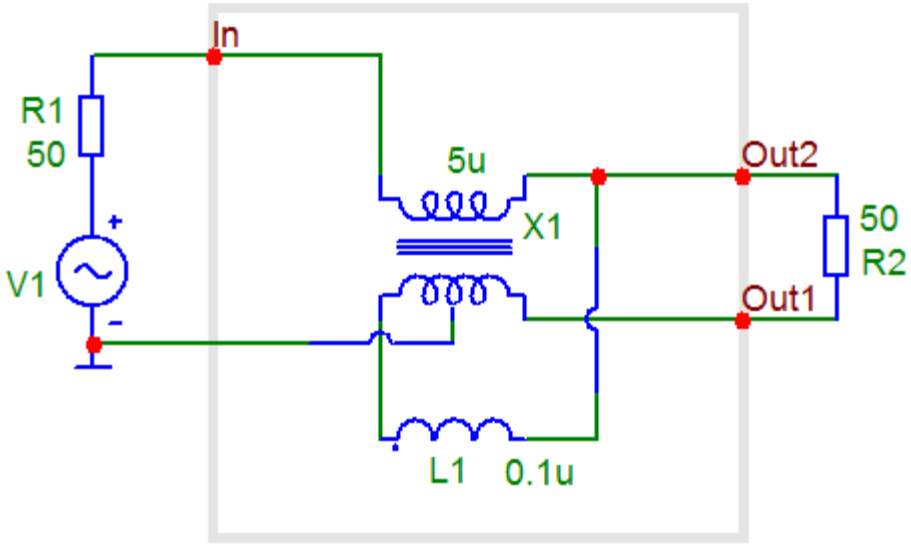
Voltage balun

With a simple modification a current balun can be converted to voltage balun, which has better symmetry

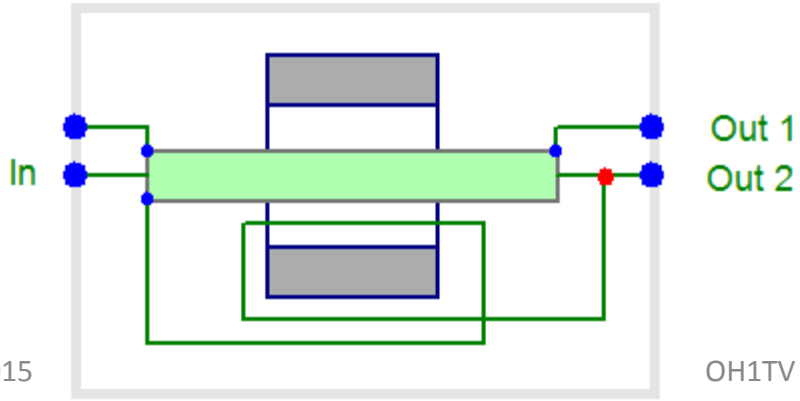
Introduction

- This is a test report. My aim was to analyze behavior of a Voltage Balun, made like current balun with ferrite beads but having one additional wire in order to force voltage symmetry.
- Amidon beads FB-43-1020 were used. One test series was made with 3 beads and another with 5 beads
- Focus was on voltage symmetry, impedance matching, frequency range and power rating.
- The analyze was made both by modeling and measuring.

Balun 50/50ohm

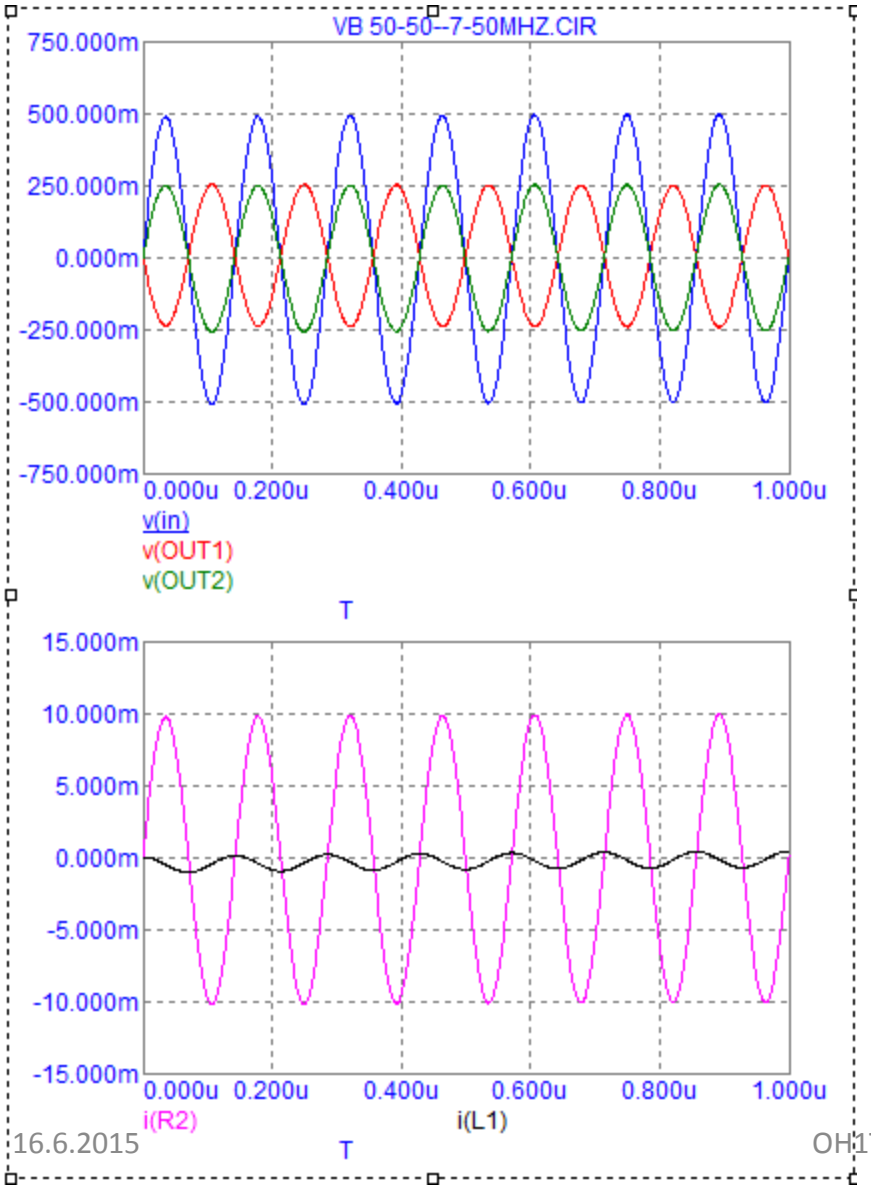


L1 stray inductance
of the non coax wire



Ferrite bead as a transformer core
- Coax cable makes 2 windings
- Additional wire makes the third winding

