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

## Application Note 346-2

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### 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.

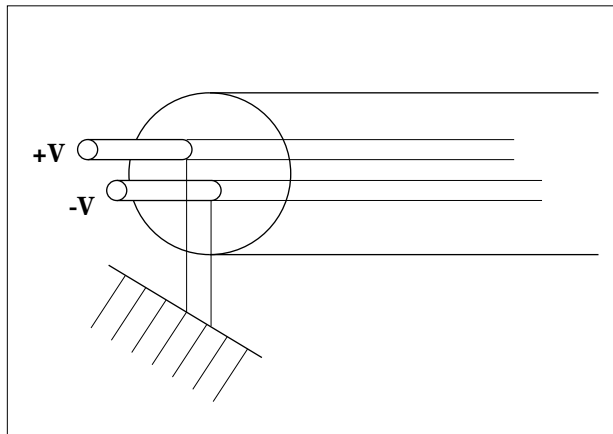


Figure 1. Balanced cable

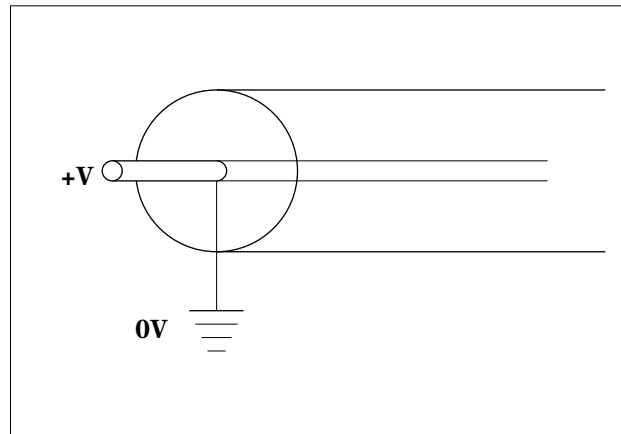


Figure 2. Unbalanced cable

## 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.

## 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

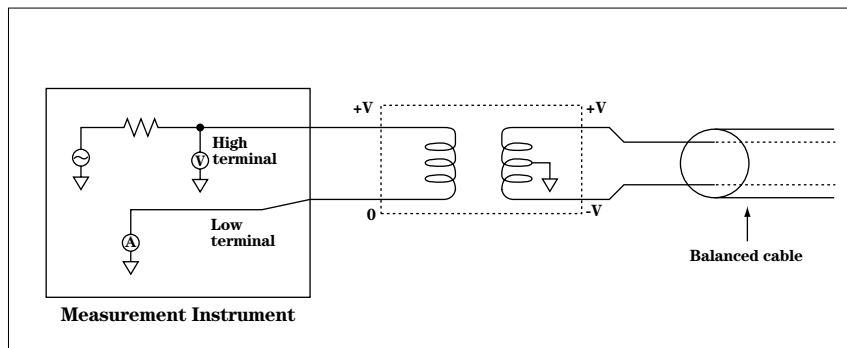


Figure 3. Balanced cable measurement configuration

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.

## 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<sup>®</sup> 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.

