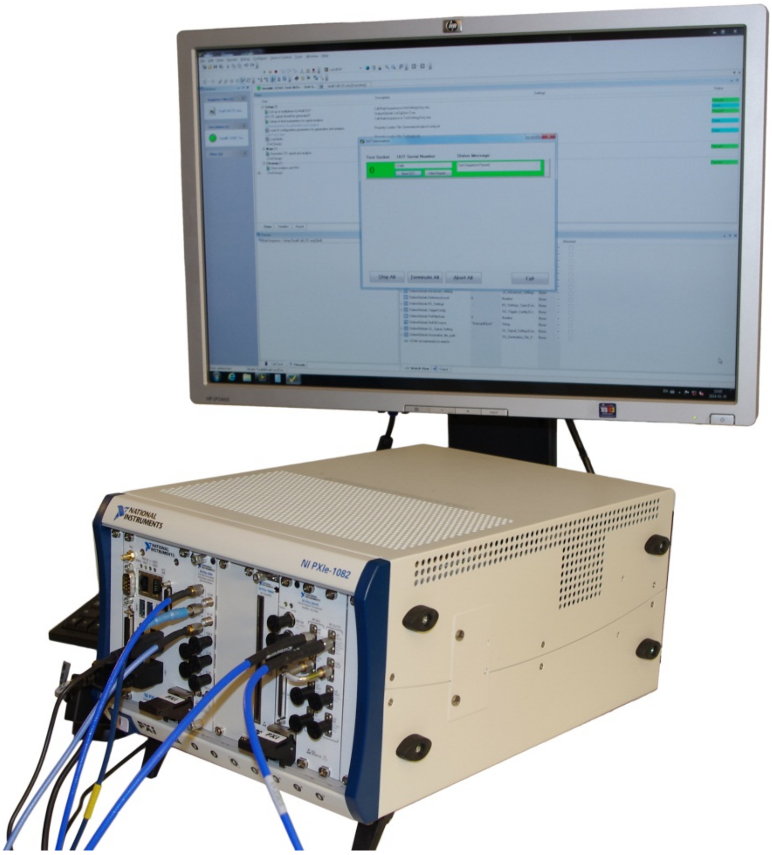
GTT LTE RBS Toolkit

User Guide



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1 Introduction

The GTT LTE RBS Toolkit is a software-suite for anyone looking for the most efficient usage of National Instruments RF-test hardware for testing RBS related products. GTT has created a versatile product suite that will help the users with everything from early verification to full scale production testing. It gives You as a customer the starting point you need for your test setup. GTT can of course assist you with optimization for your specific application.
The GTT LTE RBS Toolkit is built around a NI PXIe chassis and NI LabVIEW. It consists of NI LabVIEW toolkits for generating and analysing LTE UL/DL signals. It also supports NI RFSA and RFSG.

Add-ons are also available for even more functionality.

1.1 GTT LTE RBS Toolkit

The GTT LTE RBS Toolkit supports both generation and analysis of LTE signals. Besides the capability of analysing the downlink signal and generating uplink fixed reference signals according to FRC A1-3 (both fully filled and with 25 RBs) for receiver testing, the toolkit also comes with signal generation of downlink according E-UTRA test model (E-TM) 1.1, 1.2, 2, 3.1, 3.2, 3.3 for calibration and/or verification of the setup without a UUT..
The following measurements are supported by the toolkit:

- Base station Output Power
- Transmit ON/OFF power (PvT, only applied for E-UTRA TDD BS)
- Frequency Error (Average Carrier Frequency Offset)
- Error Vector Magnitude (EVM)
- Occupied Bandwidth (OBW)
- Adjacent Channel Leakage Power Ratio (ACLR)
- Operating band unwanted emissions
- RS TX Power
- CCDF (PAR, 0.1%, 0.01%, 0.001%)

A more detailed description of the measurements is to be found in ref [1]. For supported 3GPP revisions, see appendix A.

1.2 Add-ons

For additional functionality there are Add-ons available. All add-ons require a separate license in addition to the GTT LTE RBS Toolkit to run. For further details on the add-ons se below.

1.2.1 GTT LTE BER-BLER Add-on

The GTT LTE DL BER-BLER Add-on by Gefle Testteknik AB features demodulation of LTE signals to enable verification of RBS transmitter system performance using analysis of throughput in form of BER (Bit Error Rate) and BLER (Block Error rate).

The included soft front panels enable easy lab measurements and the high-level APIs makes custom sequences or fully customized soft front panels easy to make.

Out of the box the Add-on is capable of demodulation in the host computer and if processing power is an issue it has built in support for Xilinx IP turbo decoder to offload the computer processor by letting an FPGA do the number crunching. This option requires a separate license from Xilinx. If you wish to enable this option please contact sales@testteknik.se for further information.

For details on this add on refer to the user manual for GTT LTE DL BER-BLER Add-on Ref [4].

1.2.2 LTE DL Inband-IoT Add-on

The GTT LTE DL Inband-IoT Add-on by Gefle Testteknik AB enables demodulation of LTE NB IoT inband signal for GTT LTE RBS Toolkit and decoding of LTE NB IoT inband signal for GTT LTE DL BER/BLER Add-on. This is an add-on extending the capabilities of the GTT LTE RBS Toolkit and GTT LTE DL BER/BLER Add-on even further.

For details on this add on refer to the user manual for GTT DL Inband-IoT BER-BLER Add-on Ref [5].

