Joint TSG-S4#10 - SMG11#15 Meeting
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Title: **Echo Loss Measurements Using Various Kinds of Signals and Procedures**
Source: **HEAD acoustics, Alcatel**
Document for: **Discussion**
Agenda Item: **12.6**

1. Introduction

The purpose of this document is to present and compare various test methods and test signals for the measurement of echo loss using the RF interface. The first part of the document compares the measurement results achieved from a telephone using the DAI interface and comparing those measurement results to the ones achieved using the RF interface. It was ensured that using the RF measurements any additional signal processing was switched off and such the measurement results should have been basically the same as for the DAI measurements. In a second part of the document the measurement dynamics of the various measurement signals are compared.

Note: In all TCL-figures in this document the TCL is represented as a loss rather than an attenuation.

2. Comparison of TCL Measured over DAI and RF Interface

2.1 Test Conditions

For the tests the following signals have been used:

a) Artificial voice according to ITU Recommendation P.50 (see also GSM 03.50)

b) Swept sine wave from 100 Hz to 4 kHz

c) Multi-sine signal with a frequently spacing of 100 Hz starting from 100 Hz to 4 kHz

d) Pseudo random noise sequence with a minimum crest factor of 6 dB, band width 100 Hz to 4 kHz

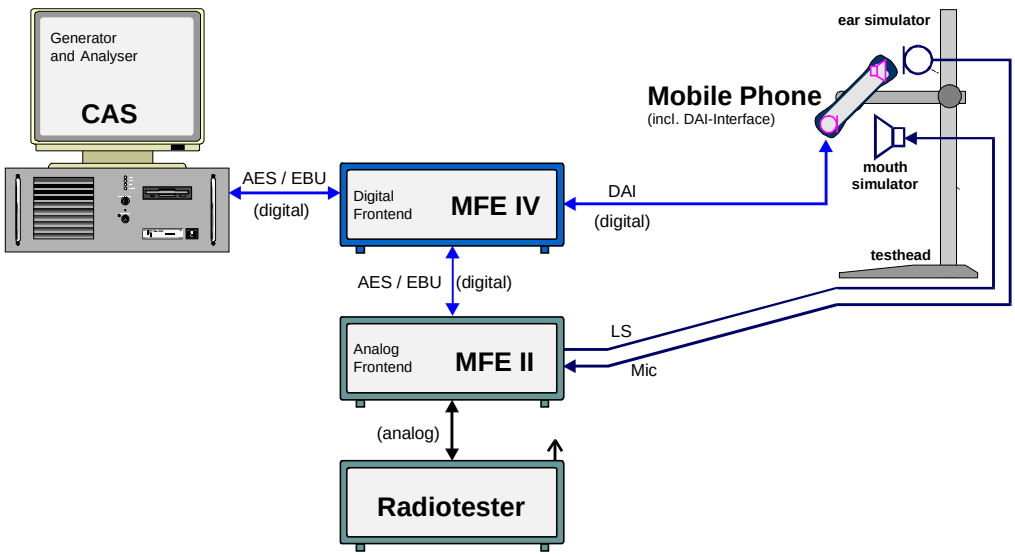

Fig.1: Test arrangement for TCL measurements

For the test a specific terminal from Alcatel was used which allowed controlled access via DAI and the RF interface.

The test equipment was the CAS from HEAD acoustics with the Frontends MFE II and MFE IV with DAI interface and a Radio Tester CMD 55 from Rohde & Schwarz. All tests have been conducted according to the GSM 11.10 (03.50) with the telephone sealed by the artificial ear type 1. All measurements have been conducted in an anechoic chamber. The test arrangement is shown in Fig. 1.

2.2 Test Results: Comparison DAI and RF Measurements

- **DAI Tests**

Figure 2 shows the results of TCL measured over the DAI interface for the signals artificial voice, pn-sequence and swept sine. It can be seen that in the high and low frequency domain already for this DAI measurement the artificial voice signal seems to give higher TCL results than the other signals. This seems to be due to insufficient signal to noise ratio in the high and low frequency domain.

