Add-On: DSL-Cable ELFEXT Measurement with Bode 100

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Note: Basic procedures like setting-up, adjusting and calibrating Bode 100 are described in the operational manual of Bode 100.

Note: All measurements in this application note have been performed with the Bode Analyzer Suite V2.21. Use this Version or a higher Version to perform measurements according to this application note

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1 Executive Summary

Based on the Application Note "DSL-Cable Measurements with Bode 100" we explain how to calculate and measure the ELFEXT (Equal Level Far End Crosstalk).

2 Measurement tasks

First we calculate the ELFEXT by the measurement results based on the mentioned Application Note. Afterwards we show a method to measure the ELFEXT directly. As a last step we compare the calculation and the measurement.

Hint: Basic measurement setups and results for other DSL-Cable Measurements like Cable-Attenuation, Impedance and Phase Delay are shown in the Application Note "DSL-Cable Measurements with Bode 100".

3 Measurement Setup & Results

3.1 Used Equipment

The following equipment is required to perform the measurements described in this application note.

- Vector Network Analyzer Bode 100 (incl. measurement accessories)
- DSL-Cable (DUT)
- BALUNs (3x)
- Connection accessories
- Calibration cables (3x)
- Thru Connector

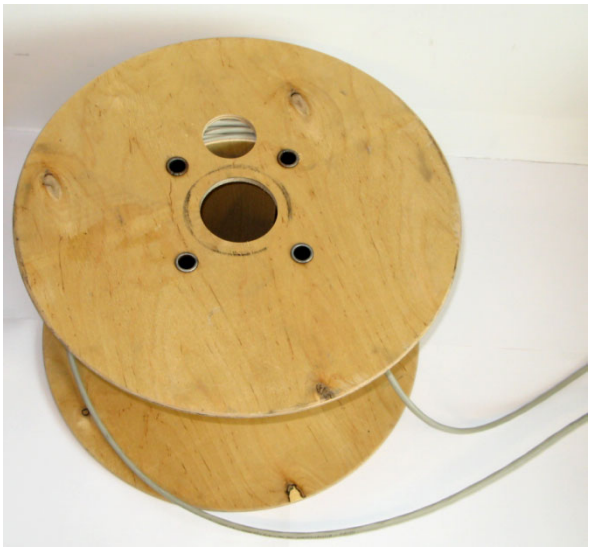
The used items are explained in the following sections.

3.1.1 DSL-Cable:

The DSL-Cable used for the measurements in this application note had following properties:

- Type: Copper cable 4x4x0.5 vDSL (CAT3)
- Manufacturer: Nexans Fumay France
- Physical properties: 4 quads 0.5mm with general braid/alu foil SF-UTQ (QIMF)
- Trade mark: ET 392121
- Model/marking: Nexans-Alcatel-Lucent 1 ACxx
- Length: 100m

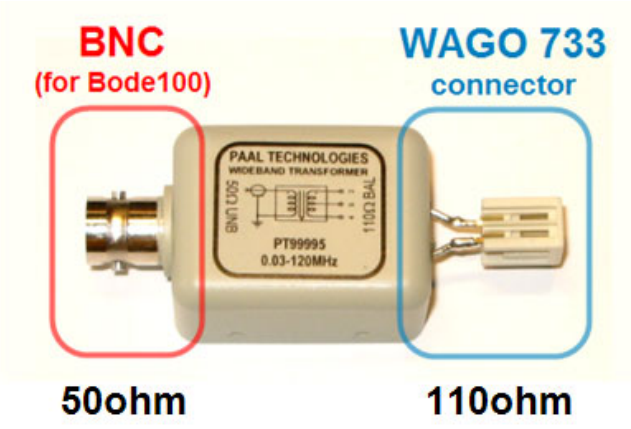
During the measurements the DSL-Cable is wrapped on a wooden cable reel.



Picture 1-1

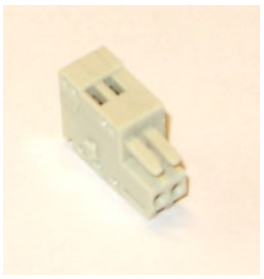
3.1.2 BALUN:

A BALUN as shown in the picture is used to match the output impedance of the Bode 100 (50 ohm) with the cable impedance of 110 ohm. The used BALUN has a balanced output signal and a frequency range from 30 kHz up to 120 MHz.

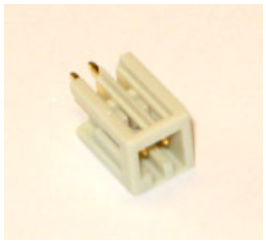


3.1.3 Connection accessories:

To connect the BALUN and the DSL-Cable we use 2 pin Wago-733 connectors.

