Less noise • More sound

Application Note

Loudness Rating Measurements with RAPID-TEST (SLR, RLR, STMR acc. to ITU-T P.79)

RAPID-TEST is a very flexible and fast audio test instrument designed for high-volume production testing of telephone sets. Apart from a wide range of standard measurement functions, the system also supports Loudness Rating analysis, described hereunder.

The subsequent instructions refer to RT-Eval V2.67 or higher and RT firmware V6.0 or higher.

Contents

1 Introduction

Loudness Rating is a measure to indicate how loud the user perceives the speech transmission through a phone. RAPID-TEST (RT) supports the following measurements:

- SLR (Send Loudness Rating)
- RLR (Receive Loudness Rating)
- STMR (SideTone Masking Rating)

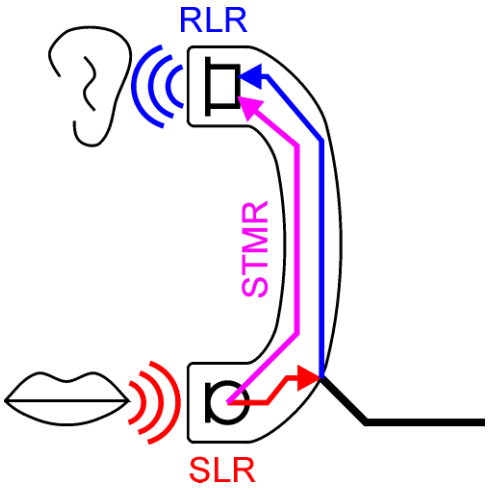

Fig. 1 SLR, RLR, STMR

The standards referring to Loudness Rating - e.g. ITU-T (CCITT) Recommendation P.79 or GSM 03.50 - specifiy the measurement setup through an artificial mouth and ear. Although the test could be executed without these items, it is recommended to comply with the standard in practice.

2 Calibration for SLR, STMR

Prior to a SLR or STMR measurement, the setup - i.e. the artificial mouth - must be calibrated to make sure that the acoustic sound pressure level at the MRP is identical for all frequencies.

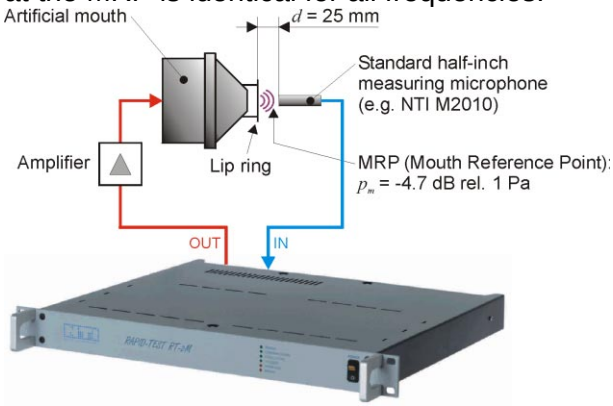

Fig. 2 SLR, STMR calibration setup

Fig. 2 shows the calibration setup. Please note that a measuring microphone such as NTI's M2010 is required.

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The following list describes the calibration with RT-Eval. Alternatively, the procedure can also be executed by sending the corresponding control commands to the unit.

1. Place a reference microphone 25 mm in front of the artifical mouth and connect it to the RT input channel 1.
2. Select the <LOUDNESS> output signal in the "Multitone" panel.
3. Open the "Signal Editor" panel, disable the curve weighting and send the signal to the RT unit (refer to *Fig. 7*).
4. Open a "RSS Selective" panel (Freq1: 20 Hz, Freq2: 20 kHz, Unit: dBPA) and a "Level" measurement panel.
5. Activate the Phantom power on input channel 1.
6. Enter the sensitivity of the microphone that is connected to the unit.
7. Set the output level to a very low voltage (e.g. -30 dBVp) to make sure that the artifical mouth will not be overdriven.
8. Execute a measurement and note the acquired RSS Selective result [dBPA].
9. Stepwise increase the RT output level and until the acquired RSS Selective result reaches -4.7 dBPA (refer to *Fig. 9*).
10. In the "Level" measurement panel, select menu "Equalize -> Generator on Chn1" (see *Fig. 8*).
11. Repeat step 9. to make sure that the acquired RSS Selective = -4.7 dBPA.
12. Save the acquired RT output level and binlevel weighting.

