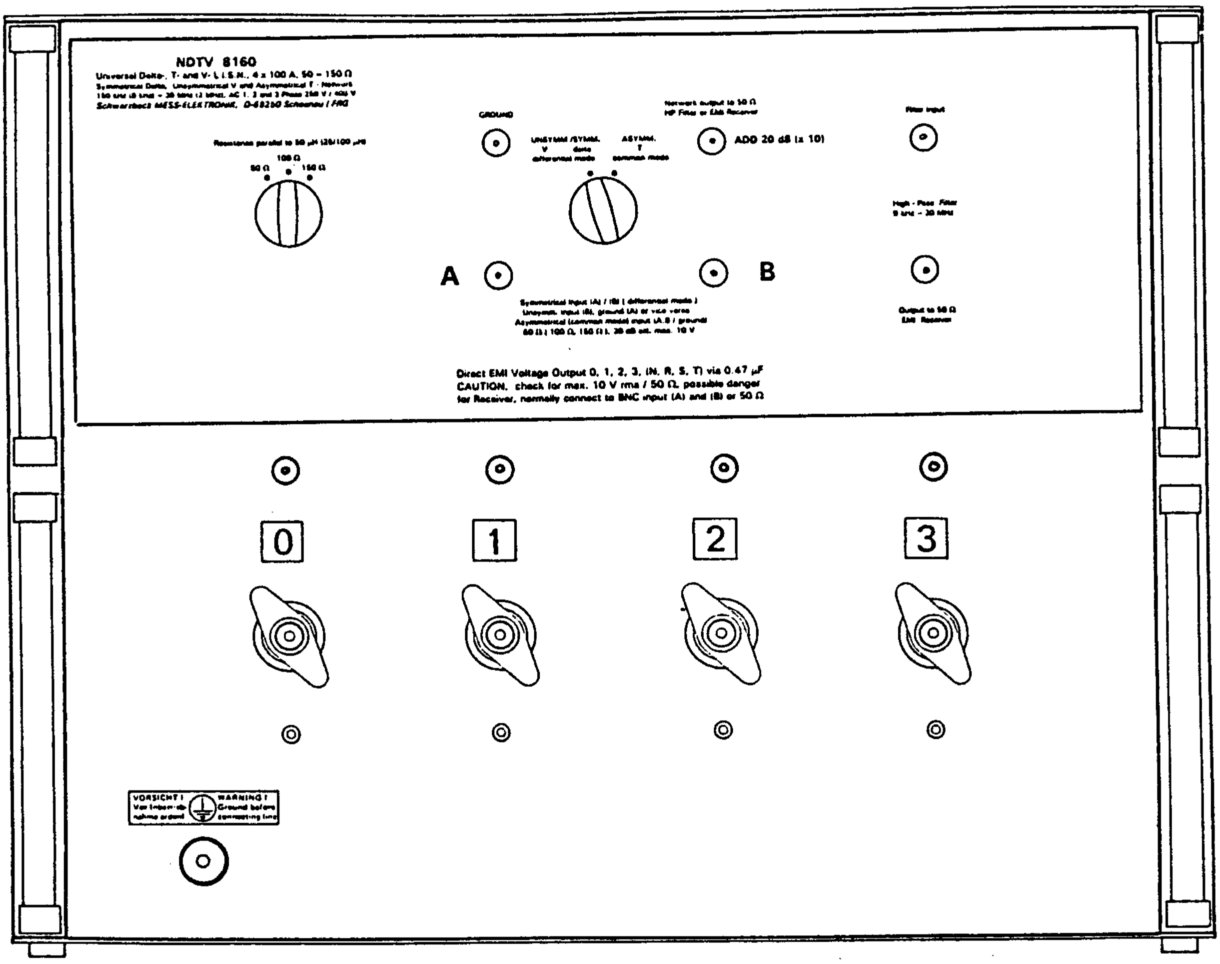
NDTV 8160

Universal Delta-, T- and V- L.I.S.N., 4 x 100 A, 50 -- 150 Ω

Symmetrical Delta, Unsymmetrical V and Asymmetrical T - Network

150 kHz (9 kHz) -- 30 MHz (2 MHz), AC 1, 2 and 3 Phase 250 V / 400 V

Schwarzbeck MESS-ELEKTRONIK, D-69250 Schoenau (FRG)



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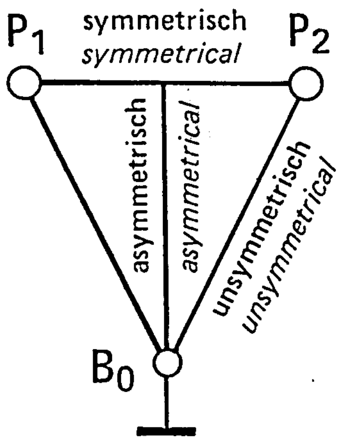
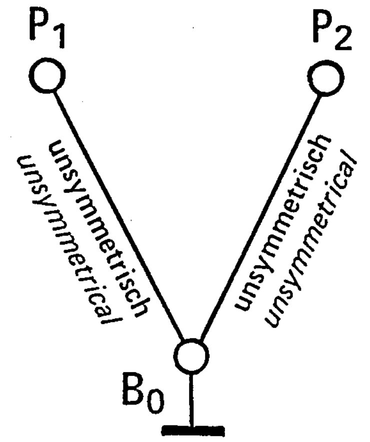
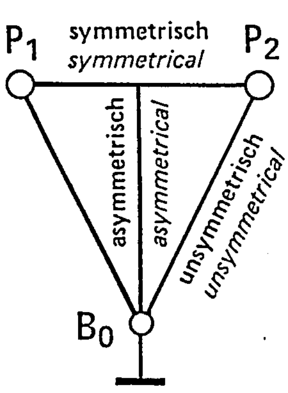
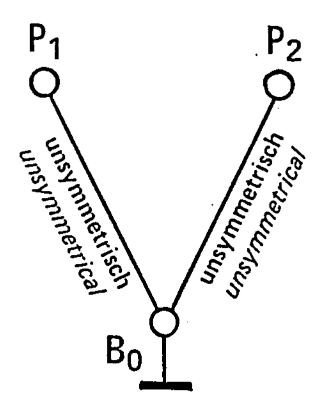
Netznachbildungen (allgem.) *L. I. S. N. s (gen.)*

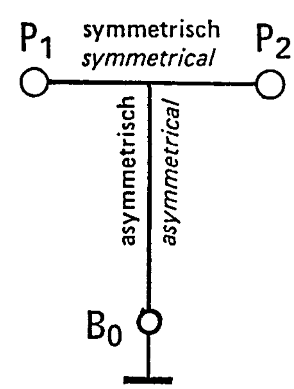




P_1: Prüflinganschluß 1 (z.B. „N")	*Terminal 1 of Equipment under Test (EuT)*
P_2: Prüflinganschluß 2 (z.B. L_1)	*Terminal 2 of Equipment under Test*
B_0: Bezugsmasse, Chassis, Metallwand	*Reference (r.-f.) Earth Ground of Test System*
P_1/P_2: symmetrische Spannung	*P_1/P_2: Symmetrical (Differential) Voltage*
Mitte v. P_1 und P_2 gegen B_0: asymmetr. Gleichtaktspannung	*Center between P_1 & P_2 to B_0 asymmetrical common mode*
P_1/B_0 und P_2/B_0: unsymmetr.Spannung	*UNSYMMETRICAL VOLTAGE (V-Network)*