The results achieved using swept sine and pn-sequence are nearly the same and cab be used as a reference for the RF measurements.

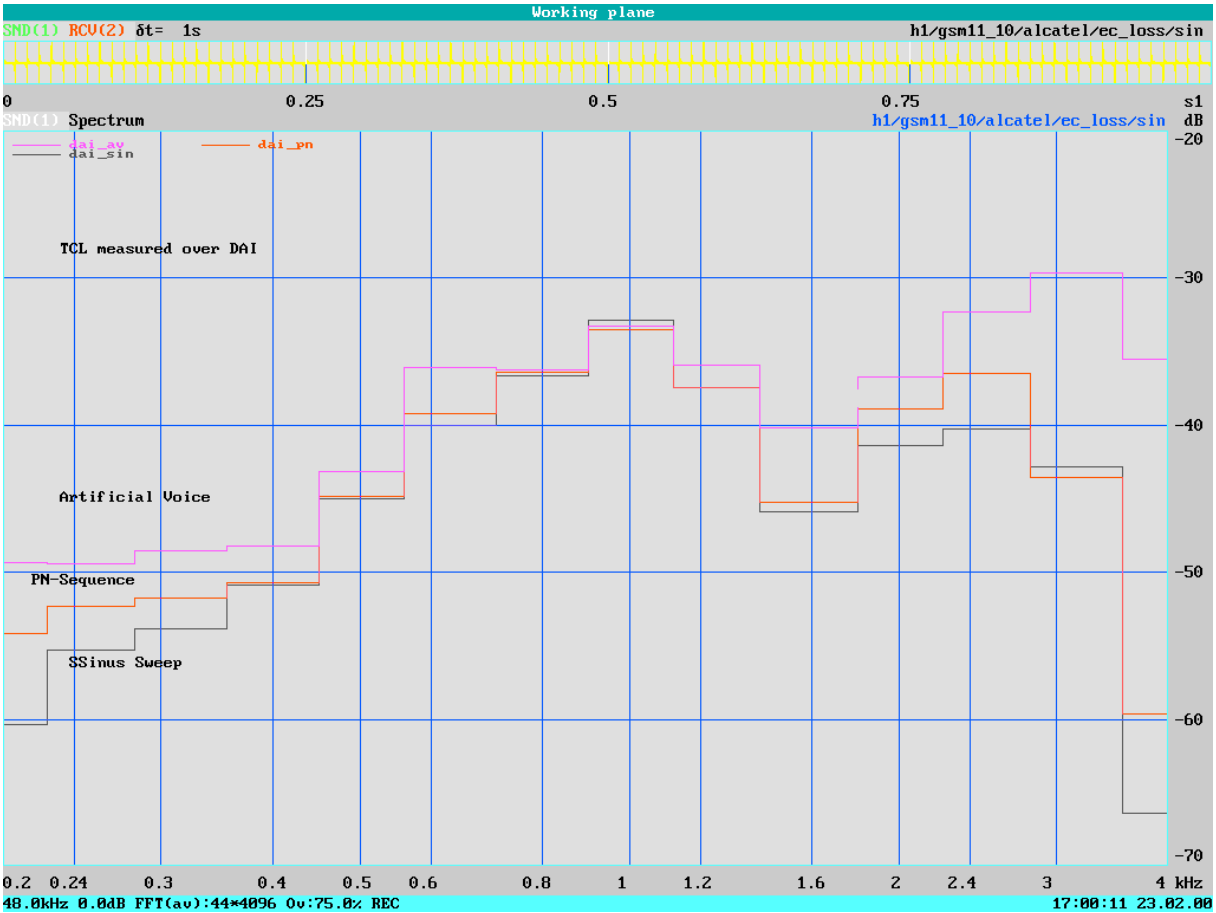

Fig. 2: TCL measured over DAI using artificial voice, pn-sequence and swept sine

	Swept sine	**Artificial Voice**	**pn-sequence**
TCL measured over DAI	39,2 dB	35,4 dB	38,7 dB

