An Improved Common Mode Noise Tolerance Test for 1000BASE-T

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Overview

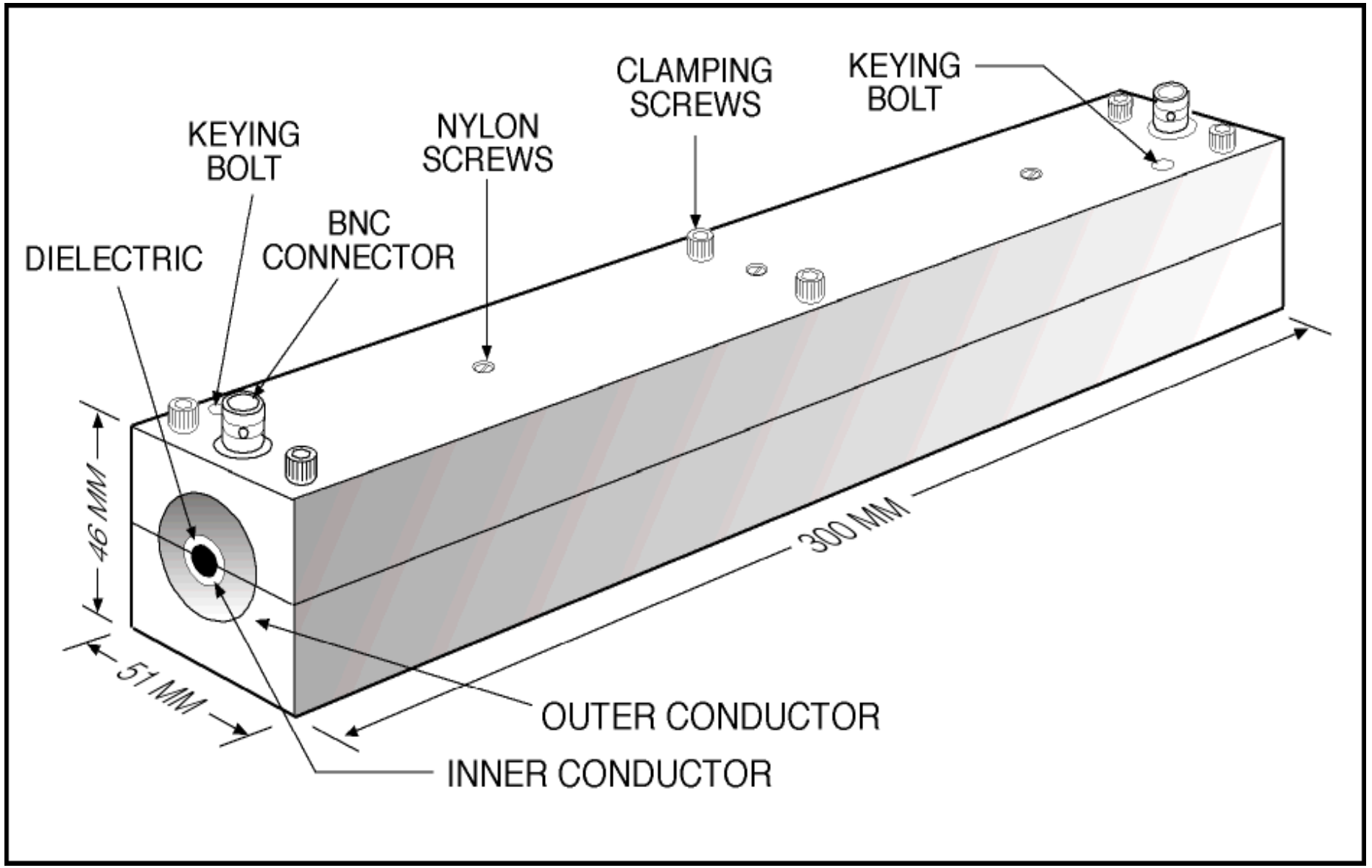
- Most external noise disturbances induce common mode, rather than differential mode, voltages in cabling
- A receiver's ability to reject common mode noise is critical to ensure adequate immunity to subjected noise
- The currently proposed receiver common mode rejection test is based on 1BASE-5 and not suitable for the 1000BASE-T frequency range
- We've developed a new test procedure that facilitates non-intrusive common mode tolerance testing at 1-250 MHz to simulate the effects of a 3 V/m radiated immunity test
- Specifics of the new test procedure are provided along with drop-in replacement text for section 40.6.1.3.3.