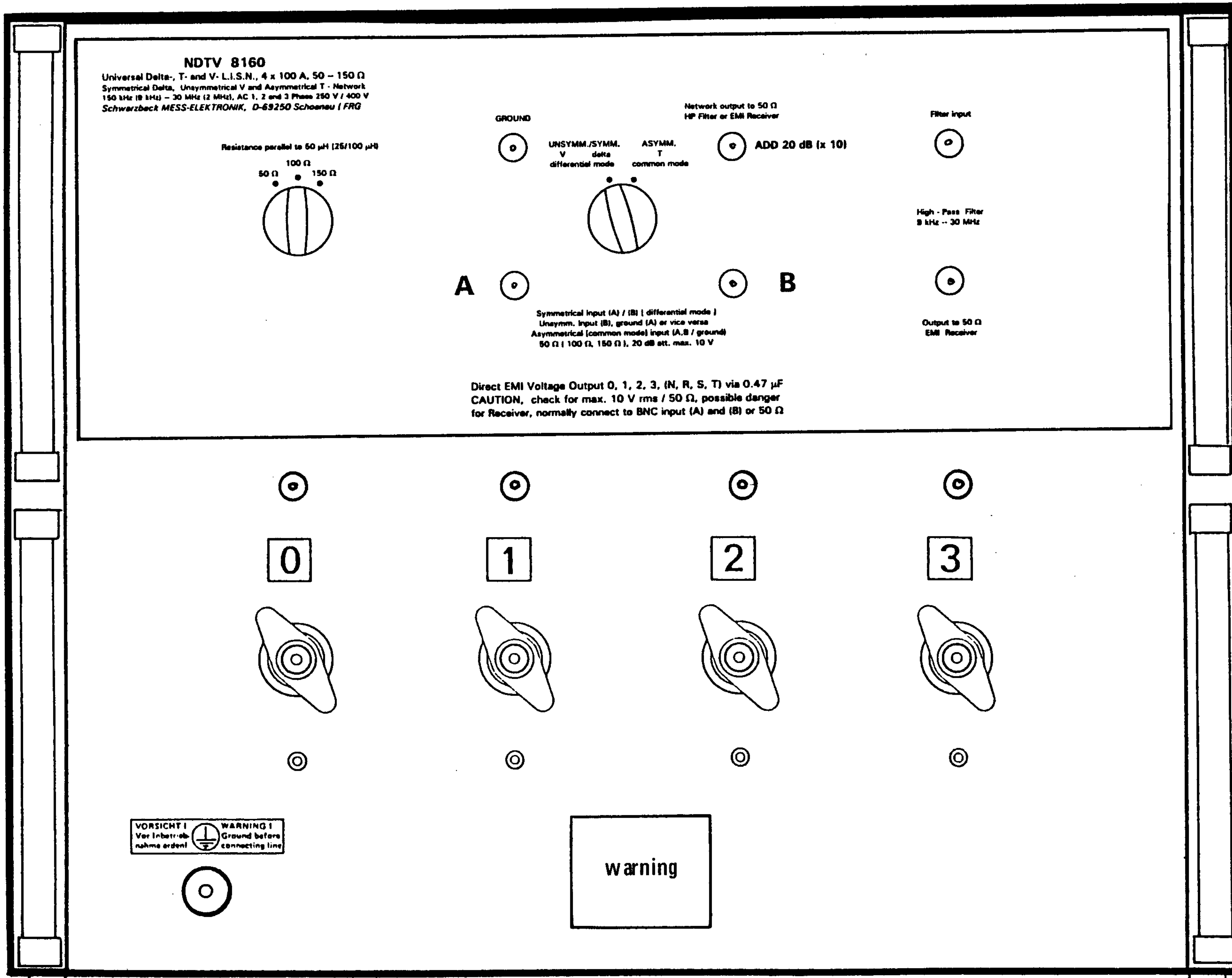


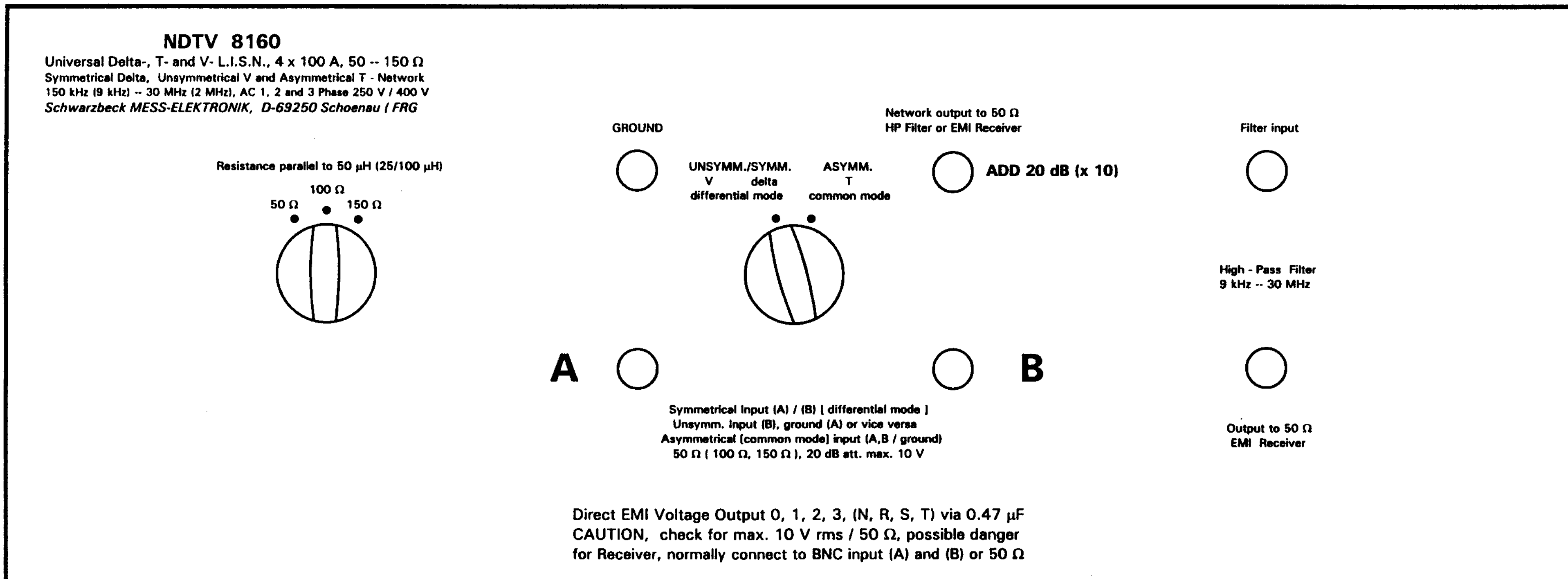


Das linke Bild zeigt die 3 Möglichkeiten der Spannungsbeziehungen von zwei Leitungen (Pole bzw. Pfade P1 und P2) und der Bezugsmasse ("Erde") B₀. Die Spannung *zwischen den Polen P1 und P2* ist gegenüber der Bezugsmasse **"erd-symmetrisch"**. Sie könnte zunächst auch "potential-ungebunden" (floating) sein, würde aber durch ein symmetrisches Belastungsnetzwerk im gedachten Mittelpunkt auf Nullpotential gebracht. Wenn diese symmetrische Spannung z.B.10 Volt beträgt, ist bei Erdsymmetrie die Spannung an Pol 1 und an Pol 2 jeweils 5 Volt gegen Bezugsmasse.

Diese 5-V-Spannung gegen Masse wird als **" unsymmetrische Spannung"** bezeichnet und tritt auf zwischen P1 gegen Bezugsmasse und ebenso zwischen P2 und Masse.Mit Spannungspfeilen ähnelt das Bild dem Buchstaben V. (jeweils zweites Bild).

Bei perfekter Symmetrie ist die "Mittelpunktspannung" zwischen P1 und P2 null Volt gegen Masse. Dieser **"asymmetrische"** Spannungspfeil ergänzt den symmetrischen Spannungspfeil zum Buchstaben "T". Wenn die symmetrische Komponente null ist, wird auch von einer **Gleichtaktspannung** der Pole P1 und P2 gegen Masse gesprochen. In der Praxis treten oft alle 3 Varianten gemischt auf, können aber meßtechnisch getrennt werden. Danach können die Filterkomponenten gezielt dimensioniert werden.


NDTV 8160
Universal Delta-, T- and V- L.I.S.N., 4 x 100 A, 50 – 150 Ω
Symmetrical Delta, Unsymmetrical V and Asymmetrical T - Network
150 kHz (9 kHz) – 30 MHz (2 MHz), AC 1, 2 and 3 Phase 250 V / 400 V
Schwarzbeck MESS-ELEKTRONIK, D-69250 Schoenau / FRG
Resistance parallel to 50 µH (25/100 µH)
50 Ω
100 Ω
150 Ω
GROUND
UNSYMM./SYMM.
V delta
differential mode
ASYMM.
T
common mode
Network output to 50 Ω
HP Filter or EMI Receiver
ADD 20 dB (x 10)
Filter input
High - Pass Filter
9 kHz -- 30 MHz
A
B
Symmetrical Input (A) / (B) (differential mode)
Unsymm. Input (B), ground (A) or vice versa
Asymmetrical (common mode) input (A,B / ground)
50 Ω (100 Ω, 150 Ω), 20 dB att. max. 10 V
Output to 50 Ω
EMI Receiver
Direct EMI Voltage Output 0, 1, 2, 3, (N, R, S, T) via 0.47 µF
CAUTION, check for max. 10 V rms / 50 Ω, possible danger
for Receiver, normally connect to BNC input (A) and (B) or 50 Ω
0
1
2
3
VORSICHT ! Vor Inbetriebnahme erden!
WARNING ! Ground before connecting line
warning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N D T V 8160 4 x 100 Amp. DELTA / T- / V- L. I. S. N.

SHORT FORM INSTRUCTION

1. **Connect Equipment under Test (EuT) to the front panel wing screw terminals, the 4 paths are alike, but normally "0" is used for the neutral line (not protection earth ground, this is connected to the chassis of the LISN, one or 2 of the naked brass screw terminals near the bottom.) W A R N I N G : these terminals** ***must be connected to earth ground b e f o r e power line voltage is applied to the rear wing screw terminals. In single phase operation very high ground currents will flow to ground through the 10 µF filter capacitors, 0.6 amp with 230 V rms., 0.3 amp. with 100 to 115 V / 50 Hz. Power lines equipped with ground-current sensing safety switches can n o t be used, except with an isolating transformer.***

   For single phase applications, terminals 0 and 1 (or 1 and 2) may be used, for 3 phase EuT's use terminal "0" for neutral potential and 1, 2 and 3 for the 3 phase power line.

2. **If you are sure that a protection earth ground connection to the brass screw terminals is perfect, connect the power line to the rear 100 amp. wing screw terminals, again with the neutral to "0" and the 3 phases R, S and T to terminals 1, 2 and 3.**

3. **Now there is mains power line voltage at the front panel wing screw terminals. There is only limited protection against touching the live terminal parts, so instruct the user or add some external protection cover. Use of such LISN's must be restricted to** ***well-trained experienced personnel.***

4. **The EMI (Electromagnetic Interference) voltage now appears at the BNC coaxial sockets via 0.47 µF coupling capacitors with 10 kilo-ohm shunts to ground to reduce the power-line sine wave 50 Hz or 60 Hz component. With great care normal conducted EMI measurements can be performed as in standard V - LISN's by connecting the 50 ohm EMI receiver input to the line to be measured and terminating all BNC-sockets not used into 50 ohm male-BNC plugs.**

CAUTION !