NOTE RAPID-TEST supports Loudness Rating measurements of A-A, A-D and D-A devices, whereby the latter two setups require the application of a RT-2X with digital option (ISDN or T1).

NOTE NTI recommends to use a RT-2X with LCL/RL option when testing telephone sets with POTS interface (refer to the Appendix).

3 Measurements

3.1 SLR (Send Loudness Rating)

SLR reflects the signal loudness in sending direction, i.e. from the artificial mouth through the phone to the transmission line.

A small SLR result indicates that the signal at the end of the transmission line is perceived as being loud. The SLR of a phone should be:

- 8 dB +6/-3 dB (acc. to ITU-T P.79)
- 8 dB ±3 dB (acc. to GSM 03.50)

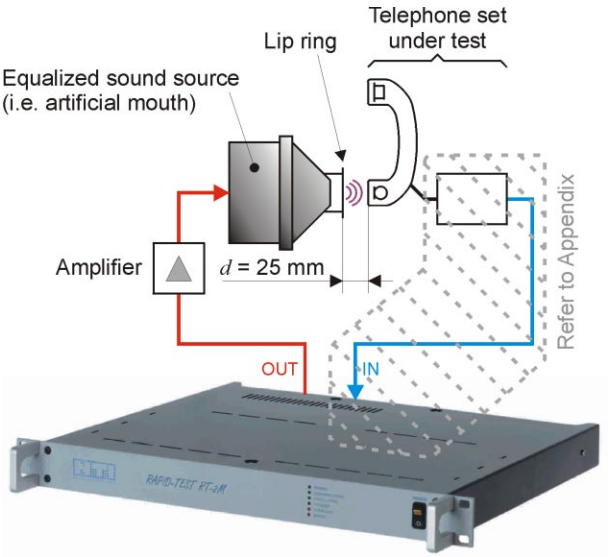

Fig. 3 SLR measurement setup

Execute a SLR measurement as described below (the listed instructions refer to RT-Eval).

NOTE Prior to SLR measurements, a calibration must be executed (*chapter 2.*).

1. Place the phone's mouthpiece 25 mm in front of the artifical mouth.
2. Connect the output of the telephone set to the RT input channel 1.
3. Activate the stored level and binlevel weighting of the calibration.
4. Activate the RT analyzer AC Coupling (only with RT-2X - refer to Appendix).
5. Select a RT input impedance that matches the DUT, e.g. 600 Ω (not required for A-D setups with RT-2X).
6. Optimize the RT input range.
7. Open the SLR measurement panel.
8. Transmit the test signal to execute the measurement (see *Fig. 11*).

3.2 RLR (Receive Loudness Rating)

RLR reflects the signal loudness in receiving direction, i.e. from the transmission line through the phone to the artificial ear.

A small RLR result indicates that the signal at the end of the artificial ear is perceived as being loud. The RLR of a phone should be in the range of 2 dB ±3 dB (acc. to ITU-T P.79, GSM 03.50).

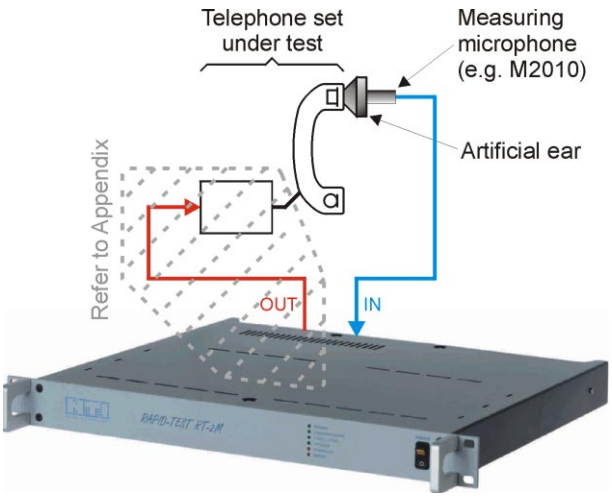

Fig. 4 RLR measurement setup

Execute a RLR measurement as described below (the listed instructions refer to RT-Eval).