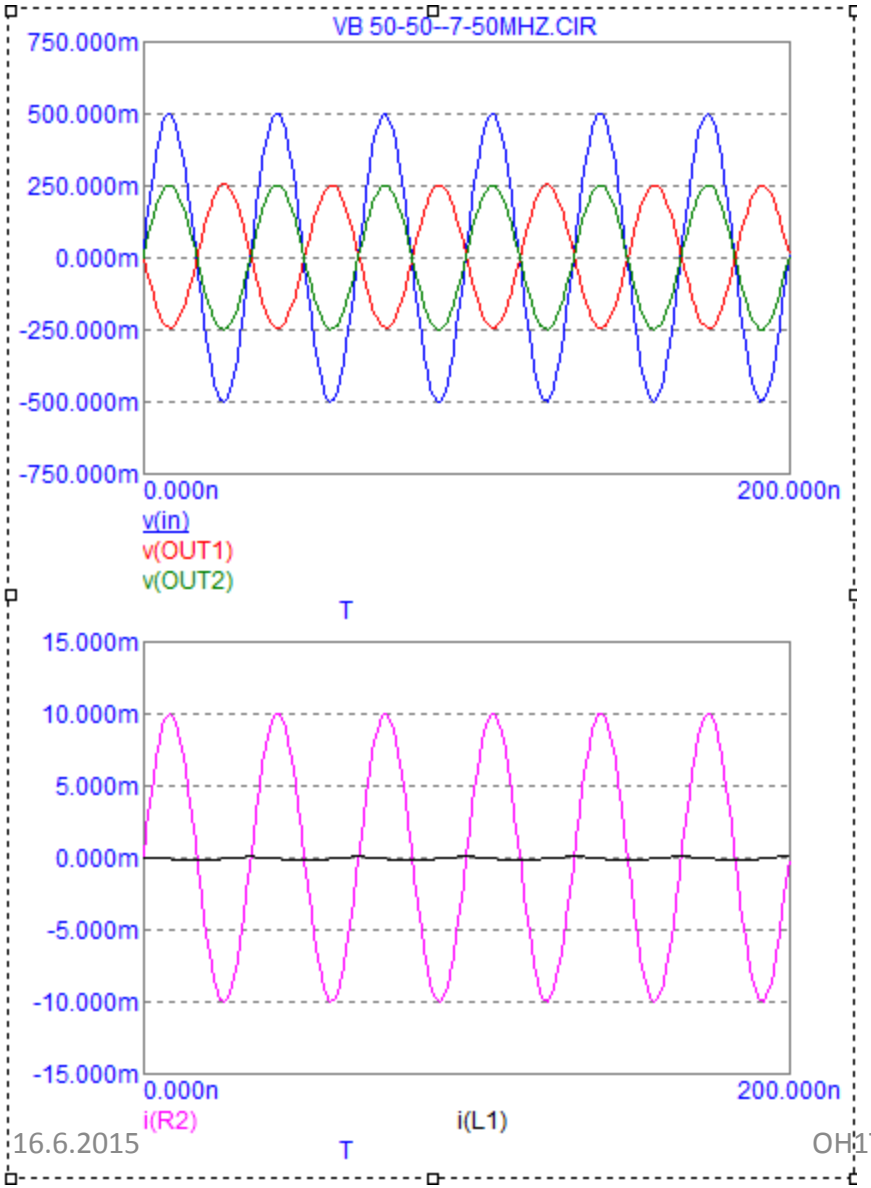
Modeled voltage and current @ 7MHz



Blue = input voltage to balun
Red = output voltage 1
Green = output voltage 2

Red = current in load resistor R2
Black= current in L1 and balancing winding

Modeled voltage and current @ 30MHz

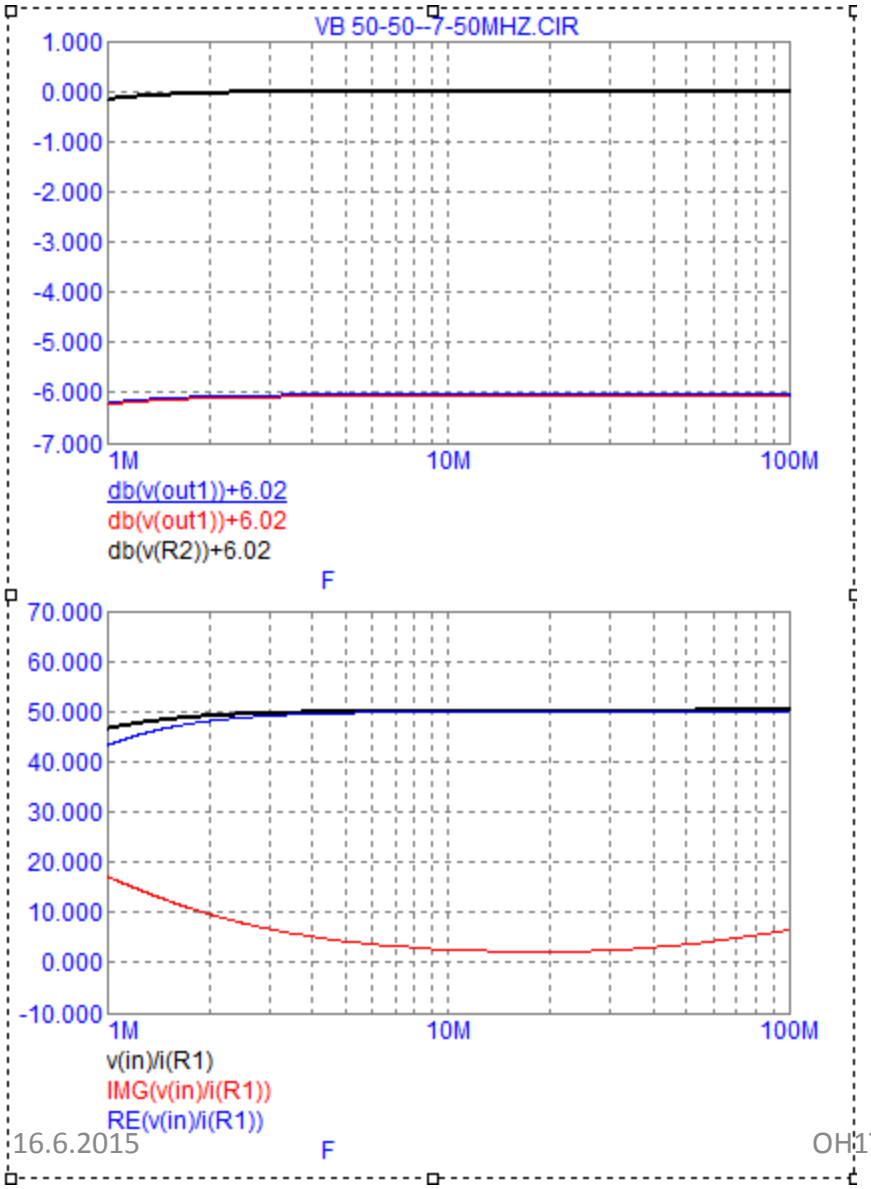


Blue = input voltage to balun
Red = output voltage 1
Green = output voltage 2

