Description, operating instructions and hardware specification of the HL 8240 - Transverse balance measurement module (TBMM).

The increasing use of telecom equipment in ultrafast applications has enhanced the need for obtaining the high-frequency measurement device in a form suitable for transverse balance measurements, controlling via USB port, and easy integrated with existing HL measurement systems like telecom conformance analyzer TCA-8200. From this view point, it is desirable to obtain sine generator providing wide frequency range, set of measurement terminations meeting most of the modern telecom standard requirements, and high-precision balanced measurement attenuators supporting self-calibration and compensation procedures.

Transverse balance measurement module HL 8240 is designed for automatic compliance testing of telecom equipment for transverse balance.

Figure 1 A general view of the Transverse balance measurement module HL 8240

TBMM Block and Connection diagrams

TBMM comprises following functional blocks (see Figure 2)

USB Controller

FTDI USB Controller supporting USB-2 interface which providing high speed controlling by software objects of the TCA unit. For testing purpose TBMM should be connected to the TCA unit via USB interface (see Figure 3).

1-2-3. Signal generator with attenuator and adjustable impedance

100/135 Ohm terminated sine-generator providing frequencies up to 35MHz and output attenuator being adjusted within range 0 – 15.5 dB and increment 0.5 dB. Generator's termination should be set providing an impedance matching with connected EUT.

4. Balancing capacitors

Capacitive compensation circuit providing separate Tip and Ring capacitance setting within range 6.4 – 13.22 pF

5. Polarity switch

Relay switch providing either normal or reverser line polarity for EUT connection

6. Internal metallic termination

Set of precision resistors terminating EUT and being either 100 Ohm or 135 Ohm

7. EUT Connection switch

Relay switch connecting the measurement circuit either internal termination (block 6) or EUT. Test signal can be applied to EUT if the switch is set to *external* state.

8. Longitudinal and 10. Metallic preamplifiers

Operational amplifier circuits composing measurement paths and providing wide measurement dynamic range. They are terminated by 50 Ohm unbalanced connectors, there are "Long/Met" and "Metallic" measurement output channels respectively. For testing purpose, only "Long/Met" channel should be connected to the TCA unit (see Figure 3)

9. Measurement switch

Relay switch providing either measurement configuration. There are two following configurations:

- *Single channel* supporting longitudinal measurements on "Long/Met" connector
- *Dual channel* supporting simultaneous longitudinal and metallic measurements on "Long/Met" and "Metallic" connectors respectively

This measurement switch simplifies a test procedure and allows using only one measurement connection with the TCA unit (see Figure 3)

Insulated GND

Insulated ground jack providing direct connection of the EUT measurement ground to the ground point of the balance measurement bridge (see Figure 3)