Table 1: TCL of Alcatel terminal, measured over DAI

- **Swept Sine Wave**

Figure 3 shows the comparison of the results using the swept sine signal measured over DAI and compared over the RF interface. Generally it can be seen that especially in the low frequency domain the RF measurements seem to give a higher echo signal as compared to the measurements over the DAI.

	Swept sine
TCL measured over DAI	39,2 dB
TCL measured over RF	36,9 dB

Table 2: TCL of Alcatel terminal, measured over DAI and RF interface

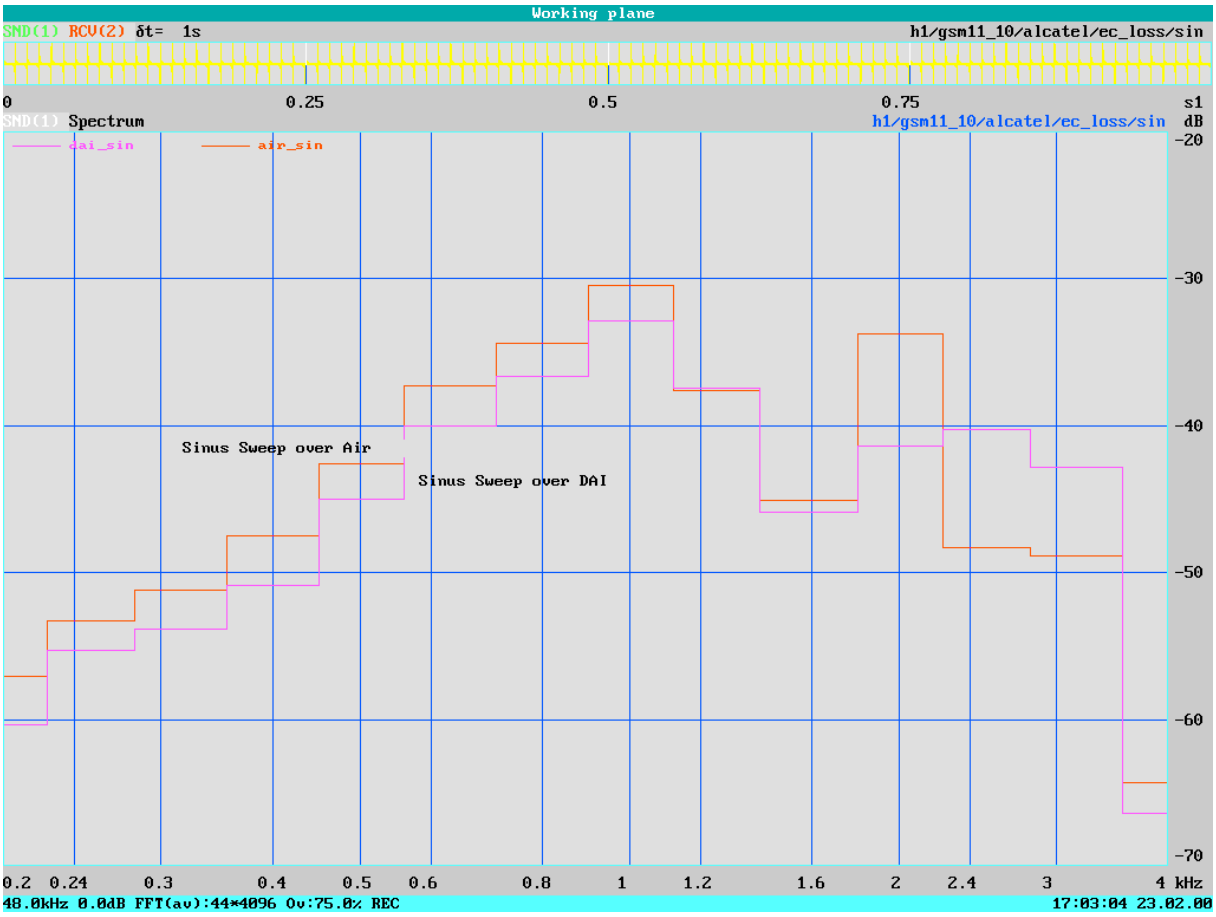

Fig. 3: Comparison of swept sine measurements over DAI and RF interface

- **PN-Sequence**

Figure 4 gives the same results, but using the pn-sequence. It can be seen that the measurement over the RF interface and DAI interface are very close together.

