Balanced Circuit Measurement with an Impedance Analyzer/ LCR Meter/Network Analyzer

Application Note 346-2

INTRODUCTION

How a Balanced Circuit Differs from an Unbalanced Circuit

A balanced circuit has its electrical midpoint grounded. An unbalanced circuit, however, has one side grounded. A balanced circuit is typically used in communications equipment because a balanced circuit has the advantage of better spurious noise suppression.

Figure 1 shows a balanced cable which is an example of a balanced circuit. The voltages of the cable's two conductors are at every point equal in amplitude and opposite in phase. Figure 2 shows an unbalanced cable which is an example of an unbalanced circuit. Most measurement circuits in HP's impedance analyzers and LCR meters are unbalanced.

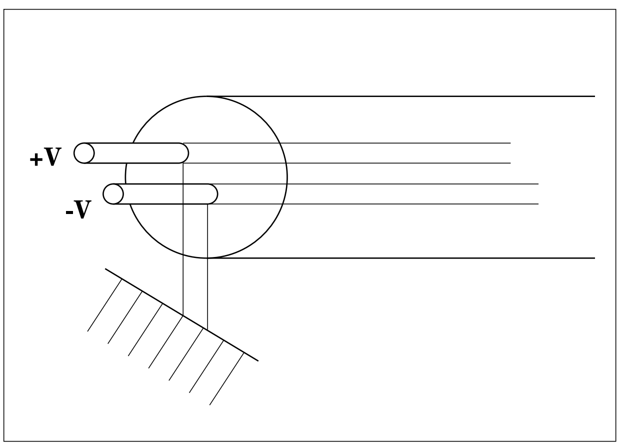

Figure 1. Balanced cable

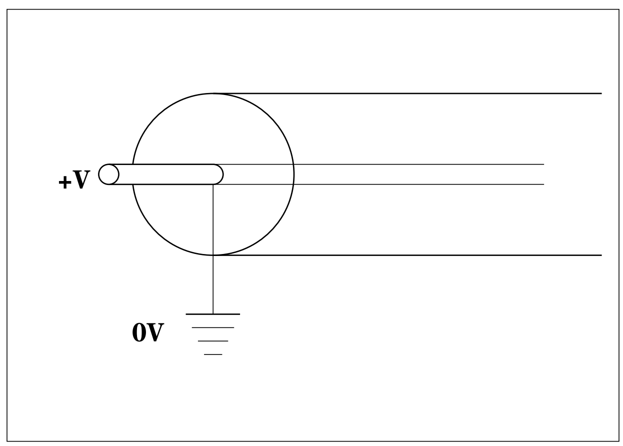

Figure 2. Unbalanced cable

Measuring a Balanced Circuit with an Unbalanced Measurement Instrument

A balanced circuit cannot be directly measured with an unbalanced measurement instrument because of the difference in their configuration.
When measuring balanced circuits, the unbalanced measuring instrument requires a balun (balanced to unbalanced) transformer. A balun is a type of impedance-matching RF transformer.

Figure 3 shows the configuration for measuring a balanced circuit with an unbalanced instrument.

Note: In balanced cable measurements, residual current in the balun or the measuring instrument can cause measurement errors.
To reduce the degree of error, perform open/short and load compensation at the measurement terminals of the balun.

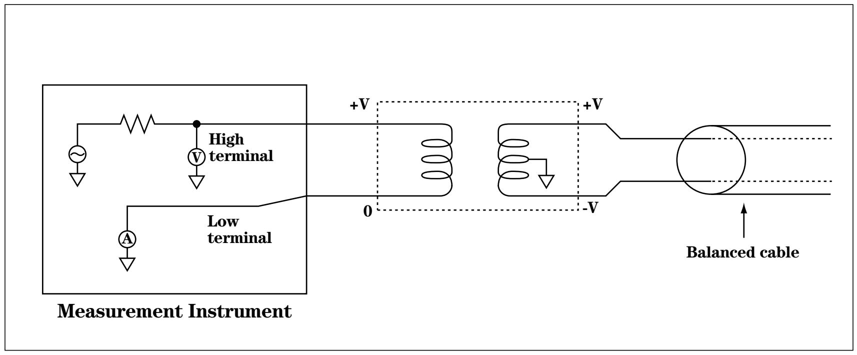

Figure 3. Balanced cable measurement configuration

SELECTING A BALUN

There are several types and brands of balun transformers. When selecting a balun, ensure that frequency is compatible with your measurement requirements. When you measure the impedance parameters of a balanced circuit, you don't have to use the balun which has the same impedance with the circuit under test. However, when you measure the transmission or reflection of it, you have to use a balun which has the same impedance with the circuit under test to keep impedance matching. Table 1 show recommended balun transformers.

