TABOR ELECTRONICS

LUCID SERIES

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

Revision 1.1

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
1.1	26-Jan-2025	• 3 Lucid PXIe Module Specifications — Updated. • Release supporting Lucid Control Panel Ver. 1.3.500 and TE Update Tool Ver. 1.1.212, Lucid-X SCPI 1.011, and Lucid-X FPGA version 1.14 or higher.	Jakob Apelblat
1.0	23-Oct-2023	• Original preliminary release. • 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.	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
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
IP	Internet Protocol

Acronym	Description
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
SPI	Serial Peripheral Interface

Acronym	Description
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 analog RF 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 analog RF signal generator
LSX2091X	20 GHz, 1 channel, PXIe analog RF signal generator
LSX4091X	40 GHz, 1 channel, PXIe analog RF 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
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-X Programming Manual
- Tabor Lucid Multi-Channel RF Signal Generators White Paper

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 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 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 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-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.

Note

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 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

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

2.4 Multi-Instrument Synchronization Operation TBD

3 Lucid PXIe Module Specifications

3.1 Frequency

Table 3.1 Frequency Specifications

Frequency	
Range	
LSX8081X	50 kHz to 8 GHz
LSX2091X	50 kHz to 20 GHz
LSX4091X	50 kHz to 40 GHz
Resolution	0.001 Hz
Phase Offset	0.01 deg
Switching Speed	
Standard	500 µs
FS Option	100 µs

3.2 Frequency Reference

Table 3.2 Frequency Reference Specifications

Frequency Reference	
Temperature Stability	±10 ppb max (0-50°C)
Aging	±0.3 ppm 1st year ±3 ppm 20 years
Warm Up time	15 min
Frequency Accuracy	±0.5 ppm

3.3 Amplitude

Table 3.3 Amplitude Specifications

Amplitude		
Max Output Power		
Settable	+15 dBm	
Calibrated	+10 dBm	
Min Output Power	Base	LP Opt.
Settable	-30 dBm	-75 dBm
Calibrated	-20 dBm	-70 dBm

Amplitude	
Resolution	0.01 dB
Power Mute	-80 dBm
Output Return Loss	-10 dBm
Accuracy (dB)	-70 dBm to +10 dBm
Up to 100 MHz	±0.3 (typ.) dBm
100 MHz to 3 GHz	±0.4 (typ.) dBm
3 GHz to 9 GHz	±0.7 (typ.) dBm
Above 9 GHz	±1 (typ.) dBm

3.4 Phase Noise and Harmonics

Table 3.4 Phase Noise and Harmonics Specifications

Phase Noise (dBc/Hz		
Measured @ 10 kHz Offset)		
100 MHz	-153 (typ.)	
250 MHz	-147 (typ.)	
500 MHz	-141 (typ.)	
1 GHz	-134 (typ.)	
2 GHz	-128 (typ.)	
4 GHz	-122 (typ.)	
8 GHz	-116 (typ.)	
10 GHz	-114 (typ.)	
20 GHz	-108 (typ.)	
40 GHz	-102 (typ.)	
Harmonics (dBc)		
Range	0 dBm	+10 dBm
Up to 8 GHz:	-50 dBc	-40 dBc
8 GHz to 20 GHz	-40 dBc	-30 dBc
20 GHz to 40 GHz	-35 dBc	-28 dBc
Sub-harmonics (dBc)		
Up to 20 GHz:	-70 dBc	
20 to 40 GHz:	-35 dBc	

Non-harmonics (dBc)	
Up to 20 GHz	-90 dBc (typ.), 60 dBc max. (1)
20 GHz to 40 GHz	-60dBc (max.)[1]

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

3.5 Modulation

Table 3.5 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	1
Resolution	0.1% of depth
Modulation Rate	DC to 100 kHz
Phase Modulation	
Peak Deviation	360 deg
Modulation Rate	DC to 100 kHz
Sweep	
Range	Same as frequency range
Modes	Frequency step, Amplitude step, List
Dwell Time	10 µs to 562,499 s
Resolution	1 µs
Number of Points	2 to 4,096
Step Change	Linear
Trigger	Free run, External, Bus, Timer
Pattern Modulation (PAT Option)	
Number of Steps	1 to 2048

Modulation	
Step Repetition	1 to 65535
On/Off Time	32 ns to 20 days
Pulse Modulation (PLS Option)	
On/Off Ratio	80 dB
Rise/Fall Time	15 ns, 10%-90% (typ.)
Resolution	8 ns
Minimum Width	32 ns
Repetition Frequency	DC to 10 MHz

3.6 Inputs/Outputs

Table 3.6 Inputs/Outputs Specifications

Inputs / Outputs	
RF Out	
Impedance	50 Ω
Connector Type	
LSX8081X	2.92 mm
LSX2091X	2.92 mm
LSX4091X	2.4 mm
VSWR	1:2.1
Reverse Power	0.5 W, 16 VDC
Reference Out	
Impedance	50 Ω
Connector Type	SMA
Frequency	10 MHz or 100 MHz
Shape	Sine
Power	3 to 7 dBm

Inputs / Outputs	
Modulation Input	
Connector Type	SMP
Input Impedance	50 Ω
Max. Input Voltage	±1 V
Input Damage Level	±3.5 V
Pulse / Trigger Input	
Connector Type	SMP
Input Impedance	50 Ω
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 Ω
Waveform	Sine or Square
Frequency	10/100 MHz
Power	-3 dBm to +10 dBm
Absolute Max. Level	+15 dBm
Clock Input/Output	
Number of Ports	2, (1 Input & 1 Output)
Connector Type	SMA
Input Impedance	50 Ω
Waveform	Sine
Frequency	2.7 GHz - 3.3 GHz
Power	+10 dBm
Absolute Max. Level	+12 dBm

3.7 Multi-Instrument Synchronization

Table 3.7 Multi-Instrument Synchronization Specifications TBD

Multi-Instrument Synchronization	
Number of Ports	2

Type	SYNC I/O & SYNC X
Connector Type	MMCX
Input Impedance	50 Ω

3.8 General

Table 3.8 General Specifications

General	
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

3.9 General PXIe

Table 3.9 General Specifications PXIe

General PXIe	
Voltage	+12.0 to +12.6 VDC
Power Consumption	
LSX8081X	25 W typ., 35 W max.
LSX2091X	30 W typ., 45 W max.
LSX4091X	35 W typ., 55 W max.
Current Consumption	
+3.3 V	0.5 A max.
+12 V	5.5 A max.
Interface	PXIe Gen3 x8 Lanes
Dimensions	8HP PXIe (2 Slots)
Weight	
Without Package	1.0 kg

Shipping Weight	1.5 kg