LabSat3

LabSat 3 is a standalone, triple constellation simulator for testing devices based on satellite navigation systems; it is capable of recording and replaying multiple raw satellite navigation RF signals including GPS, GLONASS, Galileo, BeiDou, QZSS and SBAS. The optional SatGen software package can be used to generate simulated satellite signals from a user defined trajectory, allowing tests to be carried out simulating any time, date or place around the world.

Features
- Available for GPS L1, GLONASS L1, Galileo E1, BeiDou B1, QZSS and SBAS
- Compact, lightweight and portable
- Fully standalone
- Single, dual or triple constellation files
- Battery life up to 2 hours
- Simple to use one touch recording
- Free library of pre-recorded and simulated files

The **LabSat 3** product range supports a number of powerful features for use in industries such as automotive, aviation, aerospace, marine, semiconductor, telecom and performance sports analysis. It includes up to three RF channels for multiple constellation testing, dual CAN Bus recording, digital event capture and inertial sensor logging.

Free library of scenarios
A free library of pre-recorded and simulated files from around the world is included with all **LabSat 3** systems to get you up and running as quickly as possible.

Custom test scenarios with SatGen
If you want to create your own custom test scenario using artificial signals, SatGen v3 software allows you to quickly draw a route using Google maps, and then automatically creates an RF file which can then be transferred to an SD card and replayed on a **LabSat 3**.

A 30 day SatGen demo version, limited to 2 minutes scenario creation, is available for download on the LabSat website. Please contact your local LabSat distributor for LabSat & SatGen packages.

Model Range

Part Number	Description	Constellations	GNSS Antenna
RLLS03-1P	Single constellation Replay Only	GPS L1/SBAS/Galileo E1/QZSS, GLONASS L1 or BDS B1	-
RLLS03-1RP	Single Constellation Record & Replay	GPS L1/SBAS/Galileo E1/QZSS, GLONASS L1 or BDS B1	RLACS198 Quad Constellation Antenna
RLLS03-2P	Dual Constellation Replay Only	GPS L1/SBAS/Galileo E1/QZSS, GLONASS L1 or BDS B1	-
RLLS03-2RP	Dual Constellation Record & Replay	GPS L1/SBAS/Galileo E1/QZSS, GLONASS L1 or BDS B1	RLACS198 Quad Constellation Antenna
RLLS03-3P	Triple Constellation Replay Only	GPS L1/SBAS/Galileo E1/QZSS, GLONASS L1 or BDS B1	-
RLLS03-3RP	Triple Constellation Record &Replay	GPS L1/SBAS/Galileo E1/QZSS, GLONASS L1 or BDS B1	RLACS198 Quad Constellation Antenna