Red = current in load resistor R2
Black= current in L1 and balancing winding

- Note that this current is lower than on 7MHz

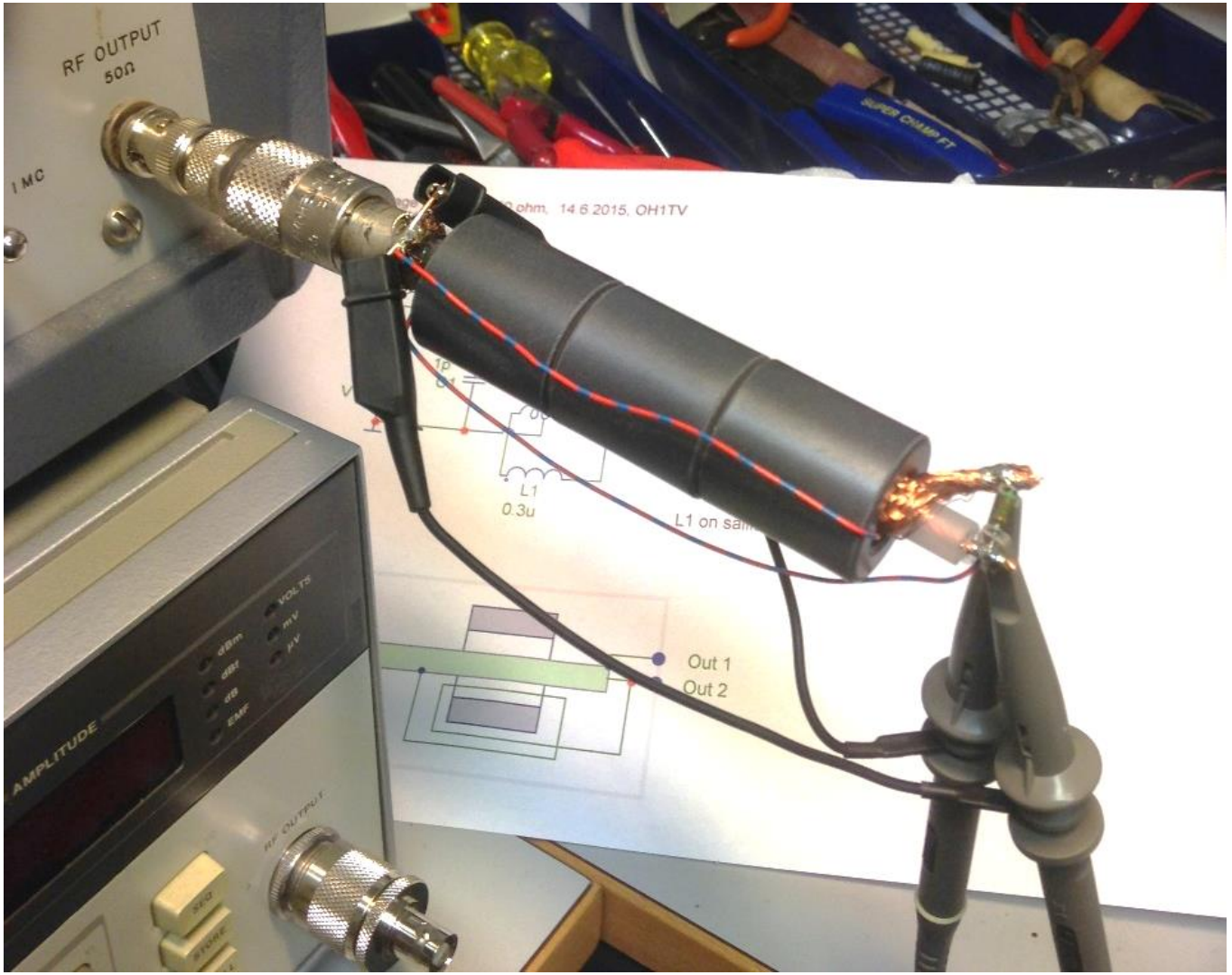
Modeled frequency response



Black = attenuation to load R2
Red = voltage level against ground at Out1
Blue = voltage level against ground at Out2

Black = total impedance at Input
Blue = real part of the impedance
Red = Imaginary part of the impedance