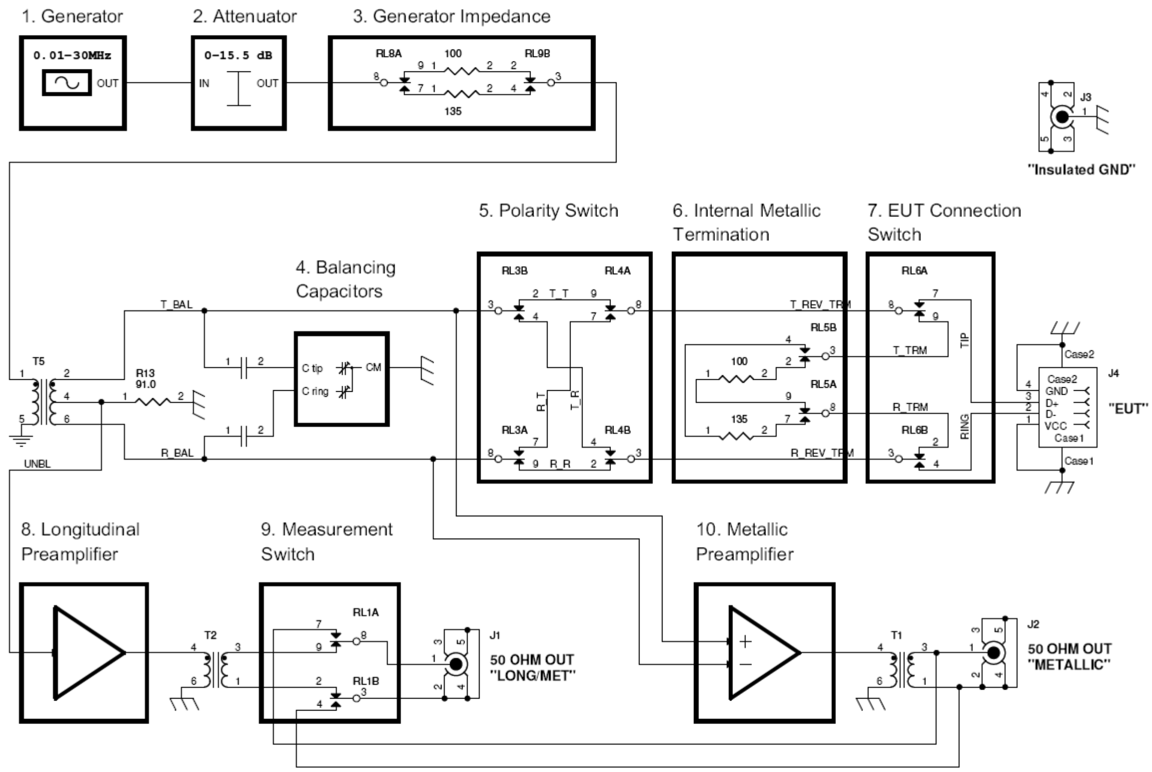

Figure 2. TBMM Block diagram

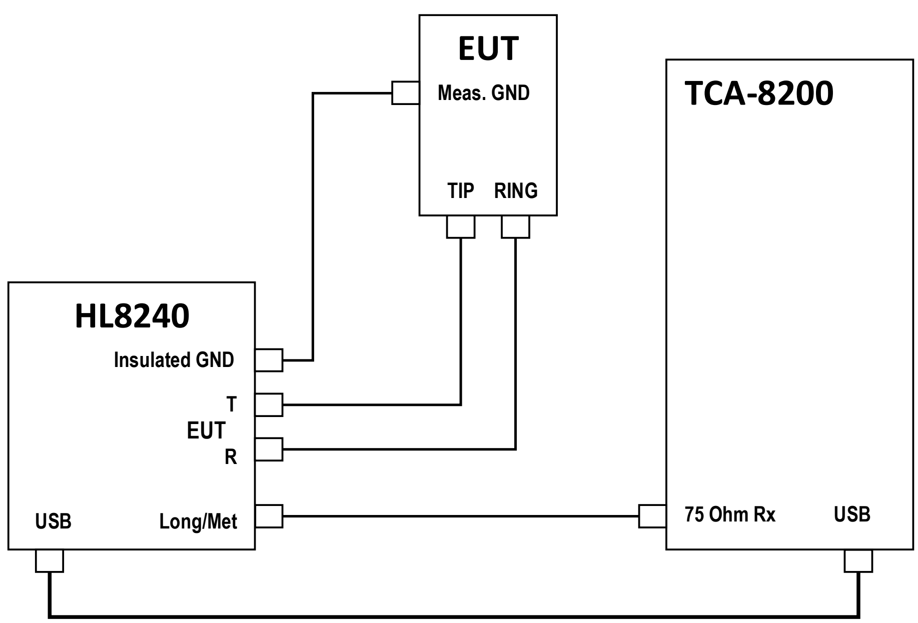

Figure 3 TBMM Connection diagram

TBMM Calibration and verification procedures

All TBMM's software applications are separated by their purpose in two suites: TBMM Calibration suite and TBMM measurements suite.

Calibration procedure of longitudinal attenuations is split up into 3 parts for 3 frequency ranges, there are up to 2MHz for reference balance 25dB, 2MHz – 12MHz for reference balance 30dB, and 12MHz – 35MHz for reference balance 35dB. Above measurement range partition provides maximum measurement precision for compliance testing because of matching with standard requirements.