Depending on the type of E.u.T. there might be considerable power (e.g. pulse spectra, transients and also some low level of power line sine wave current) at these BNC output sockets. There is d a n g e r of damaging receiver input components such as attenuator resistors or semiconductors at the front-end. Use external 20dB p o w e r attenuators and/or the High-Pass Filter in this LISN to reduce risks. The high-pass filter reduces low- and medium-frequency EMI components that might be excessively strong in the range below 9 kHz, the lowest frequency to be measured.

A very convenient chance is to start with high-impedance ***oscilloscope time domain checks*** **at these "direct" BNC outlets to make sure that only voltages compatible with the EMI receiver are present. Do not miss a transient check with turn-on / turn-off of the E.u.T. At these BNC sockets the full EMI voltage against ground is available (0dB attenuation, 0 dB correction).**
Overload problems to the receiver do not exist if the LISN mode and switching network is used as this has an inherent 10 : 1 voltage reduction. In this case +20 dB are added.

APPLICATION of L.I.S.N. N D T V 8160 w i t h mode network (Delta/V/T)

The previous instruction has shown the simple standard unsymmetrical V - LISN EMI measurement directly at the coaxial BNC outputs near the EuT wing screw terminals. This is the mostly used conducted interference testing of power line operated equipment.

The classical *DELTA NETWORK* is defined in CISPR Publication 16-1 (1st ed.1993) for an impedance of 150 ohm both symmetrical and asymmetrical. Such a device requires r.-f.-transformers of high impedance (above 1000 ohm) to avoid shunt effects to the 150 ohm network. This limits the possible frequency range to "long-wave and medium-wave" range, and the officially required specifications limit the range to 2 MHz. In the national compliance regulations it is still required by Scandinavian countries and Switzerland, and it was the preferred test method for TV equipment in France and Italy. Delta networks are used world-wide for the determination of the *type of interference* in different frequency regions to design the optimum economical EMI suppressor filters (to decide the size and connection of capaci-tors, to clear the question if ferrite toroidal coils should be wound in normal or bifilar mode etc.).

150 ohm LISNs had to be equipped with *i r o n - c o r e* inductors to meet the requirement of *high impedance* in the frequency range 150 kHz to 2 MHz. Air coils would not provide sufficient inductive impedance well over 2000 ohm, while iron-core inductors will cause severe problems due to the non-linearity, saturation effects and disturbance of the equipment under test because of the high series impedance of milli-henry coils that change the control characteristics of modern semiconductor equipment that is designed for near-zero-impedance power line supply.

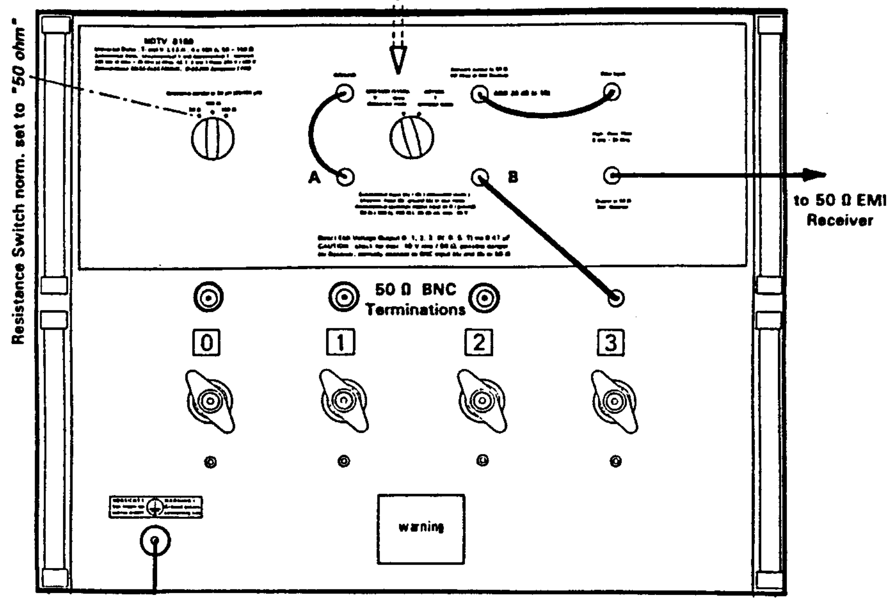
This type of iron-core 150 ohm LISN is definitely unuseable for high-current equipment because - in addition to the reasons mentioned above - the voltage drop across milli-henry iron-core inductors is far too high and might result in voltage drops of 20% or 30% or even more. A 3 phase version is not possible for other reasons shown below.

All these problems led to the preferred measurement of only unsymmetrical EMI voltages with low-impedace air-core-coil LISNs. The constant impedance of 150 ohm inde-pendent of frequency was in no way near the actual situation in modern high-power domestic and industrial power line distribution systems. The new impedance definition was 50 ohm parallel to 50 µH. This represented real-life power lines that show a small r.-f. impedance in the low frequency ranges and approaches the "characteristic line impedance" near 50 ohm in the short-wave range.

This permits the use of perfectly linear air-core coils that may be manufactured up to several hundred amperes of current. While with the classical DELTA LISN the nominal impe-dance is a pure resistance (the high Z of the main chokes may be neglected across 150 ohm symmetrical and 150 ohm asymmetrical) the inductive impedance of a 50 ohm // 50 µH system will be different in the case of symmetrical mode where two 50 µH inductors load the EuT in series connection (100 µH) and in asymmetrical (common mode) where they appear in parallel and load the EuT with 25 µH. In contrast to this the resistive part may be switched to different standardized values, e.g. 50 ohm, 100 ohm and 150 ohm. In a practical application, two different loading resistor groups must be used, one with the nominal values across the transformer section for symmetrical / unsymmetrical measurement and another twin-group of twice these values to ground for common mode / asymmetrical as they appear in parallel.

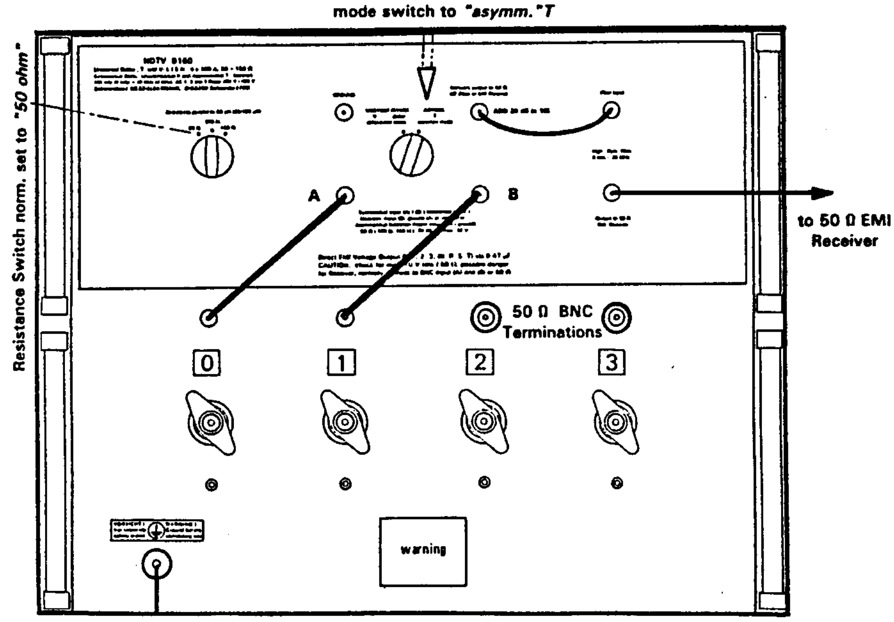
Unsymmetrical Measurement (V - mode) path 3 against ground, path 1, 2 and 3 termin. to 50 Ω BNC; add 20dB

mode switch to *"unsymm."(V), "symm."(delta)*



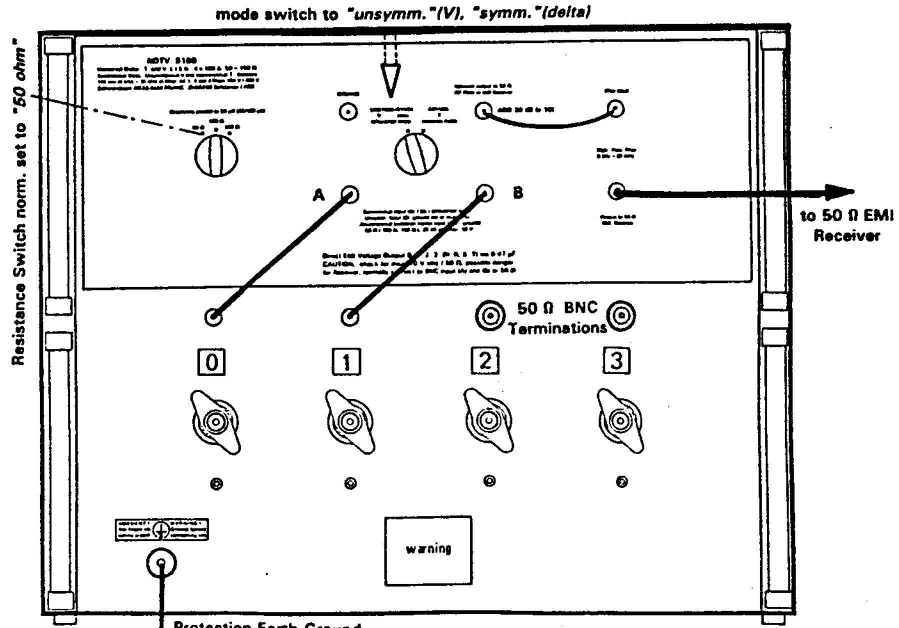
Asymmetrical Measurement, path 0 and path 1 (T-mode) common mode (0) and (1) against ground, add 20 dB

