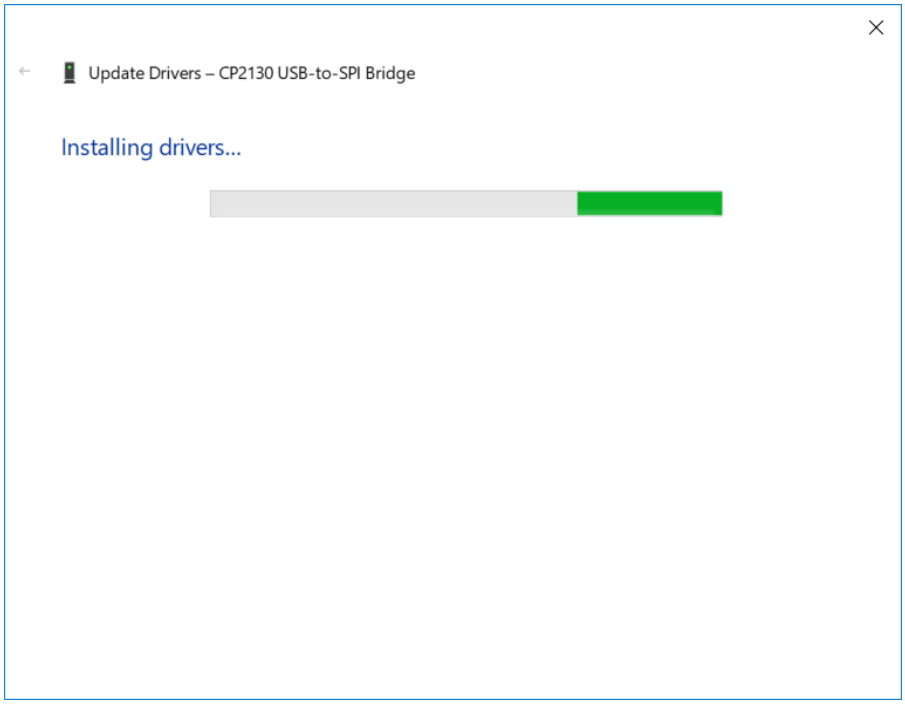
17. Browse to the driver software location on PC, select the file and click OK.



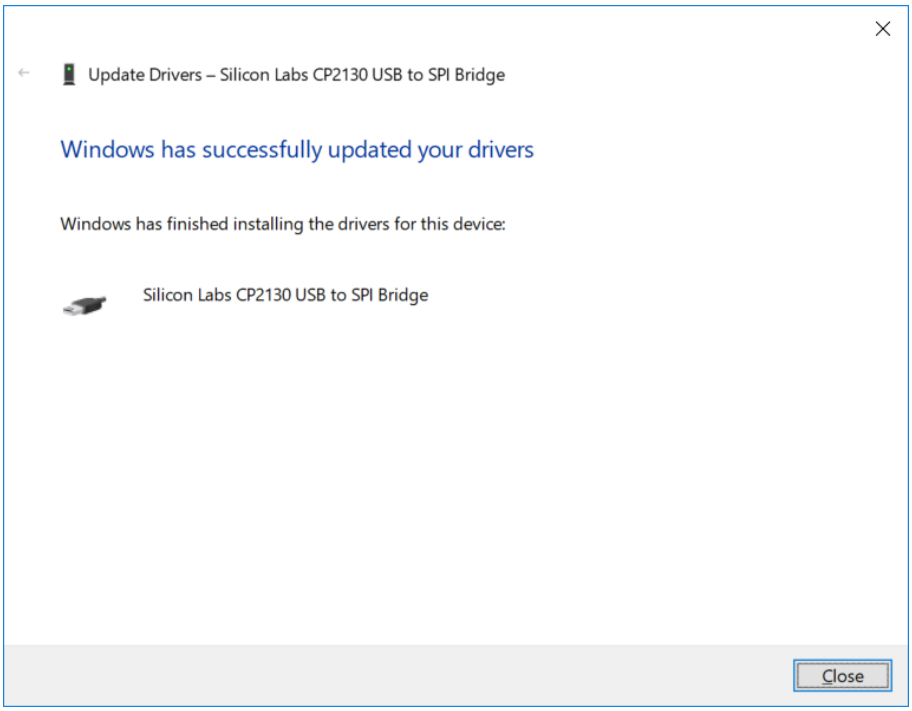
18. Driver download begins.