TBMM Calibration suite consists of 3 groups, which include tests used for calibration purposes:

- Self-verification tests
  All tests from the group are based on the TCA measurement script and intended for quick performance verification of keying TBMM characteristics at the production stage.
    a. Max longitudinal relative level
    b. Generator relative output level vs sent code
    c. Gradient of output attenuator vs sent code
    d. TBMM frequency response
- Calibration adjustment tests
  All tests from the group are based on the TCA measurement script and intended for adjustment of the internal reference calibration parameters such as metallic and longitudinal attenuations and output levels versus stimulus frequency.
    a. Metallic attenuation vs frequency
    b. Longitudinal attenuation vs frequency
    c. Generator output level vs frequency
- Calibration verification tests.
  All tests from the group are based on the TCA measurement script and intended for performing periodic calibration.
    a. Self-balance adjustment
    b. Max transverse balance
    c. Transverse balance deviation

Notes:

- ***Changing reference calibration data affects test performance.***
- ***The tests in the Calibration Adjustment group should be performed in the order they are listed.***
- ***After the Calibration Adjustment tests have been completed, the Calibration Verification tests should be performed.***
- ***Some tests in the Calibration Verification require use of external test equipment not supplied with the instrument (see #5 in Table 2).***
- ***The Calibration Adjustment tests are not necessary if the Calibration Verification tests pass***

For detailed description of the calibration tests see **Table 1**.

Test Name	***Max longitudinal relative level***
Description	This **self-verification procedure** is based on the TCA Script and should be applied in the production stage as a quality control. The procedure compares maximally available output longitudinal level with its limit on the internal balanced reference termination.
Purposes	Measures longitudinal levels, in dBV, versus stimulus frequencies within the range 100k-30MHz and find maximum level which should be less than – 55 dBV Production quality inspection “fit for purpose”. Evaluates of the general suitability of the circuit for balance measurements within high frequency range.
Tasks	1. Make a maximum unbalance of the measurement circuit

	2. Measure longitudinal voltage for the found unbalanced state 3. Compare obtained voltage with respective limits for low and high reference frequencies
Notes	Measurement limits are dependent on the actual attenuation of TCA AC attenuator "75 Ohm Rx" The test is intended for production quality inspection and should be run first of all others.
Test Name	***Generator relative output level vs sent code (output level linearity)***
Description	This **self-verification procedure** is based on the TCA Script and should be applied in the production stage as a quality control. The procedure compares maximally available output longitudinal level with its limit on the internal balanced reference termination.
Purposes	Measures generator voltage, in dBV, versus output attenuation, in sent digital code, which should be fitted to mask (limits).
Tasks	1. Measure generator voltage, in dBV, versus output attenuation, in sent digital code 2. Try to fit obtained measured points to defined mask (limits)
Notes	The test is intended for production quality inspection and should be run before any TBMM's calibrations
Test Name	***Gradient of generator output level***
Description	This **self-verification procedure** is based on the TCA Script and should be applied in the production stage as a quality control. The procedure measures gradient of the output attenuator within the range of sent controlling code and compares the gradient deviations with the limits
Purposes	Production quality inspection. Testing of TBMM's sine-generator being suitable for adjustment of its output level with defined increment
Tasks	1. Measure a difference of the output sending levels, in dB, between two neighbor codes being sent to TBMM's attenuator 2. Compare obtained level differences with defined limits
Notes	The test is intended for production quality inspection and should be run before any TBMM's calibrations
Test Name	***Metallic attenuation vs freq***
Description	This **calibration procedure** is based on the TCA Script and should be performed under TBMM calibration conditions. The procedure calculates metallic attenuation versus stimulus frequency characteristic and compares obtained values with limits for self-checking purpose. To acquire metallic voltage at the EUT measurement point the calibration procedure requires an external measurement device (see #5 in Table 2).
Purposes	Obtaining attenuation factors, in dB, versus frequency for TBMM's metallic attenuator
Tasks	1. Measure narrowband metallic output sending levels within defined stimulus frequency range at TCA's measurement point (75Ohm Rx) and respective metallic levels at the reference termination which shall be measured by external reference device, e.g. digital oscilloscope. Then, calculate attenuation factors versus frequencies and save the data into corresponding TCA calibration table 2. Compare obtained attenuation factors with defined limits
Notes	The test is intended for calibration adjustment procedure and should be run before calibration of TBMM's longitudinal attenuators
Test Name	***Longitudinal attenuation vs freq***
Description	This **calibration procedure** is based on the TCA Script and should be performed under TBMM calibration conditions. The procedure calculates longitudinal attenuation versus stimulus frequency characteristic and compares obtained values

