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RETURN LOSS BRIDGE SCHEMATIC
Models 1, 2, 3

INPUT PORT

RG-174 coax

2X
100 Ω
1206

2X
100 Ω
1206

TEST PORT

2X
100 Ω
1206

RG-174 coax
with Ferrite beads

OUTPUT PORT

This bridge design does not use a transformer with magnetic coupling.
Instead it uses a current balun to pickup the bridge voltage.
That makes it inherently very wideband. The balun impedance
must be kept high over the frequency range of the bridge,
since this impedance effectively appears in parallel with the unknown.
A compensating impedance is used across the internal bridge
reference termination to maintain balance at the frequency extremes
of the bridge. This design is used in many commercial bridges.
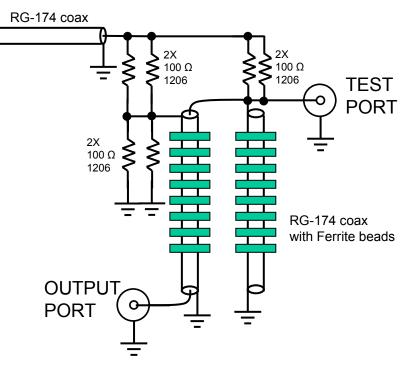
With the beads placed close to the PCB, you need to measure the bridge
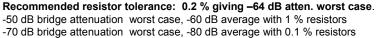directivity while you move the beads away from the PCB.
First on one side, then you try the other side.
One bead at a time, then two or three, until you find a spot that gives
the highest directivity between 300 and 2000 MHz.
It's best to use a network analyzer setup so that you can observe the frequency
response in real time.
To attach the bead, use anything that is non metallic, such as tie wraps, cords, glue.
The RG174 cable lengths should be about the same, the exact length is not critical.
Just use the length that is required as I did.
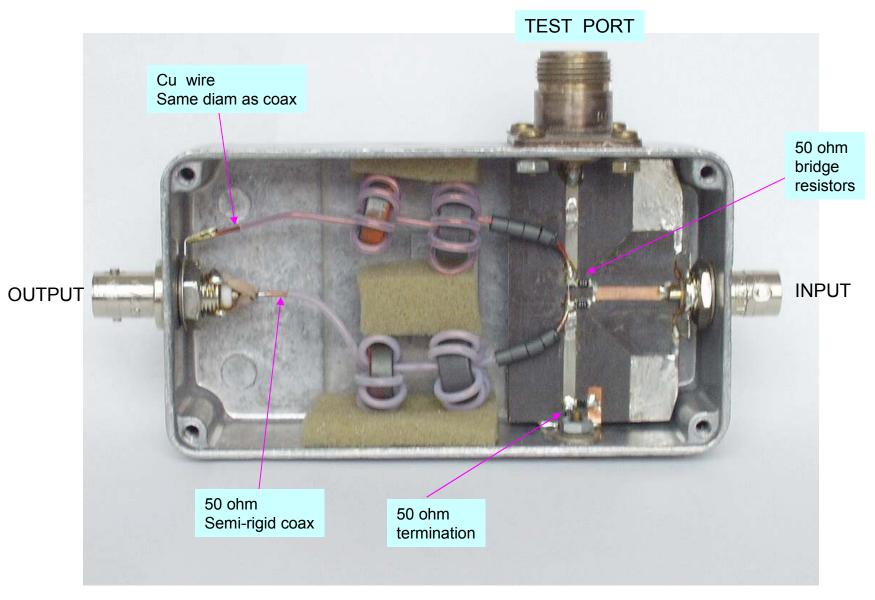
Recommended resistor tolerance: 0.2 % giving –64 dB atten. worst case.
-50 dB bridge attenuation worst case, -60 dB average with 1 % resistors
-70 dB bridge attenuation worst case, -80 dB average with 0.1 % resistors

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TEST PORT

Cu wire
Same diam as coax

50 ohm
bridge
resistors

OUTPUT

INPUT

50 ohm
Semi-rigid coax

50 ohm
termination

RETURN LOSS BRIDGE MODEL 1   100KHz – 1000 MHz

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TEST PORT

PCB as in model 3

Plexiglass 0.112 in. thick
at the bottom to space
the two toroids from ground

Plexiglass disk
(removed)
0.112 in. thick

RG-174 wound on
LF-HF large toroid
FT150A-W. 6 turns

VHF-UHF beads on RG-174 cable.
25 beads on each side, FT23-77

Note that the beads have been
attached with cords to secure them
in place and optimize directivity.

Felt pad gently holding the
toroid in place with a screw.
Two pads per toroid.

