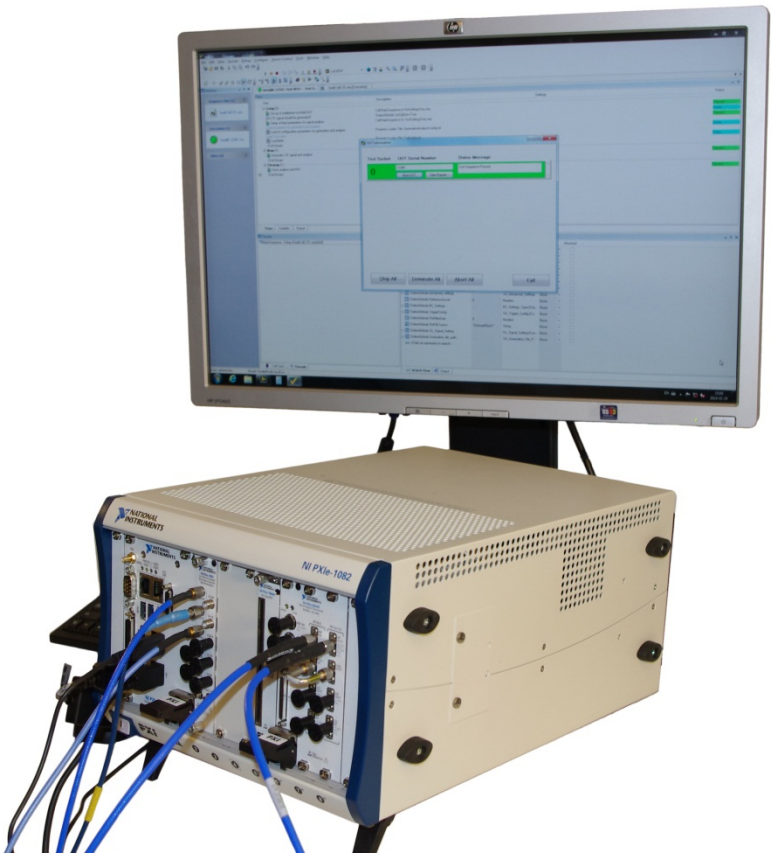
GTT NR RBS TOOLKITS

USER GUIDE



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Contents

1 Introduction

The NR RBS Toolkits are designed for anyone looking for a fast, easy to use platform and hardware independent analysis software 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. We recommend use together with VSTs from National instruments, but the software can be used together with any hardware capable of capturing IQ data. 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 Toolkits is designed to be used together with the instrument's other functionality like RFSA and RFSG in National Intruments VSTs.

There are two base toolkits, the GTT NR DL Toolkit to analyse radio performance and the GTT NR DL BER/BLER Toolkit which enables CRC checks and throughput type measurements.

Both versions are available on three platforms:

Labiview on Windows, and C-binaries on Windows and Linux.

1.1 GTT NR DL Toolkit

The GTT NR DL Toolkit supports analysis of NR (5G) signals as defined in 38.141-1 and 38.141-2 version 15.2.0 and after. It also supports the NR part of 37.141 for coexistence with LTE (4G). Besides the capability of analysing the downlink signal the toolkit ships with IQ files of downlink test models to enable testing and development without access to real devices. For receiver testing playback of IQ files is recommended. Please contact sales@testteknik.se for relevant example code.
The following measurements are supported by the toolkit:

- Base Station Output Power
- Transmit ON/OFF power (PvT, only applied for TDD)
- Frequency Error (Average Carrier Frequency Offset)
- Error Vector Magnitude (EVM)
- Occupied Bandwidth (OBW)
- Adjacent Channel Leakage Power Ratio (ACLR)
- Operating Band Unwanted Emissions (OBUE)
- CCDF

A more detailed description of the measurements is to be found in the 3GPP specifications, ref [1].

1.2 GTT NR DL BER/BLER Toolkit

The GTT NR DL BER/BLER Toolkit features demodulation of NR 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 example code enable easy lab measurements and the high-level APIs makes custom sequences or fully customized soft front panels easy to make.

The BER/BLER Toolkit includes the following

- A non standard EVM measurement suitable for relative measurement and tracking of EVM over time.
- A non 3GPP Power measurement suitable for relative measurements and tracking of transmitted power over time.
- Frequency error
- Constellation points for visual evaluation of signal quality.
- Bits and CRC errors

For details on performance of the non 3GPP measurements please contact sales@testteknik.se.

2 System Requirements

Additional information can be found on https://bluetest.se/products/rbs-toolkit.

2.1 SW

All versions require 64-bit operating system.

2.1.1 LabVIEW version

64-bit LabVIEW

The toolkit is verified using LabVIEW 2017 SP1. For other versions contact sales@testteknik.se.