mode switch to *"asymm."T*



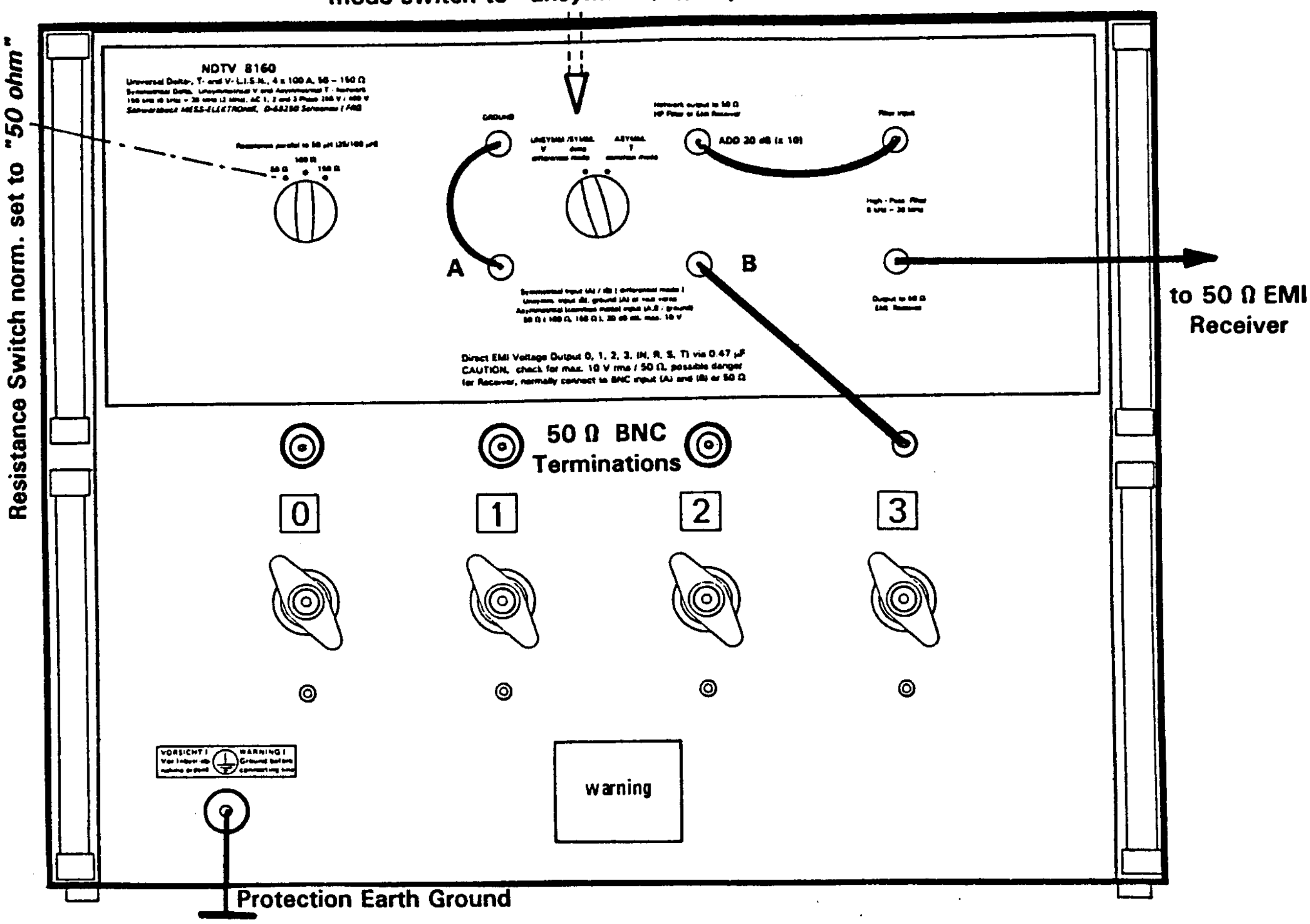
Symmetrical Measurement between path 0 and path 1, differential mode, delta symm., add 20 dB

mode switch to *"unsymm."(V), "symm."(delta)*



Unsymmetrical Measurement (V - mode) path 3 against ground, path 1, 2 and 3 termin. to 50 Ω BNC; add 20dB

mode switch to *"unsymm."(V), "symm."(delta)*



Unsymmetrical Measurement (Standard V-Mode)

EMI Voltage of o n e path against ground, other paths terminated into 50 ohm.

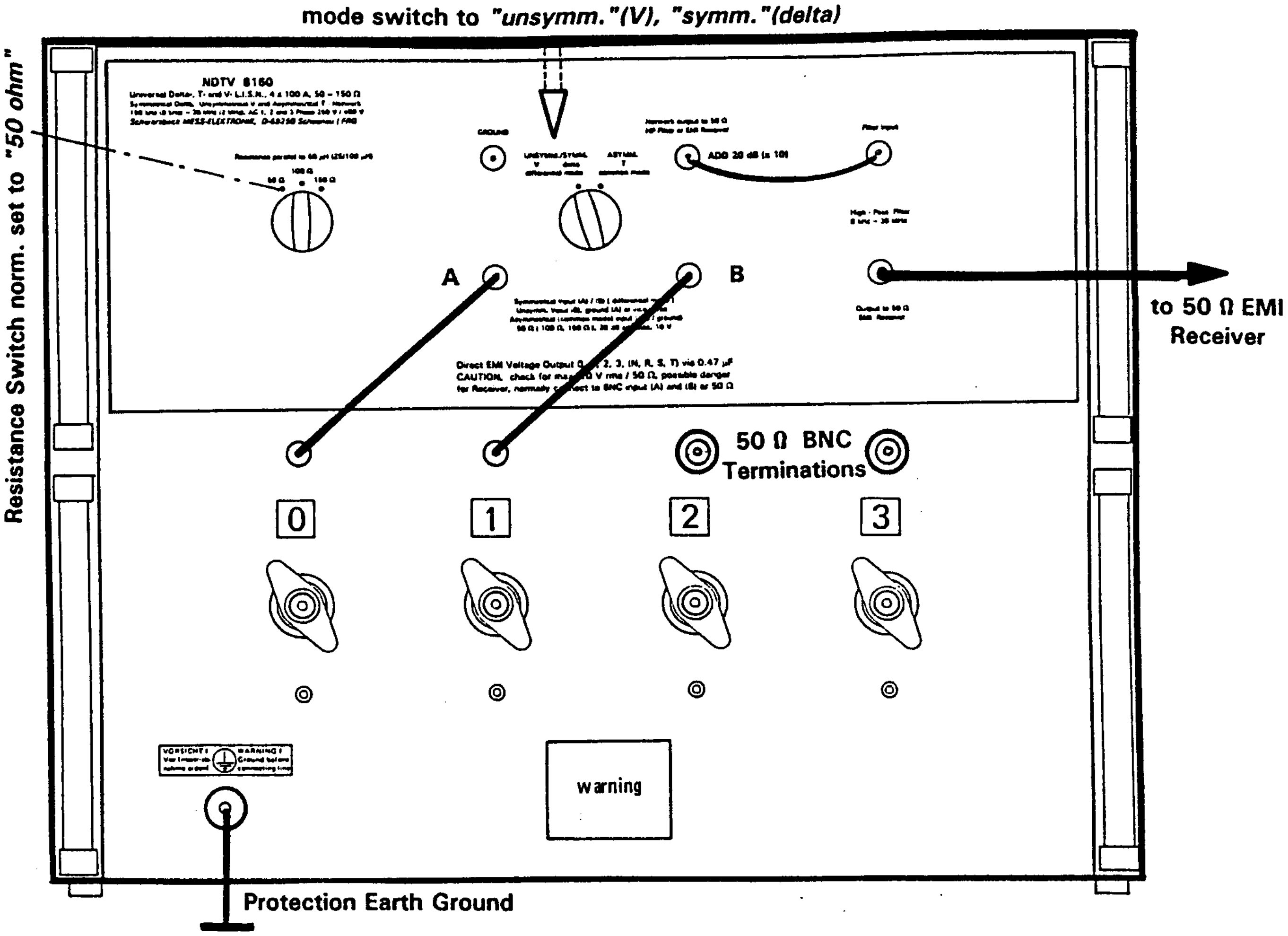
One way with 0 dB correction for highest sensitivity is possible *without* the switching and mode network by simply connecting the 50 ohm input of the EMI receiver to one of the BNC sockets above the wing screw terminals for the E.u.T. (Equipment under Test). There is some risk of damaging the receiver input by high EMI voltages, transients or harmonics of the power line frequency, high risk with semiconductor power controls without EMI suppression filter. In this case it is strongly recommended to route the receiver coaxial line via the HIGH-PASS FILTER that fully opens the transmission from 9 kHz on and the use of pulse limiters.