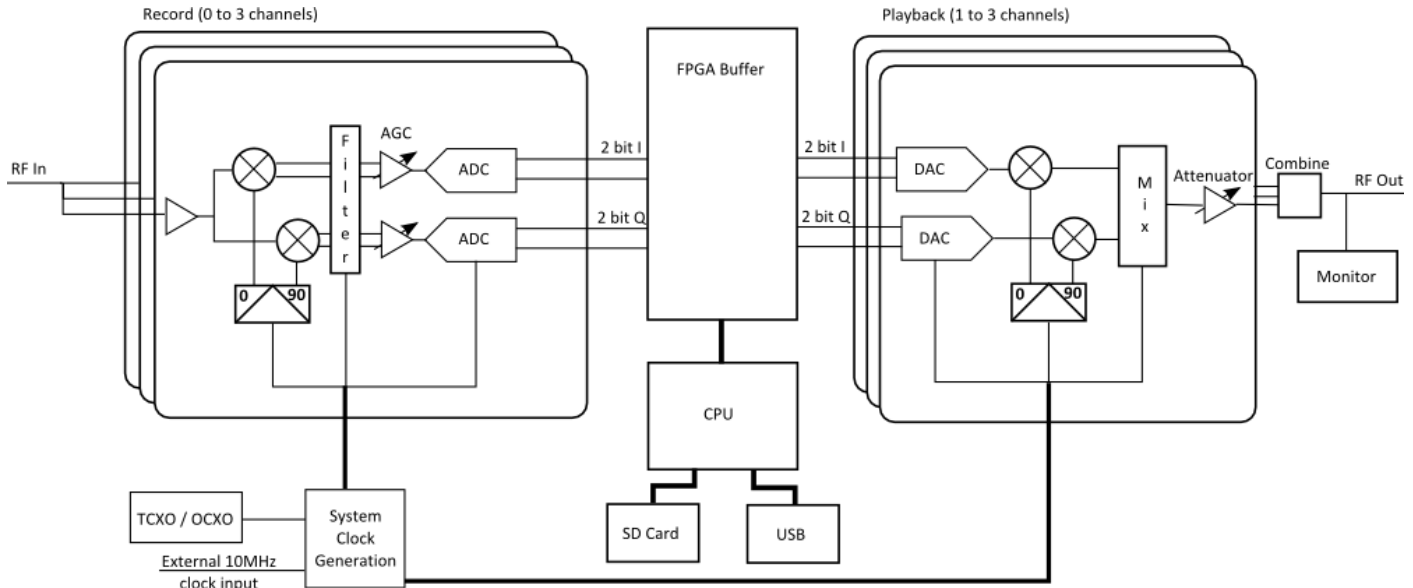Note: All units types can be factory upgraded to any other version.

4TECT

Телефон: +7 (499) 685-4444
info@4test.ru
www.4test.ru

Theory of operation

System overview

The **LabSat** 3 contains a number of record and replay blocks and a high accuracy clock generator all controlled by a CPU and FPGA.

Clock generation

In order to ensure synchronisation all critical system clocks are generated from a single low noise clock synthesiser. This system takes its reference input from either the internal TCXO or optional OCXO or the external clock input port and generates all of the required clock frequencies within the **LabSat 3.**

Record

Record and replay versions of the **LabSat 3** feature between 1 and 3 record blocks depending upon the unit type. Each of these blocks is identical and the RF input is split between all of the record blocks within a unit.
Each record block features the following stages:

> An LNA (Low Noise Amplifier) with a gain of 13dB.
> A local oscillator that generates the required signal centre frequency.
> A quadrature mixer that converts the RF input into baseband I and Q signals.

Each of the I and Q signals are then passed through:

> A low pass baseband filter.
> An automatic gain control (AGC) with a dynamic range of 59dB operating over a period of 512 samples.
> A 2-bit ADC with a sample rate of 16.368 MHz.

The resulting I and Q samples are buffered within an FPGA before being passed to the system CPU for storage on either and SD card or USB device.
The centre frequency for each record channel can be set independently allowing any channel to capture GPS, GLONASS or Beidou.

Replay

All versions of the **LabSat 3** feature between 1 and 3 replay blocks depending upon the unit type. Each playback block is identical.
During playback I and Q data is read from the storage media and buffered into the FGPA. The FPGA then passes these samples to the playback blocks at the required rate.

Each playback block features the following stages:

Twin DACs running at 16.368MHz which convert the I and Q data into analogue signals.

A local oscillator that generates the required signal centre frequency.

A quadrature modulator that combines the I and Q signals into a single signal at the required frequency.

A variable attenuator giving between 0 and 31dB of attenuation.

The outputs from each of the playback stages are then combined, filtered and further attenuated to bring the signal levels to the high end of the range normally expected for GNSS signals.

Finally the resulting signal is split between the RF Out port on the LabSat 3 and an internal GNSS receiver used for monitoring the signals.

As with the record stage the centre frequency for each channel can be set independently allowing flexibility between GPS, GLONASS and Beidou.

Thanks to each channel having an independently adjustable variable attenuator it is possible to vary the relative signal levels of different constellations within a recording as required.

Usage considerations

Recording

As with any electronic equipment the LabSat 3 outputs a small amount of unintentional RF energy. Due to the weak nature of GNSS signals it is recommended that any electrical equipment including the LabSat 3 should be placed as far away from any GNSS antennas as possible and kept below the level of the antennas ground plane.