Symmetry measurement, 3 bead version

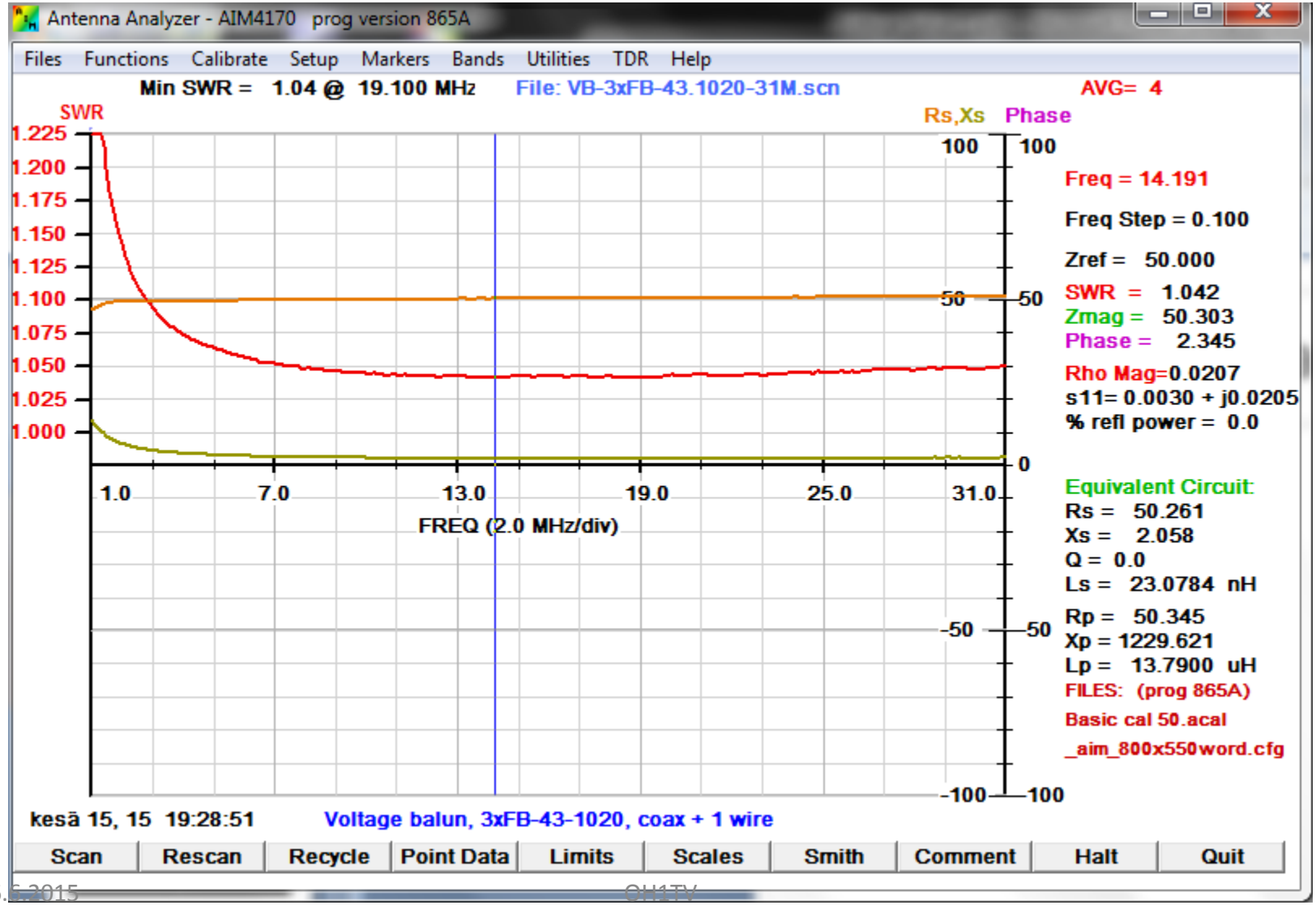


Impedance measurement, 5 bead version

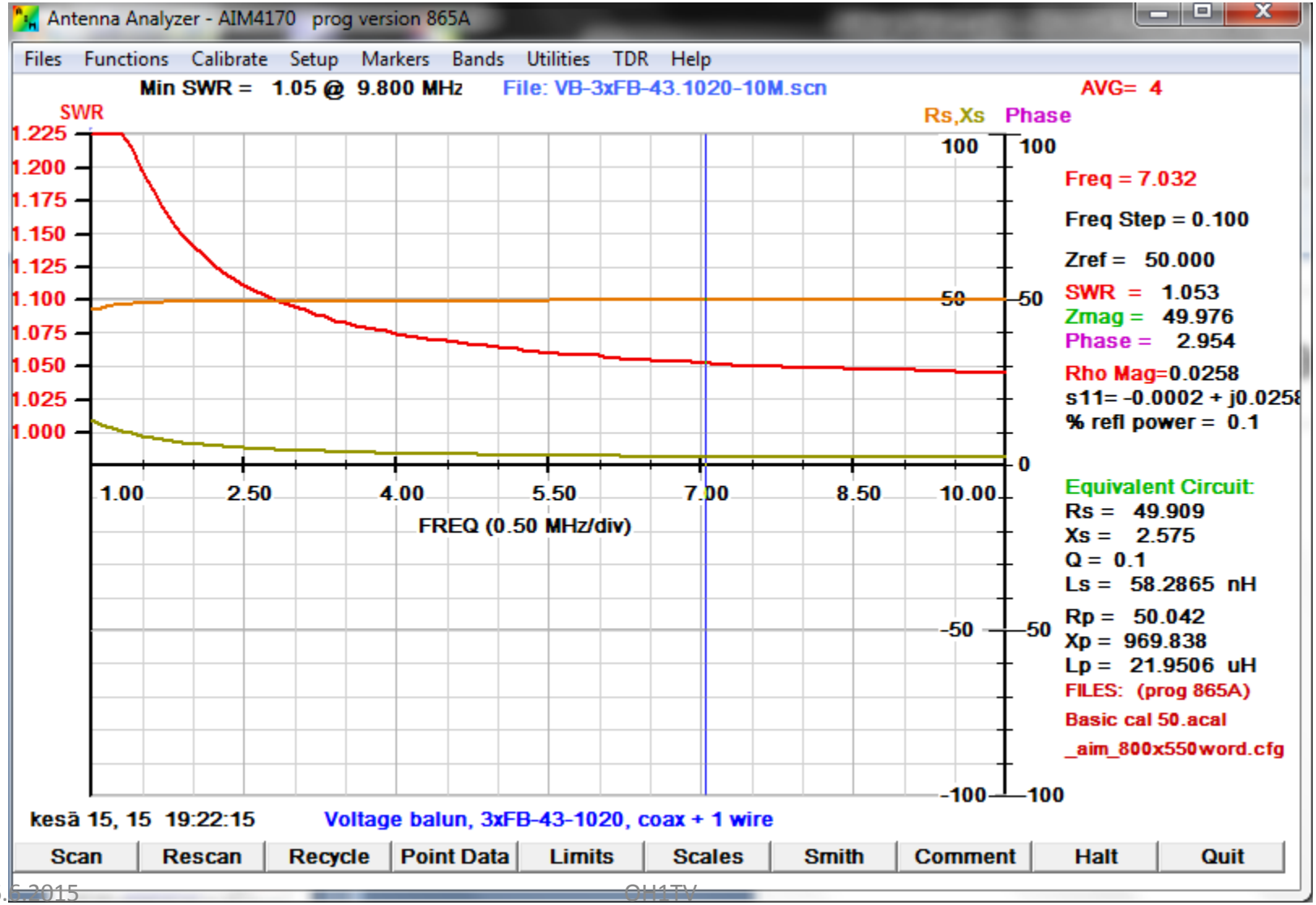
- Symmetry winding is the red and blue conductor
- AIM4170 was used for impedance measurements