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

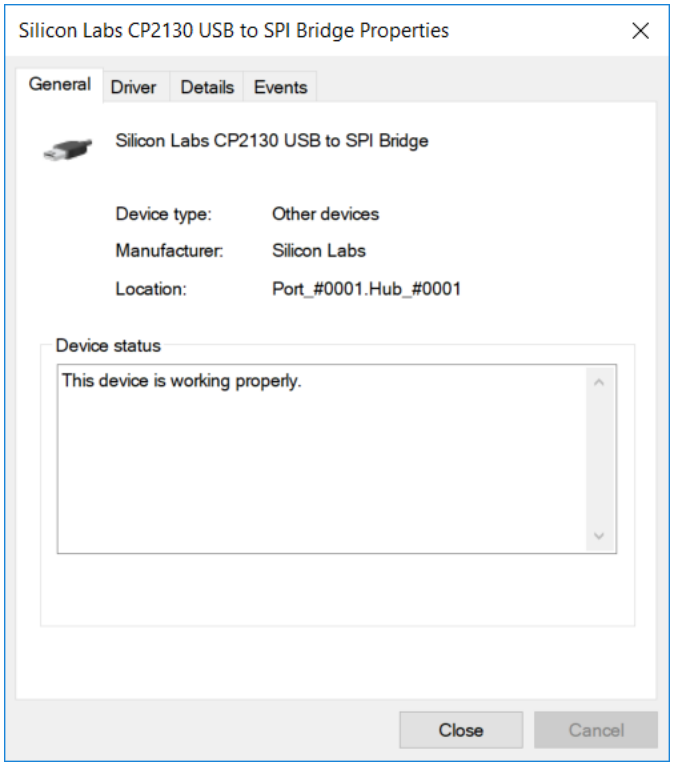


20. After the installation is complete, the following success message is displayed:



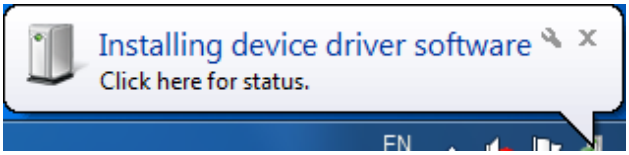
21. Click Close to close the Update Drivers window and to proceed.

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



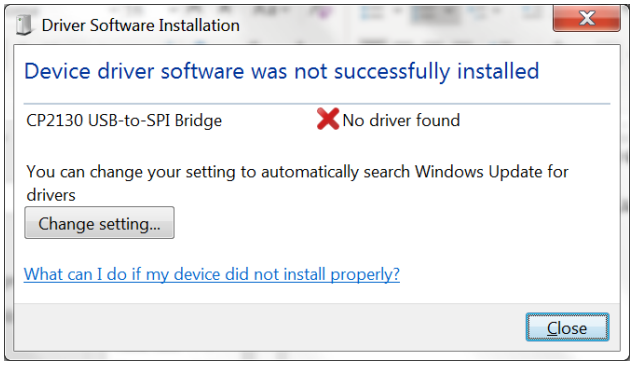
4.1.2 USB Device Driver Manual Installation (Windows 7)

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.

