Balanced measurements on Communication Cables up to and above 3 GHz

During an Ad-hoc meeting of some Experts of the International Standardisation of Communication Cables, Ballmann electronica GmbH presented their new Networkanalyser (NWA) for balanced measurements up to and above 3 GHz at the RF-and EMC-Laboratories of bedea on 4/5.09.2000 in ASSLAR .

The new Ballmann NWA is suitable to measure the electrical characteristics of balanced cables up to and above 3 GHz. In combination with the *bedea* CoMeT test set-up additionally the screening parameters like transferimpedance, screening attenuation and coupling attenuation on balanced cables may be measured up to and above 3 GHz.

Attendees:	Ralf Ballmann	Ballmann Electronica
	Hans-Joachim Fabry	
	Bernhard Mund	bedea
	Dr. Lauri Halme	Helsinki University of Technology
	Thomas Hähner	Alcatel Cable France
	Dirk Wilhelm	GHMT

Principles

Usually NWA have coaxial in- and outputs. Thus when measuring balanced cables the use of impedance transfering baluns or 180 degree hybrid coupler is required.

The drawback of such equipment is as follows:

∇ frequency range limited to approx. 1.2 GHz
∇ decreasing common mode rejection with increasing frequency
∇ the calibration and thus the measurement accuracy of S_{11}/S_{22} respectively impedance and (structural) return loss at high frequencies is faulty.

A symmetric or balanced signal is given, when the voltage amplitude against ground of the a-wire and b-wire is equal and the phaseshift is 180 degree between the two wires.

The new NWA of BALLMANN uses two generators respectively two receiver at each port respectively for each line. The generators are automatically controlled and tuned to an equal output voltage and a phaseshift of 180 degree directly at the measuring plane.

In contrary to common NWA, the BALLMANN NWA is equipped with remote test ports, which allow to connect the test specimen directly to the measuring ports without additional test leads. The external test heads includes the complete RF receiving section of the network analyzer. Thus the reproducibility and accuracy of the measurements is increased by eliminating all the errors generated by test leads.

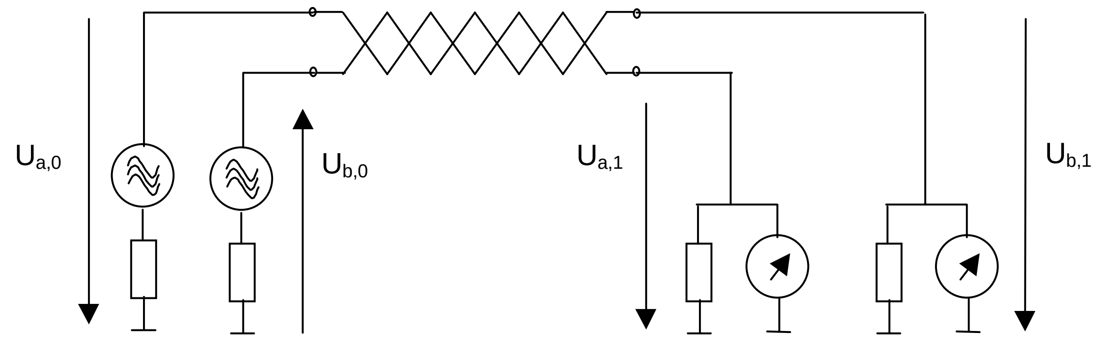

Fig. 1: Principle of the new test set-up

A symmetrical cable is then connected to the test heads at both ends. Where one test head feeds the voltage with a phase of 0 degree and the other with 180 degrees. Measuring the scattering parameters of all pairs from both ends, all electrical characteristics of the cable may be calculated from this measurement.

Scattering parameters and calibration

The most critical measurement is the S_{11}/S_{22} respectively the return loss. The measurement accuracy is strongly dependent on the calibration.
With coaxial ports of a NWA one is using usually an Open/Short/Load calibration. Where the load calibration is the most critical, as the measured cable value is close to the load value. The accuracy of the load resistance for calibration defines the directivity of the test set-up.