In addition to the normal signal integrity precautions noted above special care should be taken when using the LabSat3s internal GNSS monitor. As can been seen from the above block diagram in order for the internal GNSS monitor to operate the RF output path must be active. Due to the low signal levels involved in GNSS it is possible for a small but noticeable amount of RF energy to leak from the RF output port while recording if the internal GNSS monitor is active or power save has been disabled. In these circumstances if the unit is placed in close proximity to a GNSS antenna this RF leakage can degrade the GNSS signal quality seen by the antenna. If the monitor must be used while in proximity to a GNSS antenna it is recommended that a 50 ohm terminator be placed on the RF Out port.

Signal levels

As shown above the record path includes an AGC stage. Due to the wide range of possible input signal levels this is required to maintain the incoming signals at a level suitable for digitisation. This process has no impact on the SNR levels of the recorded signals since both the GNSS signal and the noise are amplified equally. However due to this normalisation of the input signal the RF signal strength of the output will be constant for a set attenuation level and will not accurately reflect the absolute signal level recorded.

Signal SNRs

Ideally the SNR of a recorded and replayed GNSS signal will be the same as was seen when observing the live signal since both the signal and the in-band noise are recorded and replayed. Unfortunately due to the quantising nature of record and replay systems there will inevitably be a slight drop in observed signal strengths. This is typically in the region of 0.35dB for a 2 bit recording and 0.8dB for a 1 bit recording but will vary depending on both the receiver used and the signal conditions.

SBAS systems such as WAAS or EGNOS operate at the same centre frequency as GPS and so are automatically recorded as part of any GPS recording. However due to the higher data rate and lower signal power of these signals a slightly larger decrease in SNR may be observed, this is typically 0.4dB for a 2 bit recording and 1dB for a 1 bit recording.

LabSat3

Technical Specifications

		LabSat 3 Single constellation	LabSat 3 Dual constellation	LabSat 3 Triple constellation
Simultaneous RF Constellations		1	2	3
Constellations		GPS, Galileo, SBAS & QZSS / GLONASS / Beidou		
RF Constellation Centre Frequency (MHz)		1575.4/1602.00/1561.098		
Record				
Number of Satellites		All in view		
Sampling frequency		16.368 MHz		
Bandwidth		9.66 MHz per constellation		
Quantisation modes per channel	**Single constellation mode**	1 bit I&Q 2 bit I&Q	1 bit I&Q 2 bit I&Q	1 bit I&Q 2 bit I&Q
	Multiple constellation mode	N/A	1 bit I&Q	1 bit I&Q
Data Format		I & Q		
Input noise figure		2.7 dB		
Minimum Input gain		44 dB		
Input AGC dynamic range		59 dB		
Active Antenna Voltage Supply		2.8 – 3.3 volt		
Replay				
Output DAC SNR		40 dB		
Output I & Q crosstalk		95 dB		
Output LO phase noise		-93 dBc/Hz @ 10kHz		
Output LO feedthrough		> 40dB below signal level		
Output quadrature phase error		1 degree RMS		
Output mixer sidebands		> 30dB below signal level		
Output Signal Level		-73dBm/MHz to -103dBm/MHz in 1dB steps		
System				
GNSS system SNR loss*		0.35 dB 2-bit mode 0.8 dB 1-bit mode		
Reference oscillator accuracy	**TCXO**	+/- 2.5 ppm		
	OCXO	+/- 0.3 ppm		
Reference oscillator aging	**TCXO**	+/-1 ppm / year		
	OCXO	+/- 0.3 ppm / year		
Reference oscillator stability	**TCXO**	+/- 0.05 ppm / °C		
	OCXO	+/- 0.05 ppm / °C		