	pn-sequence
TCL measured over DAI	38,7 dB
TCL measured over RF	38,1 dB

Table 3: TCL of Alcatel terminal, measured over DAI and RF interface

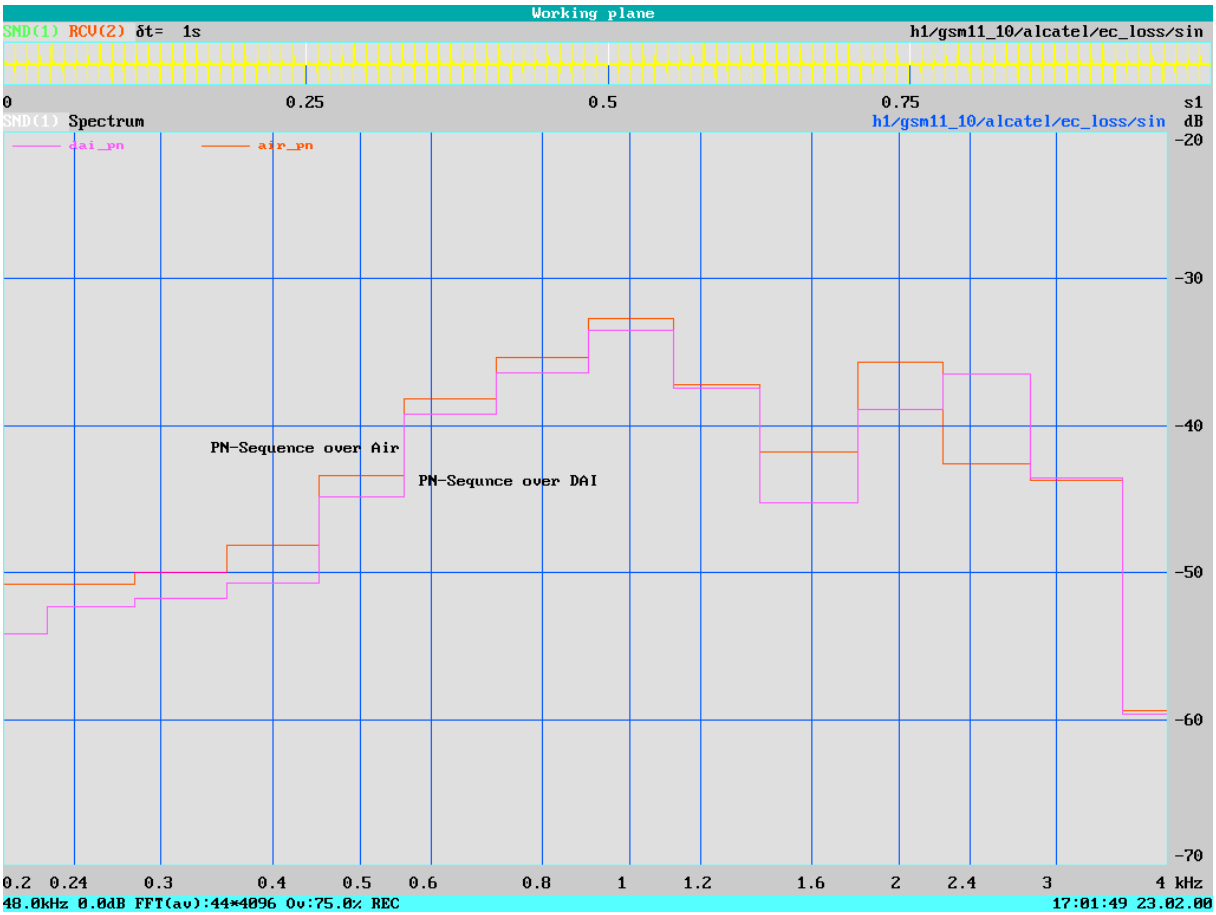

Fig. 4: TCL measured using pn-sequence over DAI and RF interface

- **Artificial Voice**

Figure 5 again gives the same results, but now using the artificial voice as a test signal. The figure shows the comparison to the measurement achieved with a pn-sequence over DAI as a reference. It can be seen that due to the insufficient signal to noise ratio the TCL over RF is measured to be even worse as compared to the measurement over DAI and significantly different to the measurement using the pn-sequence.