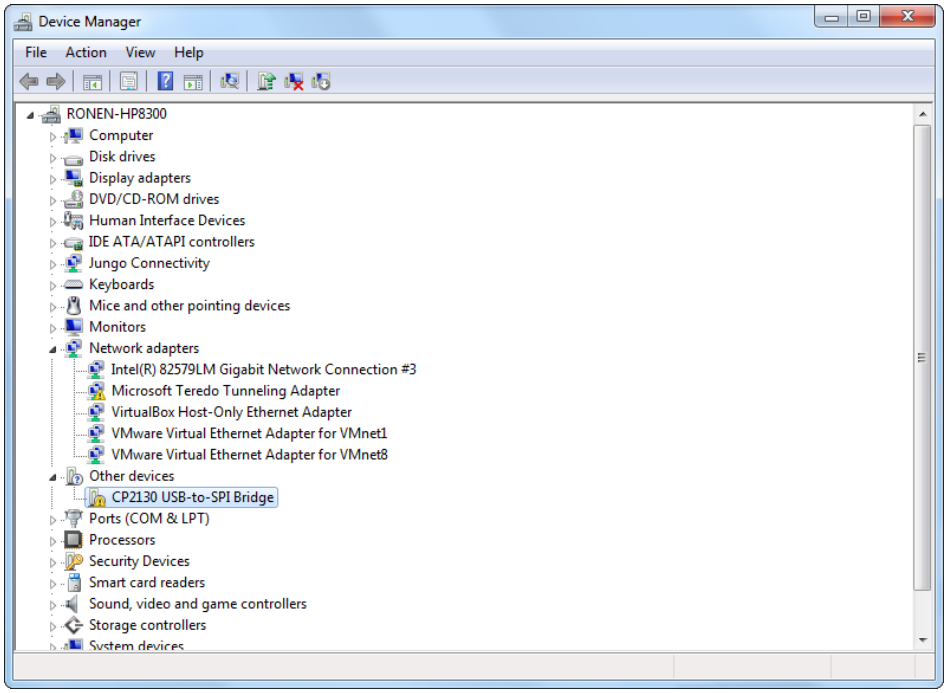


The Installing Device Driver Software message is displayed at the lower-right part of the screen.

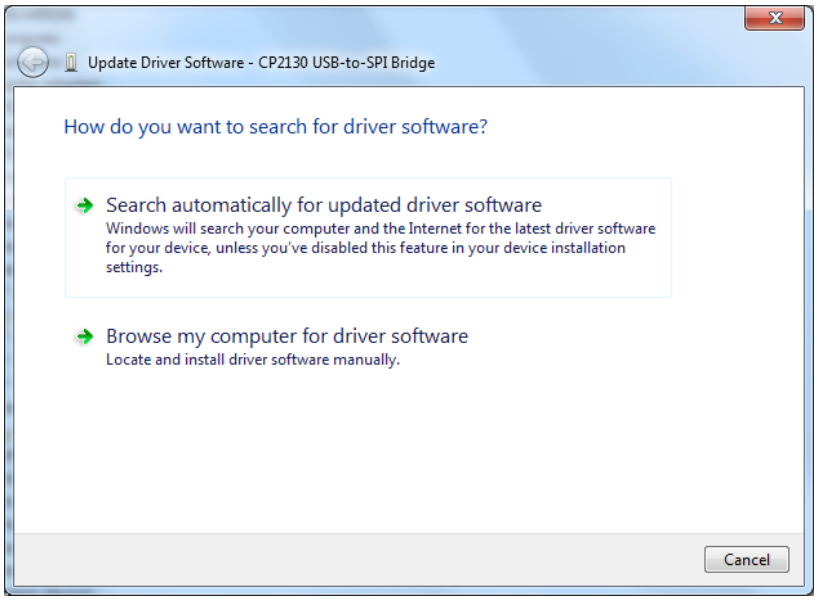
3. Wait for the following messages to appear:



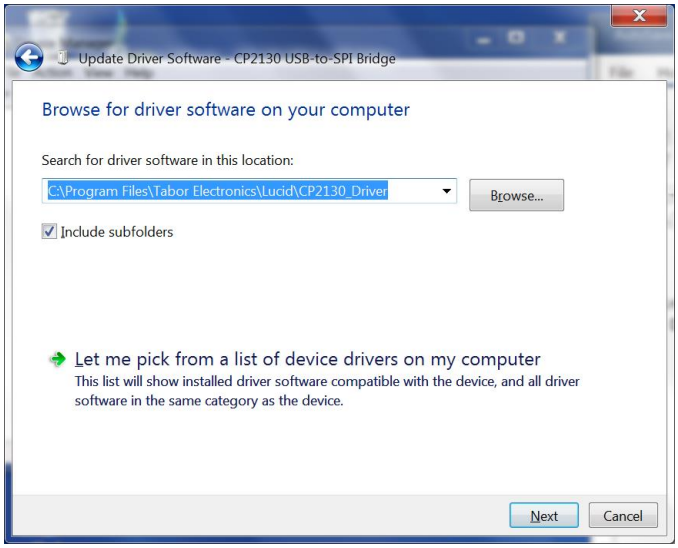
4. Click **Close**.
5. Open the **Start** menu, and in the search field, type Device Manager.
6. In the search results list, select Device Manager. The Device Manager window opens.
7. In the navigation tree, expand Other devices and select CP2130 USB-to-SPI Bridge.