1.2.3 LTE RRU Add-on

The GTT LTE RRU Add-on by Gefle Testteknik AB adds support for CPRI based Radio Remote Units (RRU, or RRH) to the GTT LTE RBS Toolkit. The complete solution features all common transmitter measurements according to 3GPP by sending down link data to the RRU over CPRI and analysing transmitted RF using the GTT LTE RBS Toolkit. It also features receiver measurements by sending up link RF to the RRU and through the CPRI interface capture the received data and perform demodulation and BER/BLER measurements.

The included soft front panels enable easy lab measurements and the high-level APIs makes custom sequences or fully customized soft front panels easy to make. This add-on extends the full capabilities of the GTT LTE RBS Toolkit to the RRU product family.

The system is built on the LabVIEW 2014 platform.

For details on this add on refer to the user manual for GTT LTE RRU Add-on Ref [6].

2 System Requirements

See http://testteknik.se/content/product for a list of software and hardware requirements for the different products.

3 Installation and Configuration

Start LabVIEW and VIPM with administrator rights and start the installation of the "LTE RBS" using VIPM 2017 or newer.

NOTE: Installing without administrator rights is the most common reason failure to install correctly.

The installed SFPs are by default located at:

32-bit Windows: C:\Program Files\Gefle Testteknik\LTE RBS
64-bit Windows: C:\Program Files (x86)\Gefle Testteknik\LTE RBS

The installed APIs are by default located at:

…\National Instruments\[LabVIEWInstallDir]\vi.lib\GefleTestteknik\LTERBS\...

4 Evaluation/Activation

The distributed executables and the GTT LabVIEW libraries (*.lvlib) are licensed and have an evaluation period of 30 days and must then be activated for continued use. The license is locked to the computer that is used during installation.

We recommend using GTT licensing toolkit for activation of licenses. The built-in activation tool in Labview may also be used.

To transfer a license, it must first be deactivated on the system where it is currently active before activation on the new system. When restoring the computer from a backup image deactivation must be performed before deleting the old system.

A product can be manually activated (i.e. offline) by sending an email to support@testteknik.se in the following format. NOTE that manually activated licenses cannot be deactivated or transferred:

Company Name:
User Name:
Executable User Code 1:
Executable User Code 2:
LabVIEW Library User Code 1:
LabVIEW Library User Code 2:

For further information refer to the preferred tool for activation.

See more information below.

The evaluation/activation process is different depending on which product and version that is used.

4.1 Evaluation/Activation for GTT LTE RBS using Third Party Add-Ons dialog

Selection of Activation/Evaluation mode of the LabVIEW libraries and the executable is done from a "`Third Party Add-ons`" dialog box inside LabVIEW. This one is shown automatically when LabVIEW is started and can also be reached from following menu inside LabVIEW: Help -> Activate Add-ons.

4.1.1 Evaluation

If Evaluation mode is wanted, no particular action is necessary. Simply click "`Continue to LabVIEW`".

4.1.2 Online activation

Open the "`Third Party Add-ons`" dialog box inside LabVIEW and select "`Activate Add-ons`". In the next dialog box, select the GTT toolkit you wish to activate and press "`Next`". In the next Dialog box, select "`Automatically activate through an Internet connection`" and press "`Next`". In the next dialog box enter the LicenseID and password you got when you bought the product and press "`Activate`".

4.1.3 Offline activation

Open the "`Third Party Add-ons`" dialog box inside LabVIEW and select "`Activate Add-ons`". In the next dialog box, select the GTT toolkit you wish to activate and press "`Next`". In the next Dialog box, select "`Use a Web browser on this or another computer to acquire an activation code`" and press "`Next`". In the next dialog box, send these two "*LabVIEW User Codes*" to support@testteknik.se, using the mail template above. GTT will send back two activation codes. Copy these two into the Activation Code 1 and 2 and press "`Activate`".

Activation Code 1 and 2 and press "`Activate`".

5 Using GTT LTE RBS Toolkit

5.1 Soft Front Panel Settings

The LTE soft front panel is started from **Windows Start -> Program -> Gefle Testteknik -> LTE RBS -> LTERBS**.

The SFP window appears:

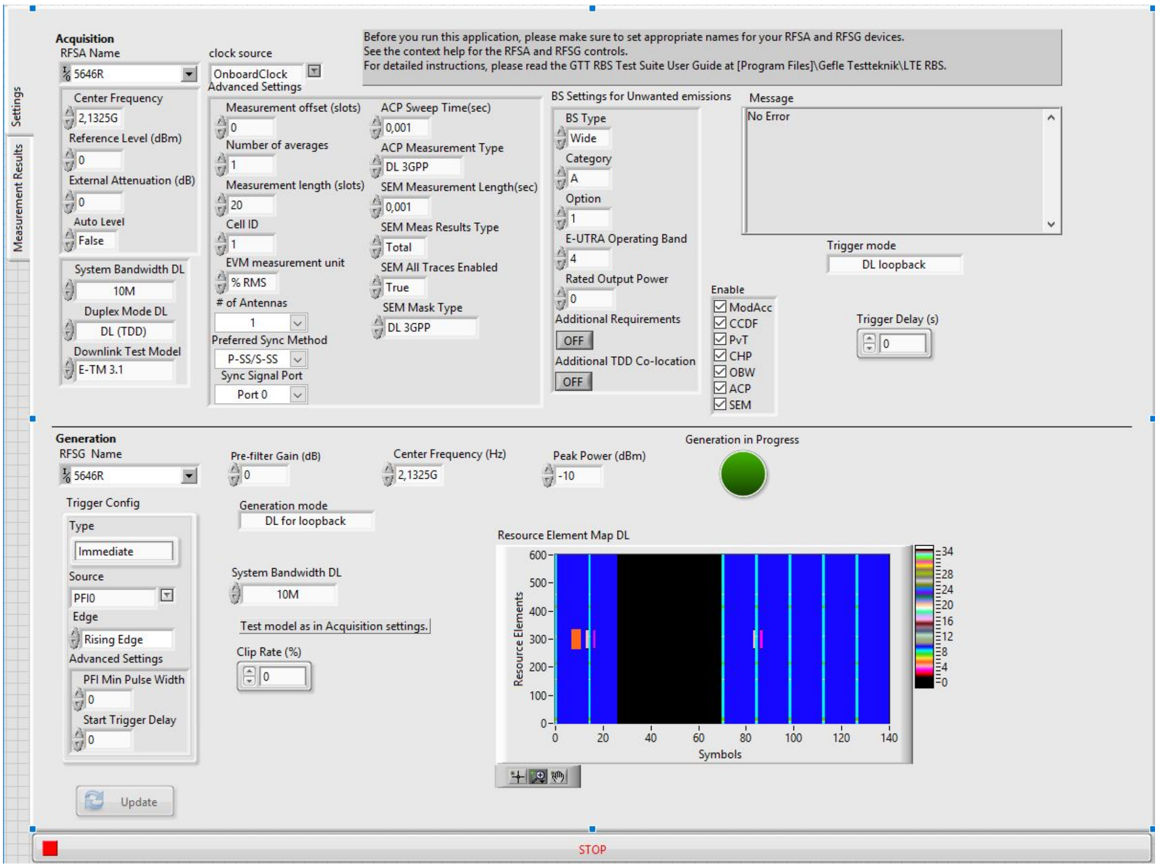
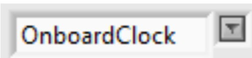


Figure-1: Settings Tab

5.1.1 Acquisition section

RFSA name: Analysis device, VST in this case.



Clock source: Reference clock source to the VST on board PLL (Phase Lock Loop)
On board clock – Selects internal 10 MHz clock

Ref In – Selects reference clock in front.

PXI Clock 10 – Selects 10 MHz clock from the PCI Express backplane.
ClkIn – This configuration does not apply to the NI 5644R/5645R (See NI documentation for more information).

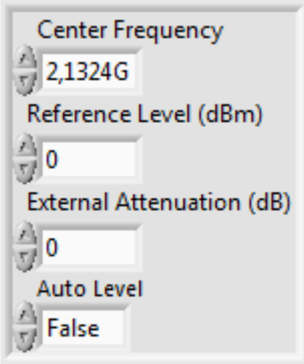


Figure 5-2: RFSA Settings

RFSA settings:

Center Frequency: Center frequency of the LTE signal.

Reference Level: LTE signal reference level

External Attenuation, dB: Attenuation in the signal path that must be taken in notice.

Auto Level: If true, the system sets the best reference level based on the peak power of the measured signal. If false, the value in the Reference Level settings is used.

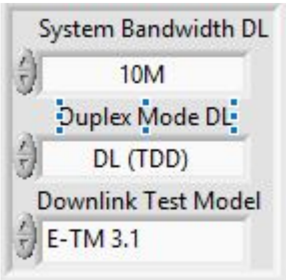


Figure 3: LTE Signal Settings

LTE signal settings:

System Bandwidth DL: Selects the bandwidth of the LTE signal.

Duplex Mode DL: Selects if the Down Link (DL) signal to be analysed is FDD or TDD mode.

Downlink Test Model: Selects the test model of the DL signal to be analysed.

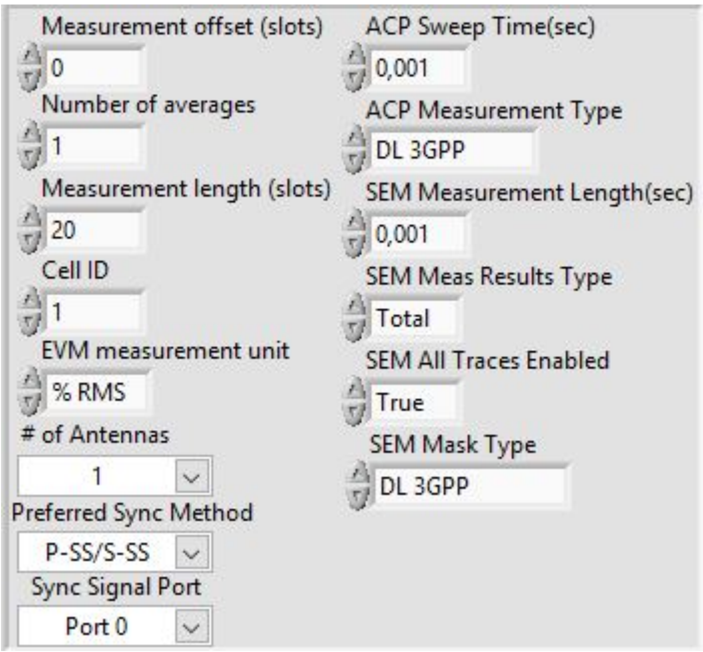


Figure 4: Advanced Settings

Advanced Settings:

Measurements offset (slots): Set on which slot the analysis of the signal shell start.

Number of averages: Set the number of averages that should be analysed.

Measurement length (slots): Set how many slots the analysis should be performed at.

Cell ID: Sets the Cell ID of the signal.

EVM measurement unit: Selects if the result should be presented in % or dB.

# of Antennas: Specifies the number of antennas used for the transmission/reception of the LTE signal.

Preferred Sync Method: Specifies the antenna ports on which the P-SS and the S-SS are transmitted.