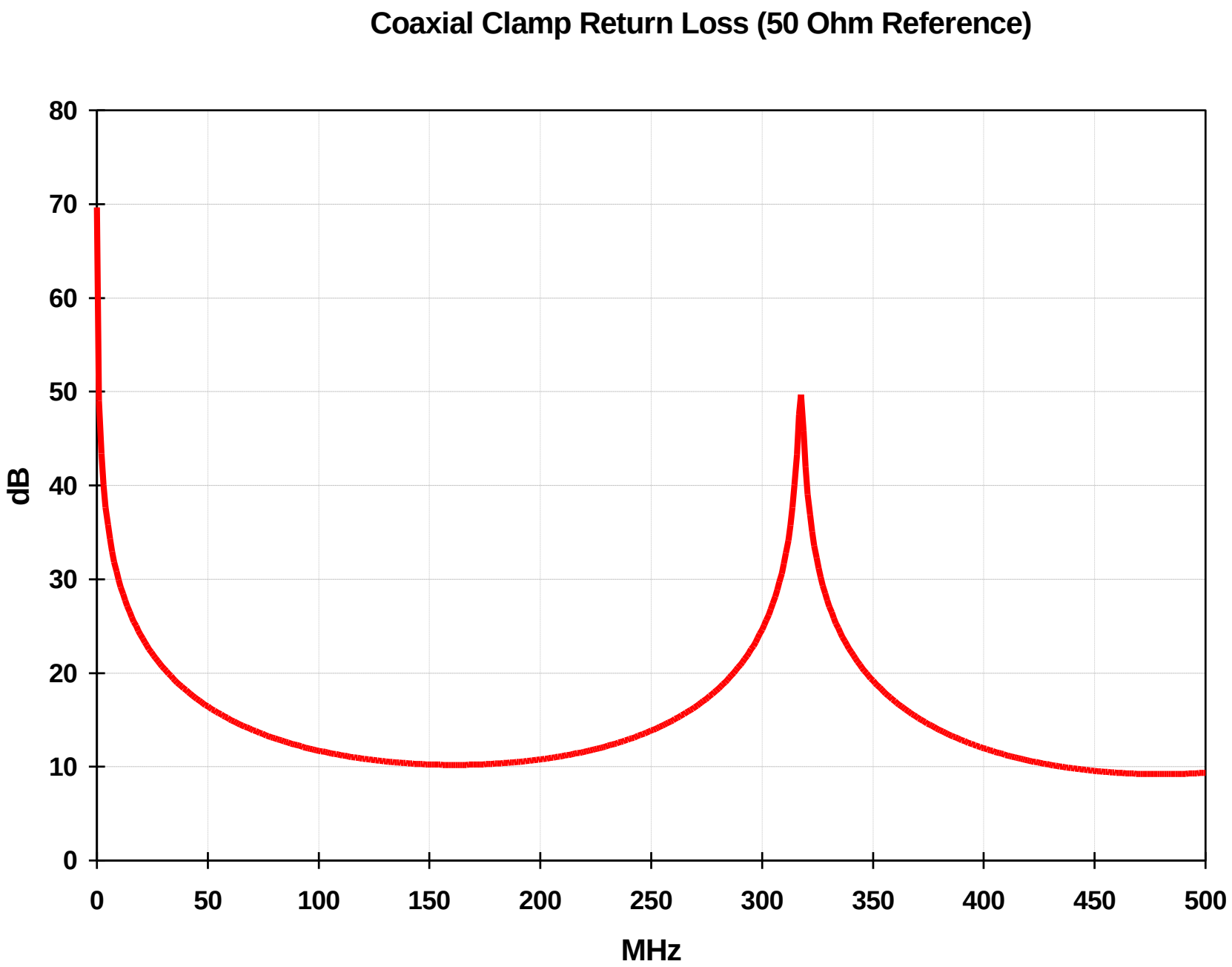
History of clamp development efforts

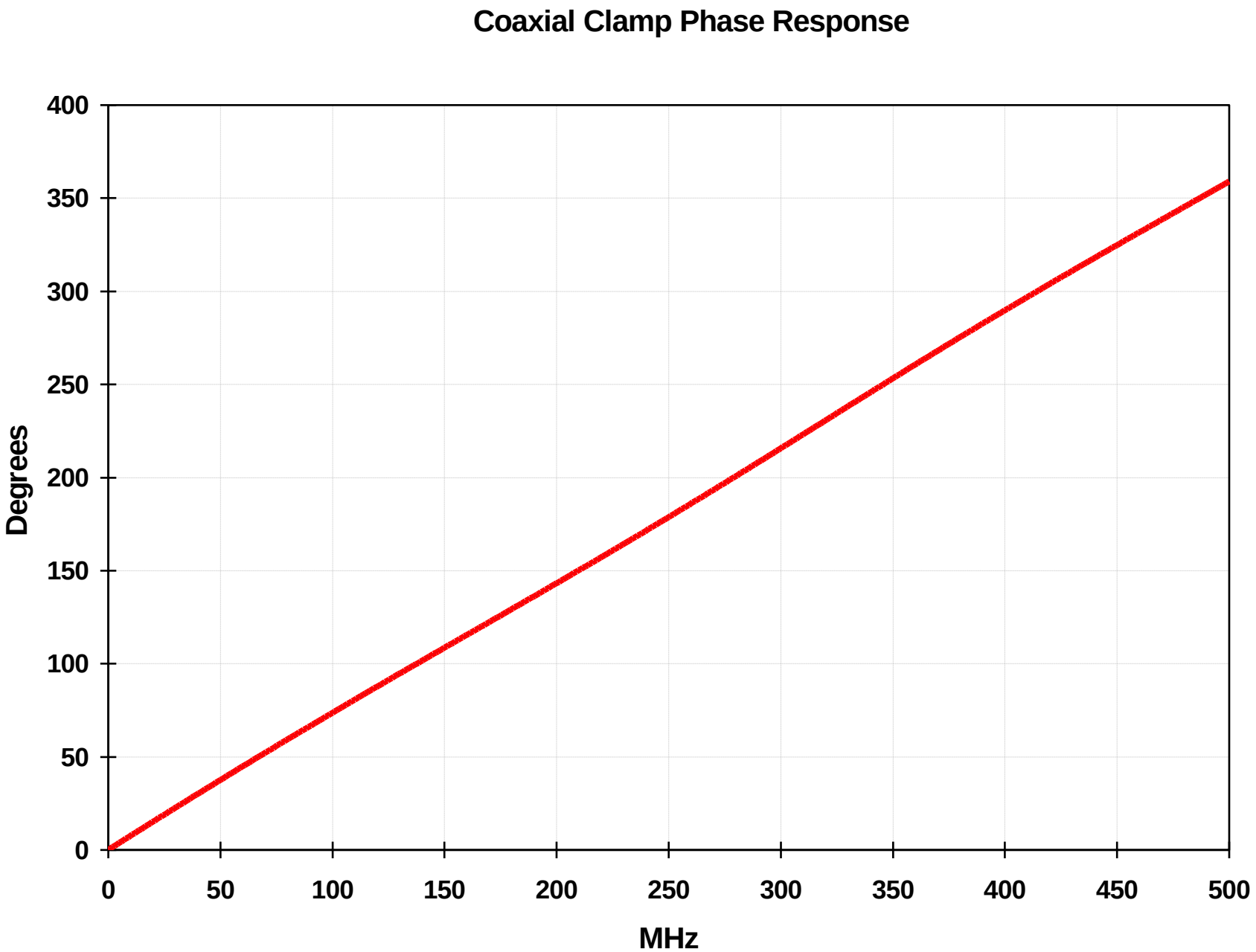
- Over the last 15 months we investigated the following methods for testing receiver common mode tolerance:
  - resistor network (poor balance, impedance, flat loss, intrusive)
  - back-to-back lab baluns (flat loss problem & intrusive)
  - inductive center tap (impedance stability & intrusive)
  - current injection via probe (probe overheating, power reqmts)
  - IEC 61000-4-4 capacitive clamp (impedance stability, antenna)
  - custom coaxial clamp (good stability & reproducibility, non-intrusive)