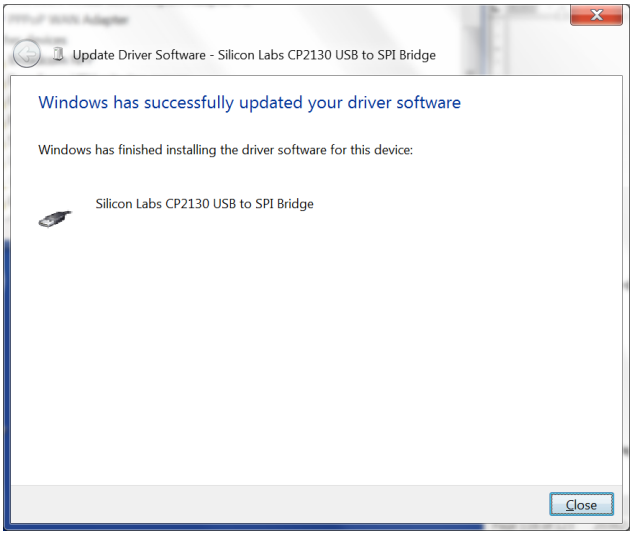
8. Right-click on CP2130 USB-to-SPI Bridge and select **Update Driver Software**…from the drop-list menu.
9. In the Update Drivers - CP2130 USB-to-SPI Bridge window, select Browse my computer for driver software.



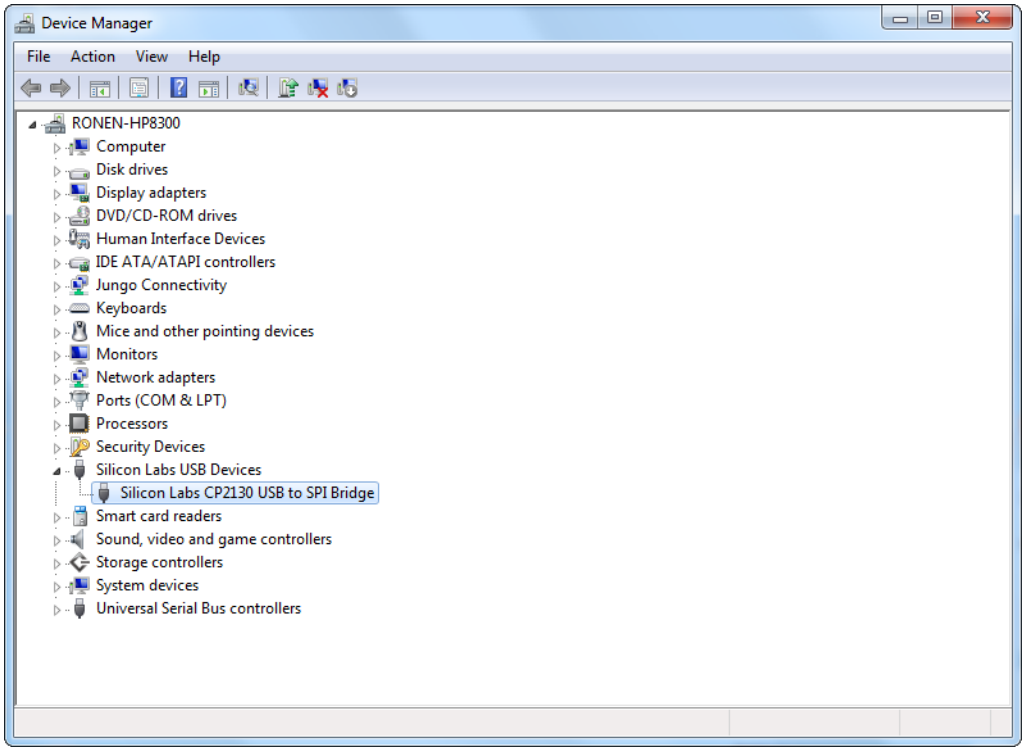
10. Browse to the driver software location on PC, select the folder and click Next.
    Driver installation begins.