1. Activate the RT generator AC Coupling (only with RT-2X - refer to Appendix).
2. Connect the input of the telephone set to the RT output channel 1.
3. Press the earpiece onto the artifical ear.
4. Select a RT output impedance that matches the DUT, e.g. 600 Ω (not required for D-A setups with RT-2X).
5. Activate the RT Phantom power (only if no external microphone power supply is used).
6. Enter the microphone sensitivity.
7. Select the <LOUDNESS> output signal.
8. Disable the curve weighting (*Fig. 7*).
9. Adjust the RT output "Sinelevel" to -12 dBV @ 150 Ω (-15.8 dBm @ 600 Ω or -12 dBFS for D-A setups).
10. Optimize the RT input range.
11. Open the RLR measurement panel.
12. Transmit the test signal to execute the measurement (see *Fig. 12*).

3.3 STMR (SideTone Masking Rating)

STMR reflects the loudness of the feedback signal, i.e. from the mouthpiece of the phone to its earpiece.

A small STMR result indicates that the signal at the earpiece is perceived as being loud. The STMR of a phone should be in the range of 15 dB ±5 dB (acc. to ITU-T P.79).

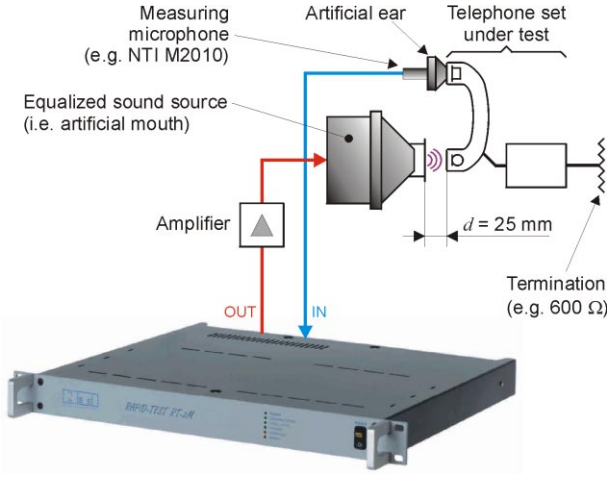

Fig. 5 STMR measurement setup

Execute a STMR measurement as described below (the listed instructions refer to RT-Eval).

NOTE Prior to STMR measurements, a calibration must be executed (*chapter 2.*).

1. Place the phone's mouthpiece 25 mm in front of the artifical mouth and press the earpiece onto the artifical ear.
2. Connect the RT output channel 1 over an amplifier to the artificial mouth and the artificial ear to the input channel 1.
3. Make sure hat the telephone set is terminated properly (if you connect it to an unused RT input or output, activate the AC coupling and the corresponding RT impedance).
4. Activate the RT settings that have been stored after calibration.
5. Enter the microphone sensitivity.
6. Activate the RT Phantom power (only if no external microphone power supply is used).
7. Optimize the RT input range.
8. Open the SMTR measurement panel.
9. Transmit the test signal to execute the measurement.

Appendix

A1 Loudness Rating Test Signal

The loudness rating test signal recommended by the ITU-T P.79 and GSM 03.50 standard has a bandwidth of 200 Hz - 4 kHz. Consequently, this specification has been applied on the default test signal of RAPID-TEST.

Table 1 shows the test signal parameters (i.e. nominal frequencies f_n, actual RT test signal frequencies f_{RT} with bin-numbers and deviation from the standard frequencies) of:

- ITU-T P.79, GSM 03.50 test signal specs.
- default test signal @ blocklength 2048 (permanently stored on RAPID-TEST)
- Loudness rating test signal @ blocklength 4096 (f_s = 48 kHz)
- Loudness rating test signal @ blocklength 8192 (f_s = 48 kHz)

NOTE The default Loudness Rating test signal (blocklength = 2048) corresponds to the ITU-T standard frequencies with a frequency accuacy of ± 5%, thus meeting the requirements of most applications.

Alternatively, loudness a rating test signal with blocklength = 4096 or 8192 can be applied as well (only at f_s = 48 kHz), thus reducing the difference to the standard frequencies. However, these test signals must be first stored on the RAPID-TEST unit and feature a longer duration.