Sync Signal Port: Specifies the antenna ports on which the P-SS and the S-SS are transmitted.

ACP Sweep Time (sec): Sets the measurement length for ACP.

SEM Measurement Length (sec): Sets the measurement length for SEM.

SEM Meas Results Type: Specifies the type of the measurement results for the SEM measurement, Total Power Reference or Power Spectral Density Reference.

SEM All Traces Enabled: Specifies whether to enable all the traces SEM measurement.

SEM Mask Type: Selects SEM mask to use in analysis. The definition of offsets and limits. Can be according to 3GPP or custom:

General: Defined in Table 6.6.2.1.3-1 in section 6.6.2 of the 3GPP TS 36.521-1 v8.6.0 specifications.

NS_03: Defined in Table 6.6.2.2.3.1-1 in section 6.6.2 of the 3GPP TS 36.521-1 v8.6.0 specifications.

NS_04: Defined in Table 6.6.2.2.3.2-1 in section 6.6.2 of the 3GPP TS 36.521-1 v8.6.0 specifications.

NS_06 OR NS_07: Defined in Table 6.6.2.2.3.3-1 in section 6.6.2 of the 3GPP TS 36.521-1 v8.6.0 specifications.

Custom: Specifies that the toolkit uses the offset frequencies that you specify in the Offset Band properties and the mask limits that you specify in the Measurement Limits properties for the SEM. Set with gttLTE - DL - SA - SetCustomSemParams.vi

DL3GPP: (Default) Defined in 3GPP TS 36.141 V11.3.0 Subclause 6.6.2

DL 3GPP (5) Specifies that the toolkit selects the offset frequencies and limits for the SEM as defined in 3GPP TS 36.141 V11.3.0 Subclause 6.6.2

.

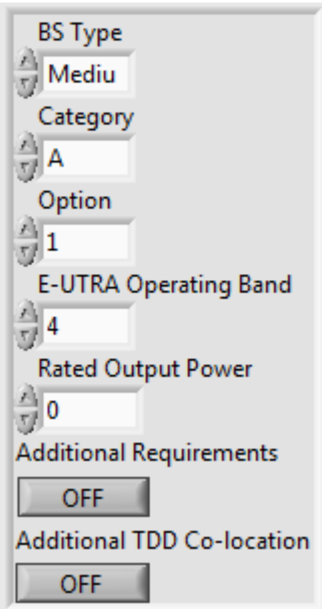


Figure 5: BS Settings for Unwanted emissions

BS Settings for Unwanted emissions: Settings for the SEM measurement see ref [1] for details of what settings is suitable for the UUT.

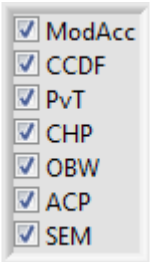
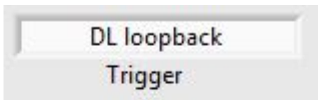


Figure 5-6: Enable

Enable: Enable which measurements to perform.

Message: Displays all errors and warnings.



Trigger: Trigger modes for analysis; None, Digital Edge, IQ Power Edge and DL loopback (Trigger generated internally in software, also for repeater) available.

Trigger Delay (s): Specifies the time to wait after start of generation before starting acquisition for downlink loopback.

5.1.2 Generation section

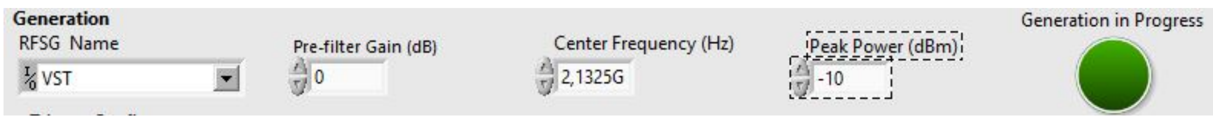


Figure 7: General generation settings

RFSG Name: Generation device, VST (PXIe-5644/5645R) is required for generation.

Pre-filter Gain (dB): Specifies the AWG pre-filter gain.

Center Frequency (Hz): Center frequency of the LTE signal.

Peak Power (dBm): Sets the signal output level. The actual signal level is the

Generation in Progress: Lights up when the toolkit is generating RF-signal on the VST.

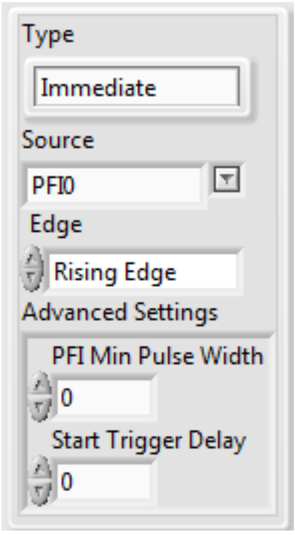


Figure-8: Trigger Config

Trigger Config:

Type: **Immediate** – No start trigger is configured

Start Trigger – Enables trigger functionality.

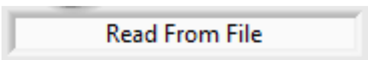
Restart Trigger – This will restart the capturing of the trigger and signal generation. Note: Start Trigger Delay must be set to at least 10 us.

Source: Trigger input select. PFI0-2 is valid for PXI-5644/5645R. PF0 is located at the front of the VST, PF1 and PF2 on digital IO connector.

Edge: Rising edge/Falling edge, selects on which edge the trigger shall be detected.

PFI Min Pulse Width: Specifies the minimal pulse width in seconds for the PFI lines.

Start Trigger Delay: A configurable trigger delay up to 35 seconds before the generation starts.