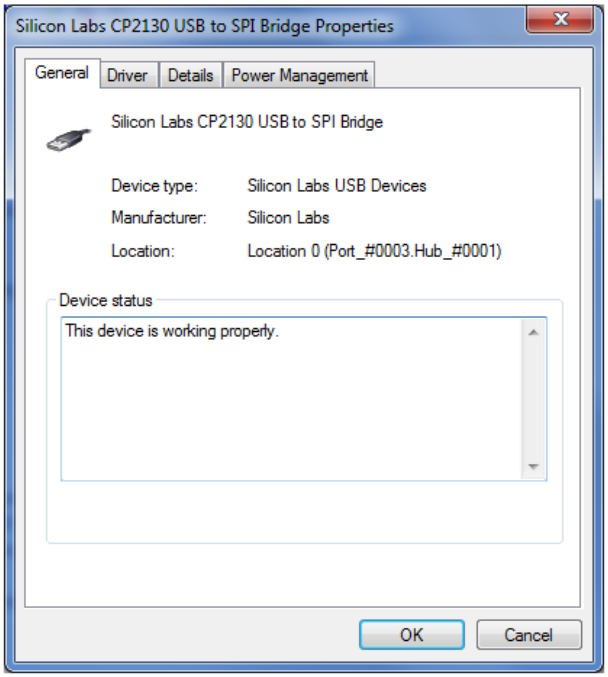
11. After the driver software installation is complete, click Close.



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.



5 Lucid Desktop Specifications

5.1 Frequency

Table 5.1 Frequency Specifications

Frequency	
Range	
LS3081D	9 kHz to 3 GHz
LS6081D	9 kHz to 6 GHz
LS1291D	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	-30 dBm	-100 dBm
Calibrated	-20 dBm	-80 dBm
Resolution	0.01 dB	

Amplitude		
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)	
100 MHz	
250 MHz	
500 MHz	
1 GHz	-138 (typ.)
2 GHz	-133 (typ.)
3 GHz	-130 (typ.)
4 GHz	
6 GHz	-124 (typ.)
8 GHz	
10 GHz	
12 GHz	-118 (typ.)
20 GHz	
40 GHz	
Harmonics (dBc)	
Range	
Up to 100 MHz	-30 dBc
Up to 8 GHz:	-50 dBc
100 MHz to 12 GHz	-50 dBc[2]

8 GHz to 20 GHz	
20 GHz to 40 GHz	
Sub-harmonics (dBc)	
6 to 12 GHz:	-55 dBm
Up to 20 GHz:	
20 to 40 GHz:	
Non-harmonics (dBc)	
Up to 12 GHz	-90 dBc (typ.)[3,4], -60 dBc (max.)[5]
Up to 40 GHz	

[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	
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

Modulation	
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
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

5.6 Inputs

Table 5.6 Inputs Specifications

Inputs	
Pulse/Trigger Input	PULSE/TRIG IN
Connector Type	MMCX
Input Impedance	50 Ω
Input Voltage	TTL, CMOS compatible
Threshold	1.5 V
Damage level	-0.42 V or +5.42 V
AM Input	AM IN
Connector Type	MMCX
Input Impedance	50 Ω