ITU-T f_n [Hz]	f_{RT} @ 2048	Bin-#	f_{RT} Error	f_{RT} @ 4096	Bin-#	% f_{RT} Error	f_{RT} @ 8192	Bin-#	% f_{RT} Error
200	210.94	9	5.47%	199.22	17	-0.39%	199.22	34	-0.39%
250	257.81	11	3.12%	246.09	21	-1.56%	251.95	43	0.78%
315	328.12	14	4.17%	316.41	27	0.45%	316.41	54	0.45%
400	398.44	17	-0.39%	398.44	34	-0.39%	398.44	68	-0.39%
500	492.19	21	-1.56%	503.91	43	0.78%	498.05	85	-0.39%
630	632.81	27	0.45%	632.81	54	0.45%	632.81	108	0.45%
800	796.88	34	-0.39%	796.88	68	-0.39%	802.73	137	0.34%
1000	1007.81	43	0.78%	996.09	85	-0.39%	1001.95	171	0.20%
1250	1242.19	53	-0.62%	1253.91	107	0.31%	1248.05	213	-0.15%
1600	1593.75	68	-0.39%	1605.47	137	0.34%	1599.61	273	-0.02%
2000	1992.19	85	-0.39%	2003.91	171	0.20%	1998.05	341	-0.07%
2500	2507.81	107	0.31%	2496.09	213	-0.15%	2501.95	427	0.08%
3150	3140.62	134	-0.31%	3152.34	269	0.07%	3152.34	538	0.07%
4000	3984.38	170	-0.39%	3996.09	341	-0.10%	4001.95	683	0.05%

Table 1 Loudness Rating test signal specifications

A2 POTS Interface Wiring

When testing analog wired phones with POTS interface, it is strongly recommended to use a RT-2X with LCL/RL option.

Fig. 6 shows the wiring of such a setup.

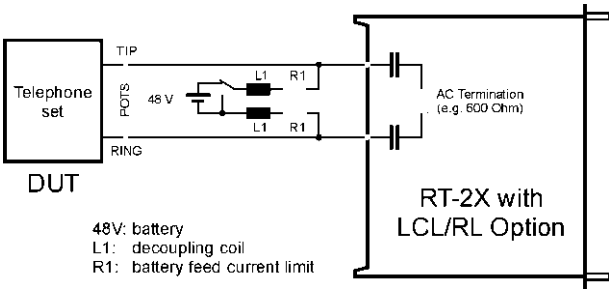

Fig. 6 Wiring of telephone set with POTS interface

NOTE Activate the AC Coupling within the RT-2X if the unit is connected to a telephone set with POTS interface.