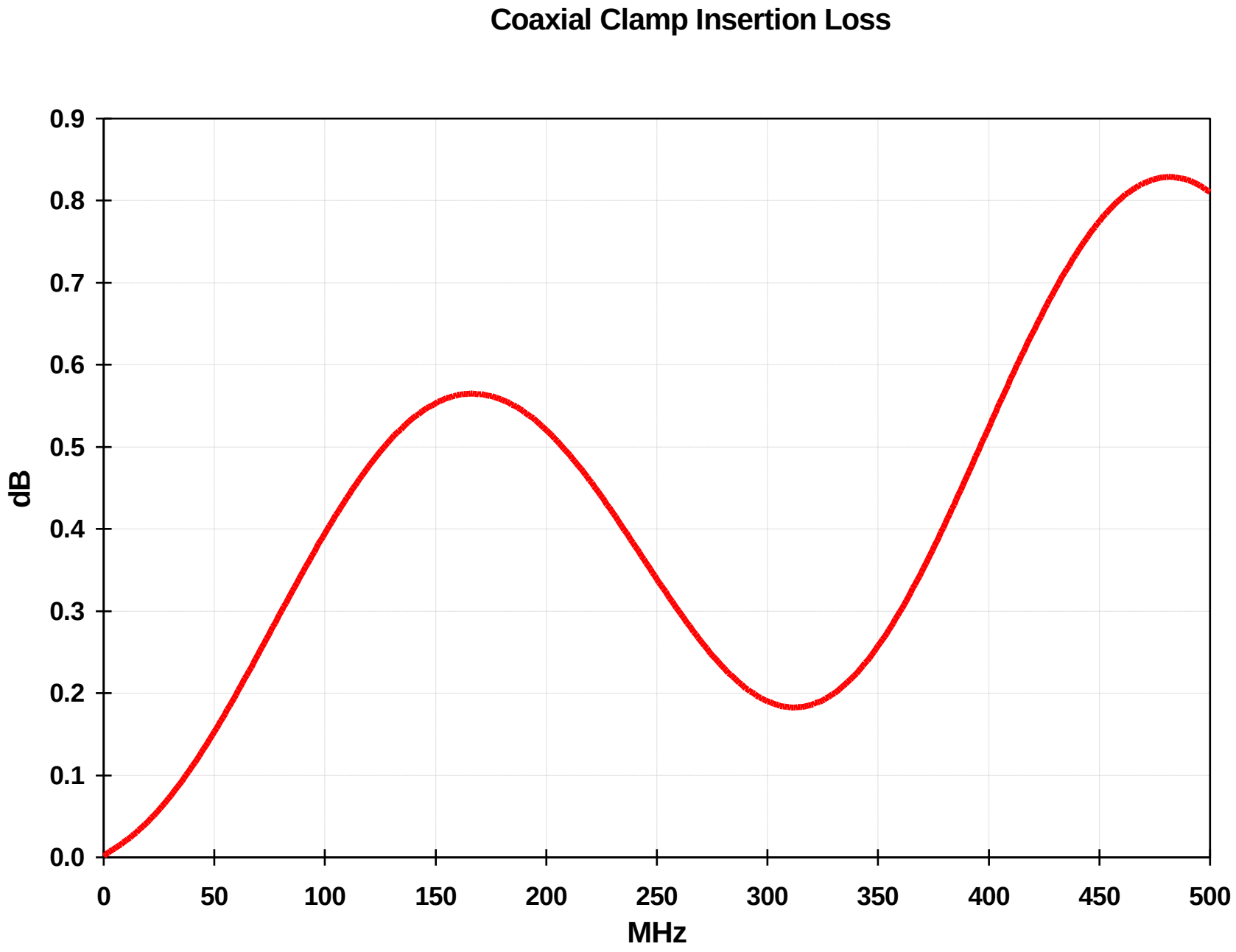
Conclusion: pursue the coaxial clamp method