TEST

RETURN LOSS BRIDGE

| OUTPUT | 20 KHz @ 2000 MHz | INPUT |
| 50 ohms | | 50 ohms |

Same enclosure
as bridge model 3

FT150A-W ferrtie core dimensions:
OD : 1.5 in.
ID : 0.75 in.
Height : 0.5 in.
Permeability : 10 000

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RETURN LOSS BRIDGE MODEL 2   20KHz – 2000 MHz

Notice the coax connection
to the BNC connector.
Keep the center conductor short.

RETURN LOSS BRIDGE MODEL 2   20KHz – 2000 MHz

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DIRECTIVITY & TEST PORT RETURN LOSS

Insertion Loss

Test Port Ret Loss

Directivity

dB

FREQUENCY MHz

0.01   0.1   1   10   100   1000   10000

0, -5, -10, -15, -20, -25, -30, -35, -40, -45, -50
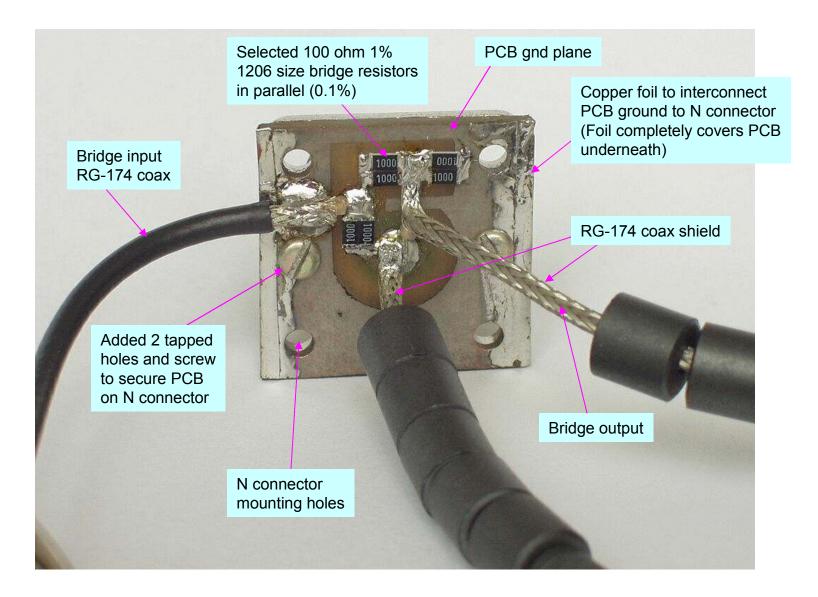
RETURN LOSS BRIDGE MODEL 2   performance tests

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RG-174 coax
(Internal cond. not used).
Same length as bridge
output coax. Connect to gnd

Bridge input

Bridge output

Crimped BNC

RG-174 coax

LF-HF toroids

VHF-UHF
beads

RG-174 coax

Use five Amidon FB43-801   beads
or Fair-Rite 43 beads : 2643000801

PCB

Use two Fair-Rite #2631250202
Amidon equivalent: FB-31-0202
u = 1500 (31 material)
0.125 in / 0.25 in. and 1.0 in. long

N connector – flat back

Test Port

RETURN LOSS BRIDGE MODEL 3   1 MHz to 2500 MHz

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Selected 100 ohm 1%
1206 size bridge resistors
in parallel (0.1%)

PCB gnd plane

Copper foil to interconnect
PCB ground to N connector
(Foil completely covers PCB
underneath)

Bridge input
RG-174 coax

RG-174 coax shield

Added 2 tapped
holes and screw
to secure PCB
on N connector

Bridge output

N connector
mounting holes
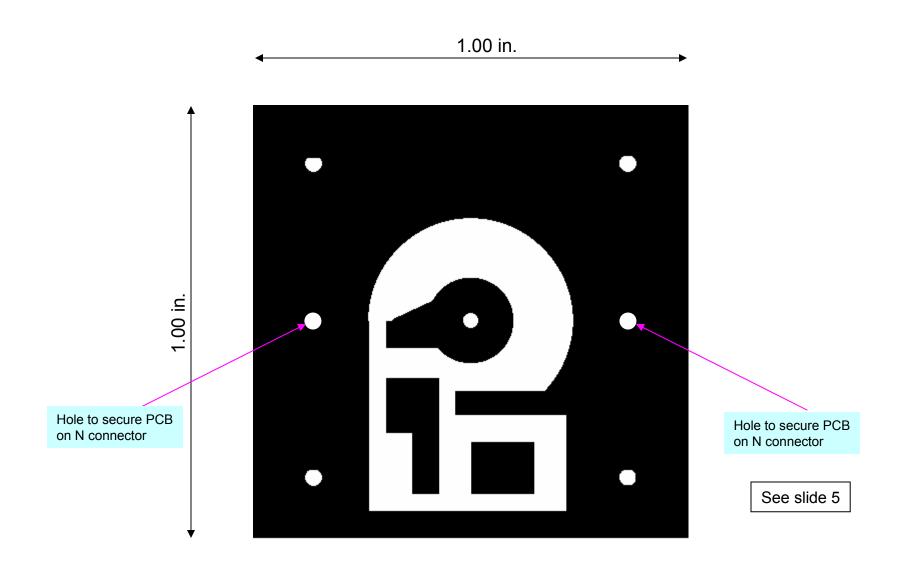
RETURN LOSS BRIDGE MODEL 3   N Connector with PCB