This inclusion of the HP filter a n d a 20 dB attenuation is the standard application of this ***Universal LISN for V, T and DELTA Measurement*** as shown in the sketch above:
The 20 dB attenuation protects the receiver by a power reduction of 100:1 which is normally acceptable as limit values usually are above 50 dB µV. The inclusion of the high-pass filter further reduces any danger for the receiver. The maximum rms voltage at the inputs (A) and (B) of the mode and resistance switching network (upper half of LISN) is **10 volt** (140 dB µV) corresponding to 2 watt of power. These values may be 10 to 50 times higher for very short pulses; only the *power* is limited to 2 watt. No pulse-sensitive elements are in the mode network, so max. pulse voltage may be10 times higher. This power limit also applies to the 3 BNC plugs with the 50 ohm terminations for the paths that are not measured.

For the unsymmetrical measurement connect as shown in the drawing above, using 3 of the four short BNC cables. Select the test path (one out of 4) and terminate the 3 other BNC outputs above the wing terminals with the 50 ohm BNC-plug terminations (not generally necessary, do *n o t* use them if the EuT generates more than 5 volt, short time 10 v rms across an external high-power 50 ohm resistor). The selected BNC output is connected to either (A) or (B) mode network input. Connect the other BNC (B or A) to the ground-BNC socket above BNC (A) to complete the unsymmetrical mode. Set mode switch to *unsymm./symm. position* (left-hand / first position) and set the resistance switch (normally to 50 ohm). Include the high-pass filter with one more BNC cable as shown. *ADD 20dB to RECEIVER READING in dB µV.*
In case of 3 phase ac change to all 4 paths by selecting each of the 4 BNC outputs.

Symmetrical Measurement between path 0 and path 1, differential mode, delta symm., add 20 dB

mode switch to *"unsymm."(V), "symm."(delta)*



Symmetrical Measurement (Differential / DELTA)

Differential Voltage between t w o path conductors

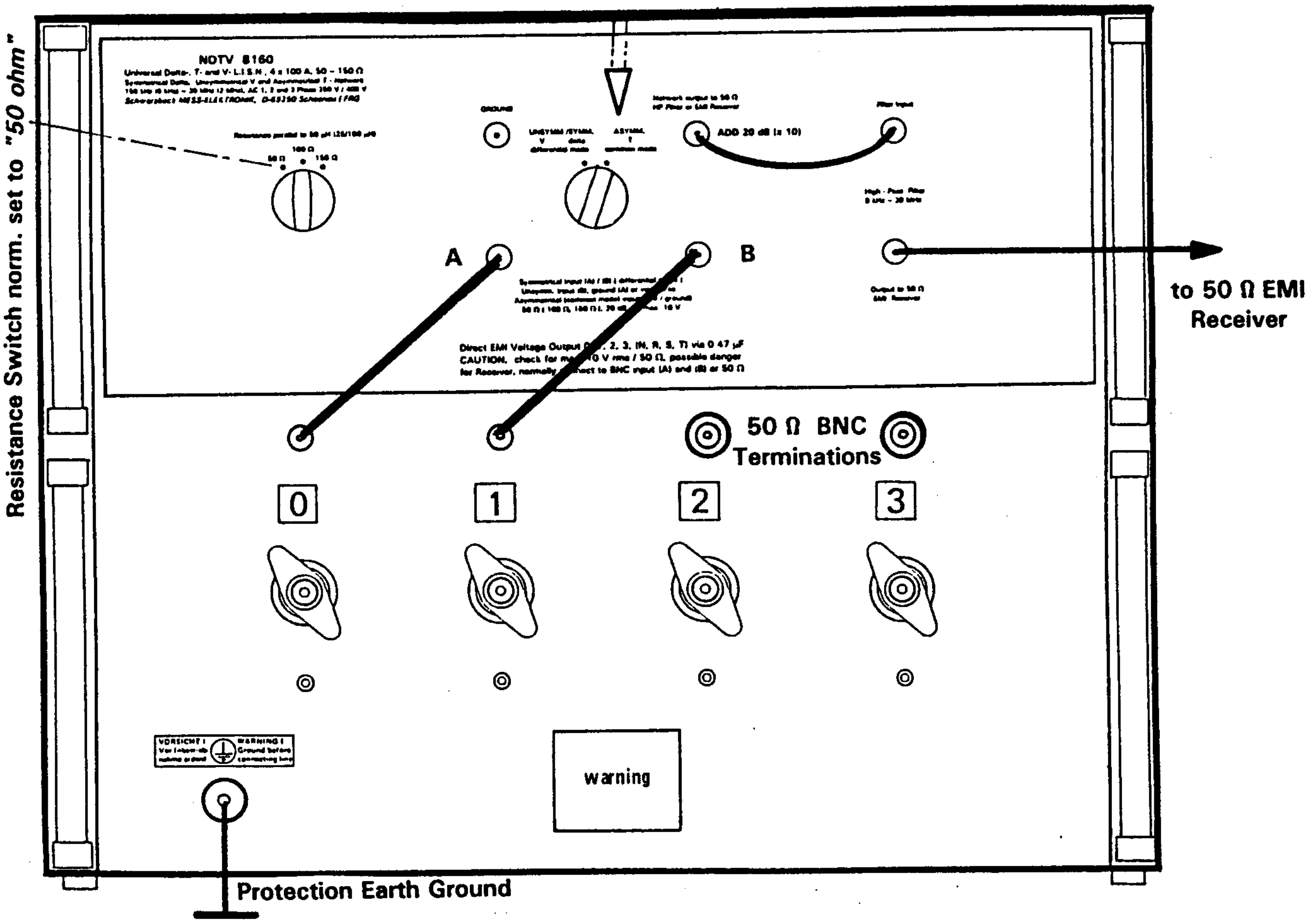
Differential / symmetric measurements can only be performed between *t w o conductors of a multi conductor system. It may be measured in the following combinations: between paths 0 and 1, 0 and 2, 0 and 3, 1 and 2, 1 and 3, 2 and 3. In case of perfect symmetry the unsymmetrical component would be one half of the symm. voltage (if impedances are equal); the asymmetrical (common-mode) component with perfect symmetry is zero.*

Connect the two BNC EMI output BNC sockets above the wing terminals in use to the mode / switching network BNC sockets (A) and (B) with two of the short BNC cables supplied. Terminate the BNC sockets not in use with the 50 ohm termination BNC plugs. Check possible max. output across an external 50 ohm load that it does not exceed 5 V (10 v short term) rms as described in the information for unsymm. measurement. Connect the mode network output BNC to the input of the high-pass filter, using the 3rd short BNC cable, and connect the 50 ohm input of the EMI receiver to the high-pass filter output BNC. *Set the mode switch to the left-hand position (V,delta) "UNSYMM. / SYMM."* and the resistance selector switch to either 50 ohm or 100 ohm.
ADD 20 dB to the RECEIVER READING in dBµV.

In the symmetrical mode the standardized 50 µH inductors load the EuT with 100 µH as both can be considered in series connection for symmetrical r.-f. voltages. This justifies the use of 2 x 50 ohm resistive load (100 ohm switch setting). In case of low EuT impedances the EMI voltage reading will not be considerably different with 50ohm/50 µH or 100 ohm / 100µH loading. With very high EuT impedance (not often found with high power equipment) the voltage will be higher with 100 ohm / 100 µH. This is a way of finding the source impedance which is an important consideration for EMI suppression.
In all applications check the safety grounding of the naked brass screw terminal before connecting LISN to power line.

Asymmetrical Measurement, path 0 and path 1 (T-mode) common mode (0) and (1) against ground, add 20 dB

mode switch to *"asymm."T*



Asymmetrical Measurement (Common Mode)

EMI Voltage of the electrical Centre of two Conductors against ground

Asymmetrical measurements (common mode against ground) can only be performed between *t w o* conductors. (A non-standardised measurement procedure for 3 paths could be a 3 resistor s t a r - connection with the centre point measured against ground. In this case 3 resistors of 50 ohm to 150 ohm 1% non-inductive are connected in a star connection. The common point is measured by using the **unsymmetrical mode** , e.g. at BNC network input (B) with (A) grounded or vice versa. The dB correction in this case would be higher than 20 dB due to the voltage division ratio caused by the star network. A similar case would be a 4 paths combination into 4 equal resistors.)

The standard two-conductor measurement is shown in the drawing above. It corresponds to the measurement set-up of T type LISNs often used for wire communication networks where the symmetrical component is the "wanted" signal (voice or digital / pulse) and the *asymmetrical voltage* represents the interference signal. With perfect symmetry both components can be perfectly separated with DELTA networks (symmetrical / asymmetrical).

The measurement of the asymmetrical voltage is shown above for the terminals (0) and (1). The BNC EMI output sockets above the corresponding wing terminals are connected to the mode network BNC inputs (A) and (B) with two of the short BNC coaxial cables. The mode network output BNC is normally connected to the high-pass filter input, the output with the EMI receiver. Set the resistance switch normally to 50 ohm.