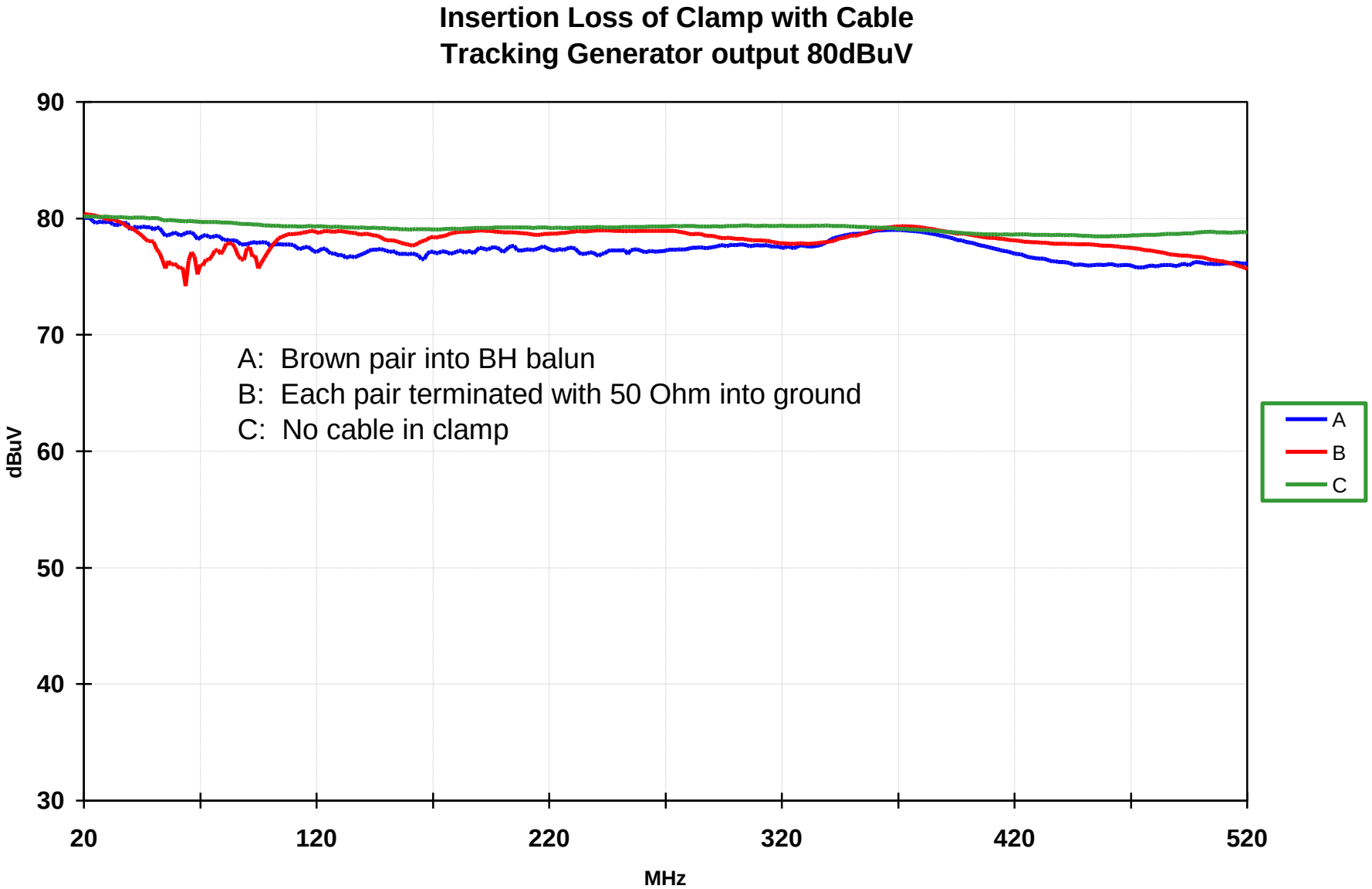
Description of cable clamp developed




Coaxial Clamp Return Loss (50 Ohm Reference)
80
70
60
50
40
30
20
10
0
dB
0
50
100
150
200
250
300
350
400
450
500
MHz

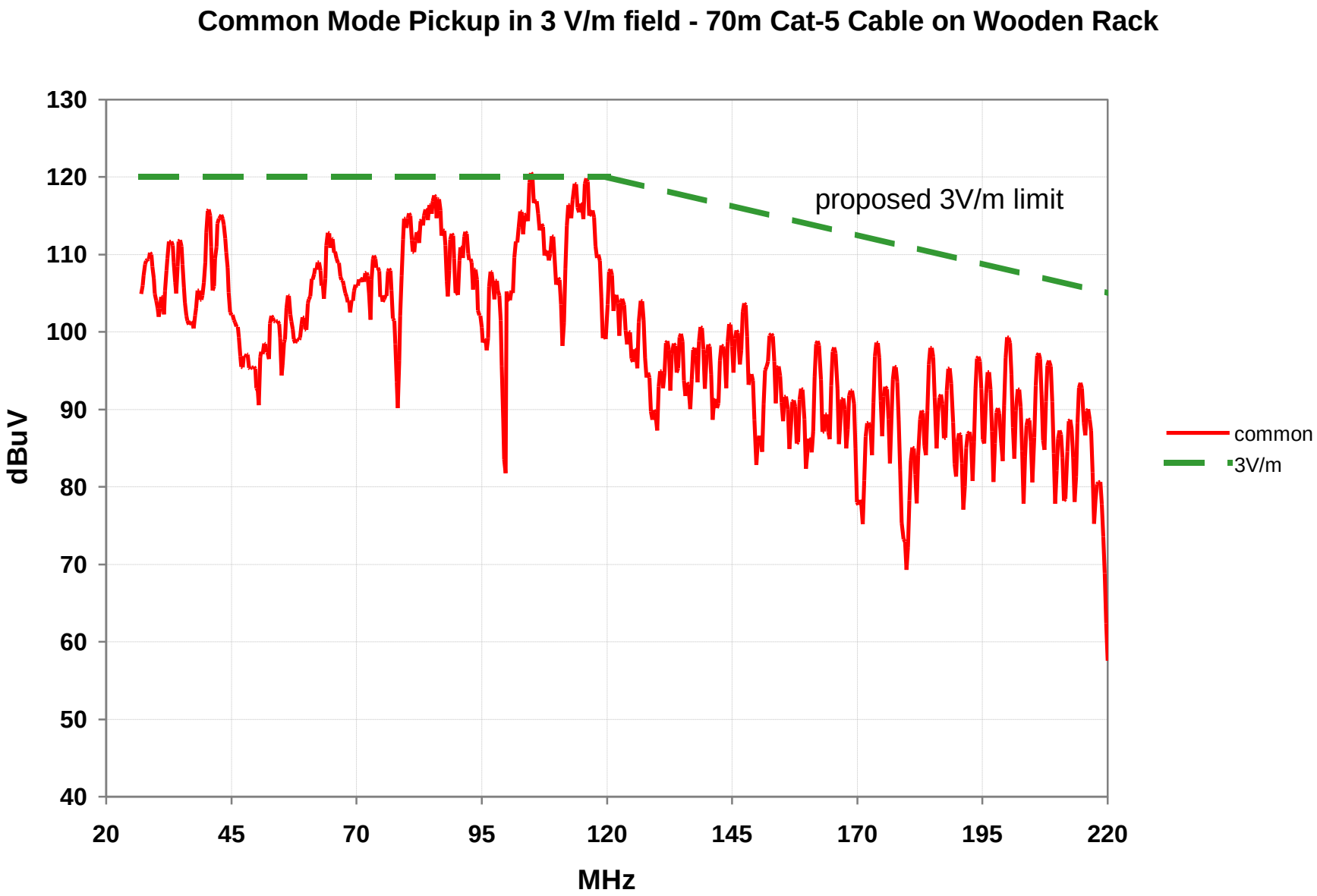

Coaxial Clamp Phase Response
Degrees
400
350
300
250
200
150
100
50
0
0
50
100
150
200
250
300
350
400
450
500
MHz