	with limits for self-checking purpose.
Purposes	Obtaining attenuation factors, in dB, versus frequency for TBMM's longitudinal attenuator
Tasks	1. Obtain mathematic dependence between longitudinal and metallic voltage for well-known balance of the reference termination 2. Measure narrowband metallic output sending levels within defined stimulus frequency range at the TCA measurement point (75Ohm Rx) and calculate respective longitudinal levels at the reference termination by using previously estimated dependences. Then, calculate attenuation factors versus frequencies and save the data into corresponding TCA calibration table 3. Compare obtained attenuation factors with defined limits
Notes	The test is intended for calibration adjustment procedure and should be run after calibration of TBMM's metallic attenuators.

Table 1 Calibration and verification procedures

TBMM calibration hardware requirements

In order to perform TBMM's calibration and verification procedures the calibration person should use reference terminations (RT) supplied with the measurement module and reference measurement device (RMD), e.g. a selective voltmeter or a digital oscilloscope (see Table 2) not supplied with TBMM.

#	Description	Model	Key specifications
1	Floating termination 100 Ohm	HL Part number	Resistance: 100 Ohm ± 0.1% Frequency range: 0 – 40 MHz
2	Unbalanced termination 25dB	HL Part number	Metallic impedance: 100 Ohm ± 1% Balance: 25 dB ± 1 dB Frequency range: 10 kHz – 40 MHz
3	Unbalanced termination 30dB	HL Part number	Metallic impedance: 100 Ohm ± 1% Balance: 30 dB ± 1 dB Frequency range: 10 kHz – 40 MHz
4	Unbalanced termination 35dB	HL Part number	Metallic impedance: 100 Ohm ± 1% Balance: 35 dB ± 1 dB Frequency range: 10 kHz – 40 MHz
5	Selective voltmeter / oscilloscope Active Differential Probe	LeCroy Model: LC584AL Model: AP033	1 GHz, 4 channels, High impedance; Selective measuring in 10 kHz – 40 MHz frequency range with 100 Hz window
6	Active differential probe	LeCroy Model: AP 033	500 MHz Bandwith 2 pF/Side Input C Autobalance Feature

Table 2 Hardware requirements on the reference terminations and measurement devices being applied for calibration/verification purpose

TBMM Compliance testing

Compliance Transverse Balance tests are located in **TMBB 30M** section of the **Generic suite**. All these tests are based on the respective Generic test and intended for compliance testing in accordance with respective standard. Limits of the measured values are set according to the ANSI/TIA-968-B standard. User suggested to create a User suite based on that test group and, if necessary, modifies test limits according to the tested standard.

Tests existed in the group are:

a. **Transverse balance (100 Ohm; 50 kHz - 12 MHz**) – purposed to verify the transverse balance of the EUT in the frequency range 50 kHz - 12 MHz (Metallic termination Zm=100 Ohm, Longitudinal termination Zl=90 Ohm)
b. **Transverse balance (135 Ohm; 50 kHz - 12 MHz)** – purposed to verify the transverse balance of the EUT in the frequency range 50 kHz - 12 MHz (Metallic termination Zm=135 Ohm, Longitudinal termination Zl=90 Ohm)
c. **Transverse balance (100 Ohm; 50 kHz - 30 MHz)** – purposed to verify the transverse balance of the EUT in the frequency range 50 kHz - 30 MHz (Metallic termination Zm=100 Ohm, Longitudinal termination Zl=90 Ohm)
d. **Transverse balance (100 Ohm; 50 kHz - 12 MHz**) – purposed to verify the transverse balance of the EUT in the frequency range 50 kHz - 12 MHz (Metallic termination Zm=100 Ohm, Longitudinal termination Zl=90 Ohm)