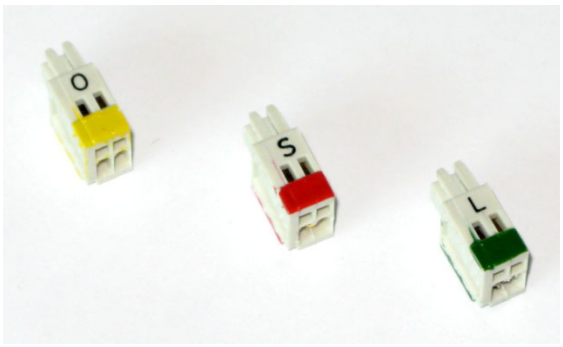


(female plug)



(male plug)

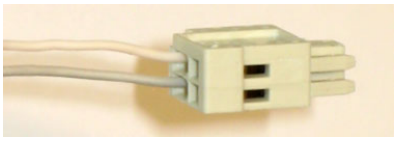
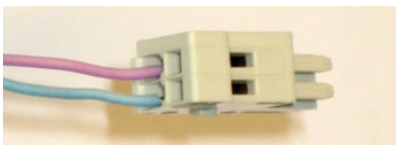
Three special connectors **O**pen, **S**hort and **L**oad are used for the calibration later on. The load resistor has a value of 110 ohm.



Picture 1-5

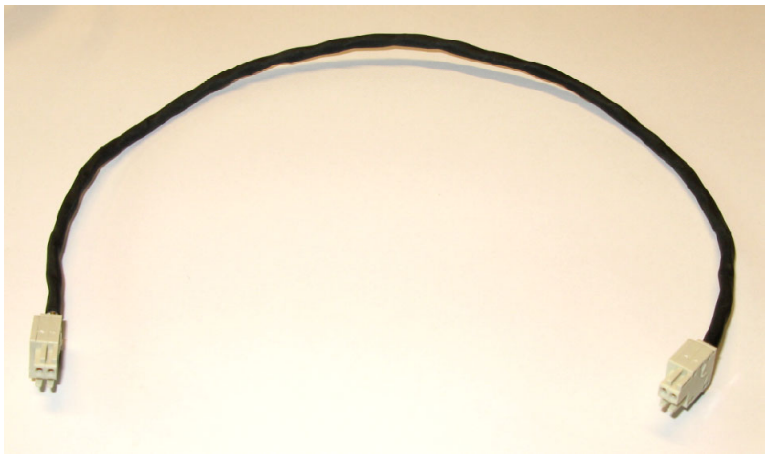
Connection table:

The different cable pairs of the DSL-Cable are connected with WAGO-733 female plugs.

Pair Nr.	Quad	Short name	Color	Picture
1	1	Q1/1	White Grey	
2	1	Q1/2	Orchid Blue	

3.1.4 Calibration cable:

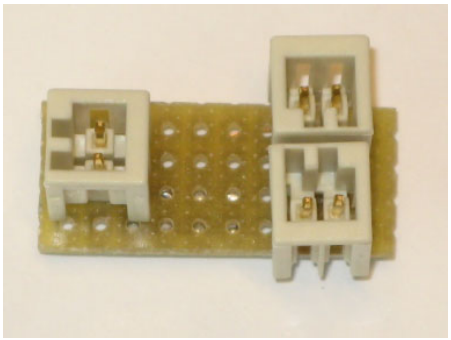
To minimize the influence of the BALUNs, BNC cables and connectors we have to calibrate our measurement setup. Therefore a calibration cable with two female plugs is required. The explicit use of our calibration cable will be shown in 3.3.

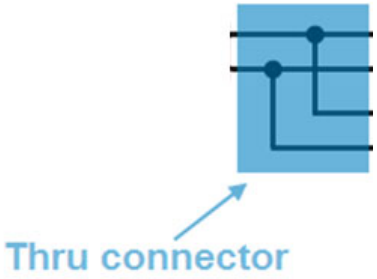


Picture 3-13

3.1.1 Thru Connector:

For the calibration of the ELFEXT measurement a thru connector is needed. All male plugs are connected thru.