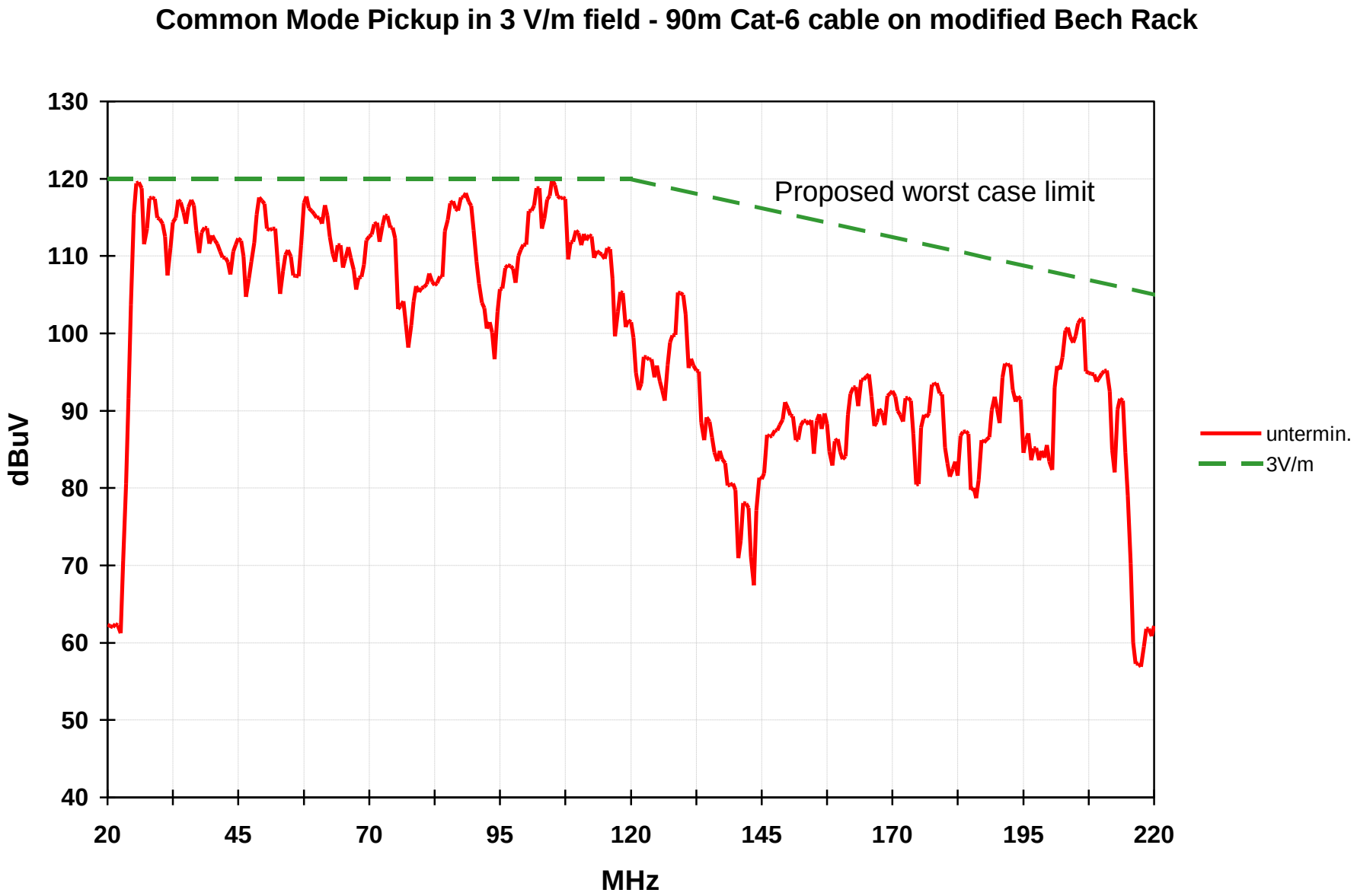

Coaxial Clamp Insertion Loss
dB
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
50
100
150
200
250
300
350
400
450
500
MHz