Inputs	
Maximum Input Voltage	±1 V
Input Damage Level	±3.5 V
FM Input	FM IN
Connector Type	MMCX
Input Impedance	50 Ω
Maximum Input Voltage	±1 V
Input Damage Level	±3.5 V
AM Input	
Clock Input 3 GHz	
Connector Type	
Input Impedance	
Waveform	
Frequency	
Power	
Absolute Maximum Level	
10/100 MHz Input	10/100MHz IN
Connector Type	SMA
Input Impedance	50 Ω
Waveform	Sine or Square
Frequency	10 MHz/100 MHz
Power	-3 dBm to +10 dBm
Absolute Maximum Level	+15 dBm

5.7 Outputs

Table 5.7 Outputs Specifications

Outputs	
RF Output	RF OUT
Impedance	50 Ω
Connector Type	SMA
Number of Outputs	1
10 MHz Output	10MHz OUT
Impedance	50 Ω

Outputs	
Connector Type	2 x SMA
Frequency	10 MHz, 100 MHz
Shape	Sine
Power	3 to 7 dBm
Clock Output	
Connector Type	
Input Impedance	
Waveform	
Frequency	
Power	
Absolute Maximum Level	

5.8 General

Table 5.8 General Specification

General	Lucid
Power Supply	Input: 90 – 264 V AC, 1 A, 47-63 Hz. Output: 12.0 V DC, 3.0 A, 36 W
Power Consumption	
Normal Operation	18 W nom.
Max	24 W max.
Interface	
Device (remote connection to PC)	1 x micro-USB, 1 x SPI
Dimensions (WxHxD)	12 x 16 x 2.5 cm
Weight	
Without Package	1 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

6 Appendix A. Lucid SPI Interface

Host Setup

- SPI Mode: Sampling on rising edge and transmit on rising edge
- Level: LVTLL (3.3 V)
- Bit order: MSB first
- Clock rate: Up to 10 MHz

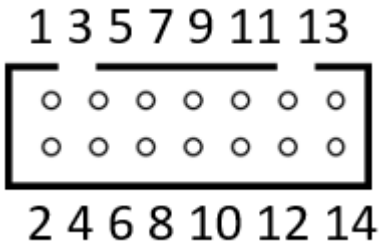


Figure 6.1 SPI Connector Pin Numbering

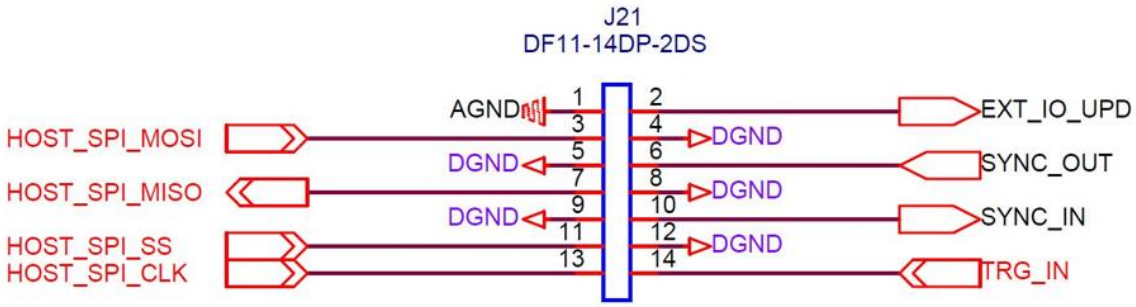


Figure 6.2 SPI Connector Pad Description

The SPI hardware interface consists of a standard SPI interface plus additionally assigned lines as defined in the table below.

Table 6.1 SPI Connector Pin Description

Signal	Description	Pin
SPI_MOSI	Master Out, Slave In. Command and query data sent from remote PC (Master) to Instrument (Slave).	3
SPI_MISO	Master In, Slave Out. Data sent from the instrument to the remote PC.	7
SPI_CLK	SPI clock, supplied by remote PC	13

Signal	Description	Pin
SPI_SS	Slave Select. This line uses an active low logic. Before data is sent to the instrument the line goes low and when done the line is made high again.	11
EXT_IO_UPD	For factory use only. Do not connect	2
SYNC_OUT	For factory use only. Do not connect	6
SYNC_IN	For factory use only. Do not connect	10
TRG_IN	When enabled the trigger signal to the instrument can initiate a signal, a frequency change or step through a sweep or list.	14
GND		1,4,5,8,9,12