A3 SLR Calibration Routine

The listing below provides an example of a SLR calibration routine.

```
// -------------------- SLR Calibaration on CH1 --------------------
// ---------------------- INITIALIZATION PART ----------------------

SendToRT("SYSTEM:RESET")

// *************** MTONE INITIALIZATION (ACTIVE SIGNAL) ***************
// The RT Loudness signal is a read-only signal; no initalization necessary.

// *************** MTONE SETTINGS ***************
SendToRT("OUTPUT:MTONE:ACTIVE  LOUDNESS" );
// Clear possible weightings on the active loudness signals
SendToRT("OUTPUT:MTONE:CLEARWEIGHTINGS" );

// *************** OUTPUT SETTINGS ***************
SendToRT("OUTPUT1:MUTE OFF" );
SendToRT("OUTPUT:FLOAT OFF" );

// *************** INPUT SETTINGS ***************
SendToRT("INPUT1:RANGE 0.00 dBVp" );
SendToRT("INPUT1:LINK OFF" );
SendToRT("INPUT:SYNC INTNOHEADER" );
SendToRT("INPUT1:IMPEDANCE PHANTOM" );

// *************** OUTPUT LEVEL SETTINGS ***************
SendToRT("OUTPUT1:LEVEL -20.00000 dBVp" );

// --------------------- END INITIALIZATION PART ---------------------
```

```
// --------------------- First Pressure Measurement -------------------
// execute the measurement:
SendToRT("OUTPUT:MTONE:START" );
SendToRT("MEAS1:SEL:UNIT dBPA" );
// query and interpret the channel 1 measurement result string:
SendToRT("MEAS1:SEL? 1 853" );
ReceiveFromRT();
// --> received value: A in dBPA
// required: -4.7 dBPA => LevelCorr = -4.7 - A

// check for errors:
SendToRT("SYSTEM:ERR?" );
ReceiveFromRT();

// -------- Corrected Pressure Measurement shall reach -4.7dBPA -------
// NEW output level: B = -20.00000 + LevelCorr
// set corrected New output level in order to reach -4.7dbPA:
SendToRT("OUTPUT1:LEVEL <B> dBVp" );
// execute the measurement:
SendToRT("OUTPUT:MTONE:START" );
// query and interpret the channel 1 measurement result string:
SendToRT("MEAS1:SEL? 1 853" );
ReceiveFromRT();
// --> received value should be -4.7 dBPA

// ---------------- Equalize Artificial Mouth acoustically -------------
// equalization is done according to the last measurement:
SendToRT("OUTPUT1:MTONE:EQUALIZE" );
// inverse of level measurement is used as signal weighting for active signal

// ------------------ ReAdjust Pressure Measurement --------------------
// same procedure as before...
SendToRT("OUTPUT:MTONE:START" );
SendToRT("MEAS1:SEL? 1 853" );
ReceiveFromRT();
//--> received value: C in dBPA
// required: -4.7 dBPA => LevelCorr = -4.7 - C

// -------- Corrected Pressure Measurement shall reach -4.7dBPA -------
// NEW output level: D = B (former set corrected Level) + LevelCorr
// eet corrected New output level in order to reach -4.7dbPA
SendToRT("OUTPUT1:LEVEL <D> dBVp" );
SendToRT("OUTPUT:MTONE:START" );
SendToRT("MEAS1:SEL? 1 853" );
ReceiveFromRT();
// --> received value should be -4.7 dBPA

// => set the Output Level D for the SLR Measurement
// => set the active Loudness signal for the SLR Measurement
//    (do not clear the weightings !)
```

A4 RLR Measurement Routine

The listing below provides an example of a RLR measurement routine.

```
// ------ RLR Measurement on RT2X with LCL/RL/CAP option installed ------
// Setup with Analog telephone, POTS interface connected to RT2X output Ch1,
// artificial ear with external mic Power connected to RT2X input CH1, mic
// sensitivity = 10mV/PA. Frequency response and RLR measurement with a
// single transmission of the Loudness test signal.

// ------------------------ INITIALIZATION PART -----------------------
// ******************* BRIDGE MODE TO OFF  *******************
SendToRT( "INOUT:LCLBRIDGE:MODE OFF");
SendToRT( "INOUT:RLBRIDGE:MODE OFF");

// ******************* SYSTEM MODE INITIALIZATION  *******************
SendToRT( "SYSTEM:MODE 48KSAMPLINGRATE");

// *************** MTONE INITIALIZATION (ACTIVE SIGNAL) ***************
// The RT Loudness signal is a read-only signal; no initalization necessary.

// *************** MTONE SETTINGS ***************
SendToRT( "OUTPUT:MTONE:ACTIVE  LOUDNESS");

// *************** OUTPUT SETTINGS ***************
SendToRT( "OUTPUT:SOURCE ANALOG");
SendToRT( "OUTPUT1:MUTE OFF");
SendToRT( "OUTPUT:FLOAT OFF");
SendToRT( "OUTPUT1:IMPEDANCE 600");
SendToRT( "OUTPUT1:ACCOUPLING ON");

// *************** INPUT SETTINGS ***************
SendToRT( "INPUT:SOURCE ANALOG");
SendToRT( "INPUT1:RANGE -27.90 dBVp");
SendToRT( "INPUT1:LINK OFF");
SendToRT( "INPUT:SYNC INTNOHEADER");
SendToRT( "INPUT1:MICSENSITIVITY  10.00");
SendToRT( "INPUT1:IMPEDANCE 100k");
SendToRT( "INPUT1:ACCOUPLING OFF");

// *************** OUTPUT LEVEL SETTINGS ***************
SendToRT( "OUTPUT1:SINELEVEL -12.00000 dBV");
// --------------------- END INITIALIZATION PART --------------------

// -------------------- MULTITONE MEASUREMENT PART ------------------
// execute the measurement:
SendToRT( "OUTPUT:MTONE:START");

// *************** MEASUREMENT Level [dBVp] ***************
SendToRT( "MEAS1:LEVEL:UNIT dBV");

// query and interpret the channel 1 measurement result string:
SendToRT( "MEAS1:LEVEL?");
ReceiveFromRT();

// check for errors:
SendToRT( "SYSTEM:ERR?");
ReceiveFromRT();
```

```
// *************** MEASUREMENT RECEIVE LOUDNESS RATING ***************

// query and interpret the channel 1 measurement result string:
SendToRT( "MEAS1:LOUDNESSRATING:RLR?");
ReceiveFromRT();

// check for errors:
SendToRT( "SYSTEM:ERR?");
ReceiveFromRT();

// ------------------ END MULTITONE MEASUREMENT PART ------------------
```