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		LabSat 3 **Single constellation**	LabSat 3 **Dual constellation**	LabSat 3 **Triple constellation**
Reference oscillator phase noise	TCXO	-130 dBc/Hz @1kHz		
	OCXO	-145 dBc/Hz @1kHz		
External reference input		10MHz 50Ω 0.5V to 3V p-p		
User Control		6 Button Membrane Keypad		
Display		Backlit LCD Dotmatrix		
Additional Logging		1 channel CAN, RS232 or Digital (firmware upgrade)	2 channels of CAN, RS232 or Digital	
Removable Battery Pack		Li_Polymer 2260mAh		
Media Storage Included		32 GB SD Card & 1TB USB HDD		
SD Card Media		Class 10 max size 512GB (FAT32)		
Operating Voltage		8V to 30VDC		
Size		167mm x 128mm x 43mm		
Weight		960g with battery (910g without battery)		
Operating Temperature		-20°C to +60°C Note: Battery will not charge below 0°C or above +45°C (charger shuts down outside this range). Unit will shut down outside operating temperature range.		
Storage Temperature		−20°C to +60°C Note: Battery will discharge whilst in storage and discharge rate will increase at higher storage temperatures.		

* Average decrease in C/N0 signal strength measured by GNSS receiver for a replayed signal relative to the same signal measured live when using a high quality GNSS antenna with good signal strength. Performance may vary depending upon signal levels and GNSS receiver used.