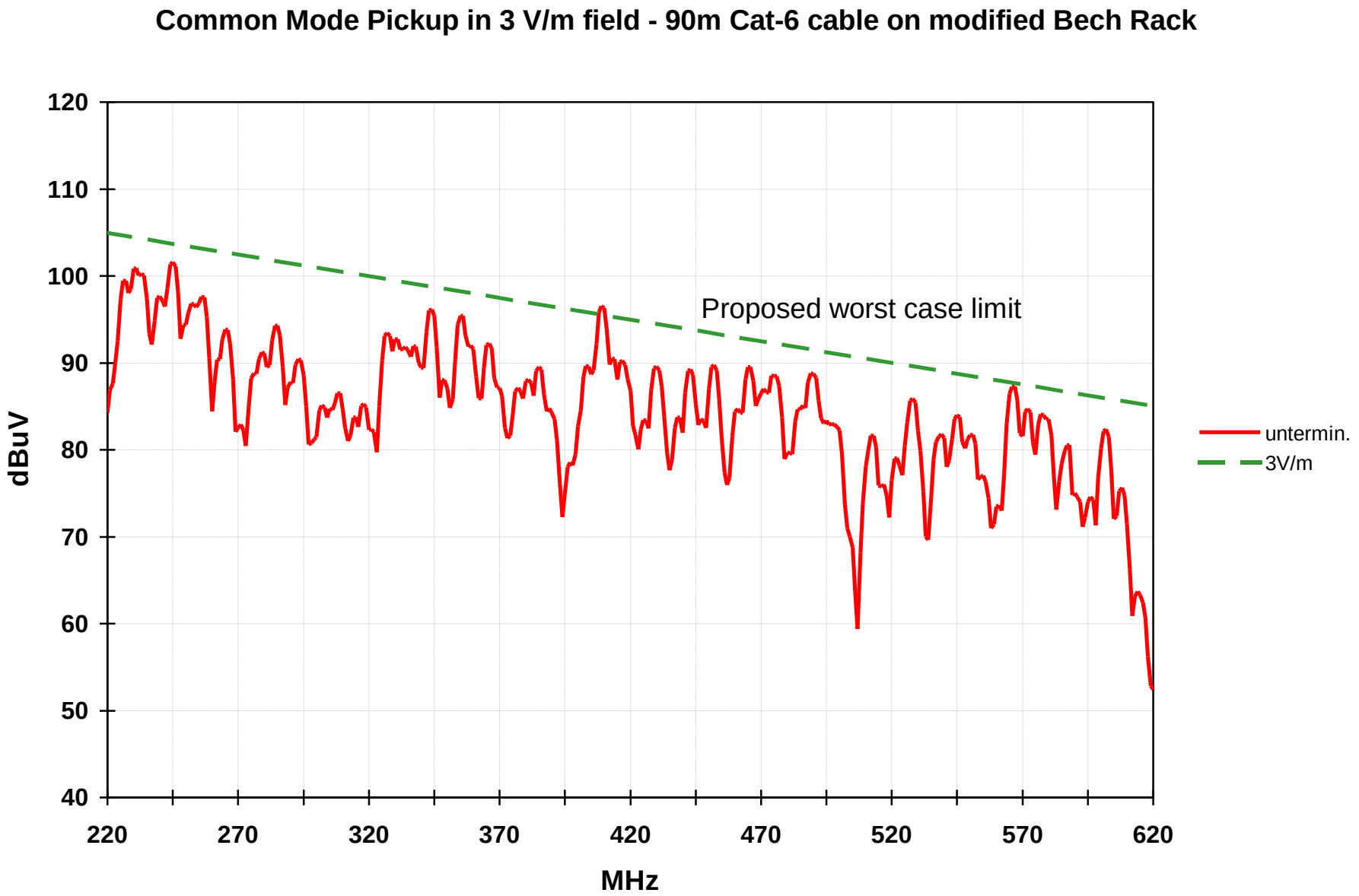

Insertion Loss of Clamp with Cable
Tracking Generator output 80dBuV
90
80
70
60
50
40
30
dBuV
20
120
220
320
420
520
MHz
A: Brown pair into BH balun
B: Each pair terminated with 50 Ohm into ground
C: No cable in clamp
A
B
C

Conclusions on clamp characteristics

- The cable clamp is reasonably sized and easy to manufacture (external source to manufacture located)
- The clamp has acceptable return loss for use with typical 50 ohm voltage sources
- The clamp has minimal insertion loss & linear phase response
- The presence of a cable in the clamp has minimal effect on the clamp's insertion loss (consistent voltage on center conductor)


Common Mode Pickup in 3 V/m field - 70m Cat-5 Cable on Wooden Rack
130
120
110
100
90
80
70
60
50
40
dBuV
20
45
70
95
120
145
170
195
220
MHz
proposed 3V/m limit
common
3V/m


Common Mode Pickup in 3 V/m field - 90m Cat-6 cable on modified Bech Rack
Proposed worst case limit
dBuV
MHz
130
120
110
100
90
80
70
60
50
40
20
45
70
95
120
145
170
195
220
untermin.
3V/m