Voltage balun with 3pcs Amidon FB-43-1020

3xFB-43-1020, 50ohm: R,X,SWR measurement



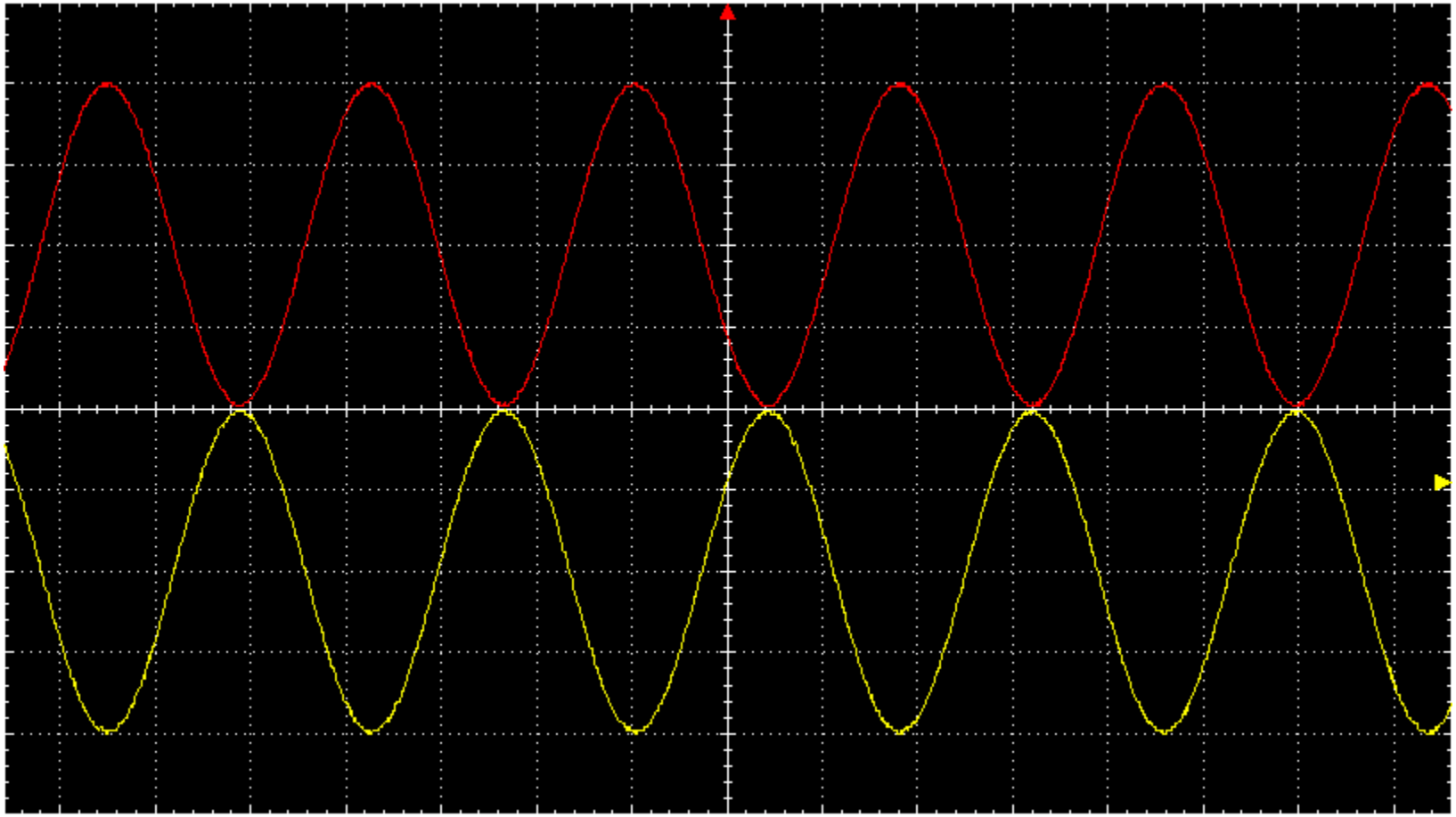
3xFB-43-1020, 50ohm: R,X,SWR measurement



3xFB-43-1020 @ 1.8MHz, 50ohm load

Symmetry measurement

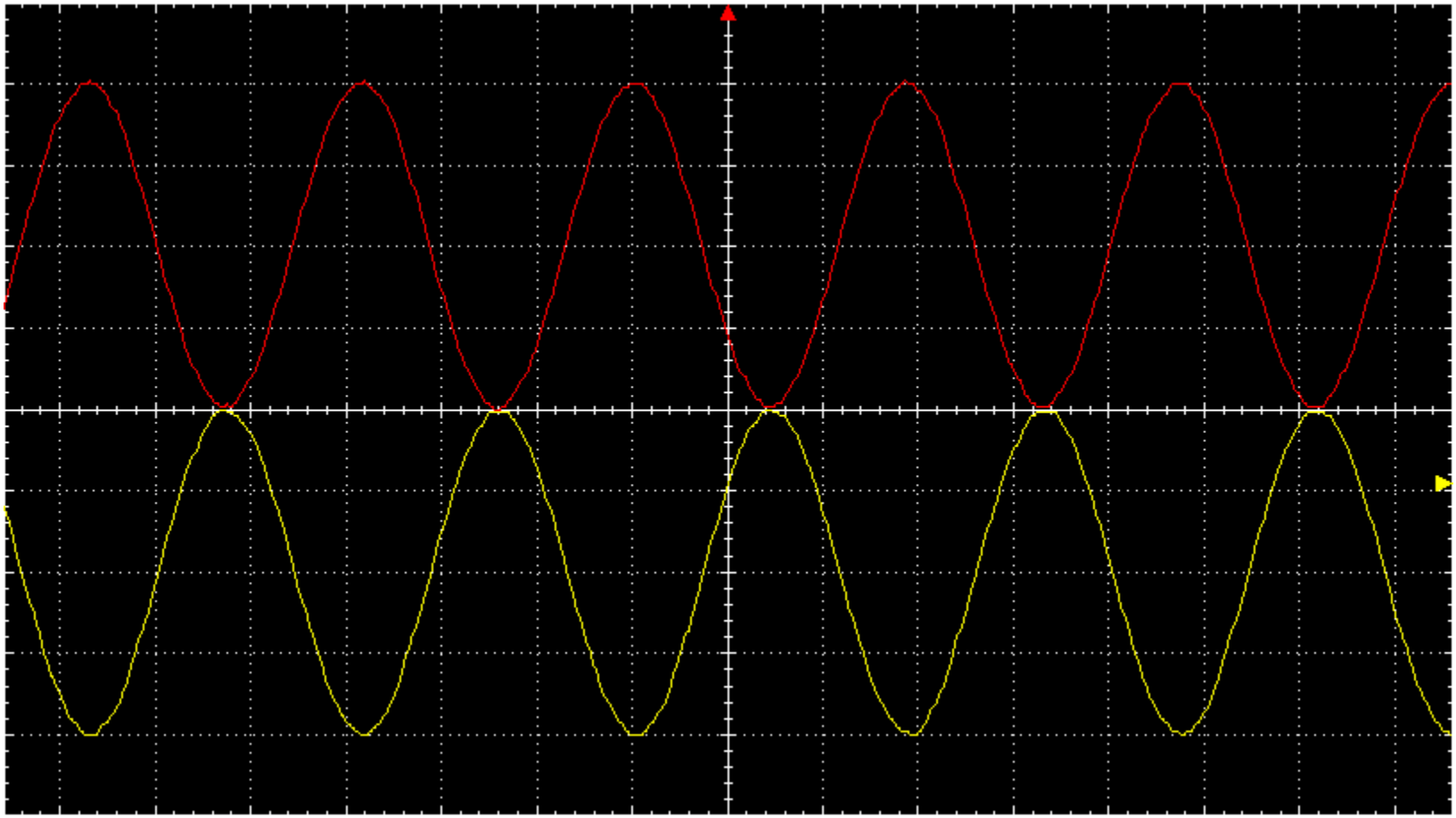
Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)