Picture 3-14

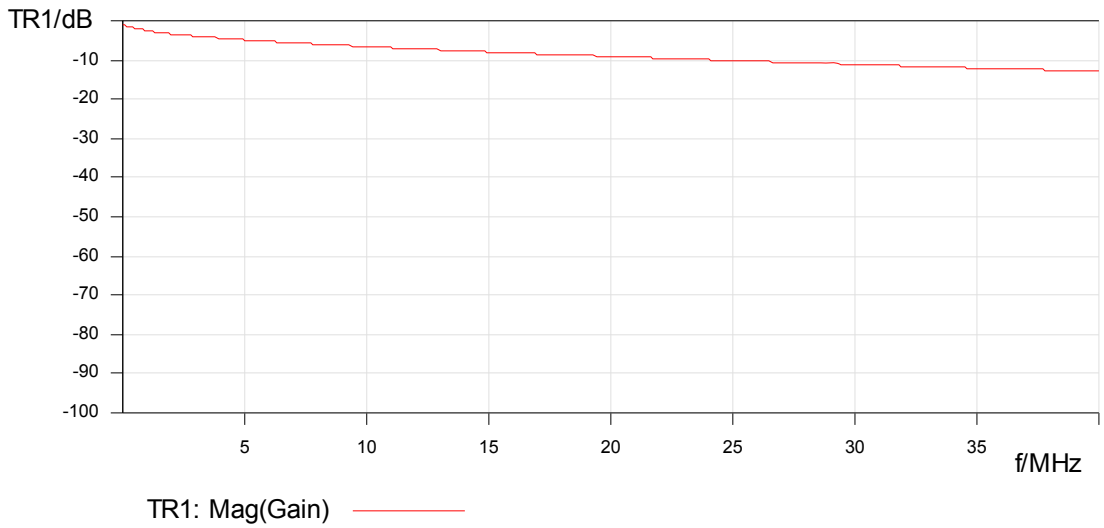
3.2 Measurement setup instructions:

- The measurement examples covered in this application note are only performed for one pair. The other wire pairs are measured exactly the same way.

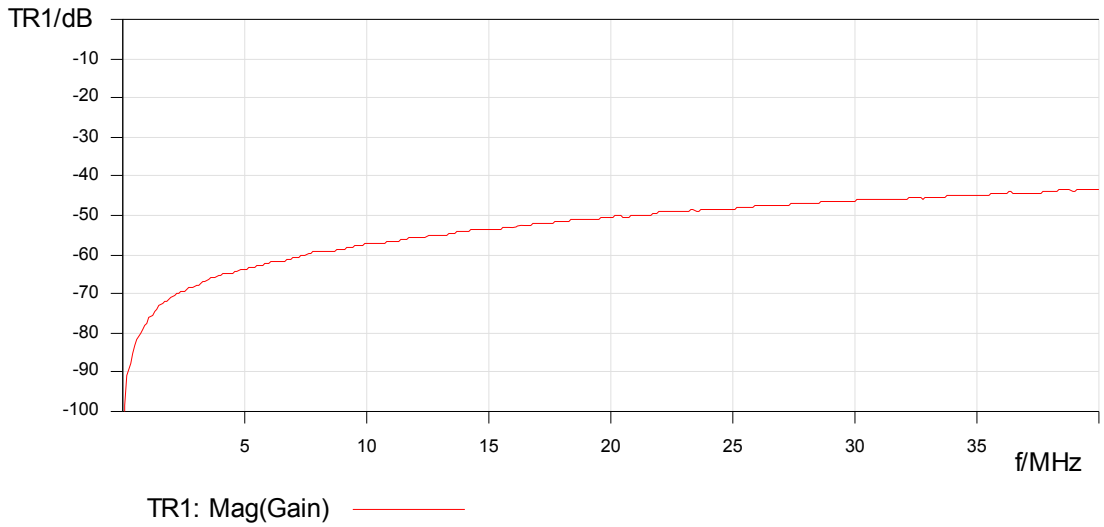
- The used DSL-Cable consists of 4 quads. Every quad has 2 pairs. To obtain an accurate measurement result all unused pairs (of every quad) should be connected to a LOAD resistor at the near and far end. This additional information is not mentioned at every measurement setup.

3.3 ELFEXT calculation:

To calculate ELFEXT of our DSL-Cable, we need the Cable-Attenuation and FEXT measurement results from mentioned Application Note.
Here are the Cable-Attenuation measurement results:



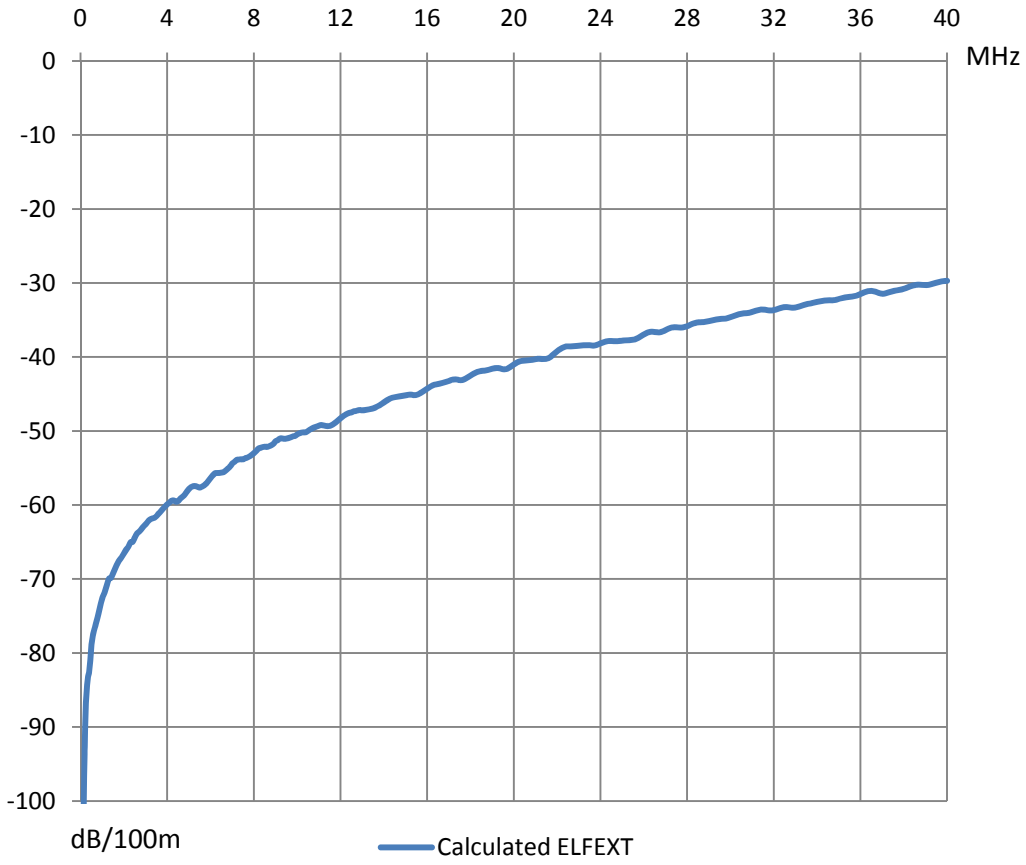
And the FEXT measurement:



Note: To measure the Cable-Attenuation and FEXT, see the mentioned Application Note.

Now it is possible to calculate the ELFEXT by:

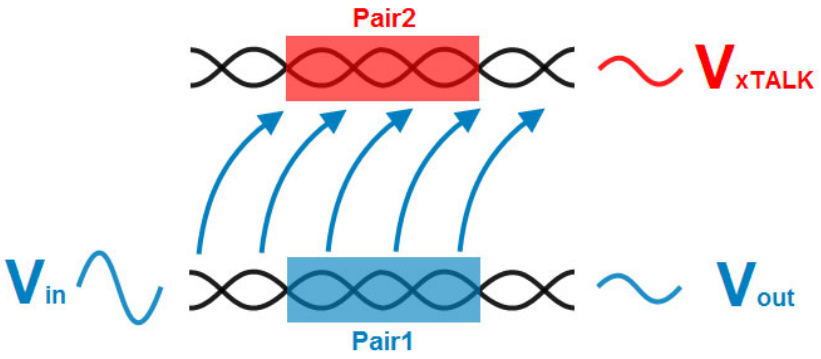
ELFEXT = FEXT – Cable-Attenuation



Note: To calculate ELFEXT it is advisable to export the measurement data traces to EXCEL as shown on page 11 of the App-Note.

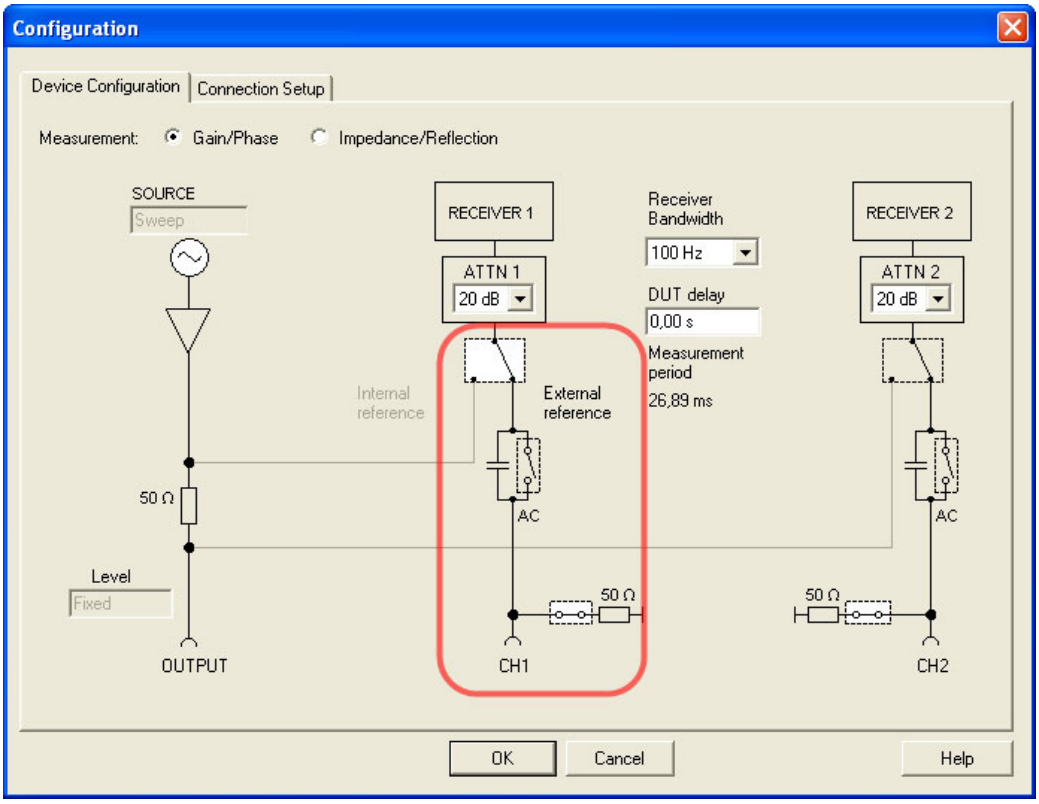
3.4 ELFEXT measurement:

Far End Crosstalk (FEXT) is the coupling between nearby pairs at the far end of the cable pair. Far end crosstalk can also be expressed as Equal Level Far End Crosstalk (ELFEXT), measured in dB. ELFEXT is measured with respect to the attenuated test signal as shown.

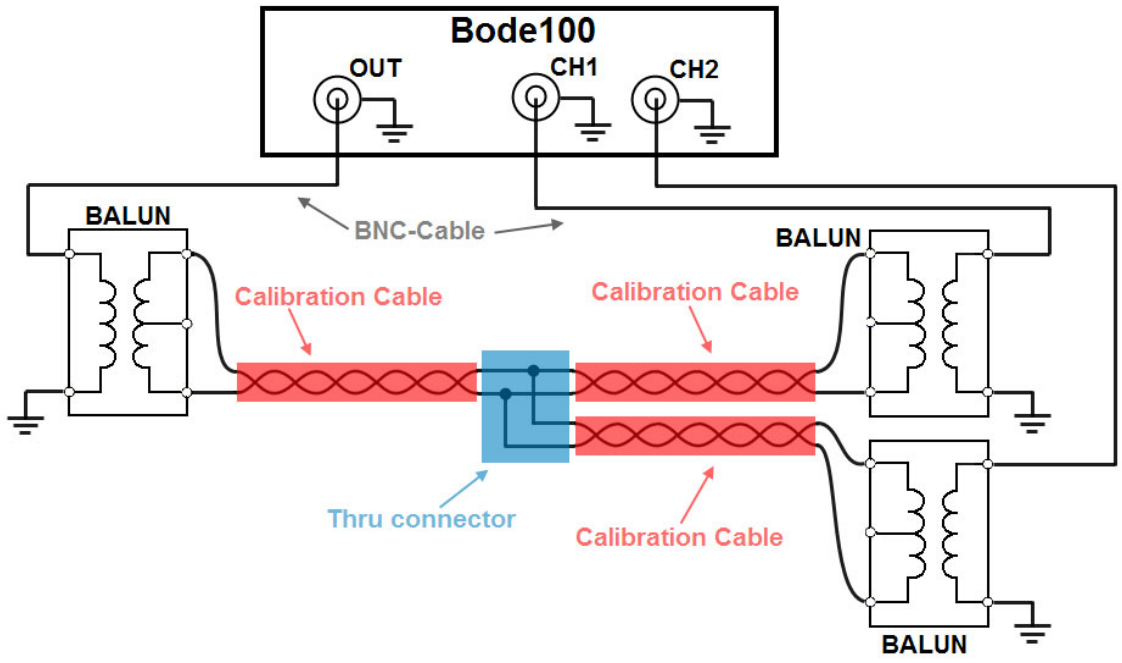


$$ELFEXT = \frac{V_{xTALK}}{V_{out}}$$

The setup for the ELFEXT measurement is almost similar to the NEXT setup. Change to the following configuration:

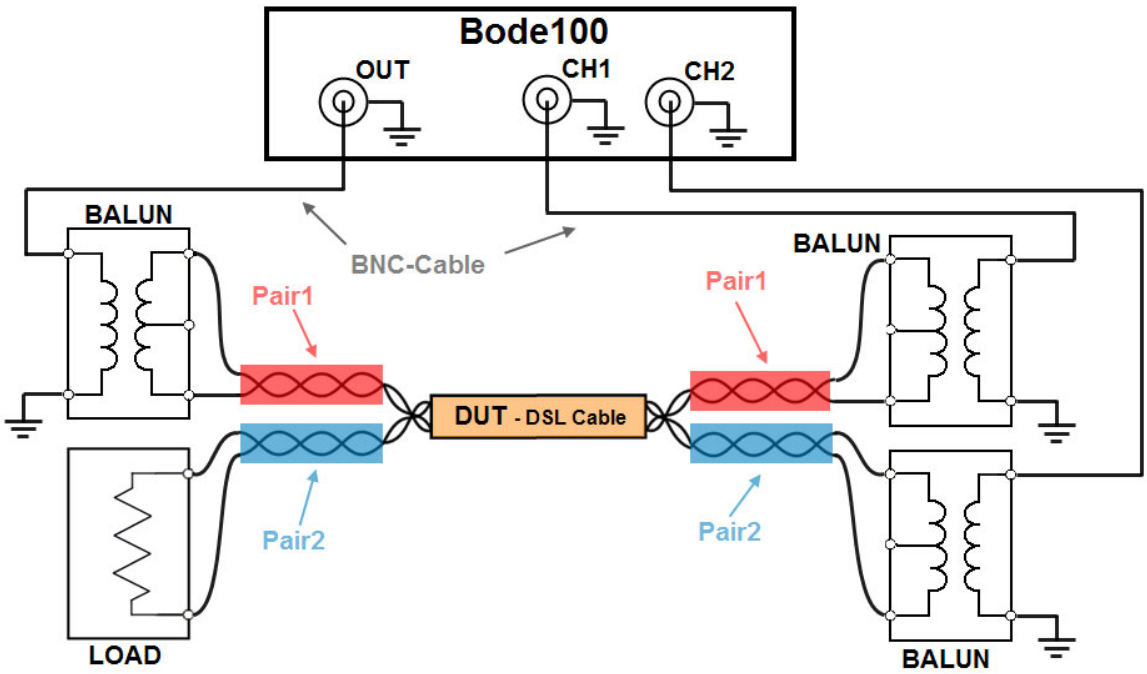


To minimize the influence of the BALUNs and cables used to connect the DUT to the Bode 100 it is advisable to perform a THRU calibration as shown in the manual in the section "Calibration in the Gain/Phase mode". Connect the Bode 100 as shown.

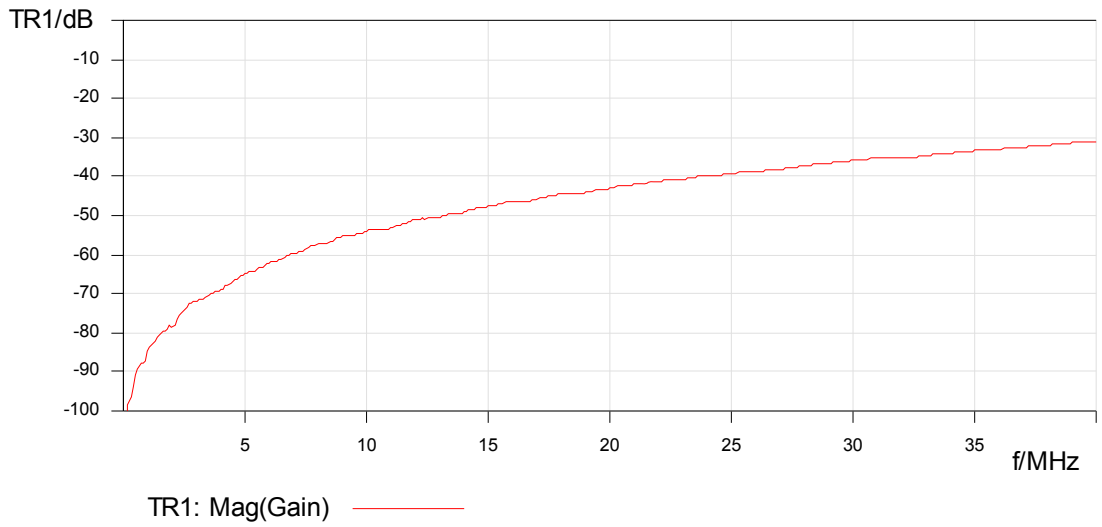


Note: As we can see, there is a mismatch, because two Baluns with an impedance of 50ohm are connected parallel. We are aware of this mismatch, but for the calibration we indicate, that CH1 and CH2 of the Bode 100 need the same signal level.