Table 1. Recommended balun transformers

Unv/Bal. (W)	Bandwidth	Type No.	Suppliers
50:50	0.1–125MHz	0001BB	North Hills Electronics
50:75	0.1–125MHz	0101BB	North Hills Electronics
50:100	0.1–125MHz	0300BB	North Hills Electronics
50:600	0.1–65MHz	0700BB	North Hills Electronics
75:50	0.1–100MHz	1000	North Hills Electronics
75:75	0.1–100MHz	1100	North Hills Electronics
75:100	0.1–100MHz	1300	North Hills Electronics
75:600	0.1–60MHz	1700	North Hills Electronics
75:75	20Hz–9MHz	T32–9808–23180	NEC
75:110	300kHz–30MHz	T32–9801–40046	NEC

MEASUREMENT CONFIGURATION WITH A BALUN AND COMPENSATION

Impedance Measurement Configuration with HP4194A Impedance Analyzer

Figure 4 shows impedance measurement configuration (1) with the HP4194A.

To Calibrate/Compensate for (1):

1. Perform open/short/load calibration at the APC7® connector of the HP 16085B which has an internal balun.

   Standards:
   0Ω .... HP PN 04191-85300
   0S............ HP PN 04191-85302
   50Ω .... HP PN 04191-85301

2. Perform 0Ω/0S zero offset at the closest terminal to the DUT.

To Calibrate/Compensate for (2):