Expansion port 36 way MDR type connector

Rear View of Labsat
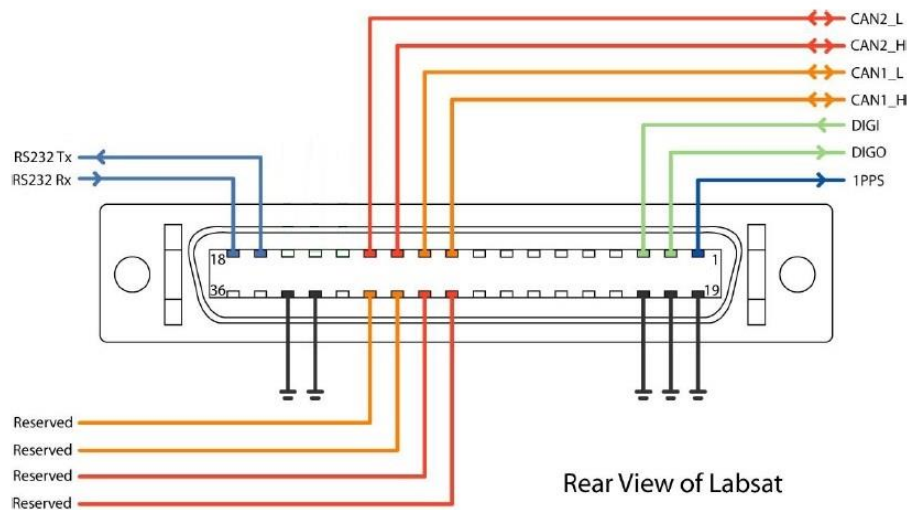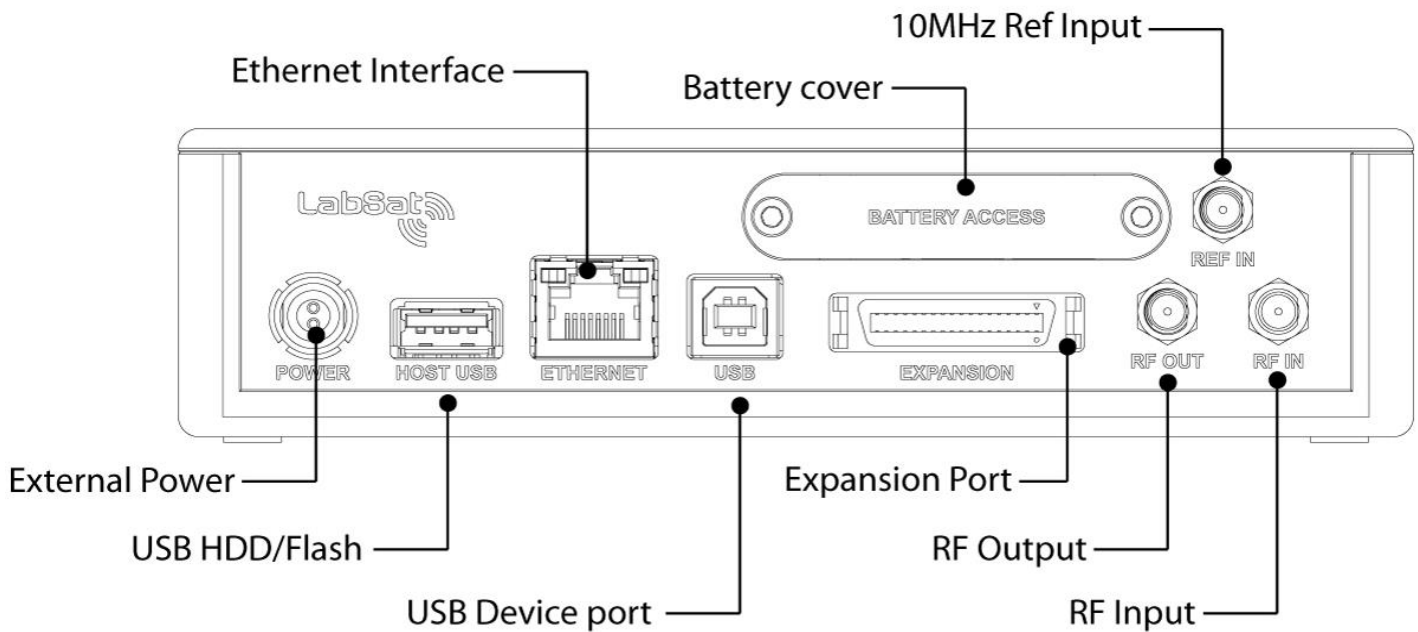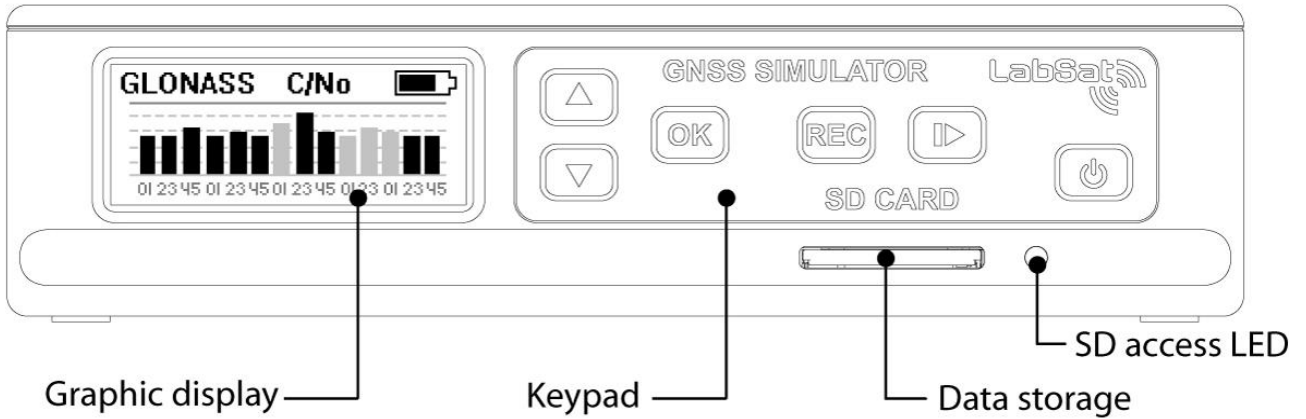
Connections

Name	Connection	Description
Power	2 pin LEMO	8 to 30VDC Power Supply input
HOST USB	USB	For connection of USB Storage devices
ETHERNET	RJ45	Remote access and control (Contact local distributor for details)
USB	USB	NMEA Output. (Requires PC drivers, see LabSat website)
RF Out	SMA	Output for RF signal replay for connection to receiver under test
RF IN	SMA	RF signal input from antenna (Record & Replay models only)
REF IN	SMA	10 MHz Reference Clock Input
Expansion	36 Way MDR	1-PPS, NMEA, Digital I/O*, CAN Bus*, RS232 *