Set the mode network switch to the right-hand position ASYMMETRICAL / common mode. Add 20 dB to the receiver dBµV reading to obtain the EMI voltage at the wing terminals against reference ground. Before connecting to the power line always check the safety ground connection as described. Terminate unused EMI voltage output BNC sockets with the 50 ohm termination plugs, *check for excessive output EMI voltages at the BNC sockets above the wing terminals (max. 10 v rms short term, 5 v continuous).*

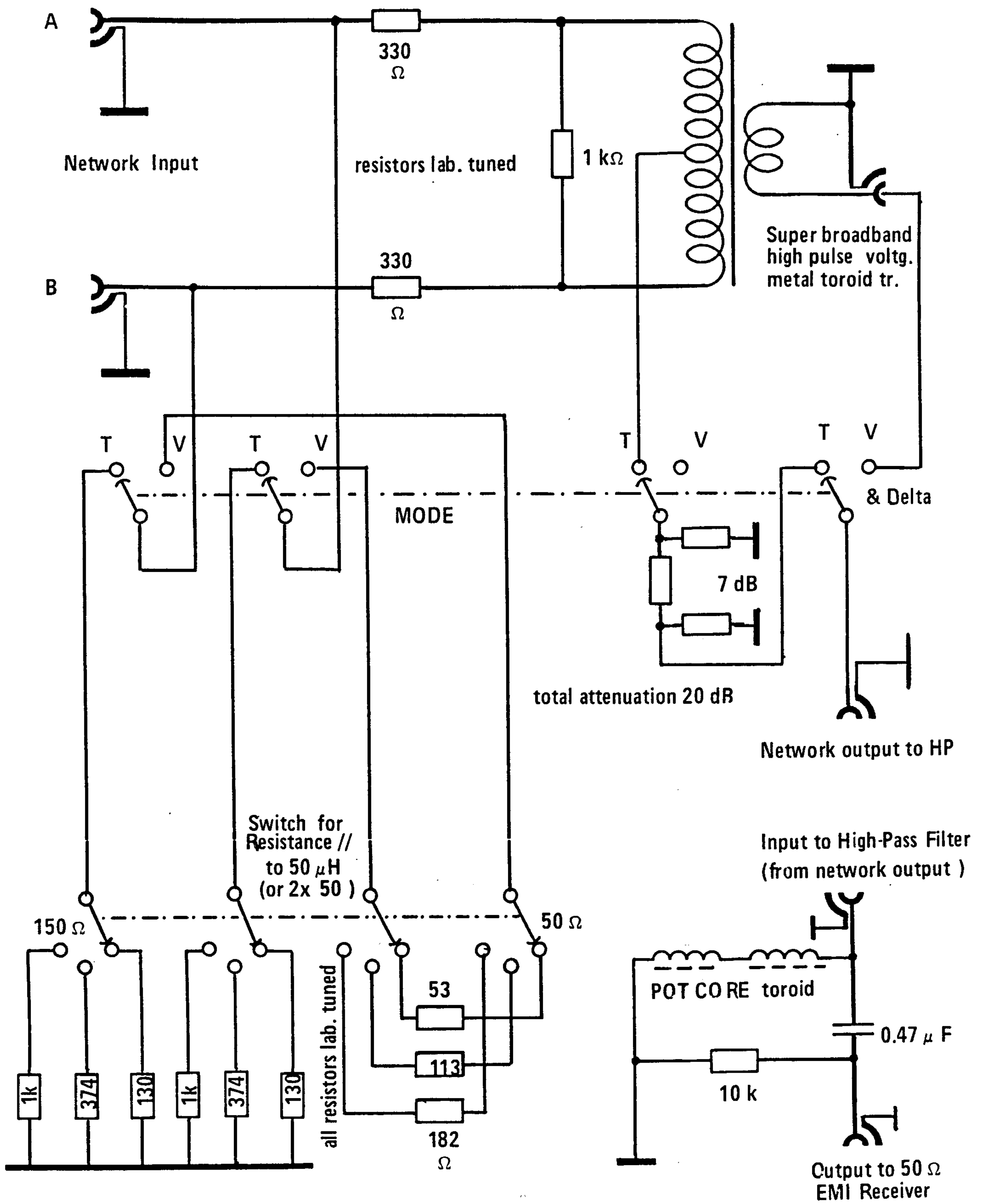
NDTV 8160

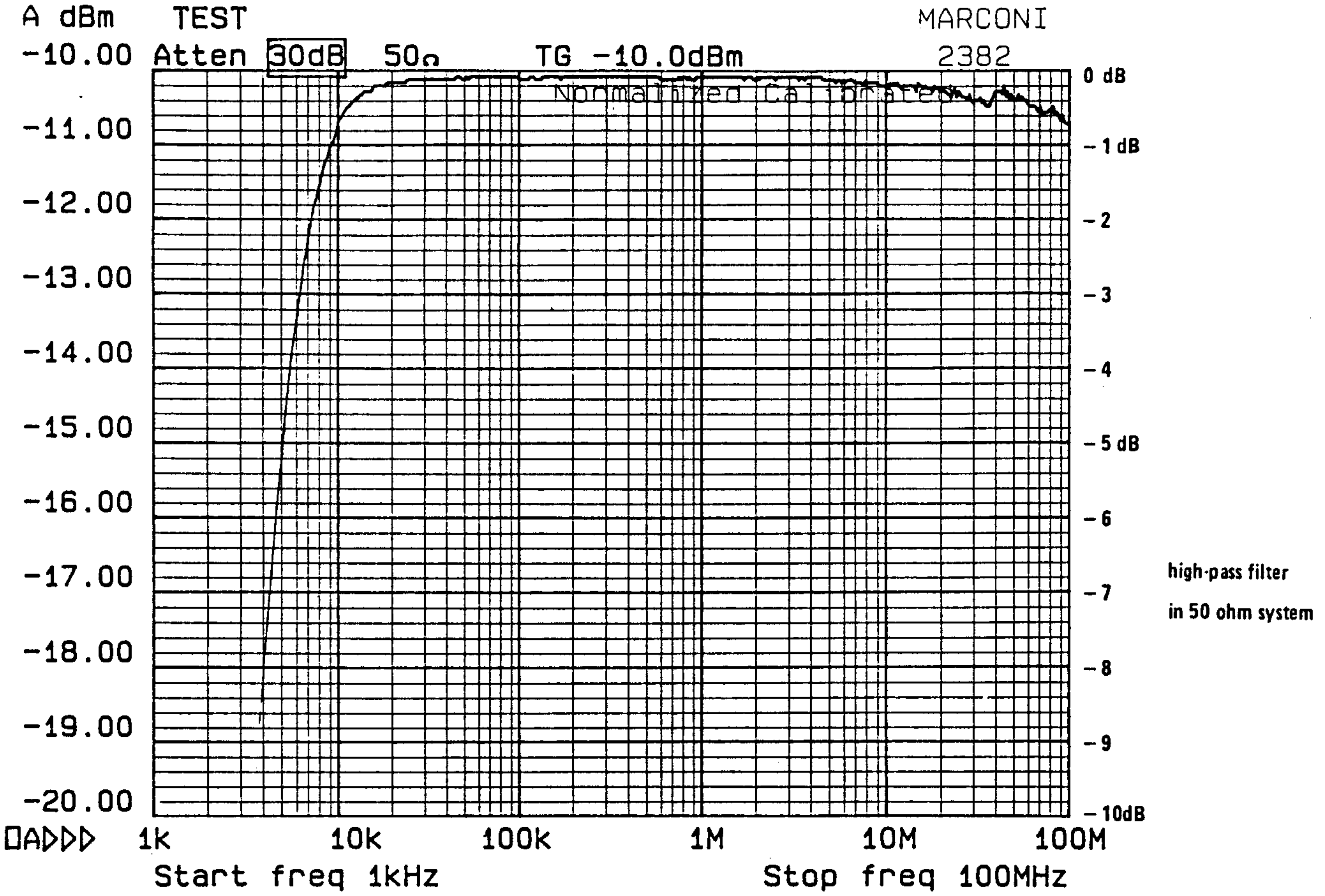
Universal Delta-, T- and V- L.I.S.N., 4 x 100 A, 50 -- 150 Ω