3xFB-43-1020 @ 7.1MHz, 50ohm load

Symmetry measurement

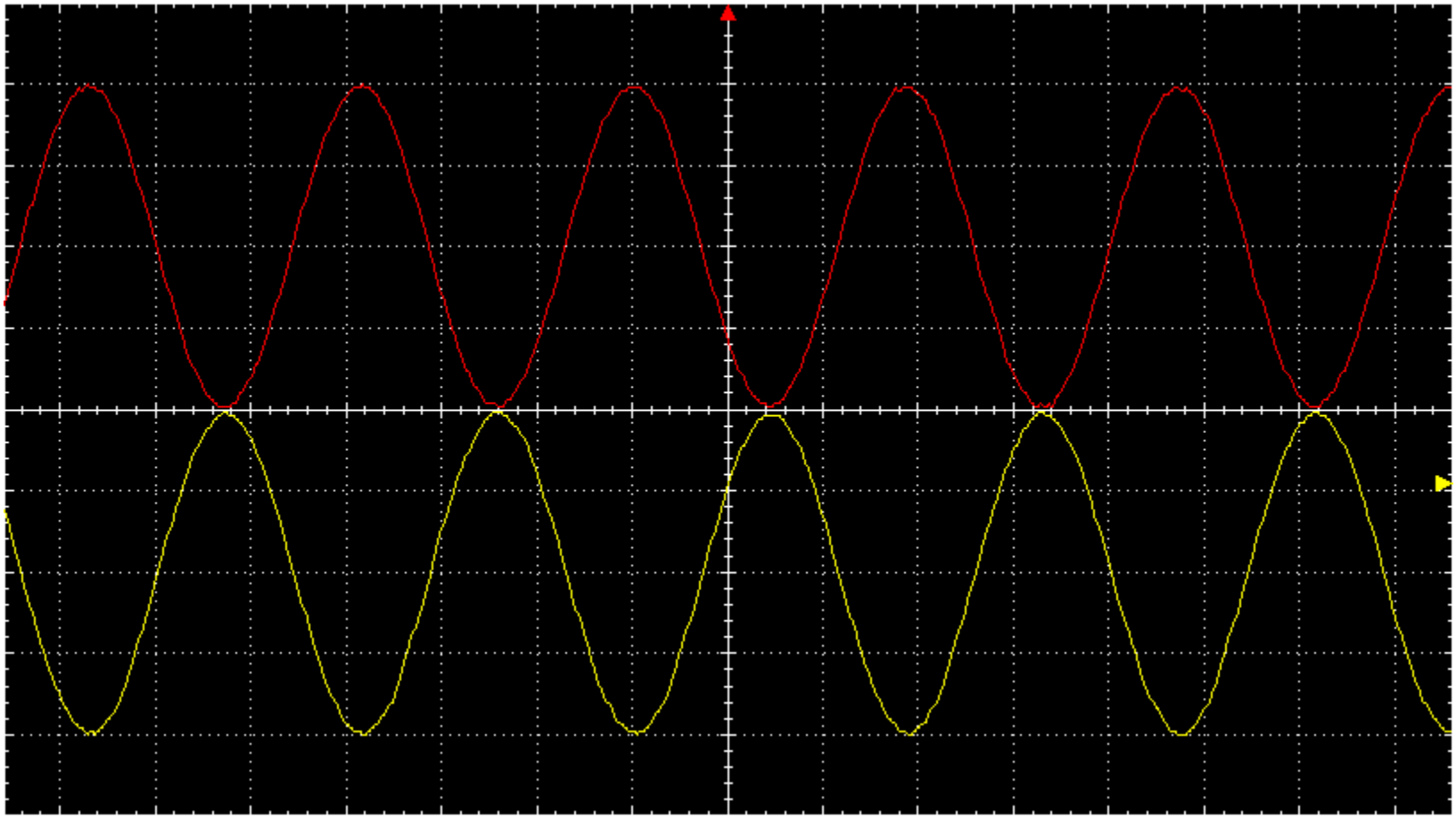
Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)



3xFB-43-1020 @ 7.1MHz, 150ohm load

Symmetry measurement

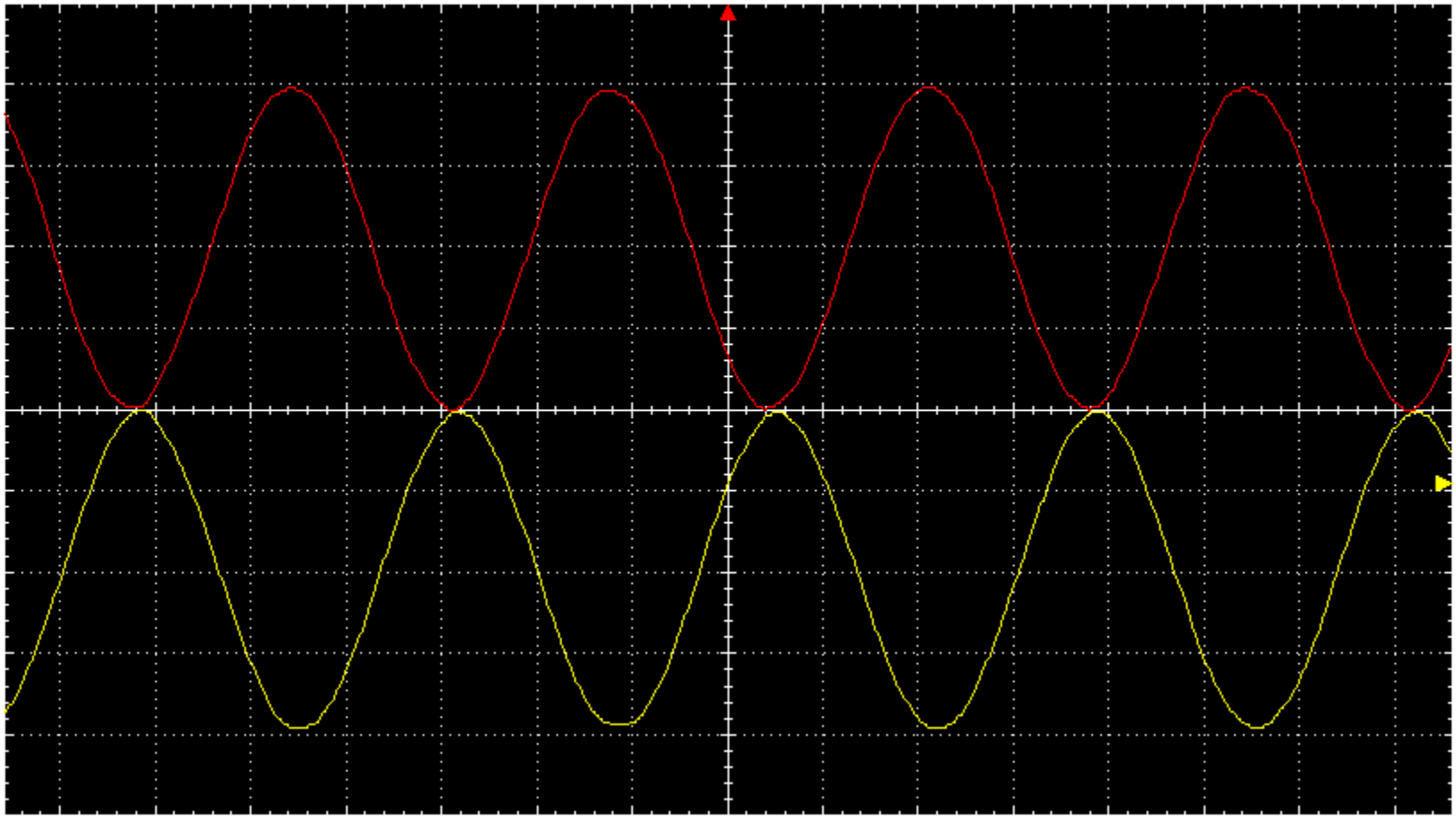
Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)