2.1.2 Linux and Windows

The binaries are C-based with standard C-API.

For wrappers and example code, contact sales@testteknik.se

2.2 HW

64-bit CPU with support for the AVX2 instruction set.

3 Installation

Contact sales@testteknik.se for information on how to download installers.

To install follow the instructions for the appropriate environment.

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

3.1 Install on Labview

1. Make sure you have administrator rights to the computer and have the installer available on the computer.
2. Start VIPM with administrator rights (VIPM, VI Package Manager, installs with Labview).
3. Use File -> Open package File(s) and browse for the installer.
4. Start installation, "GTT License manager NG" will be installed automatically during toolkit installation.

The installed APIs are by default located at:
C: \Program Files\National Instruments\LabVIEW[InstallDir]\vi.lib\GefleTestteknik\NRRBS\...

[InstallDir]=replace with appropriate version number i.e. 2017 for LabVIEW 2017

3.2 Install on Windows and Linux

Contact sales@testteknik.se for information

4 Managing the License

To activate the license, do the following:
If the computer has internet access use instructions for “On-Line Activation”. If the computer is behind a closed firewall or not connected to the internet, please use instructions for “Off-Line Activation”.

Licenses can sometimes be transferred under a support agreement. This can however not be done automatically. Please contact sales@testteknik.se for details.

Refer to the user manual for the GTT License Manager NG (ref [4]) for more info on managing licenses.

4.1 On-Line activation

1. Start ”GTT License manager NG".
   Windows: Find shortcut on Desktop and/or Start menu under Gefle Testteknik
2. Select Activation->Activate...
3. Enter License Number and Password, press Ok

4.2 Off-Line activation

Activation on an off-line computer, called the “Toolkit Computer” requires access to a computer with internet access, “On-Line Computer”.

1. Start ”GTT License manager NG" on the Toolkit Computer.
   Windows: Find shortcut on Desktop and/or Start menu under Gefle Testteknik
2. Select Activation->Save Machine ID and save to a media you can make available to the On-Line Computer.
3. Start ”GTT License manager NG" on the On-Line 1 Computer.
4. Select Activation->Activate.
5. Fill in License number and Password and browse to the file generated in 2.
6. Save the License file to a media you can make available to the Toolkit computer.
7. On the Toolkit computer, Select Activation->Install License
8. Browse to the file stored in 6)
9. Done

4.3 Evaluation

30 day evaluation licenses are available. Please contact sales@testteknik.se for details.

5 Parameters

5.1 Input Parameters for the Labview interface

Parameter	Type	Range	Description
Cell ID	Unsigned Integer	0-1007	Network Cell ID. Necessary for demodulation and decoding.
Test Model	Enum	NR-TM{x.y} {x.y}= see description	Test model according to 3GPP 38.141 or 37.141 For BER/BLER only {x.y}=1.1, 3.1, 3.1a For NR toolkit {x.y}=1.1, 2, 2a, 3.1, 3.1a, 3.2, 3.3
DL Test Model Duplex Scheme	Enum	TDD, FDD, BC3	TDD or FDD for 38.141 (NR), BC3 for 37.141 (Multi Standard)
Bandwidth (Hz)	Enum	5M, 10M,…	Signal bandwidth accoding to 3GPP
Subcarrier Spacing (Hz)	Enum	15kHz, 30kHz, 60kHz, 120kHz	Relates to mu in 3GPP specification. SCS=15k*2mu
Frequency Range	Enum	Range 1, Range 2	Frequency range, FR1 and FR2 according to 3GPP.
Ph Compensation	Unsigned Integer	-	Frequency used for phase compensation of the signal. Normal values: 0 (no phase compensation) or RF frequency in Hz.
MCS index	Unsigned Integer	-	Modulation Coding Scheme. See 3GPP 38.214-Table 5.1.3.1-1 -2, -3
MCS Table	Enum	MCS Table 1, 2, 3	MSC Table to use. See 3GPP. From Version 2.2
IQ-Data	Array CDL	-	IQ-Data to be analyzed. Complex array. All measurements assume scaling to be Volts over 50Ω. See chapter 6.5 IQ configuration for requirements.
IQ Scaling	Double	-	IQ-voltage scaling factor. Use “1” for IQ data with scaling “volts over 50Ω”) From Version 2.2
Sampling Rate		-	Sample rate used to acquire IQ data in Hz. Shall be according to 3GPP see chapter 6.5 IQ configuration for details
Measurement	Enum	BLER, EVM, EVM and BLER	Select which measurements to perform. Note that enabling EVM or Power measurements will increase analysis time.