Generation mode: Selects how to generate the signal. Each selection displays relevant settings for the selected mode. The modes are:

Read from File: Select to read IQ data from a file.

UL Generate: Build the uplink signal to generate. Available for Sync test. BER/BLER measurements not supported.

DL For Loopback: Generates a DL signal for analysis. Available for repeater testing or testing the whole system, using a loop cable between RF out and RF in.

5.1.2.1 Generation mode - Read From File settings

Figure-9: File Settings

Path: Select the IQ file to be used.

Sample rate file: Set the sample rate for the IQ data in the file (ex 15.36M).

File Type: Selects format of the File to read,
ASCII:, Reads a ASCII file with TAB-separated values with one I-Q pair per row. (Correctly formatted files are found in the examples folder).

BIN: Reads a binary file with 32 (2x16) bit little endian complex values.

TDMS: Reads a TDMS file with interleaved IQ format, i.e. first column with I and second with Q.

5.1.2.2 Generation Mode - UL Generate settings

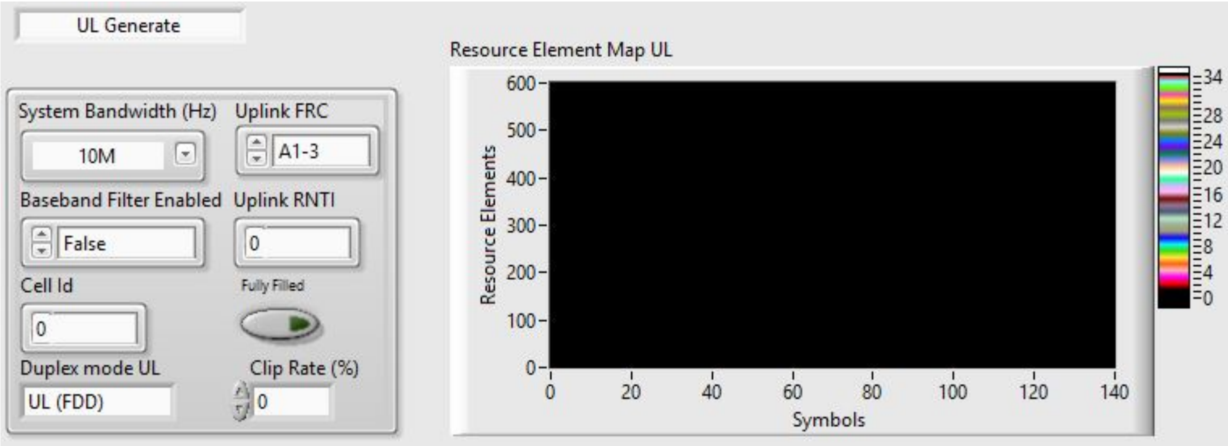


Figure-10: UL Generate Settings

System Bandwidth (Hz): Set the bandwith of the signal, 1.4MHz - 20MHz.

Basband Filter Enabled: Enable baseband filter.

Cell ID: Sets the Cell ID of the signal.

Duplex mode UL: Sets the duplex mode of the signal, FDD or TDD.

Uplink FRC: Select FRC model, A1-1 – A1-5.

Uplink RNTI: Set the RNTI of the signal.

Fully filled: Select if the FRC A1-3 should fully filled or have 25RBs.

Resource Element Map UL: Displays a resource element map of the generated LTE signal.

Clip Rate (%): Selects strength of clipping to apply. From 0% (No clipping) to 100% (Strong clipping).

5.1.2.3 DL for loopback settings

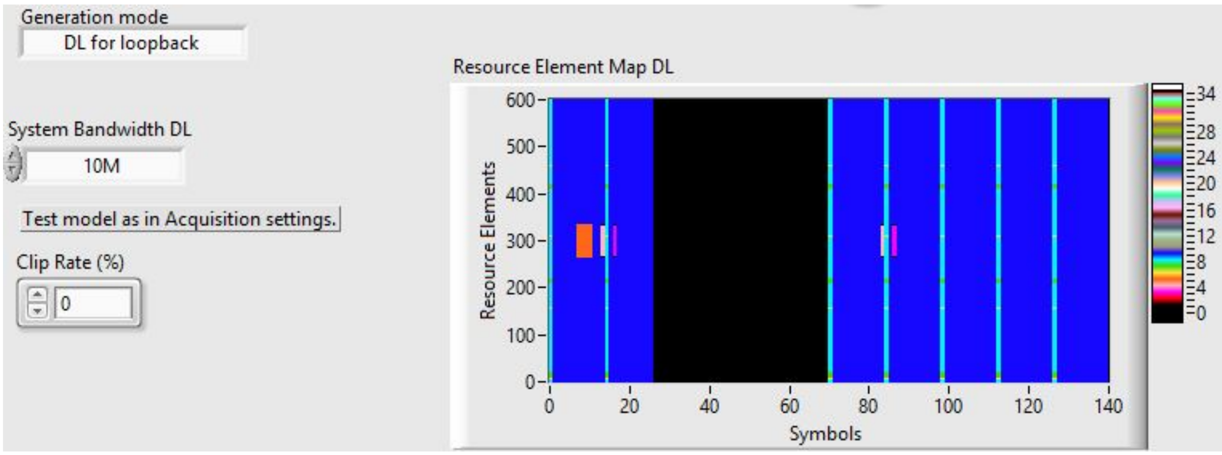


Figure-11: DL for loopback Settings

System Bandwidth (Hz): Set the bandwith of the signal, 1.4MHz - 20MHz.