	Artificial Voice
TCL measured over DAI	35,4 dB
TCL measured over RF	34,1 dB

Table 4: TCL of Alcatel terminal, measured over DAI and RF interface

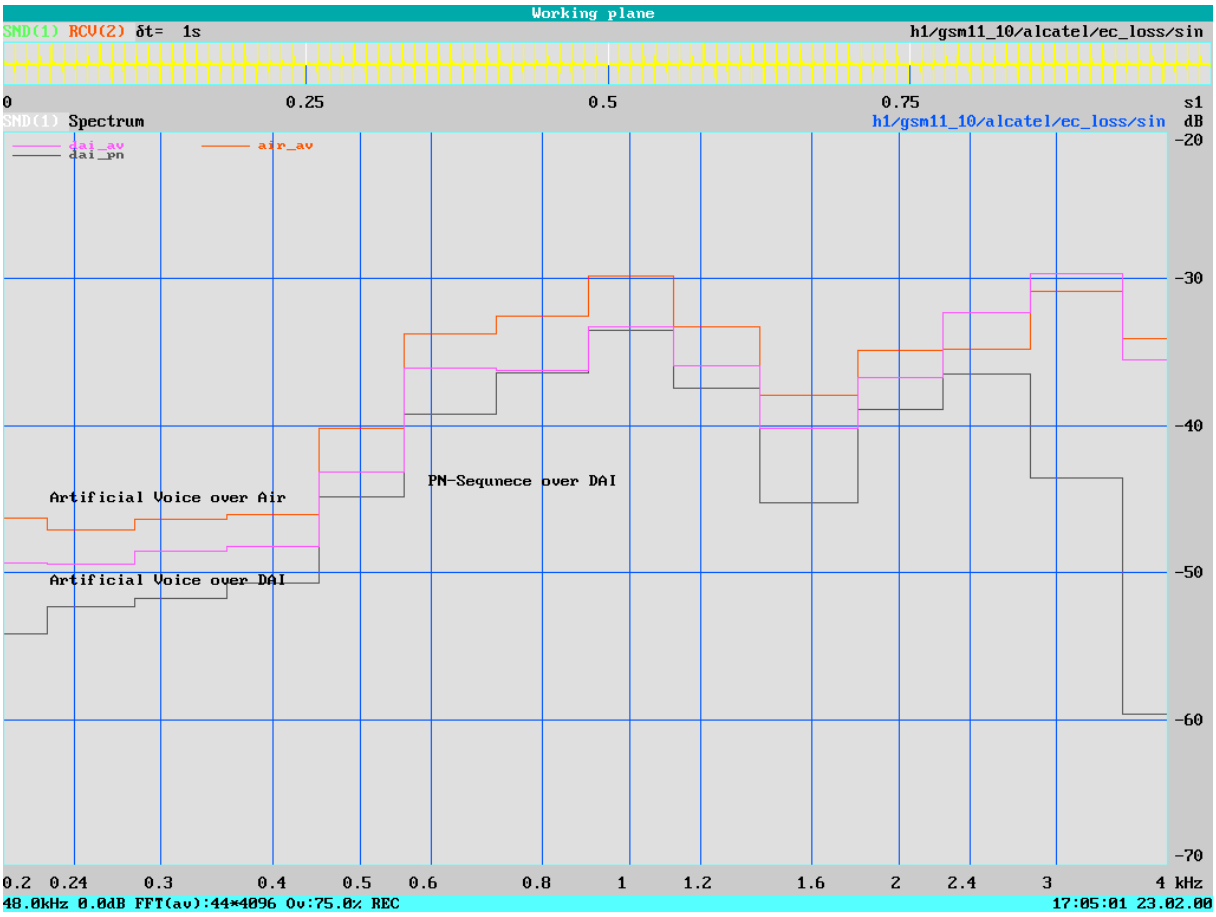

Fig. 5: TCL measurement using artificial voice over DAI and RF interface

- **Multi-Sine Signal**

The same measurement using multi-sine signal over RF is shown in Figure 6 and compared to the swept sine measurement over DAI. It can be seen that results are significantly different as compared to the sine wave measurements over DAI which can be considered as a reference. The virtual increase of TCL at the 250 Hz is a result of the non-sufficient signal energy in this frequency band and can be avoided if the frequency spacing is not 100 Hz but at least 50 Hz which, however, than will reduce the measurement dynamics since the complete signal energy has to be distributed over more frequencies.