3xFB-43-1020 @ 30MHz, 50ohm load

Symmetry measurement

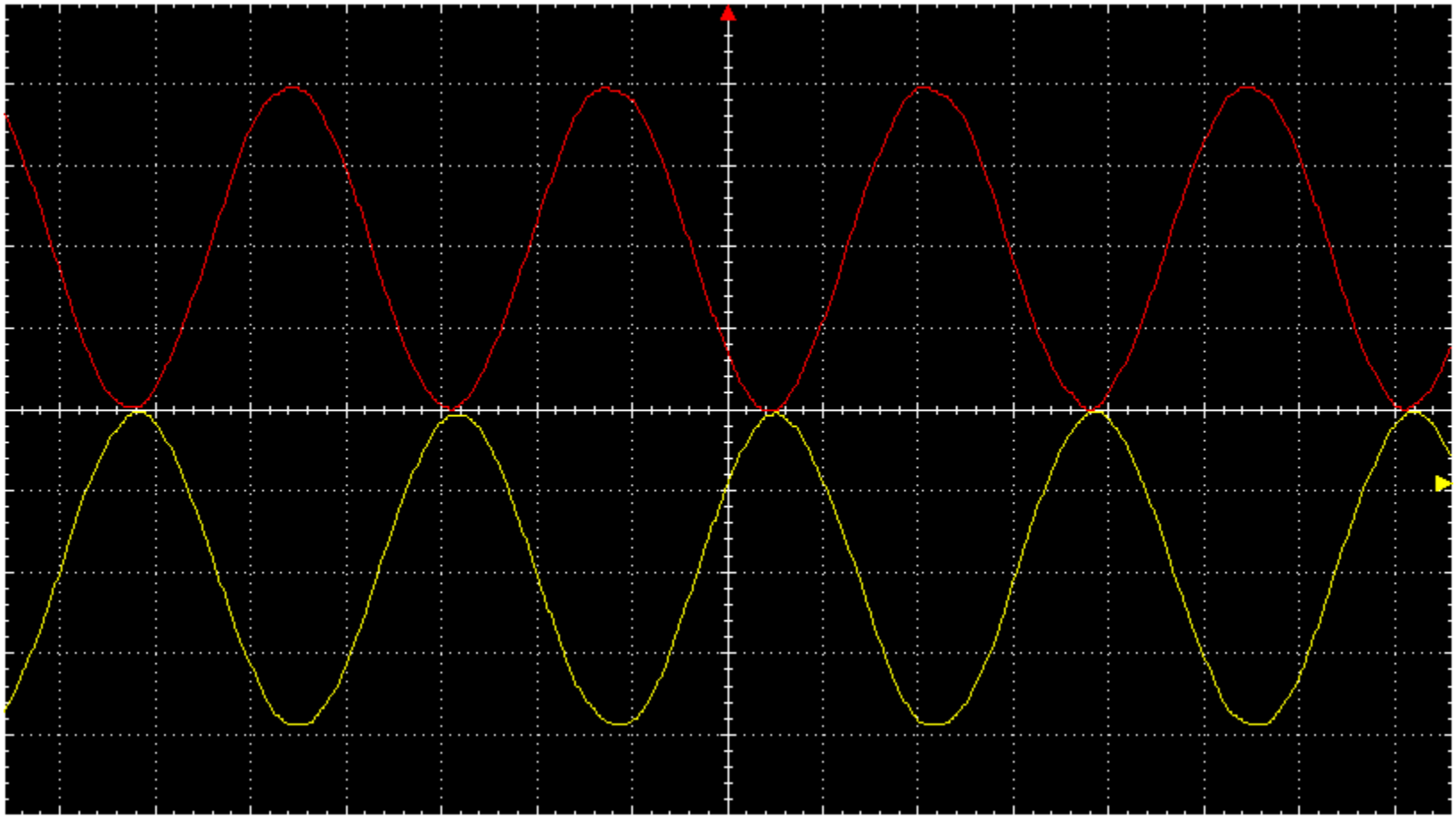
Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)