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INPUT

Tie-wrap

OUTPUT

Air bubble material
to hold coax cables

Test Port

Silicone to hold the
ferrites in place after adjustment
by changing the ferrite position
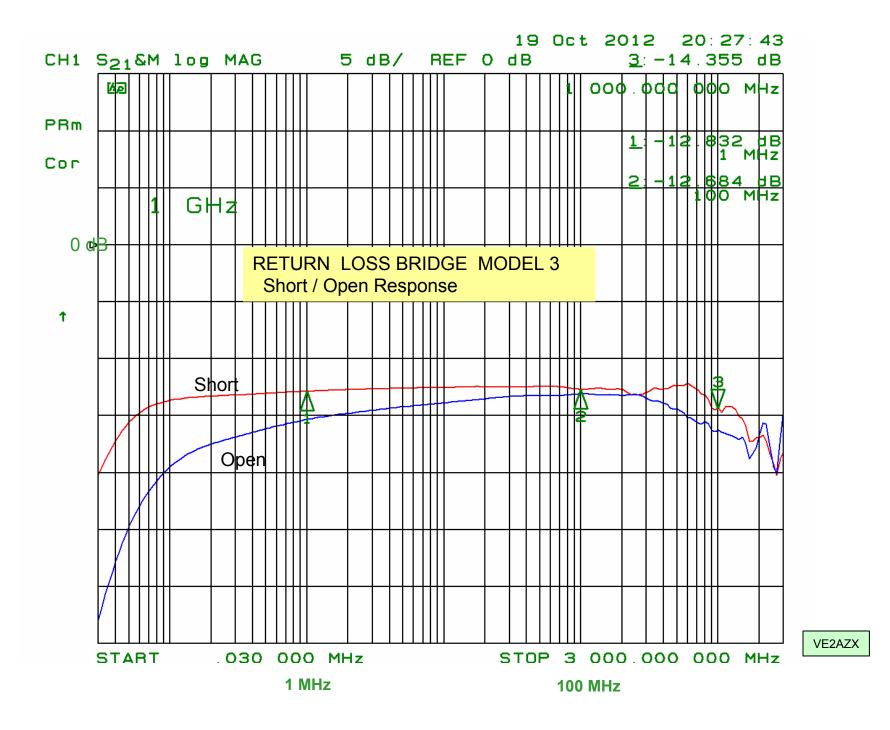
RETURN LOSS BRIDGE MODEL 3   bridge mounted in its enclosure

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1.00 in.

1.00 in.

Hole to secure PCB
on N connector

Hole to secure PCB
on N connector

See slide 5

PCB for return loss bridge models 2 and 3

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RETURN LOSS BRIDGE MODEL 3
Return Loss at Input – 50 ohm at test port