Symmetrical Delta, Unsymmetrical V and Asymmetrical T - Network

150 kHz (9 kHz) -- 30 MHz (2 MHz), AC 1, 2 and 3 Phase 250 V / 400 V

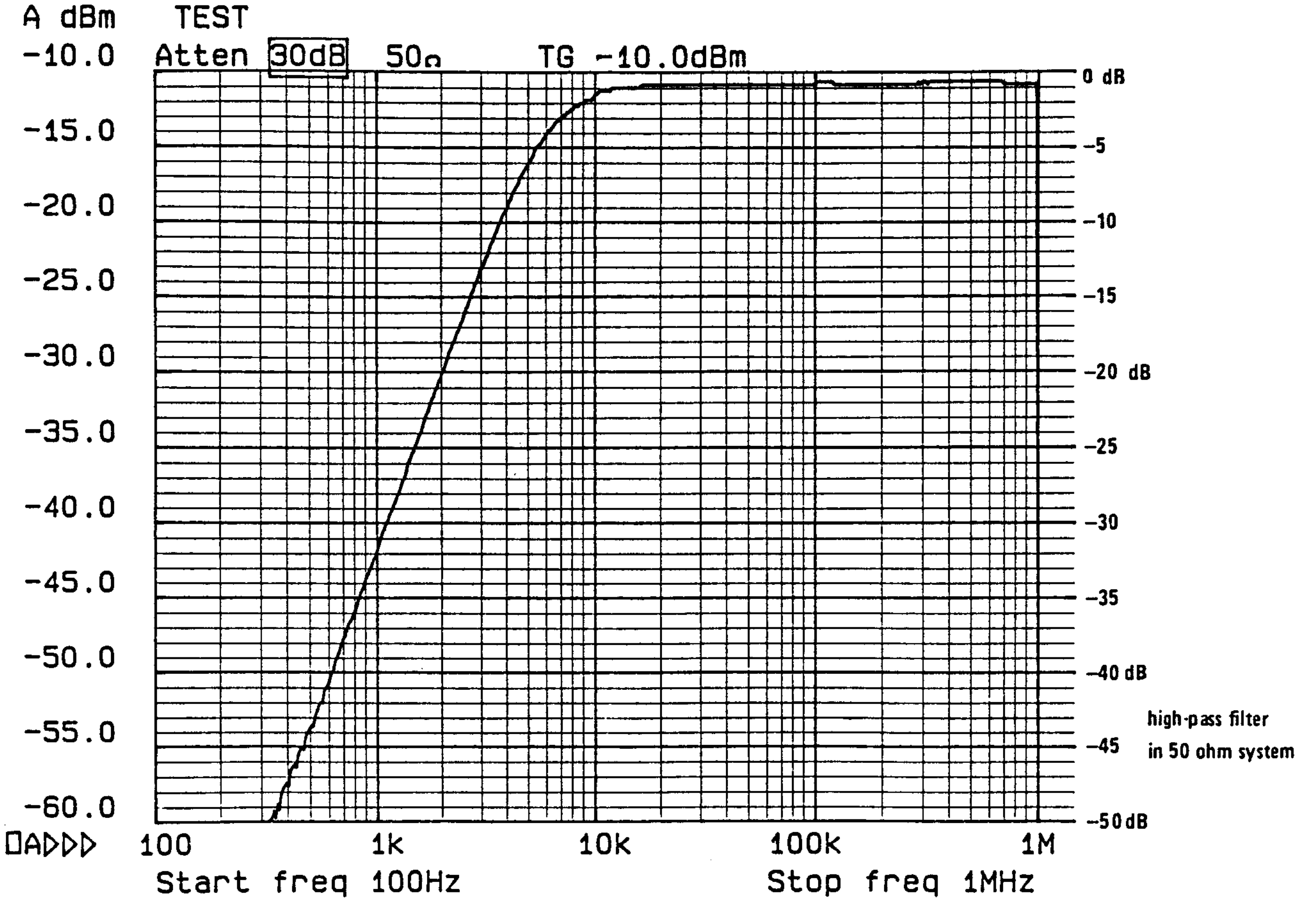
Schwarzbeck MESS-ELEKTRONIK, D-69250 Schoenau (FRG)





NDTV 8160, Universal Delta, T- and V - L.I.S.N., 4 x 100A, 50/100/150 Ω

High-Pass Filter 9 kHz (-- 30 MHz), 50 ohm, for EMI receiver protection



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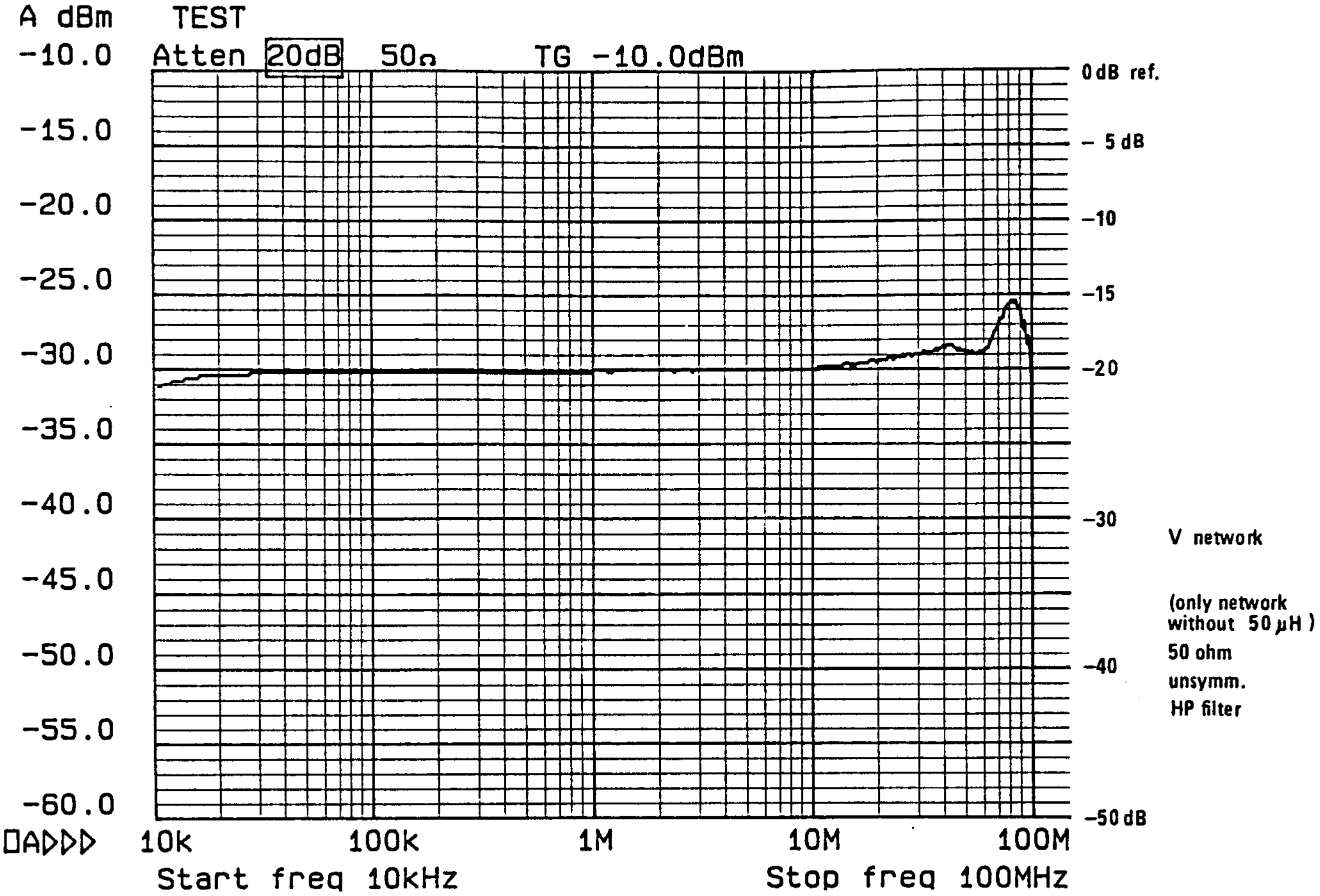
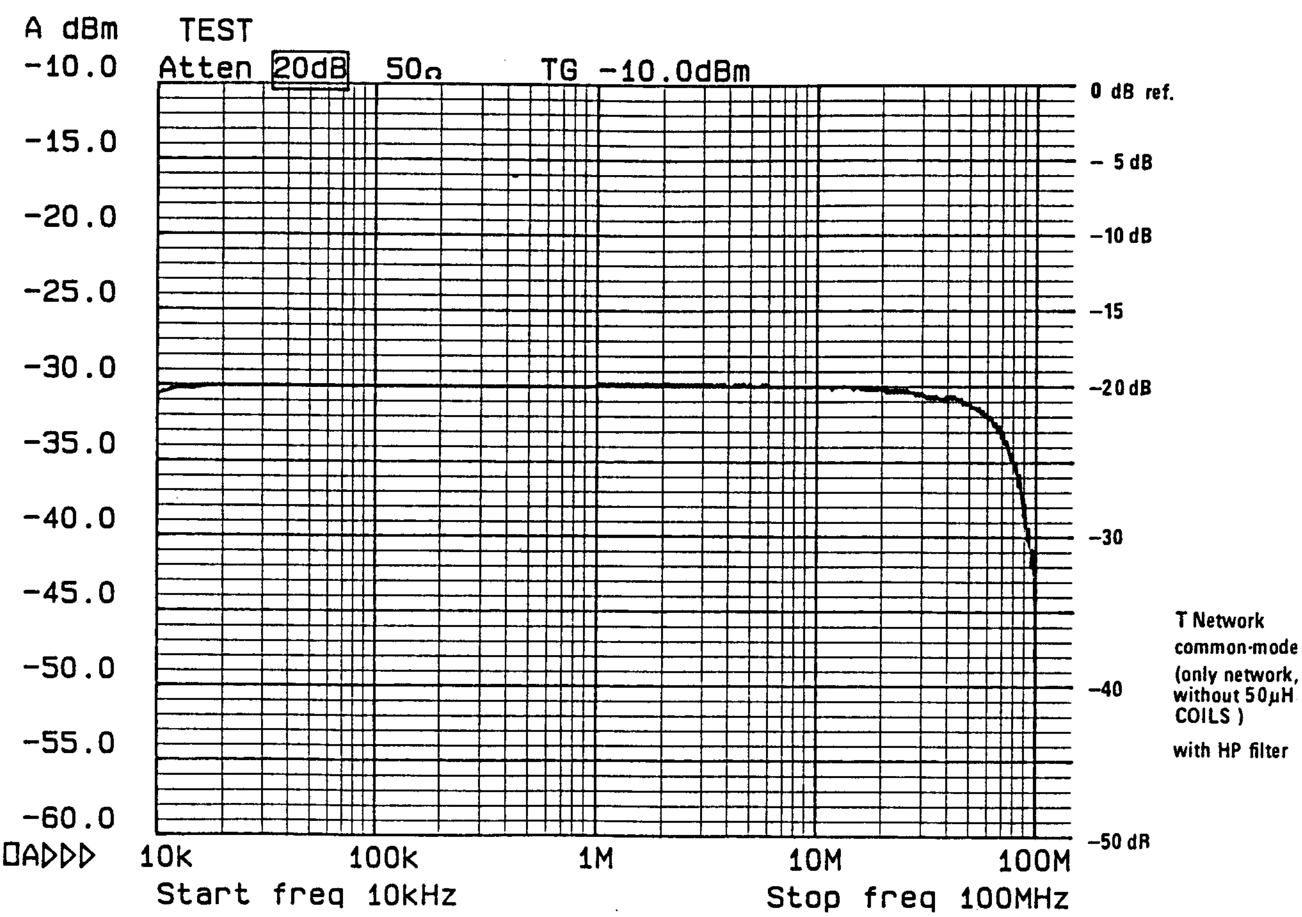