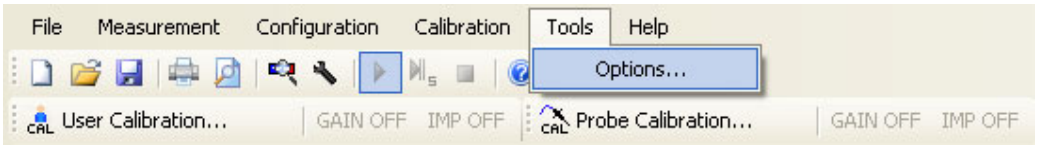
After the calibration connect the DSL-Cable as shown and start the ELFEXT measurement.

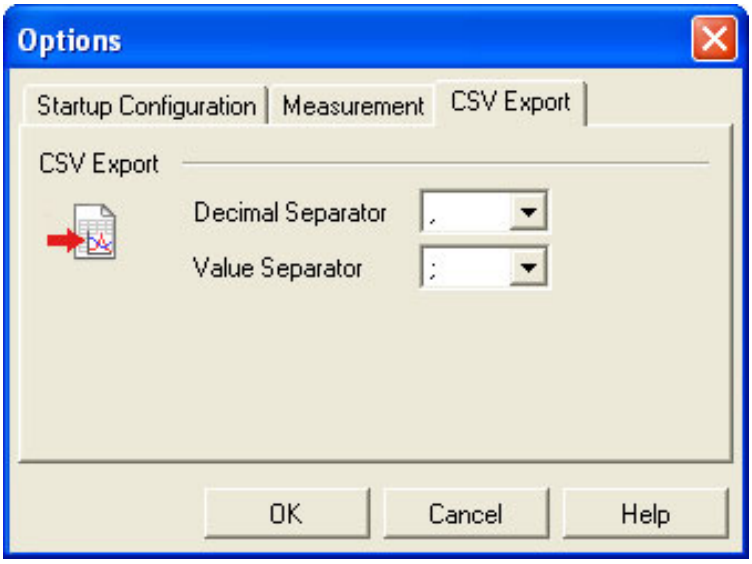


The diagram below shows the result of the ELFEXT measurement.

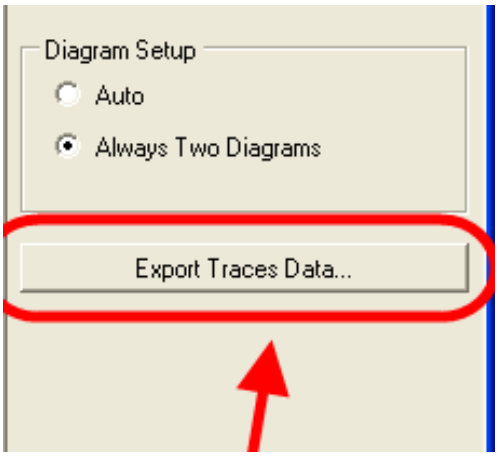


To add an "upper limit" (to find out if the cable passes the requirements defined in the chosen normative std.), export your traces data into CSV File which can be processed in software such as e.g. EXCEL or MATLAB. Before you export the traces data, set the CSV-Export settings according to your requirements as shown.