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

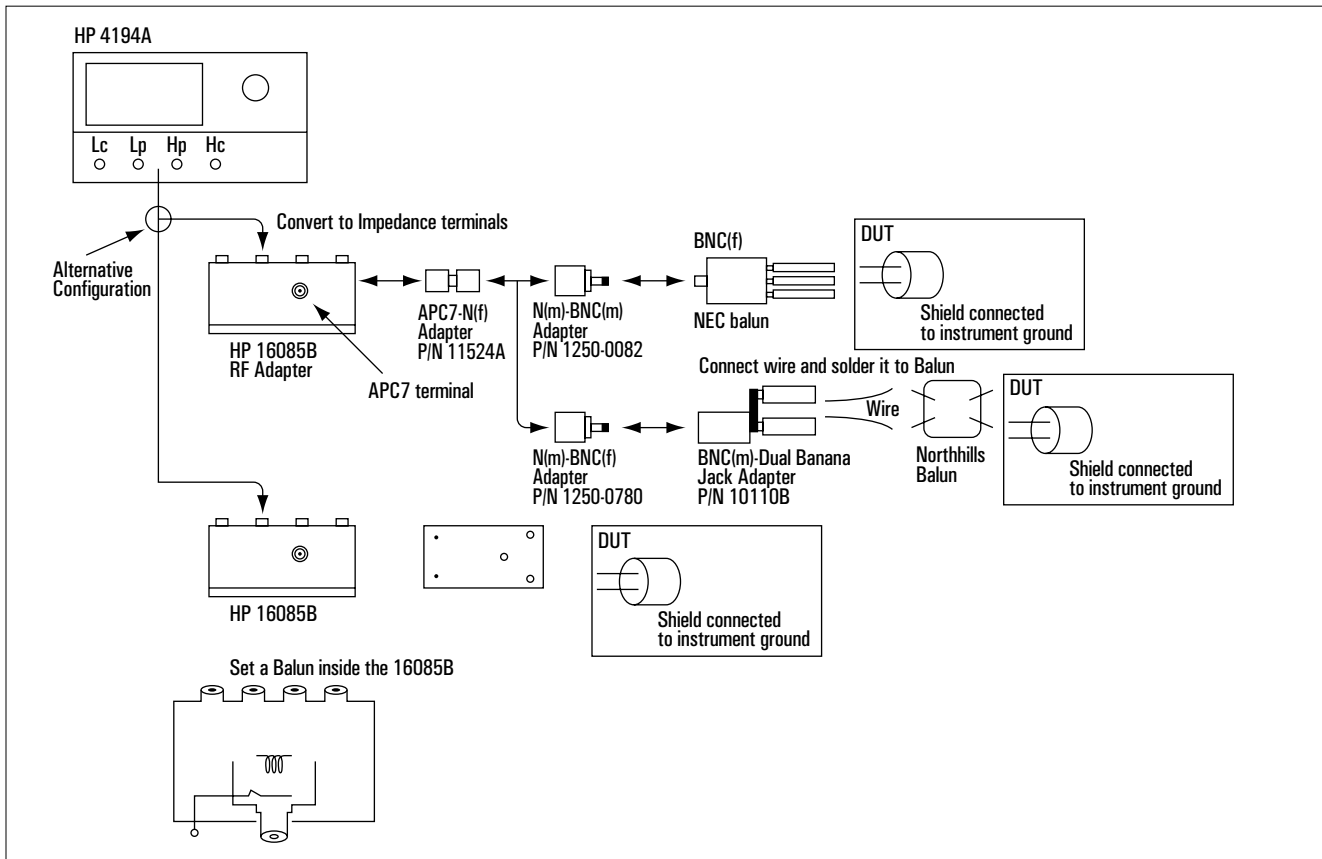


Figure 4. Measurement Configuration (1)

**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.

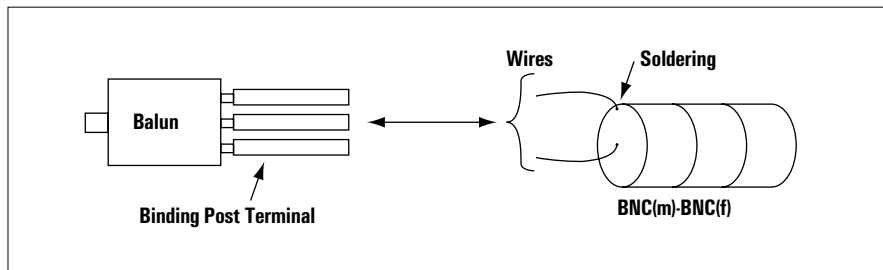


Figure 5. Assembling BNC connector

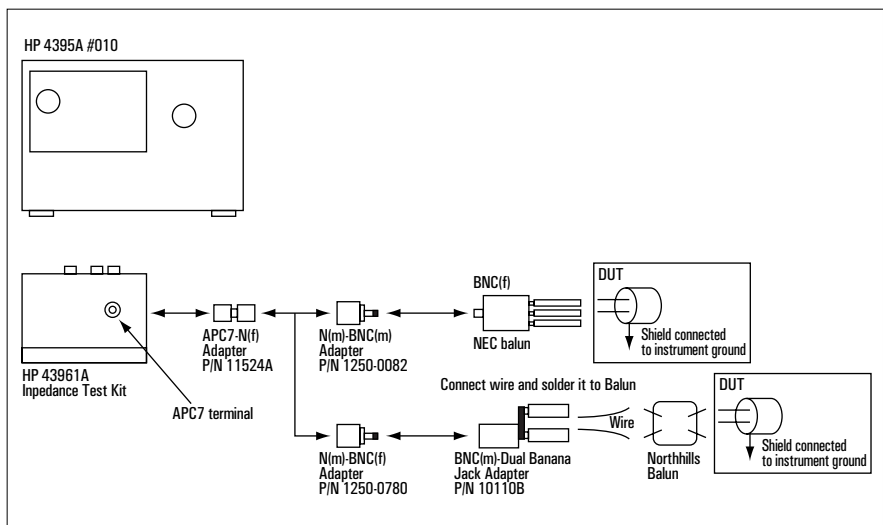


Figure 6. Measurement Configuration (2)

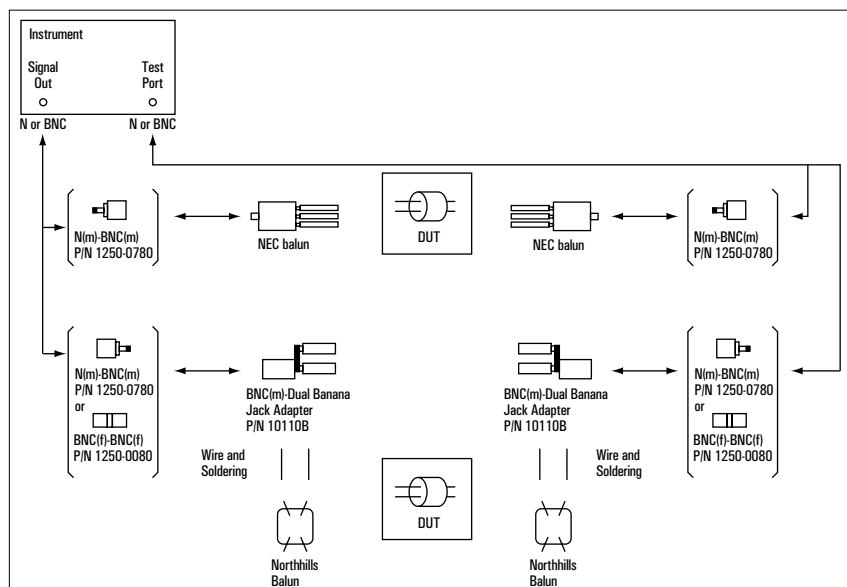


Figure 7. Measurement Configuration (3)

### 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 or 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  
Tel: (03) 3454-1111

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Hewlett-Packard Company  
Test and Measurement Call Center  
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Englewood, CO 80155-4026  
1 800 452 4844

**Canada:**  
Hewlett-Packard Canada Ltd.  
5150 Spectrum Way  
Mississauga, Ontario  
L4W 5G1  
(905) 206 4725

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Hewlett-Packard  
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1180 AZ Amstelveen  
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(31 20) 547 9900

**Japan:**  
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