Clip Rate (%):	Selects strength of clipping to apply. From 0% (No clipping) to 100% (Strong clipping).
Resource Element Map DL:	Displays a map of the resource elements for the generated LTE signal.

5.2 Soft Front Panel Measurement Results

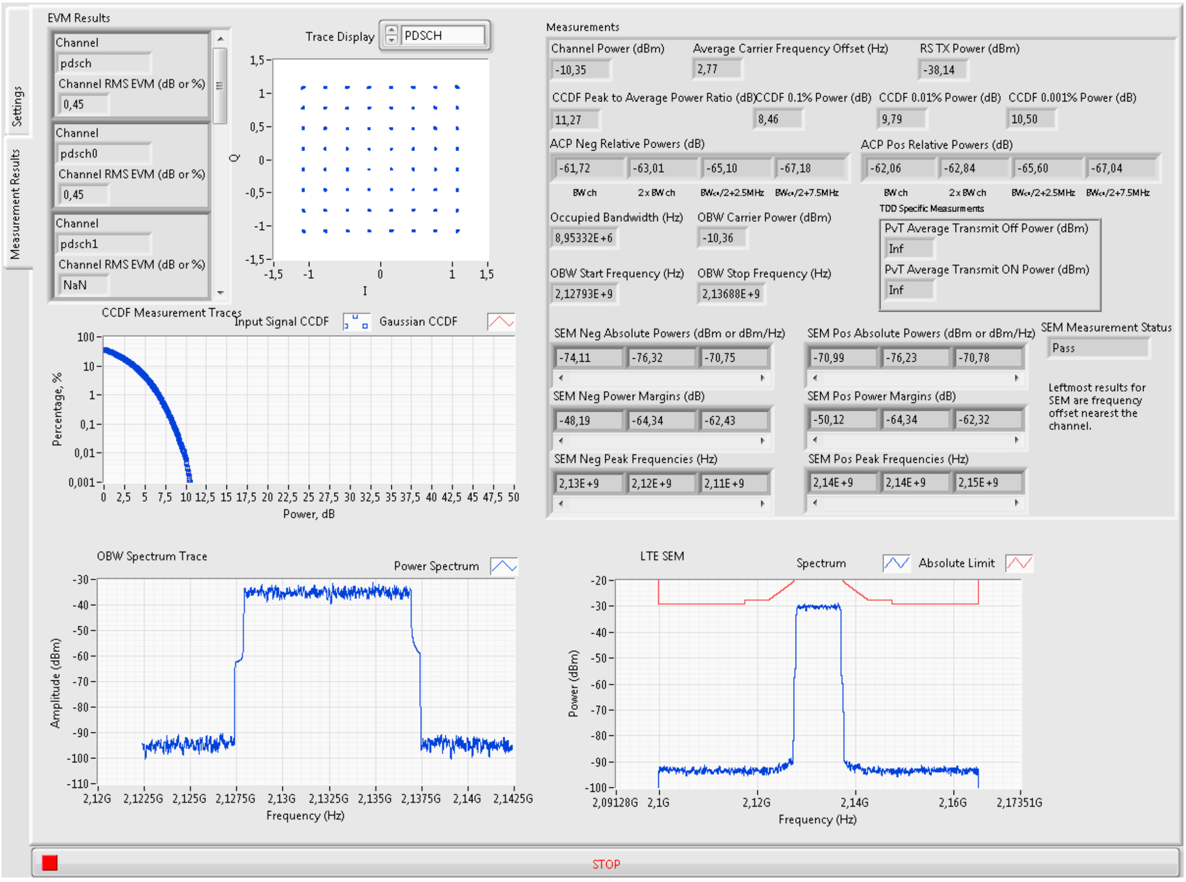


Figure 5-12: Measurement Results tab.

5.3 Measurement definitions according to 3GPP

5.3.1 Base station output power (Channel Power in SFP)

The test purpose is to verify the accuracy of the maximum output power across the frequency range and under normal and extreme conditions for all transmitters in the BS.

5.3.2 Frequency error (Average Carrier Frequency Offset in SFP)

Frequency error is the measuring of the difference between the actual BS transmit frequency and the assigned frequency. The same source shall be used for RF frequency and data clock generation.

5.3.3 EVM (Error Vector Magnitude)

The Error Vector Magnitude is a measure of the difference between the ideal symbols and the measured symbols after the equalization. This difference is called the error vector. The EVM result is defined as the square root of the ratio of the mean error vector power to the mean reference power expressed in percent.

5.3.4 DL RS power (RX TX Power in SFP)

DL RS power is the resource element power of Downlink Reference Symbol.

5.3.5 Occupied bandwidth (OBW Spectrum Trace in SFP)

The occupied bandwidth is the width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage $\beta/2$ of the total mean transmitted power.

The test purpose is to verify that the emission of the BS does not occupy an excessive bandwidth for the service to be provided and is, therefore, not likely to create interference to other users of the spectrum beyond undue limits.

5.3.6 Adjacent Channel Leakage power Ratio (ACP relative power in SFP)

Adjacent Channel Leakage power Ratio (ACLR) is the ratio of the filtered mean power centred on the assigned channel frequency to the filtered mean power centred on an adjacent channel frequency.

5.3.7 Operating band unwanted emissions (SEM measurements in SFP)

This test measures the emissions of the BS, close to the assigned channel bandwidth of the wanted signal, while the transmitter is in operation.

5.3.8 Complementary Cumulative Distribution Function (CCDF measurements in SFP)

This test measures the complementary cumulative distribution function (CCDF) of the RF signal, peak power and average power.