HL 8240 hardware specification

Transverse balance general parameters

Test setup:	According to: 5.3.2.2 TIA-968-B Fig.42 (FCC Part 68), CS-03 Part VIII clause 3.4, fig. 3.4(a)
Frequency range:	50 kHz – 30 MHz
Max measured Transverse balance:	- 55 dB in range 0.05 MHz – 1.544 MHz; - 50 dB in range 1.544 MHz – 12 MHz; - 45 dB in range 12 MHz – 30 MHz
Measurement uncertainty:	Expanded uncertainty, k=2 (95% confidence): - Balance (6 - 25 dB) @ 50 kHz – 12 MHz ±0.08 dB; - Balance (6 - 25 dB) @ 12 MHz – 30 MHz ±0.13 dB; - Balance (25 - 35 dB) @ 50 kHz – 12 MHz ±0.11 dB; - Balance (25 - 35 dB) @ 12 MHz – 30 MHz ±0.15 dB; - Balance (35 - 45 dB) @ 50 kHz – 12 MHz ±0.15 dB; - Balance (35 - 45 dB) @ 12 MHz – 30 MHz ±0.75 dB; - Balance (45 - 55 dB) @ 50 kHz – 12 MHz ±0.45 dB; - Balance (45 - 55 dB) @ 12 MHz – 30 MHz ±1.25 dB;
Metallic voltage (V_M):	0.2V - 0.75 V
Reference metallic impedance (include generator's impedance (Z_M):	100Ω and 135Ω
Reference longitudinal termination (Z_L):	90Ω
Polarity:	Normal (+) and Reverse (–)

Tracking Generator

Frequency range:	12 kHz to 35 MHz
Frequency tuning resolution:	0.1 Hz
Metallic voltage (V_M):	0.2V - 0.75 V, programmable
Output:	Balanced and floating
Output GND connector:	Floating
Output protection:	none
Attenuator range:	0 – 15.5 dB
Attenuator resolution:	0.5 dB steps
Waveform:	Sine from 10-Bit DAC
DAC clock rate:	125MHz
Amp. accuracy:	≤0.5 dB
Freq. accuracy:	≤ 0.001%

Longitudinal Voltage measurements

Max. AC Voltage measured:	0.1 V @ 12 kHz to 30 MHz
Output port impedance:	50Ω (Balanced and floating)
Min. Longitudinal Voltage measured:	
	Limit: -80 dBV (BW=100Hz) @ (12 kHz to 100 kHz)
	Limit: -70 dBV (BW=1kHz) @ (100 kHz to 2 MHz)
	Limit: -60 dBV (BW=1kHz) @ (2 MHz to 12 MHz)
	Limit: -50 dBV (BW=10kHz) @ (12 MHz to 30 MHz)

Metallic Voltage measurements

Max. AC Voltage measured:	0.8 V @ 12 kHz to 30 MHz
Output port impedance:	50Ω (Balanced and floating)

USB interface

Input:	Isolated from all exits excepting a power supply input
Type:	USB 2.0 Full Speed (12 Mbits / Second) compatible
Driver Support:	Windows 98, 98SE, ME, 2000, Server 2003, XP, Windows Vista / Longhorn, Windows XP 64-bit

Fixed voltage 5 VDC power supply

Output voltage:	+ 5 VDC fixed 1A, floating
Output Ripple, Noise:	50 mV p-p in 0 – 20 MHz
Load regulation:	±5%
Features:	Double Insulated, Class B EMI, Low Leakage Current
Safety Approvals:	cUL/UL, CE, TUV, C-Tick, SAA
AC Input Voltage Rating:	100 to 240VAC
AC Input Voltage Range:	90 to 264VAC
AC Input Current:	0.25A (RMS) max. @ 120VAC
	0.125A (RMS) max. @ 240VAC
Leakage Current:	0.25mA max. @ 254VAC
Input Power Saving:	0.5W maximum at no load
Hold-up Time:	10mS min. @ 120VAC and max. load
Circuit Protection:	> 120%, auto restart
Over-voltage Protection:	> 120%, Zener Clamp
Temperature Operation:	0 to +40°C
Temperature Non-operation:	-25 to +85°C
Humidity Operation:	10 to 90%
Emissions:	FCC Class B
	EN55022 Class B
Dielectric Withstand (Hi-pot) Test:	Primary to Secondary: 3000VAC
AC Input Clips (sold separately):	US: RPA, Europe: RPE, UK: RPK, Australia: RPS

Note: **HL 8240 requires both 5 VDC of external power supply and from USB connector.**