RETURN LOSS BRIDGE MODEL 3

Stocklist

QTY
10   Amidon FB43-801   Ferrite beads (u=850)
       or Fair-Rite 43 SHIELD BEAD: 2643000801
       u = 800 (43 material)
       0.094 in / 0.296 in. and 0.297 in. Long
       Use 5 per side.
4   Use Fair-Rite 31 SHIELD BEAD: 2631250202
       Amidon equivalent: FB-31-0202
       u = 1500 (31 material)
       0.125 in / 0.25 in. and 1.0 in. long
       Use two per side.
2   BNC Bulkhead Jacks, RG174   Digikey # A1813-ND
1   N type connector with flat back
1   Al Case Hammond Manufacturing # 1590B
6   Selected 100 ohm +/- 0.1 ohm 1206 SMT resistors
1   PCB
18 in.   RG174 miniature coax.
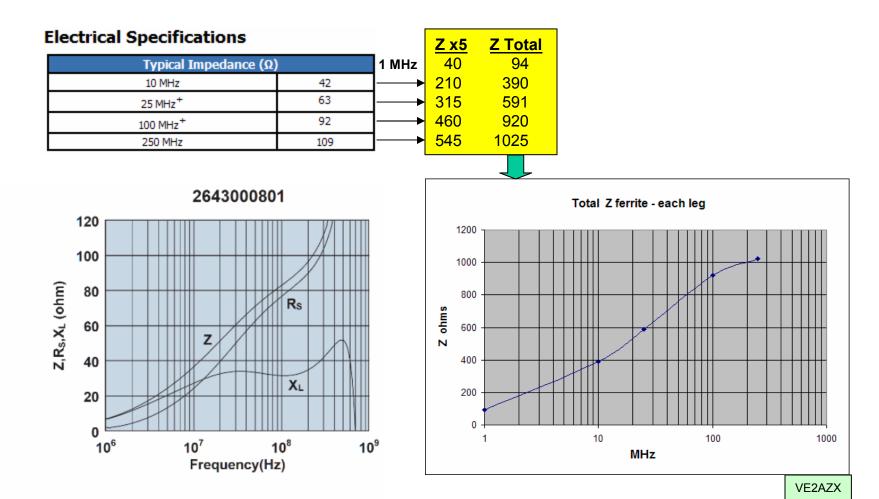
Note that high freq performance critically depends on:
1- Using a small PCB, located behind the N test connector.
2- Using RG174 bulkhead BNC connectors.
3- Adjusting the location of the ferrite beads for best balance, preferably by looking at the
    S21 curve from 500 to 3000 MHz.

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Fair-Rite 43 SHIELD BEAD: 2643000801

u = 800 (43 material)
0.094 in / 0.296 in. and 0.297 in. long
Very close to Amidon FB43-801
Use five per side

http://www.fair-rite.com/cgibin/catalog.pgm

Fair-Rite authorized distributors:
http://www.fair-rite.com/newfair/support.htm

Electrical Specifications

Typical Impedance (Ω)			Z x5	Z Total
		1 MHz	40	94
10 MHz	42		210	390
25 MHz⁺	63		315	591
100 MHz⁺	92		460	920
250 MHz	109		545	1025

2643000801

Impedance, reactance, and resistance vs. frequency.

Total Z ferrite - each leg

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Fair-Rite 31 SHIELD BEAD: 2631250202
u = 1500 (31 material)
0.125 in / 0.25 in. and 1.0 in. long
Use two per side

Electrical Specifications

Typical Impedance (Ω)		Z x2
1 MHz	27	54
5 MHz	70	140
10 MHz+	90	180
25 MHz+	138	276
100 MHz+	230	460
250 MHz	240	480

Impedance, reactance, and resistance vs. frequency.

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Amidon FT-23H Measured data vs Fair-Rite spec for type 31 #2631250202

Ferrite **Z Mag**   Blue: FT23H 20 beads   Pink: Fair Rite#2631250202 2 pieces

RL Bridge Simulations

Ref: BridgeSim.wsp

Effect of the ferrite resistance

INPUT PORT

RG-174 coax

2X 100 Ω 1206

2X 100 Ω 1206

TEST PORT

2X 100 Ω 1206

RG-174 coax with Ferrite beads

OUTPUT PORT

Circuit used for simulations

INPUT from 50 ohm source

(1)

OUTPUT to 50 ohm det.

(2)

R1 R=50 ohm

T1 P=1

R2 R=50 ohm

Ideal 1:1 transformer

R5 R=1000 ohm [Rf]

R3 R=50 ohm

R6 R=1000 ohm [Rf]

R4 R=25.975 ohm [RX]

R4 = Zx the DUT

R5 and R6 are the ferrite resistance

SIMULATION RESULTS

Rferrite = R5 = R6

Ohms	Bridge Insertion Loss dB		
Rferrite	Short	Open	Open - Short
100000	12.040	12.040	0.000
30000	12.048	12.066	0.018
10000	12.058	12.113	0.055
5000	12.075	12.183	0.108
2000	12.123	12.390	0.267
1000	12.204	12.728	0.524
500	12.362	13.378	1.016
200	12.821	15.147	2.326

NOTES

- Simulations use 50 ohm source and detector.
- The ferrite impedance is assumed to be resistive.
- The resistance of the ferrites increases bridge losses above its 12.04 dB basic loss.
- Worst case RL measurement errors occur at impedance extremes: short and open. Errors are at minimum with Zx around 50 ohms.
- Ferrite resistance affect more the open.
- Higher Zx above 50 ohms will give more error in RL measurements.
- Open - short attenuation difference is directly related to the resistance of the ferrites.
- The ferrite should provide > 500 ohms resistance
  At 500 ohms the difference open - short = 1 dB
- For best accuracy, refer the RL measurements to the <u>average</u> open and short attenuation.

Blue = Open - Short, Pink = Short, Yellow = Open