1. Assemble a female BNC connector as shown in Figure 5.

2. Perform open/short/load calibration at the BNC connector using the following BNC Calibration standards:

   Short Standard:
   HP PN 1250-0929

   50Ω Load Standard:
   HP PN 11652-60001

3. Remove the connector and connect the DUT. Measure the DUT.

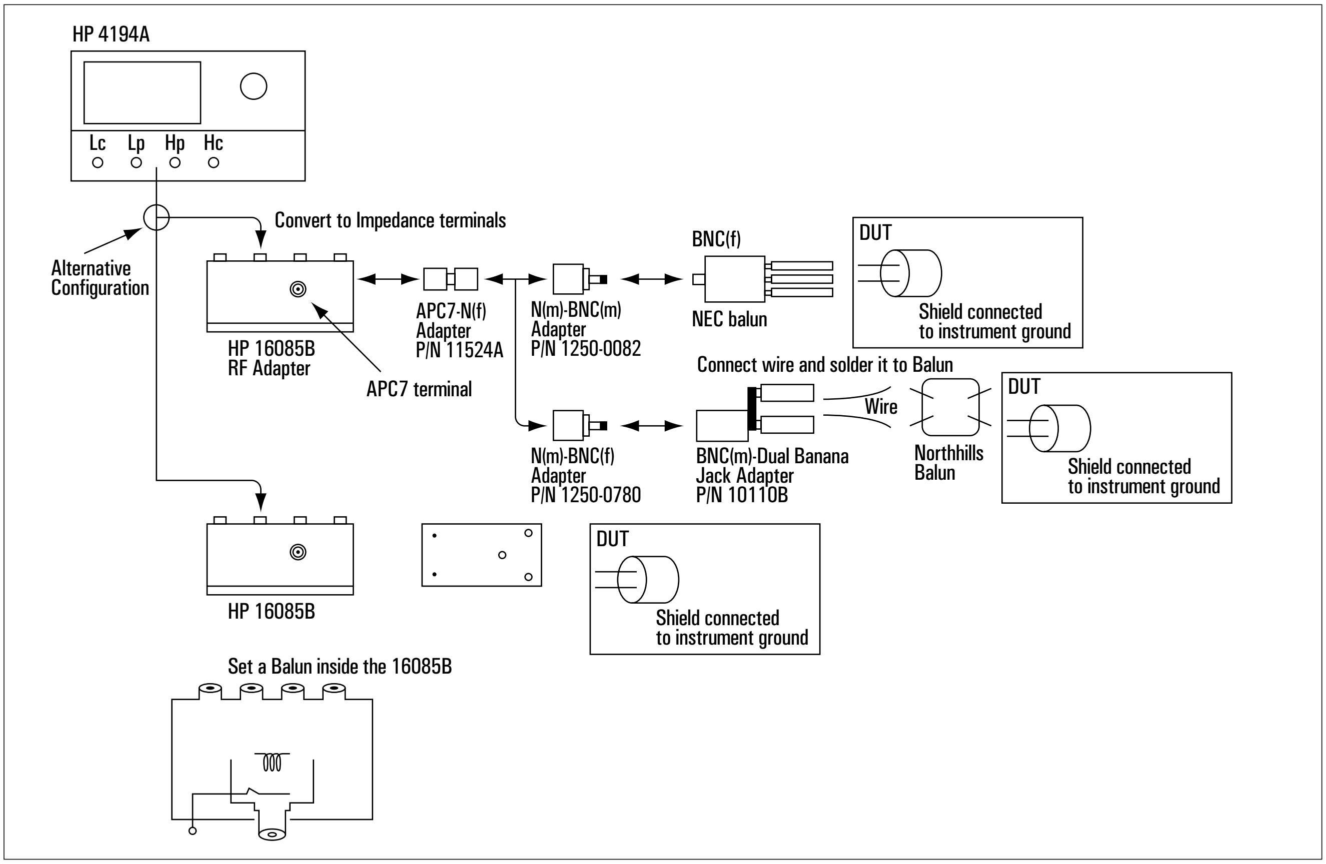

Figure 4. Measurement Configuration (1)

Impedance Measurement Configuration with the HP4395A(#010)

Figure 6 shows impedance measurement configuration (2) with the HP4395A.

To Calibrate/Compensate:

Refer to “To Calibrate/Compensate for (2)” of Impedance Measurement Configuration with HP4194A Impedance Analyzer.