*Model dependent – available as options

LabSat3

DESCRIPTION	Part Number
LabSat 3 **SINGLE CONSTELLATION REPLAY ONLY MODEL**	**RLLS03-1P**
LabSat 3 **DUAL CONSTELLATION REPLAY ONLY MODEL***	**RLLS03-2P**
LabSat 3 **TRIPLE CONSTELLATION REPLAY ONLY MODEL***	**RLLS03-3P**
EACH SYSTEM INCLUDES:	**-**
LABSAT 3 UNIT	**-**
COUNTRY SPECIFIC MAINS CHARGER	**RLVBACS020**
32GB SDHC CARD	**LS03SDCARD**
SMA-SMA CABLE – RG174 - 1M	**RLCAB071-1**
SMA PLUG TO MCX PLUG CABLE – 1M	**RLCAB082-1**
SMA PLUG TO MMCX PLUG CABLE – 1M	**RLCAB083-1**
SMA PLUG TO TNC PLUG CABLE – 1M	**RLCAB084-1**
1 TB SCENARIO HARD DISK DRIVE	**LS03HDD-1TB**
BATTERY (All VERSIONS)	**RLACS201**
* INCLUDES: DUAL CAN REPLAY, RS232 REPLAY, DIO REPLAY FIRMWARE	

LABSAT 3 **SINGLE CONSTELLATION FIRMWARE UPGRADES**	
FIRMWARE UPGRADE TO CAN BUS	**RLLSUP3-05**
FIRMWARE UPGRADE TO RS232	**RLLSUP3-06**
FIRMWARE UPGRADE TO DIGITAL I/O	**RLLSUP3-O7**

LabSat 3 **SINGLE CONSTELLATION RECORD AND REPLAY MODEL**	**RLLS03-1RP**
LabSat 3 **DUAL CONSTELLATION RECORD AND REPLAY MODEL***	**RLLS03-2RP**
LabSat 3 **TRIPLE CONSTELLATION RECORD AND REPLAY MODEL***	**RLLS03-3RP**
Same as RLLS03-1P, RLLS03-2P, RLLS03 -3P plus:	
BLUE LABSAT CARRY CASE	**RLACS197**
LEMO 2 WAY TO 12V CIGAR LIGHTER POWER LEAD – 2M	**RLCAB010L**
FOUR CONSTELLATION MAGNETIC MOUNT ANTENNA	**RLACS198**
EXPANSION CONNECTOR ADAPTOR	**RLACS202**
*INCLUDES: DUAL CAN RECORD & REPLAY, RS232 RECORD & REPLAY, DIO RECORD & REPLAY	

LabSat 3 **OVEN CONTROLLED OSCILLATOR OPTION (OCXO)**	
LabSat 3 OVEN CONTROLLED OSCILLATOR OPTION (OCXO) SINGLE & DUAL CONSTELLATION	**RLLSUP04**
LabSat 3 OVEN CONTROLLED OSCILLATOR OPTION (OCXO) TRIPLE CONSTELLATION	**RLLSUP03**

LabSat 3 **ACCESSORIES**	
SDHC EXTREME MEMORY CARD - 32GB	**LS03SDCARD**
SDHC EXTREME MEMORY CARD - 64GB	**RLACS210**
SDHC EXTREME MEMORY CARD - 128GB	**RLACS211**
ACTIVE GPS ANTENNA	**RLACS205**
PASSIVE GPS/GLONASS ANTENNA	**RLACS206**
USB 3.0 DUAL SLOT READER	**RLACS163**
1TB SCENARIO HARD DRIVE (HDD)	**LS03HDD-1TB**
BATTERY	**RLACS201**
BATTERY CHARGER	**RLACS200**
EXPANSION CONNECTOR ADAPTOR	**RLACS202**

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