6 Contact Information

http://testteknik.se/

Support contact:

support@testteknik.se

Sales contact:

sales@testteknik.se

7 Abbreviations

ACLR	Adjacent Channel Leakage power Ratio
ACP	Adjacent Channel Power
API	Application Programming Interface

ARFCN	Absolute Radio Frequency Channel Number
AWG	Arbitrary Waveform Generator
BER	Bit Error Rate
BLER	BLock Error Rate
BS	Base Station
BTS	Base Transceiver Station
CCDF	Complementary Cumulative Distribution Function
CDP	Code Domain Power
CDR	Relative Code Domain Power
CHP	CHannel Power
DL	Down Link
DUT	Device Under Test
E-TM	E-UTRA Test Model
E-UTRA	Evolved UTRA
EVM	Error Vector Magnitude
FDD	Frequency Division Duplex
FRC	Fixed Reference Channels
IQ	in-phase and quadrature modulator
LTE	Long Term Evolution
NI	National Instruments Corporation
OBW	Occupied Bandwidth
P-SS	Primary Sync Signal
PAR	Peak to Average Ratio
PLL	Phase Lock Loop
PVT	Power Verses Time
RB	Resource Block
RBS	Radio Base Station
RF	Radio Frequency
RFSA	RF Signal Analyser
RFSG	RF Signal Generator
RNTI	Radio Network Temporary Identifier
S-SS	Secondary Sync Signal
SCH	Synchronisation CHannel
SEM	Spectrum Emission Mask
SFP	Soft Front Panel
TAE	Time Alignment Error
TDD	Time Division Duplex

TDMS	Technical Data Management Streaming
TM	Test Models
TRX	Transceiver
UE	User Equipment
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
UTRA	UMTS Terrestrial Radio Access
UUT	Unit Under Test
VI	National Instruments Virtual Instrument
VST	Vector Signal Transceiver

8 References

[1] 3GPP TS 36.141 (LTE)

[2] MIL-STD-1235C (Single and Multi-Level Continuous Sampling Procedures and Tables for Inspection by Attributes)

[3] Implementing Six Sigma: Smarter Solutions Using Statistical Methods, 2nd Edition (Forrest W. Breyfogle III)

[4] LTE DL BER/BLER Add on – User Guide 522A1-SW03004-3

[5] LTE DL Inband-IoT Add on – User Guide 522A1-SW03006-1

[6] LTE RRU Add on – User Guide 522A1-SP04002-1

[7] 3GPP TS 36.521-1

Appendix A - 3GPP versions for LTE measurements

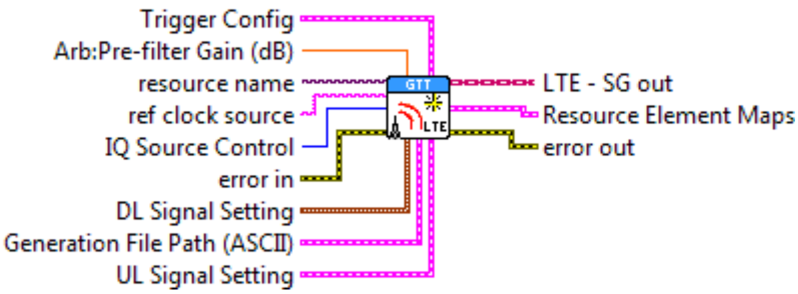
List of the versions of the 3GPP standard [1] used for each LTE measurement.

GTT LTE RBS Toolkit revision	Base Station Output Power	Transmit ON/OFF Power	Frequency Error	OBW	ACLR	SEM	RS TX Power	CCDF
1.0.1	11.3.0	11.3.0	11.3.0	11.3.0	11.3.0	11.3.0	11.3.0	11.3.0

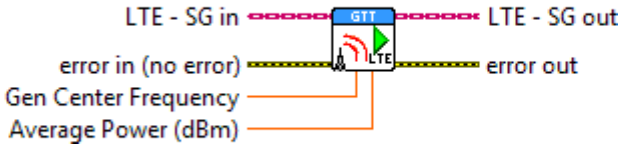
Appendix B

VIs used for the SFP's.

Generation



gttLTE - SG - VST - Initialize.vi



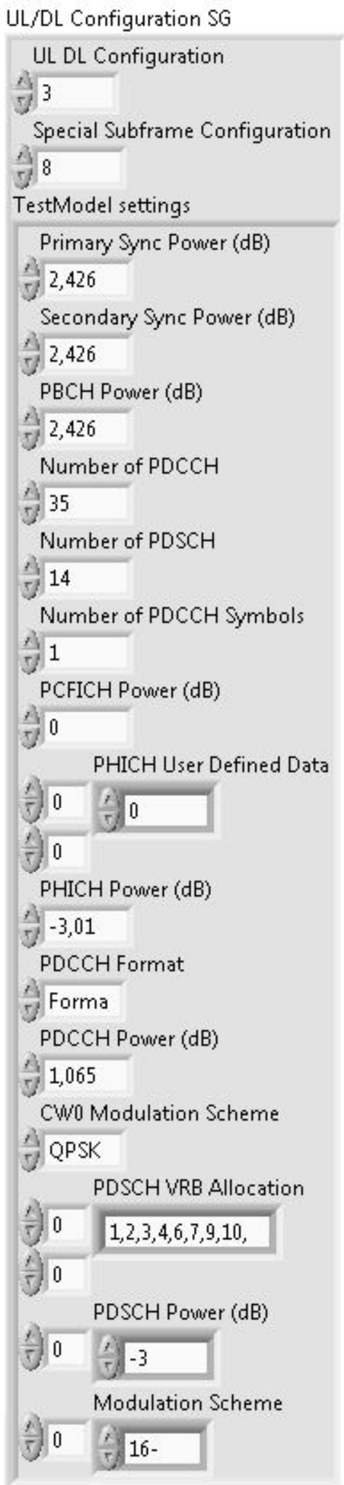
gttLTE - SG.lvclass:gttLTE - SG - Generate.vi