A5 RT-Eval Reference Screenshots

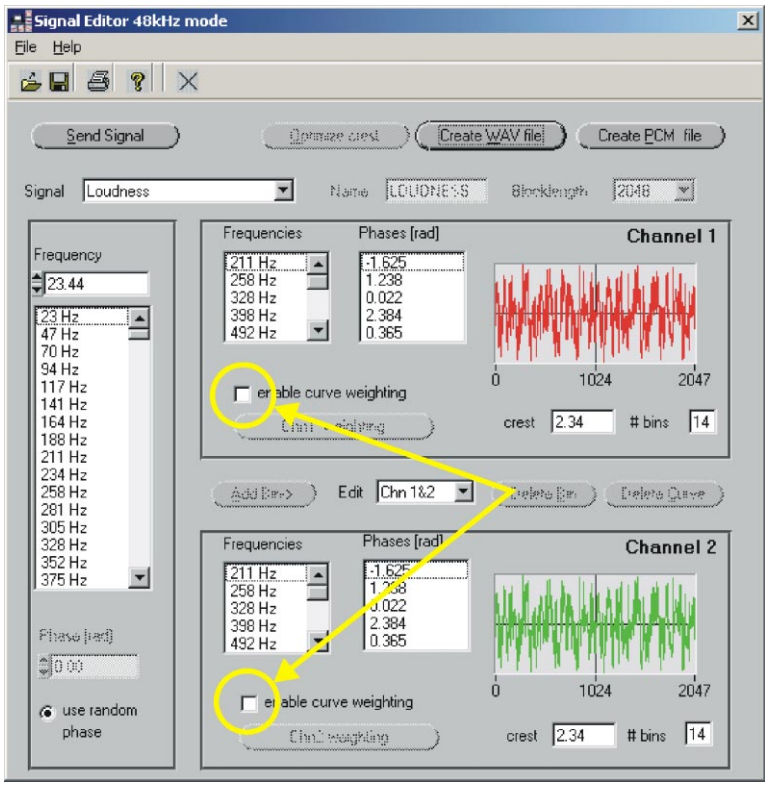

Fig. 7 "Signal Editor" panel - disable curve weighting

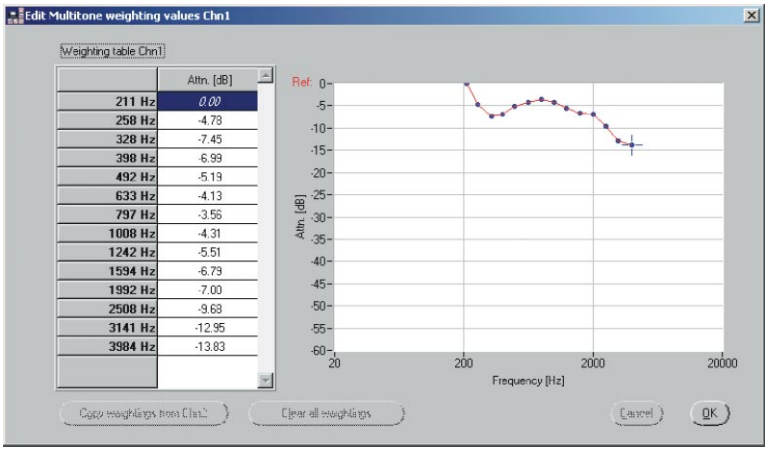

Fig. 8 Test signal equalization

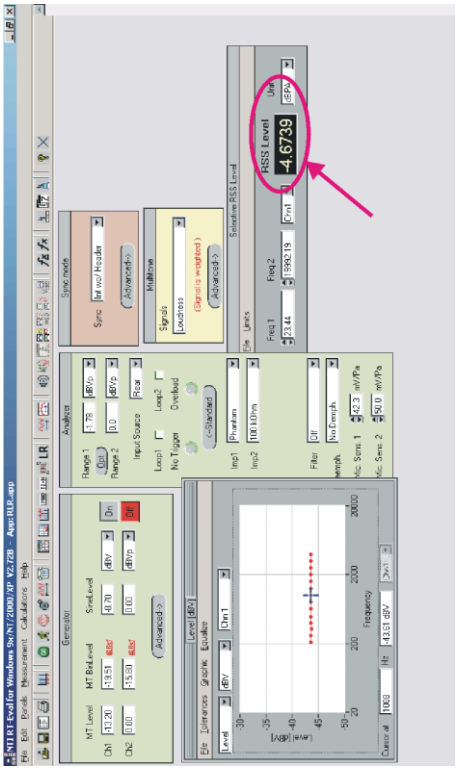