	Multi-sine
TCL measured over DAI	-
TCL measured over RF	35,8 dB

Table 5: TCL of Alcatel terminal, measured over DAI and RF interface

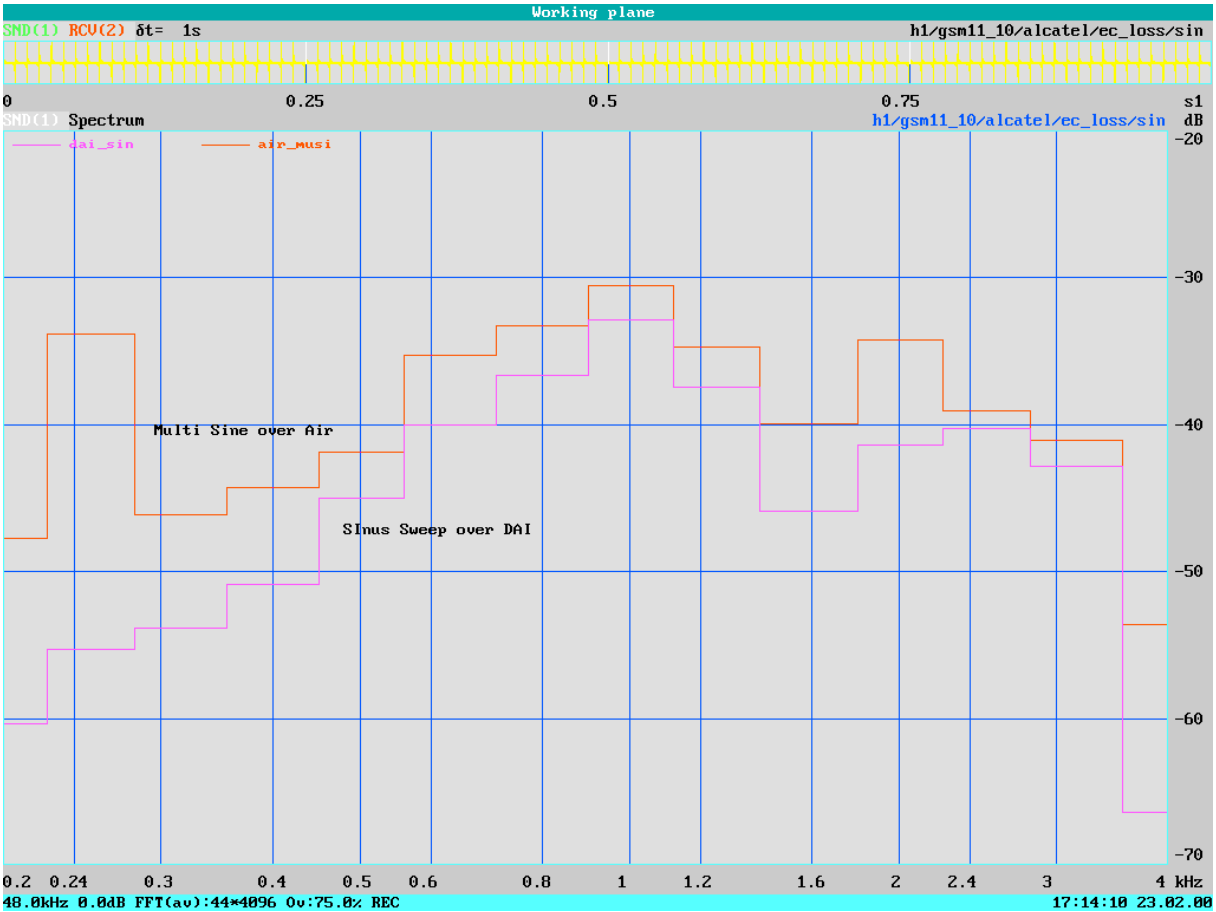

Fig. 6: Comparison of the multi-sine measurement over RF to the swept sine measurement over DAI

When assuming the swept sine measurement conducted over the DAI interface to be the reference (best signal to noise ratio and no nonlinearities or codecs in the telephone present) the following table sums up the differences of the TCL when measuring over the RF interface:

	Artificial Voice	Multi-sine Signal	Swept Sine Signal	pn-sequence
Difference between reference and RF-measurement	5,1 dB	3,4 dB	2,3 dB	1,1 dB

3. Measurement dynamics

The general problem of the TCL measurement is the insufficient measurement dynamics using the test signals which are currently used. For all test signals used in this experiment the frequency dependent measurement is shown in Figure 7. The measurement was achieved by just measuring the noise signal of the terminal in the sending direction with no echo present. This is measuring the idle channel noise with a telephone present and basically is the maximum "TCL" which can be measured if no echo is present.