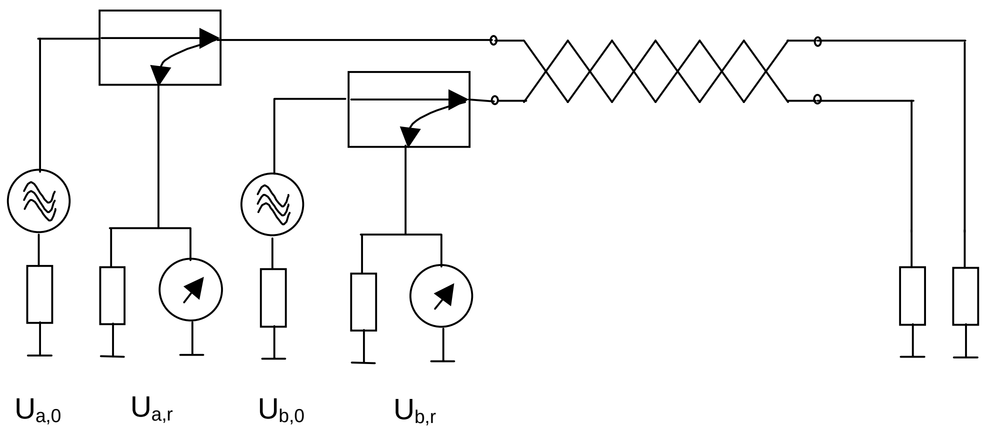

Fig. 2 – Test set-up for impedance and return loss measurements

At balanced measurements, when baluns or hybrid coupler are used, usually one take a commercial available 100Ω resistor to achieve the load calibration. But at high frequencies the value of the load resistor changes due to parasite capacitances and inductances.
Assuming, that at high frequencies the load resistance is 120Ω one get an error of 5,5 dB when measuring a value of –20 dB.

With the BALLMANN system one could use the coaxial calibration standards, which are working up to several GHz with high accuracy. The influence of the port extension (semirigid cables) to connect the cable under test (see above clause 1) could be eliminated by the electrical delay function of the NWA. Thus the directivity is about 50 dB (also for balanced measurements) and the measurement errors are reduced significantly compared to balun measurements.

Screening Characteristics

With the new NWA in combination with the *bedea* CoMeT system it is possible to measure the screening attenuation and the coupling attenuation of screened balanced cables up to and above 3 GHz.

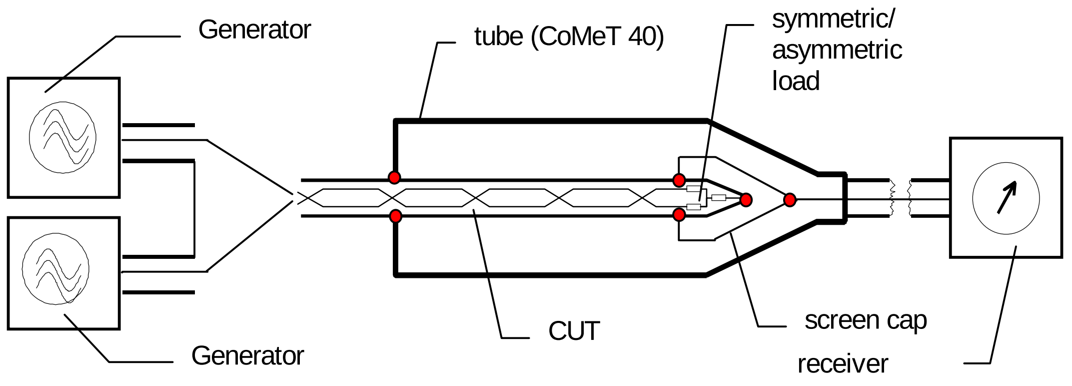

Fig. 4 – Priciple set-up to measure the coupling attenuation of screened balanced cables

The coupling attenuation is the sum of the screening attenuation and the unbalance attenuation.

Thus, when measuring screening attenuation and coupling attenuation, the difference of both measurements may be calculated as the unbalance attenuation. In this way, direct unbalance measurements may be proven.