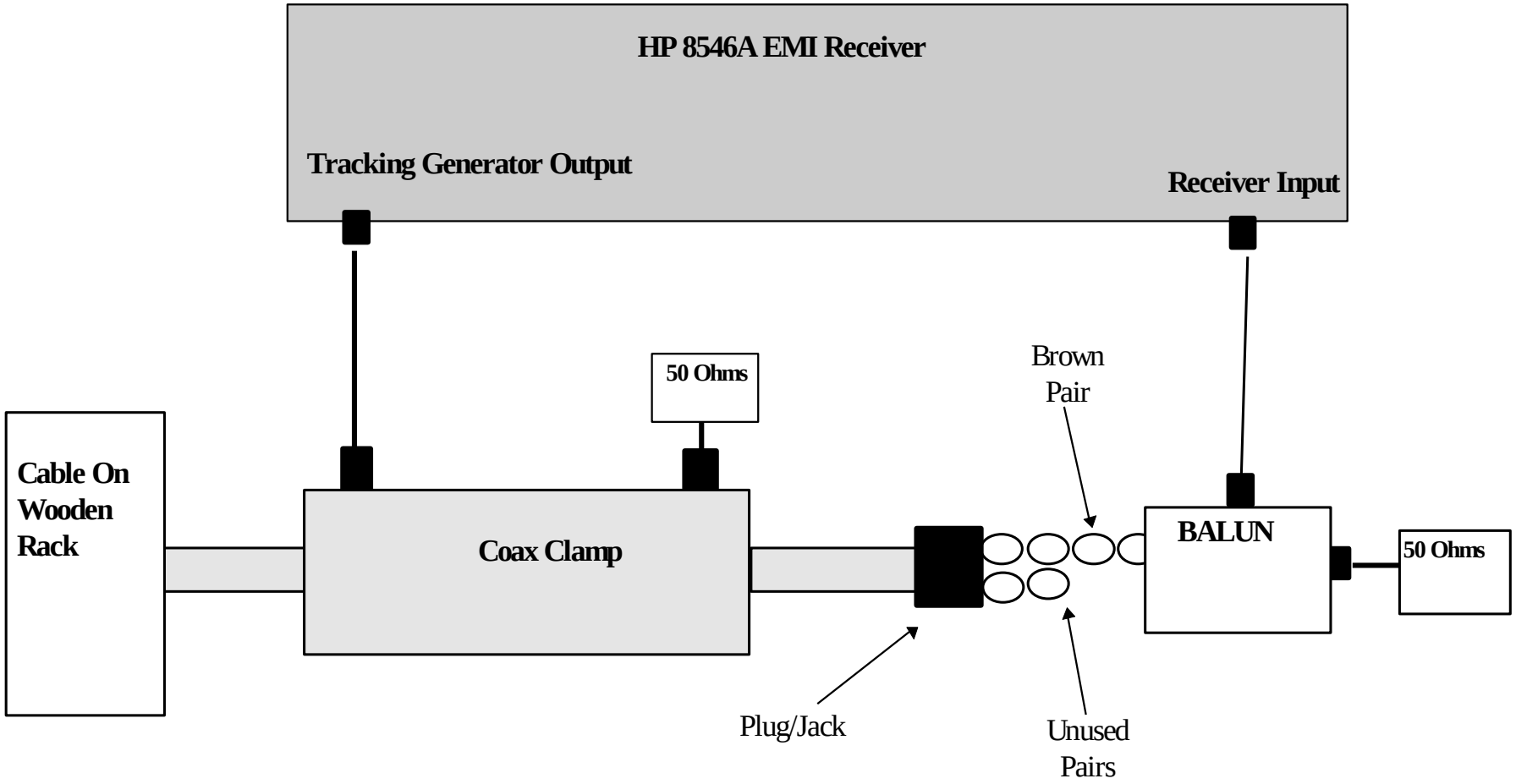

Common Mode Pickup in 3 V/m field - 90m Cat-6 cable on modified Bech Rack
120
110
100
90
80
70
60
50
40
dBuV
220
270
320
370
420
470
520
570
620
MHz
Proposed worst case limit
untermin.
3V/m

Conclusions on common mode pickup from a 3 V/m radiated field

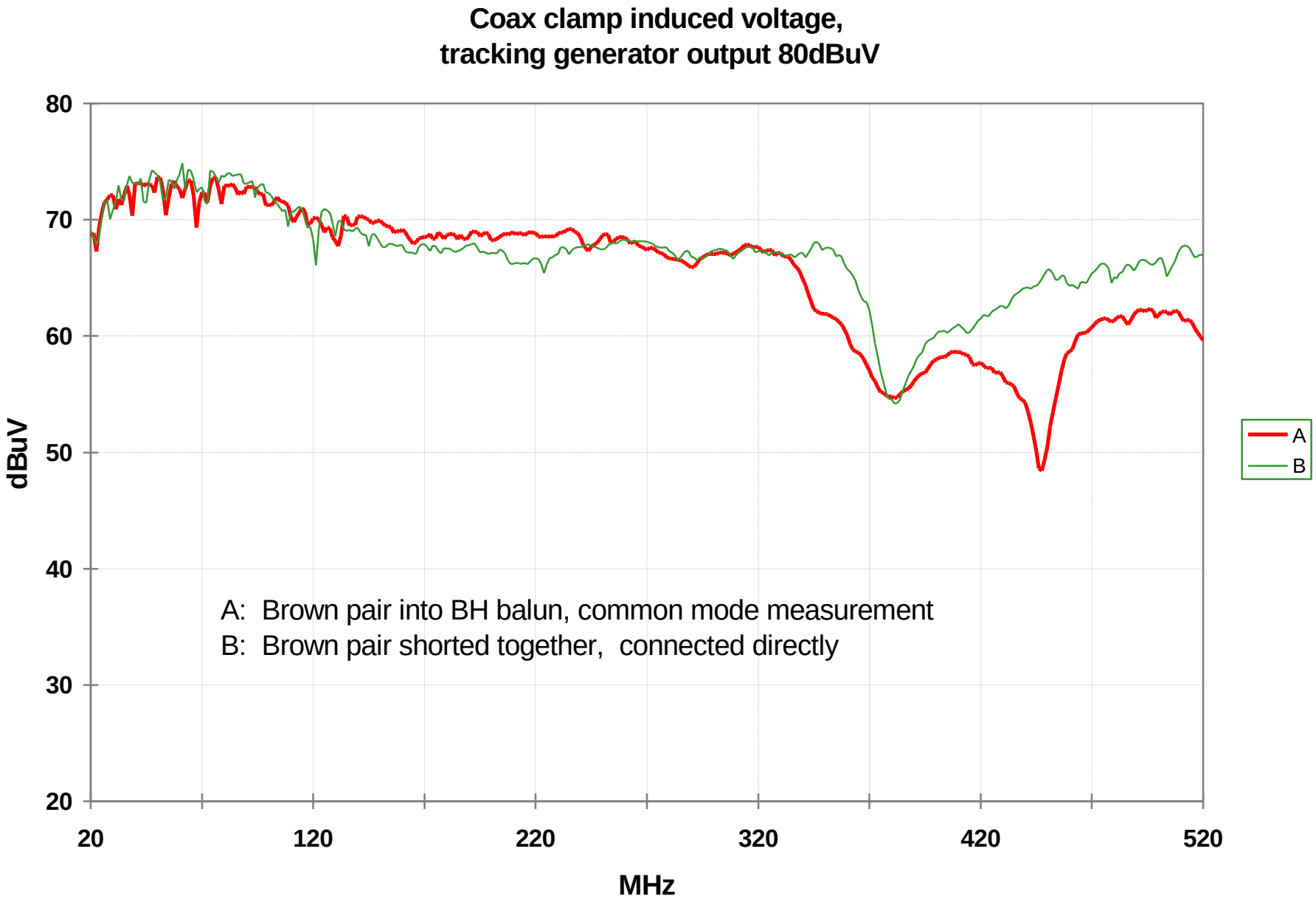
- Two measurements made under slightly different conditions (70m Cat-5 cable on wooden rack, 90m Cat-6 cable on reduced size Bech Rack[1]) showed consistent worst-case common mode pickup of 120 dBuV.
- At frequencies above 120 MHz, the worst-case pickup is gradually reduced up to at least 620 MHz (beyond the range of interest).
- Although the worst-case common mode pickup of cables is fairly consistent, the pickup varies sporadically with frequency which yields the poor reproducibility we've come to accept in the black art of EMC testing.