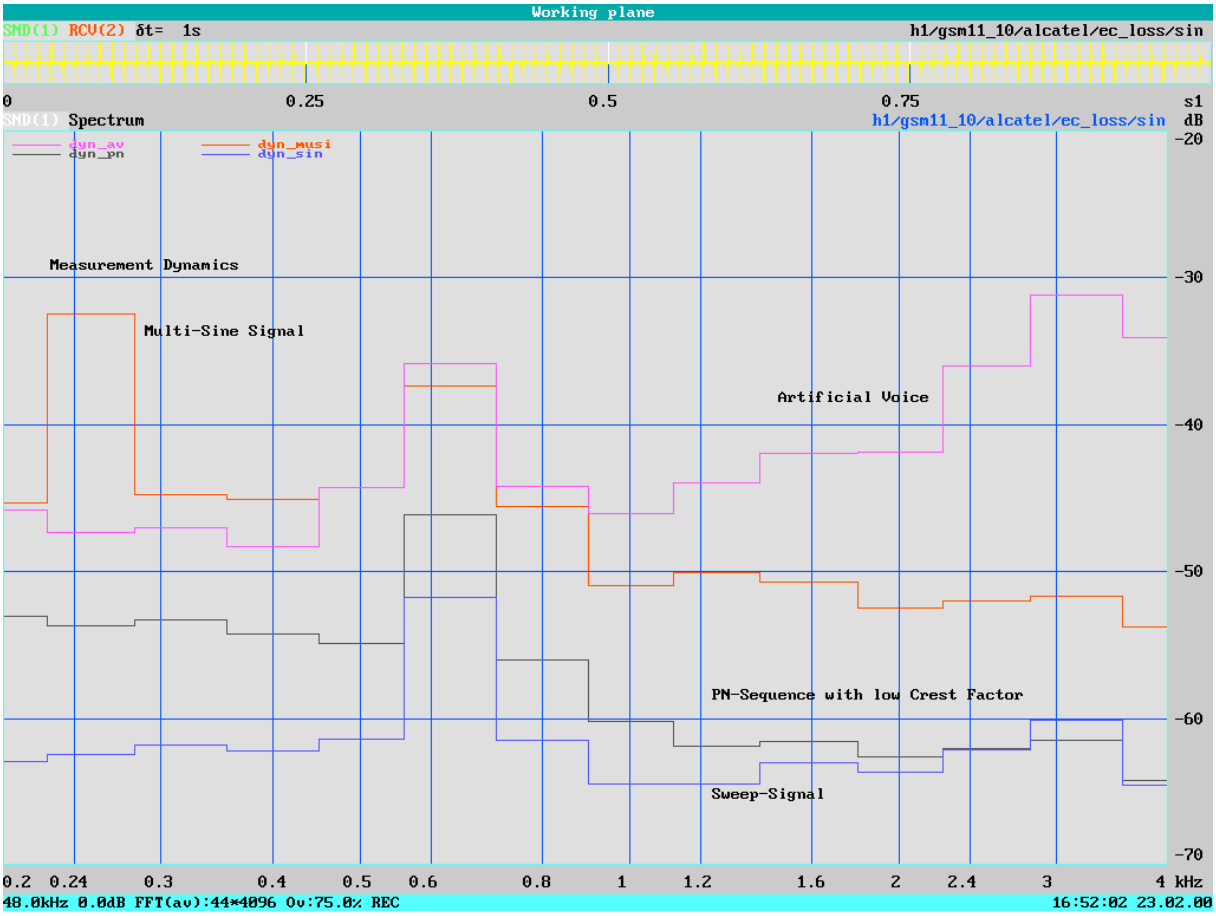

Fig. 7: Measurement dynamic achieved on a real telephone with no echo, but just the noise of sending direction present using all types of test signals

It clearly can be seen that the worst measurement dynamics is achieved by the artificial voice signal followed by the multi-sine signal. The best measurement dynamics are provided by the swept sine wave signal and the pn-sequence with a low crest factor.

Due to a specific noise component produced by the individual telephone a peak at around 650 Hz for all measurements can be seen which simply is a noise component of the terminal in sending direction.

	Artificial Voice	**Multi-sine Signal**	**Swept Sine Signal**	**pn-sequence**
Measurement Dynamics	38,7 dB	44,6 dB	59,3 dB	54 dB

Table 6: Measurement dynamics

4. Conclusions

From the test conducted the following results can be concluded:

1. Measurements over the DAI interface lead to comparable TCL values for all test signals except artificial voice where already the insufficient signal to noise ratio gets obvious.
2. Comparison of measurements over DAI and RF interface show that the measurement using the pn-sequence with a low crest factor of 6 dB give comparable results for both DAI and RF measurements.
3. Analysis of the measurement dynamics show that the best measurement dynamics is provided by the pn-sequence with a low crest factor and a swept sine signal. Both provide a sufficient high enough measurement dynamics in order to reliable measure TCL of 46 dB.

It can be concluded that the pn-sequence provides both, sufficient measurement dynamics and comparable measurement results to the reference measurement conducted over the DAI interface. This conclusion applies for both, GSM terminals and UMTS terminals.