Fig. 10 RSS with equalized test signal

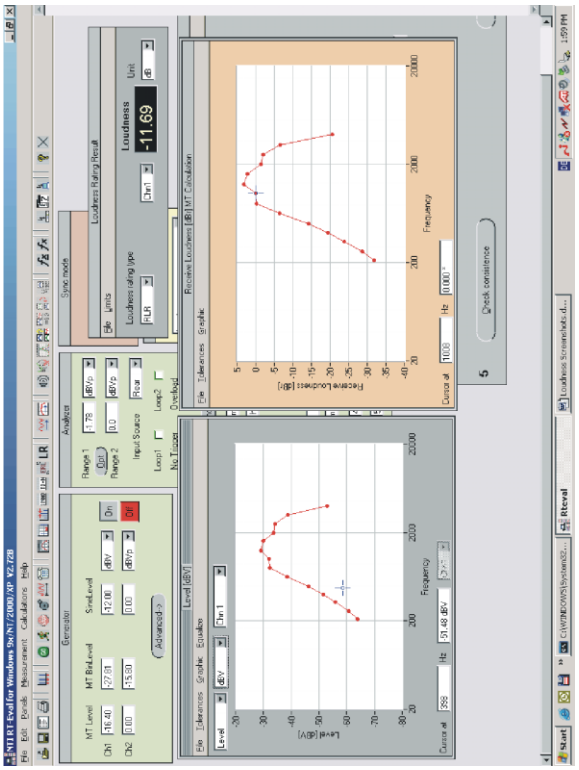

Fig. 12 RLR measurement example

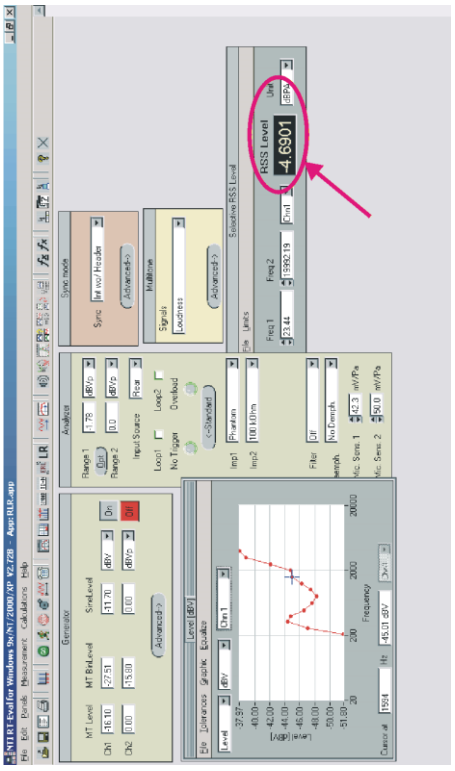

Fig. 9 RSS Level adjustment

Fig. 11 SLR measurement example