5.2 Output Parameters for the Labview interface

Parameter	Type	Range	Description
Transport Block	Array U8	0, 1, 255	2D array with payload bits. Each row corresponds to one slot. Total number of columns is equal to the maximum value in “Bits Per Slot”. For slots with fewer payload bits the remaining positions are filled with 255.
Bits Per Slot	Array I32	-	Array with length equal to number of slots containing number of payload bits for each slot.
CRC	Array U8	0, 1	Array with length equal to number of slots. 1=CRC OK, 0=CRC Not OK
Block Count	U32	-	Number of decoded blocks (slots)
BLER	Double	-	BLock Error Rate in %.
EVM Result	Double		Error Vector Magnitude in %[1].
Constellation	Array CDL	-	Array of of demodulated PDSCH symbols. Subset of symbols used for decoding.
Frequency Error	Double		Average channel frequency offset in Hz
IQ Power	Double		IQ Capture Power[2]. From Version 2.2 (January 2020)
CCDF			Complementary Cumulative Distribution Function. See chapter 7 for definition. Will be added March 2020.
OBUE			Operation Band Unwanted Emissions. See chapter 7 for definition. Will be added March 2020.
OBW			Occupied Band Width. See chapter 7 for definition. Will be added March 2020.
ACLR			Adjacent Channel Leakage Power Ratio. See chapter 7 for definition. Will be added March 2020.
Channel Power	Double		Channel Power. See chapter 7 for definition. Will be added January 2020

[1] Note that the EVM in the BER/BLER toolkit is calculated from the demodulated data used in the data throughput measurement and therefore not fully 3GPP compliant.
[2] The IQ Capture Power measurement included in the BER/BLER toolkit does not use channel filters according to 3GPP.
Contact sales@testteknik.se for details.

5.3 Input Parameters for the C-API

Parameter	Type	Range	Description
cell_id[3]	uint32_t	0-1007	Network Cell ID. Necessary for demodulation and decoding.
test_model[3]	enum	GTT_NR_TMNR-TM{xy} {xy}= see description	Test model according to 3GPP 38.141 or 37.141 (remove".") For BER/BLER only {xy}=11, 31, 31A For NR toolkit {xy}=11, 2, 2A, 31, 31A, 32, 33
division duplex[3]	enum	GTT_TDD, GTT_FDD, GTT_BC3	TDD or FDD for 38.141 (NR), BC3 for 37.141 (Multi Standard)
bandwidth[3]	double	According to 3GPP 5e6, 10e6, 15e6 …	Signal bandwidth
mu[3]	uint32_t	0-3	Distance between subcarriers. SCS=15k*2^{mu}
frequency_range[3]	enum	GTT_NR_FR1, GTT_NR_FR2	Frequency range, FR1 and FR2 according to 3GPP.
fc[3]	double	-	Frequency used for phase compensation of the signal. Normal values: 0 (no phase compensation) or RF frequency in Hz.
scale[3]	double	-	IQ-voltage scaling factor. Use "1" for IQ data with scaling "volts over 50 Ω").
mcs_index	uint32_t	0-31	Modulation Coding Scheme. See 3GPP 38.214-Table 5.1.3.1-1 -2, -3
in_computation	enum	GTT_DECODE_BLER, GTT_DECODE_EVM, GTT_DECODE_EVM_BLER	Select which measurements to perform. Note that enabling EVM or Power measurements will increase analysis time.
fs[4]	double	Special	Sample rate used to acquire IQ data in Hz. Shall be according to 3GPP see chapter 6.5 IQ configuration for details
len[4]	uint32_t	Special	Number of samples in IQ data.
data[4]	array float complex	-	IQ data. See chapter 6.5 IQ configuration for requirements.

[3] Part of struct gtt_nr_signal_info: {bandwidth, fc, division_duplex, frequency_range, test_model, cell_id, mu}
[4] Part of struct {in_meas_waveform: fs, len, data, scale}

5.4 Output Parameters for the C-API

Parameter	Type	Range	Description
out_payload	struct	0, 1	data (uint8_t): Array with payload bits. Concatenated in order. len (uint32_t) total length of data.
out_bits_per_slot	struct	-	data (uint32_t): Array with length equal to number of slots containing number of payload bits per slot. len (uint32_t) total length of data.
out_crc	struct	0, 1	data (uint8_t): Array with length equal to number of slots. 1=CRC OK, 0=CRC Not OK len (uint32_t) total length of data.
out_bler	double	-	BLock Error Rate in %.
out_evm	double		Error Vector Magnitude in %[5].
out_constellation	struct	-	data (float complex): Array of of demodulated PDSCH symbols. Subset of symbols used for decoding.
out_frequency_error	double		Average channel frequency offset in Hz
out_iq_power	double		IQ Capture Power[6]. From Version 2.2 (January 2020)
CCDF			Complementary Cumulative Distribution Function. See chapter 7 for definition. Will be added March 2020.
OBUE			Operation Band Unwanted Emissions. See chapter 7 for definition. Will be added March 2020.
OBW			Occupied Band Width. See 7 for definition. Will be added March 2020.
ACLR			Adjacent Channel Leakage Power Ratio. See chapter 7 for definition. Will be added March 2020.
Channel Power			Channel power. See chapter 7 for definition. Will be added March 2020.