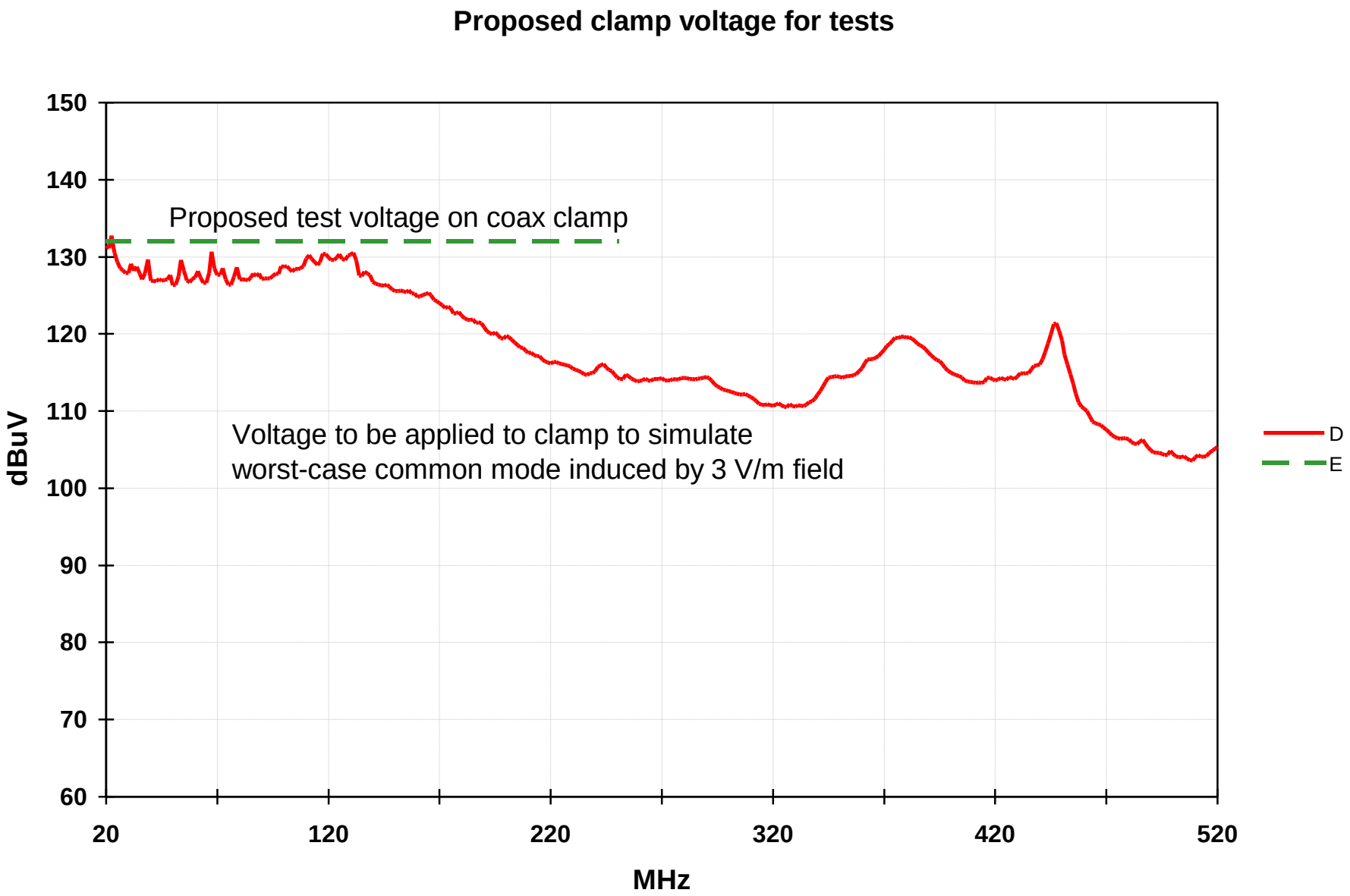
[1]**Eric Bech, "Proposed cabling set-up for electromagnetic characterisation of cabling and EMC measurements on LAN systems", DELTA European Cabling, April 1997.**

Setup for Clamp Induced Voltages



Setup for clamp induced voltage measurements


Coax clamp induced voltage,
tracking generator output 80dBuV
80
70
60
50
40
30
20
dBuV
20
120
220
320
420
520
MHz
A
B
A: Brown pair into BH balun, common mode measurement
B: Brown pair shorted together, connected directly


Proposed clamp voltage for tests
150
140
130
120
110
100
90
80
70
60
dBuV
Proposed test voltage on coax clamp
Voltage to be applied to clamp to simulate
worst-case common mode induced by 3 V/m field
20
120
220
320
420
520
MHz
D
E

Conclusions on clamp induced voltage

- The common mode voltage induced by the clamp onto the cabling is fairly consistent up to at least 250 MHz.
- Applying a 4 volt (132 dBuV) signal to the clamp over the 1-250 MHz frequency range adequately simulates the worst-case common mode disturbance that would be generated by a 3 V/m radiated field.
- This simple procedure results in repeatable common mode tolerance tests of receivers.
- The drop-in text for section 40.6.1.3.3 is provided as a separate handout.