gttLTE - SG.lvclass:gttLTE - SG -Error Check.vi

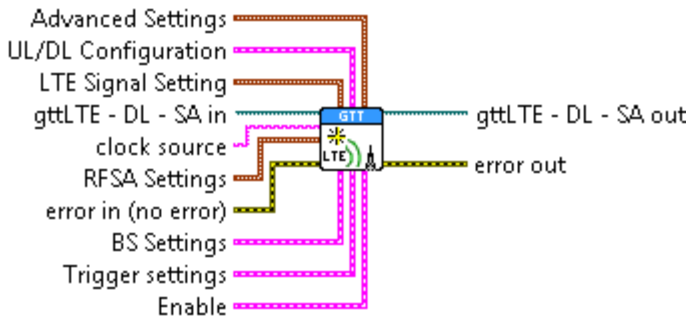
gttLTE - SG.lvclass:gttLTE - SG -Error Check.vi

Generation-Utilities

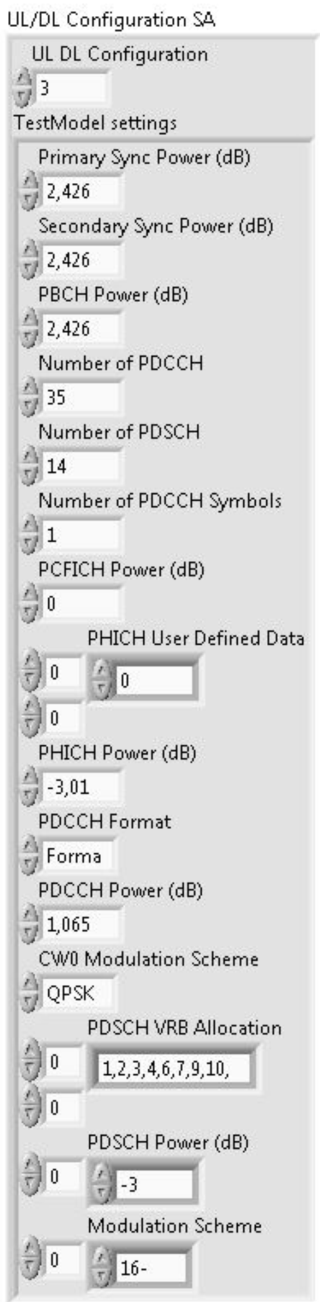
gttLTE - SG - SetULDLConfiguration.vi

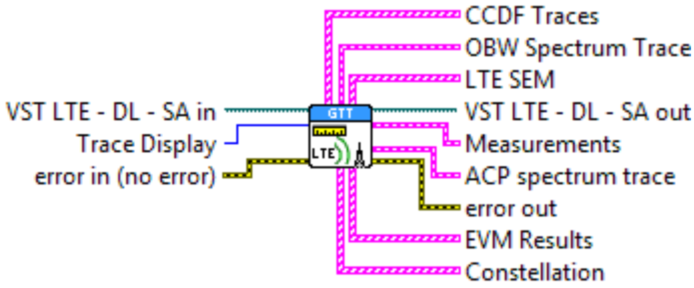


Analysis

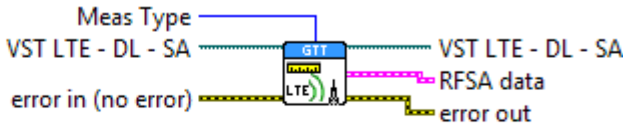


gttLTE - DL - SA - Initialize .vi

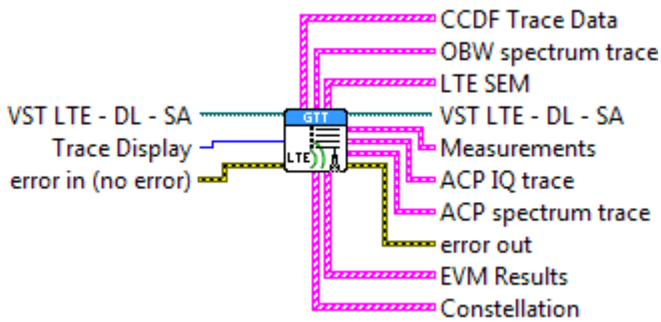




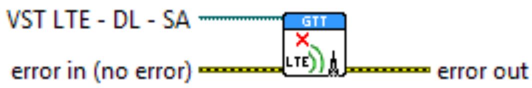
gttLTE - DL - SA - Analyze.vi



gttLTE - DL - SA - Measure .vi

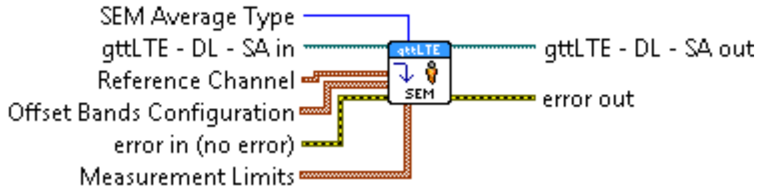


gttLTE - DL - SA - Fetch Results .vi



gttLTE - DL - SA - Close.v

Analysis-Utilities



gttLTE - DL - SA - SetCustomSEMParams.vi