[5] Note that the EVM in the BER/BLER toolkit is calculated from the demodulated data used in the data throughput measurement and therefore not fully 3GPP compliant.
[6] The IQ Capture Power measurement included in the BER/BLER toolkit does not use channel filters according to 3GPP.
Contact sales@testteknik.se for details.

6 Using the Toolkits

6.1 Coverage

The toolkits are made to analyze test models according to the 3GPP specifications 38.141 and 37.141 as indicated. If analysis of signals outside standard test models is needed, please contact sales@testteknik.se. Some support outside the standard models is implemented and more can be added on request.

6.2 Examples

GTT supplies example code to illustrate how the different functions can be used. The example code is open and not part of the toolkit and not included in any warranties. The examples are open and you may copy and use freely at your own risk.

6.3 Tools

Beside the analysis itself GTT plans to add functions to help with setup and control of the measurements. Contact sales@testteknik.se for details.

6.4 Test signals

The toolkit ships with DL IQ-files to enable verification and trouble-shooting before real product are available. GTT can as a service generate other signals with or without coded data. Contact sales@testteknik.se for details

6.5 IQ configuration

The toolkit works with asynchronous data. If the IQ data is captured without knowledge of the start of a frame the data needs to be 10,1ms longer than the data to be analyzed. This is to ensure that one continuous set of samples containing a complete set needed for analysis can be extracted. This means that FDD signals need 20,1ms of data and TDD requires 30,1ms of data.

If a trigger can be used to capture the data the amount of data can be reduced. The minimum requirement is 0,1ms longer than the data to be analyzed or 10,1ms for FDD and 20,1 for TDD. The data should contain at least a few samples on each side of the frame to enable analysis of non-ideal signals where the sync may not be perfect.

For performance reasons the GTT NR DL Toolkit does not resample the data, therefore it is important that the sample rate of the data to be analyzed is according to standard. See table below. To request a re-sampler is needed please contact sales@testteknik.se

Bandwidth (MHz)	Sample Rate (MHz)	Bandwidth (MHz)	Sample Rate (MHz)	Bandwidth (MHz)	Sample Rate (MHz)
5	7,68	30	46,08	80	122,88
10	15,36	40	61,44	90	122,88
15	23,04	50	61,44	100	122,88
20	30,72	60	92,16	200	245,76
25	30,72	70	92,16	400	491,52

7 Measurement definitions

7.1 Base station output power (Channel Power)

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.

7.2 IQ Capture Power

This IQ Capture power is generic and not 3GPP specific. Is recommended for fast relative measurements. Typical use is tracking of power over temperature.

7.3 Average Carrier Frequency Offset in (Frequency error)

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.

7.4 Error Vector Magnitude (EVM)

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.

7.5 Occupied bandwidth (OBW)

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.

7.6 Adjacent Channel Leakage power Ratio (ACLR)

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.

7.7 Operating band unwanted emissions (OBUE)

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

7.8 Complementary Cumulative Distribution Function (CCDF)

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

7.9 Bit Error Rate (BER)

Relative number of faulty bits after demodulation and decoding.

7.10 Block Error Rate (BLER)

Relative number of faulty Blocks after demodulation and decoding. A faulty if it contains data with faulty CRC.

8 Contact Information

https://bluetest.se/products/rbs-toolkit

Support contact:

support@testteknik.se

Sales contact:

sales@testteknik.se

9 Abbreviations

ACLR	Adjacent Channel Leakage power Ratio
API	Application Programming Interface
BER	Bit Error Rate
BLER	BLock Error Rate
BS	Base Station
CCDF	Complementary Cumulative Distribution Function
DL	Down Link
EVM	Error Vector Magnitude
FDD	Frequency Division Duplex
IQ	in-phase and quadrature modulator
LTE	Long Term Evolution
NI	National Instruments Corporation
OBW	Occupied Bandwidth
PVT	Power Verses Time
RBS	Radio Base Station
RF	Radio Frequency
RFSA	RF Signal Analyser
RFSG	RF Signal Generator
TDD	Time Division Duplex
TM	Test Models
VI	National Instruments Virtual Instrument
VST	Vector Signal Transceiver

10 References

[1] 3GPP TS 38.141-1, 38.141-2, 37.141 (NR)

[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] User Guide 522A1-SW02002-2 GTT License Manager NG. (Find latest version on https://bluetest.se/products/rbs-toolkit)