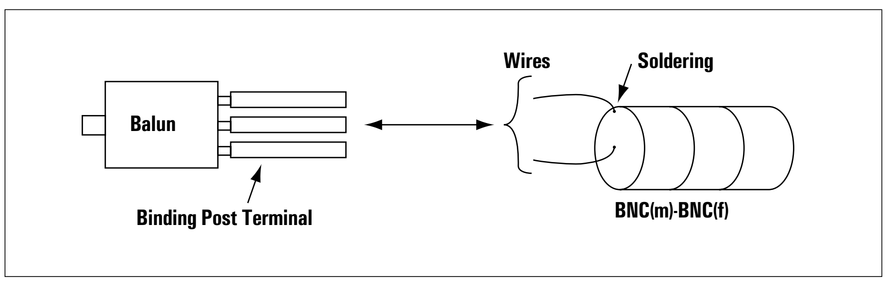

Figure 5. Assembling BNC connector

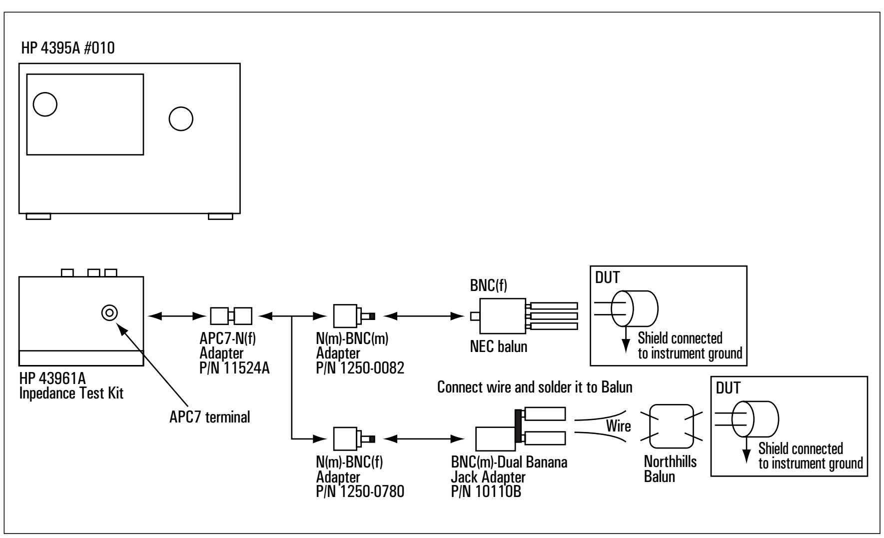

Figure 6. Measurement Configuration (2)

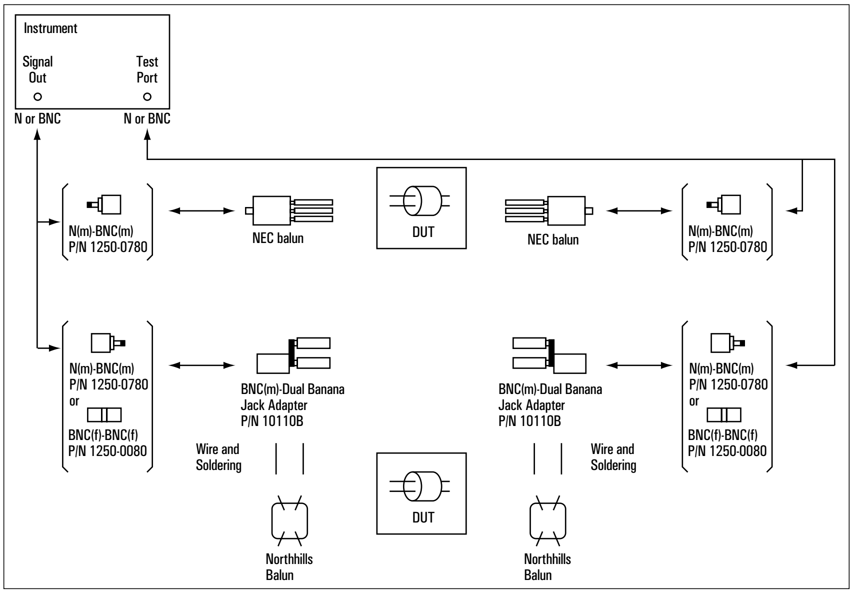

Figure 7. Measurement Configuration (3)

Transmission Measurement Configuration with a Network Analyzer or Gain-Phase Analyzer

Now we change a subject from impedance parameter measurements to network parameter measurements.

Figure 7 shows transmission measurement configuration (3) with a network analyzer of gain-phase analyzer.

To Calibrate/Compensate:

Short the terminals closest to the DUT to the signal out and to the test port, then perform response/thru calibration.

REFERENCES

Application Note 339-4
Measuring The Impedance of Balanced Cables
HP Pub. No.: 5950-2918

Application Note 380-2
Measuring Cable Parameters
HP Pub. No.: 5950-2399

For Information on Balun, Contact the Manufacturers:

North Hills Electronics, Inc.
Alexander Place Glen Cove, New York, USA, 11542
Tel: (516) 671-5700
Telex: 46-6886
Fax: (516) 759-3327

NEC Corporation
1-4-28 Mita Minato-ku Tokyo, Japan
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Fax: (81) 426 56 7840

Latin America:
Hewlett-Packard
Latin American Region Headquarters
5200 Blue Lagoon Drive
9th Floor
Miami, Florida 33126
U.S.A.
Tel: (305) 267-4245
(305) 267-4220
Fax: (305) 267-4288

Australia/New Zealand:
Hewlett-Packard Australia Ltd.
31-41 Joseph Street
Blackburn, Victoria 3130
Australia
Tel: 1800 629 485 (Australia)
0800 738 378 (New Zealand)
Fax: (61 3) 9210 5489

Asia Pacific:
Hewlett-Packard Asia Pacific Ltd.
17-21/F Shell Tower, Times Square,
1 Matheson Street, Causeway Bay,
Hong Kong
Tel: (852) 2599 7777
Fax: (852) 2506 9285

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