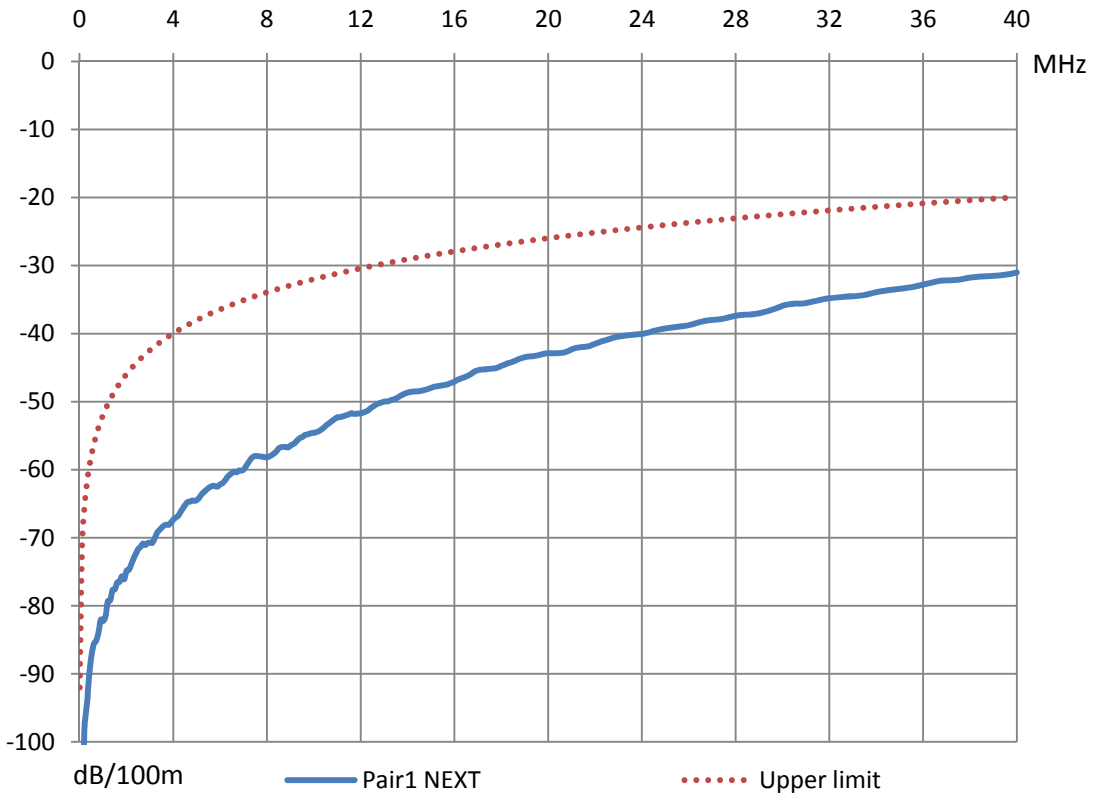




Now press the "Export Traces Data..." button on the right side of the Bode Analyzer Suite. Save the .CSV-File and open with EXCEL or MATLAB.

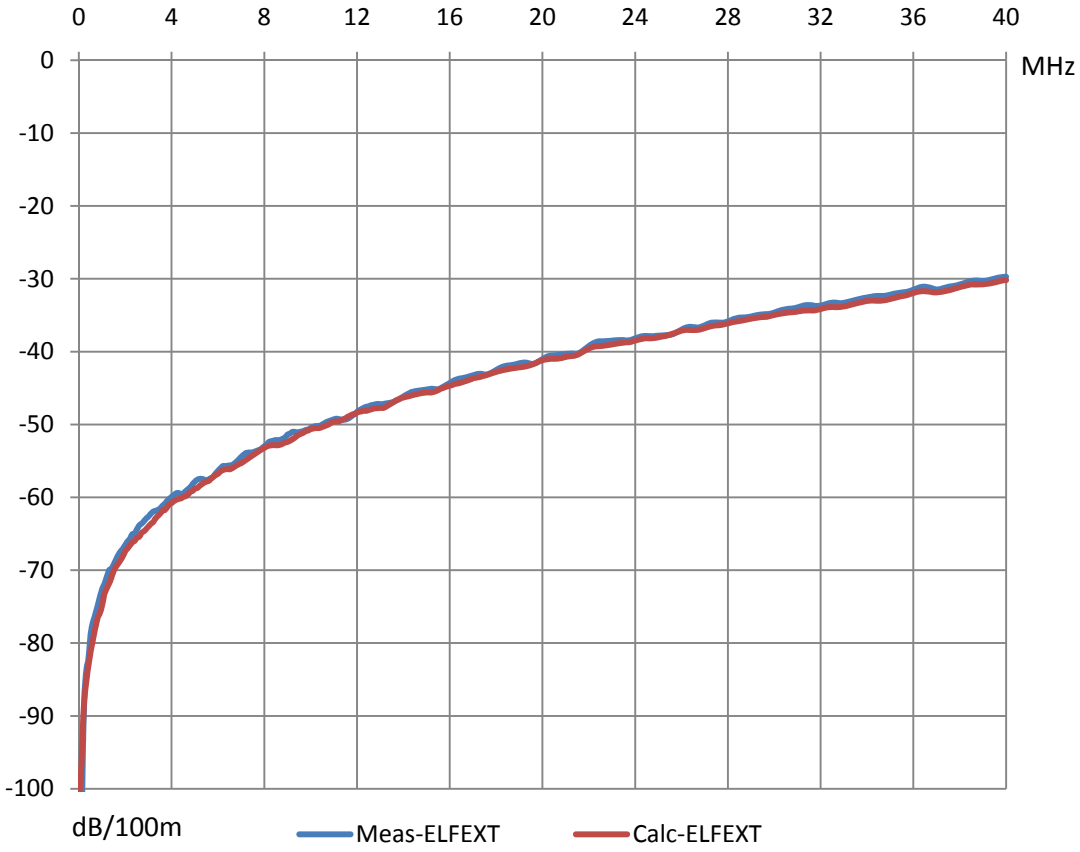


This graph shows that the ELFEXT is below the required limit. The used DSL-Cable has passed the crosstalk test. The "upper limit" is according to IEC 62255-3.



3.5 Comparison of ELFEXT calculation and measurement:

To verify the ELFEXT measurement result we compare it to the calculation.



As we can see, there is no significant difference between the calculation and measurement. For that reason the direct measurement somehow is an alternative to the calculation and can be used to verify calculation results.