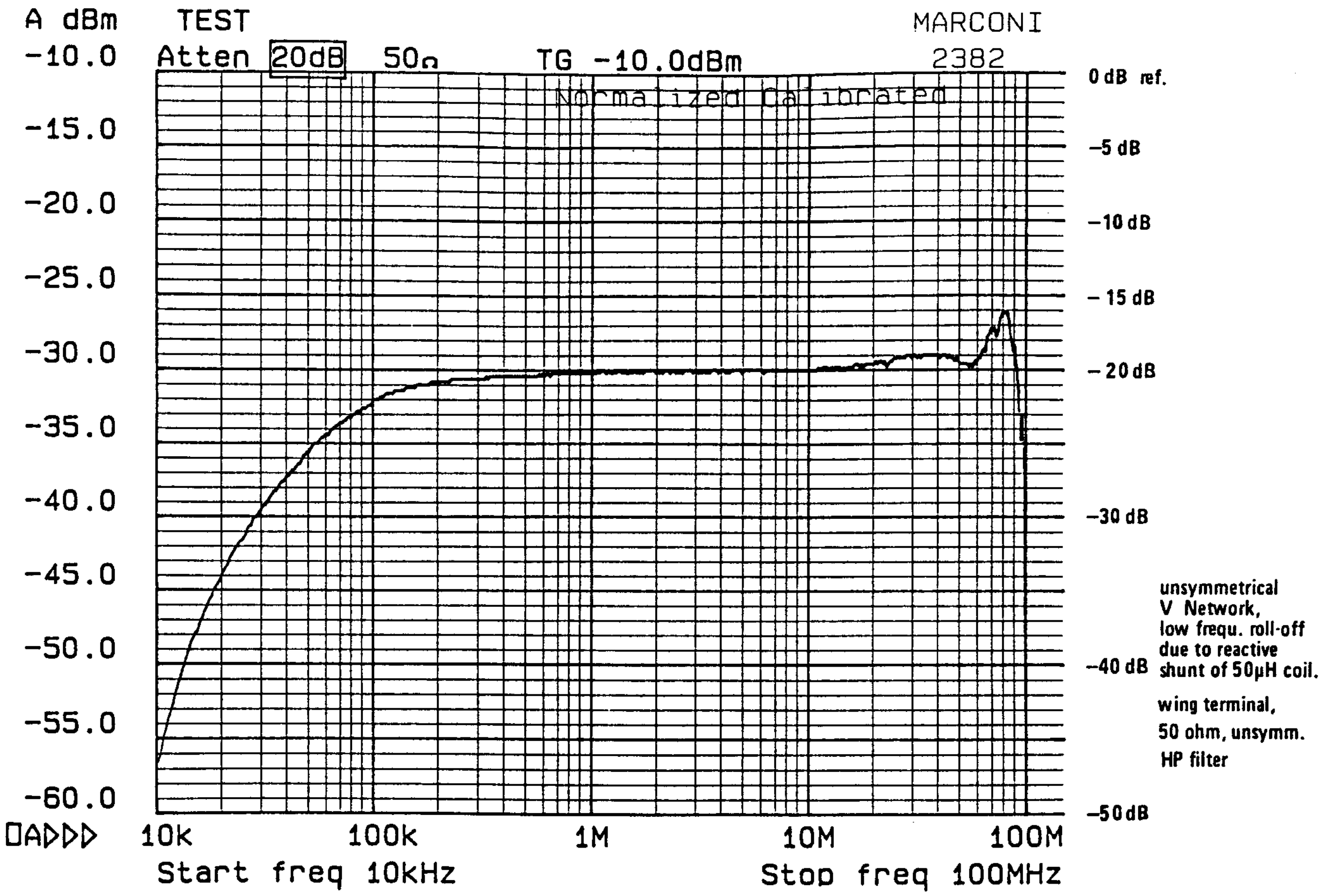
NDTV 8160, Universal Delta, T- and V - L.I.S.N., 4 x 100A, 50/100/150 Ω

V Network for unsymmetrical voltages into BNC (B), BNC (A) conn. to ground
no LISN chokes 50 µH included, High-Pass Filter included, 50 ohm resistance



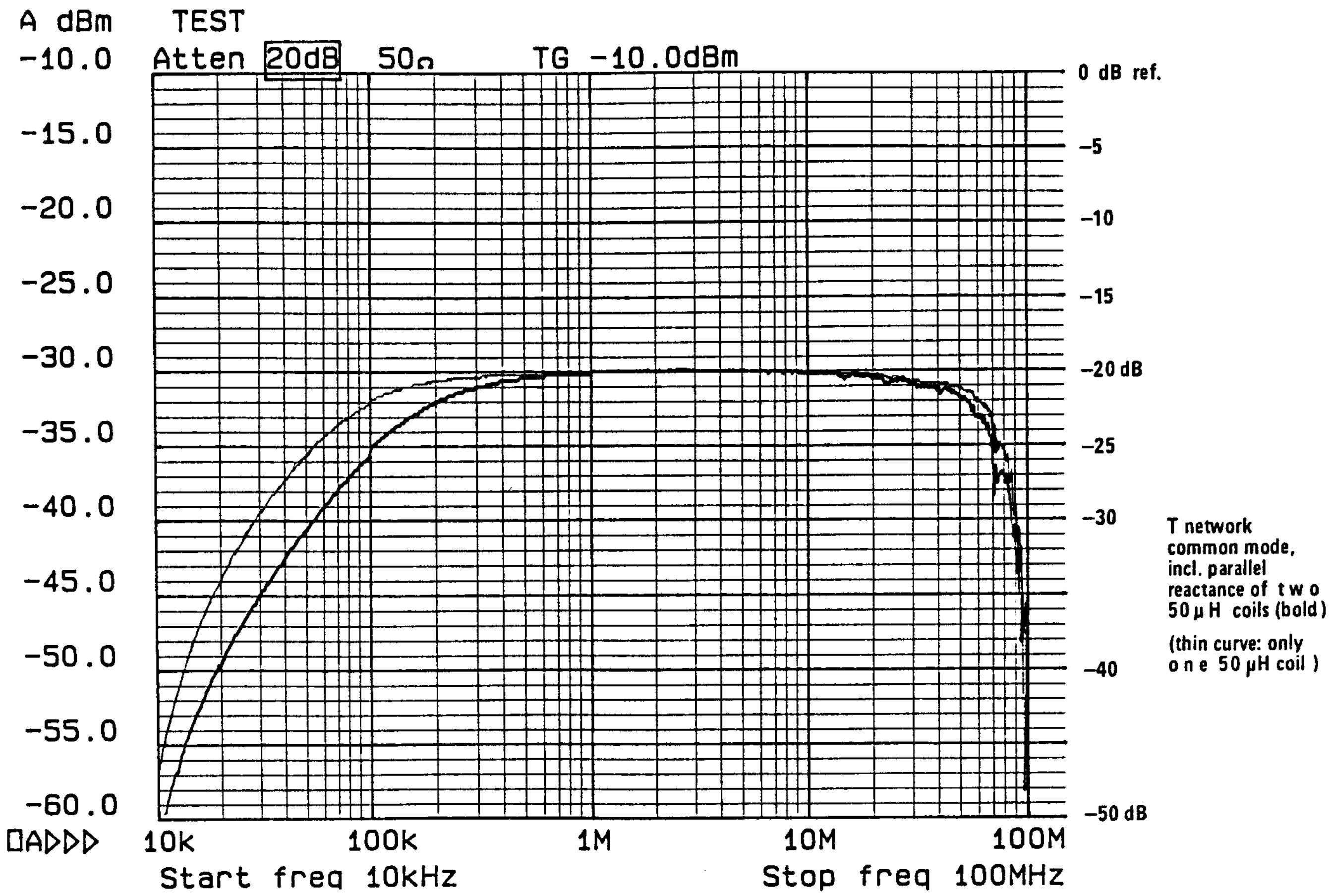
NDTV 8160, Universal Delta, T- and V - L.I.S.N., 4 x 100A, 50/100/150 Ω

T Network (asymmetrical / common mode), only switching network & HP filter
(A and B input parallel against ground, mode T, no 50 µH LISN coils, 50 ohm)



NDTV 8160, Universal Delta, T- and V - L.I.S.N., 4 x 100A, 50/100/150 Ω

Unsymmetrical V Network, − 20 dB output, low frequency roll-off due to reactive shunt of 50 µH main LISN chokes (voltage at wing terminal to output)



NDTV 8160, Universal Delta, T- and V - L.I.S.N., 4 x 100A, 50/100/150 Ω

T Network for asymmetrical voltage, includes reactive shunt effect of (1) 2 coils (50 µH) / 25 µH main LISN chokes at wing terminals (mode T asymmetrical)