3xFB-43-1020 @ 30MHz, 100ohm load

Symmetry measurement

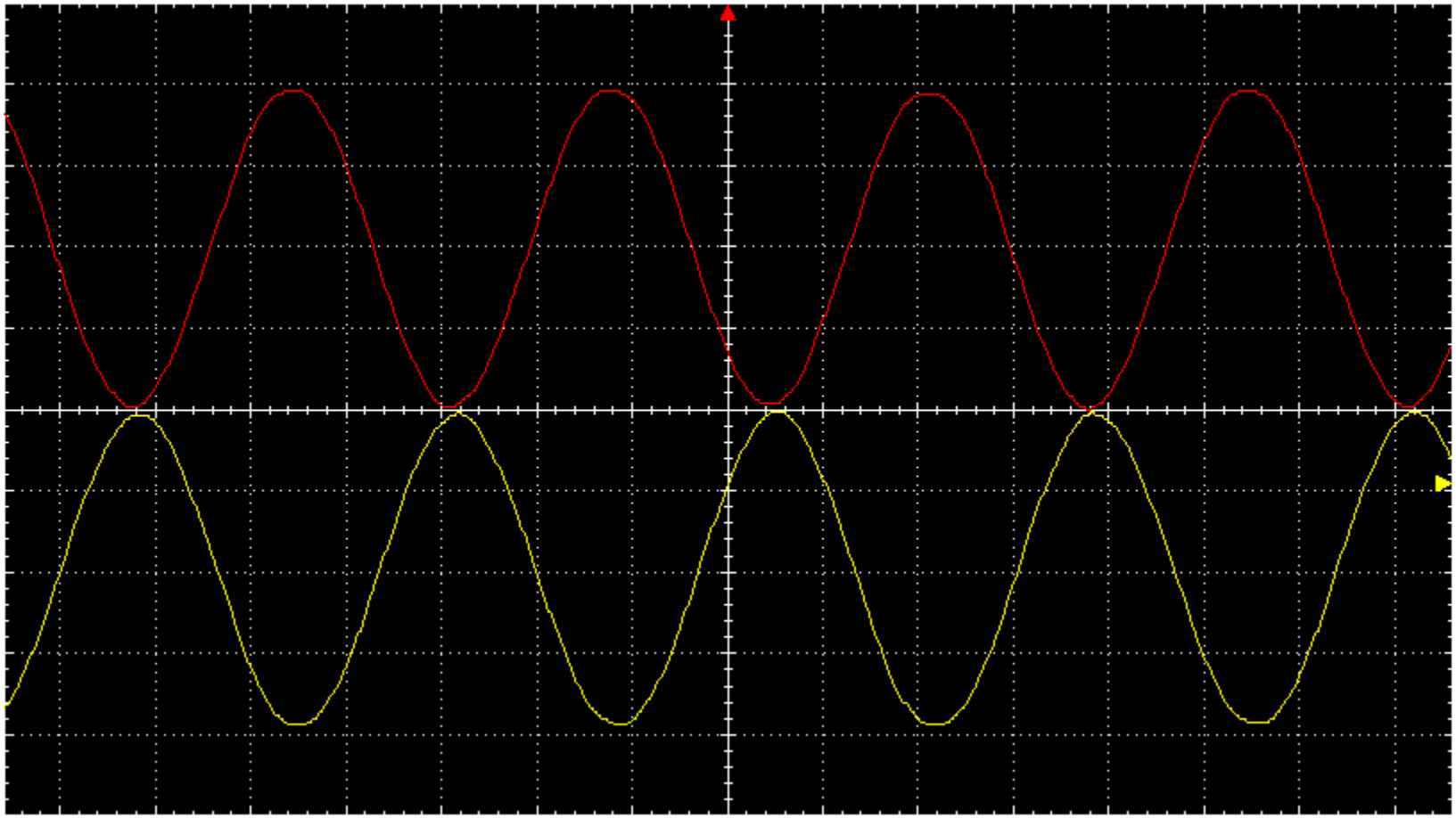
Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)



3xFB-43-1020 @ 30MHz, 150ohm load

Symmetry measurement

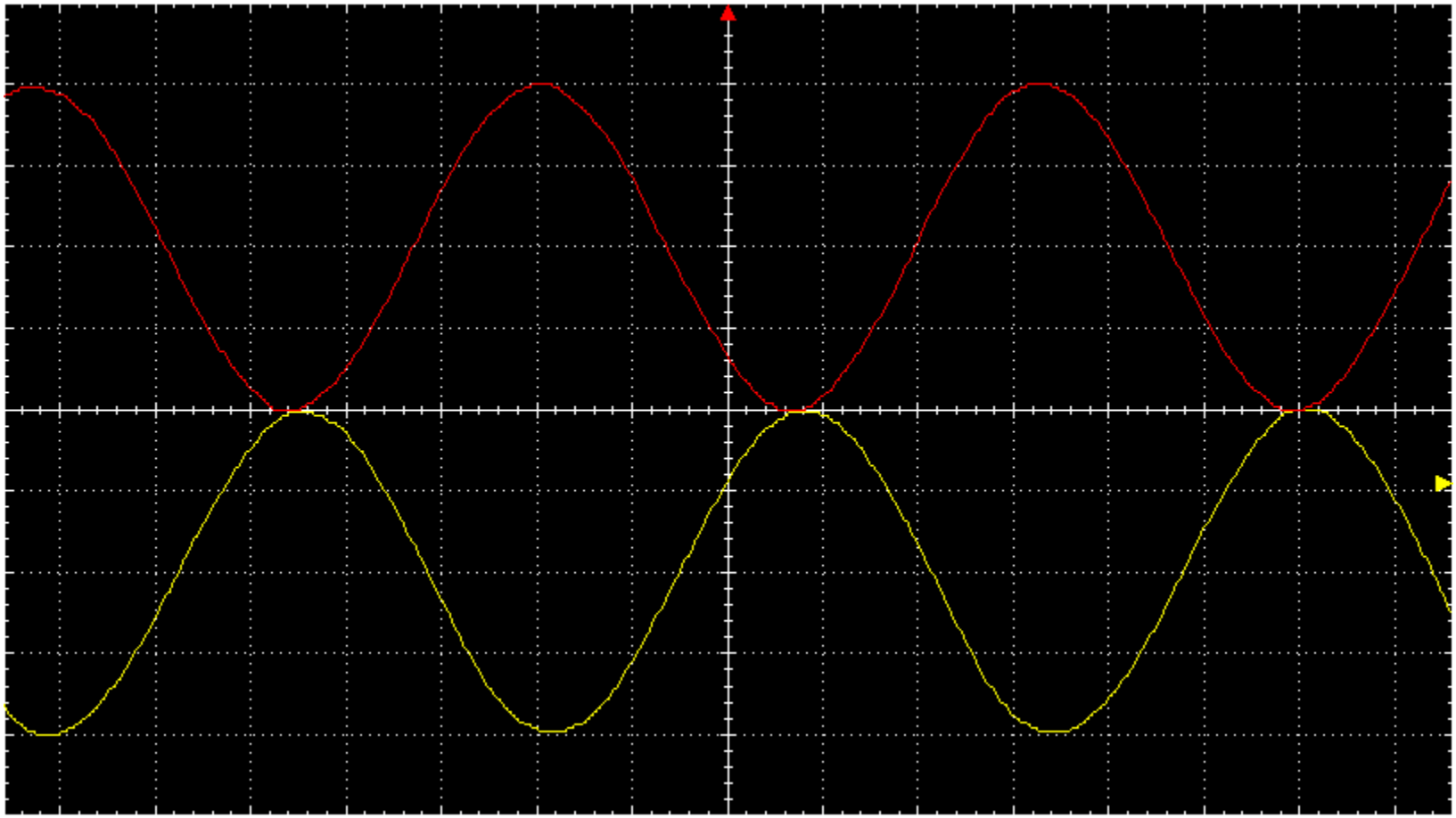
Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)



3xFB-43-1020 @ 50MHz, 150ohm load

Symmetry measurement

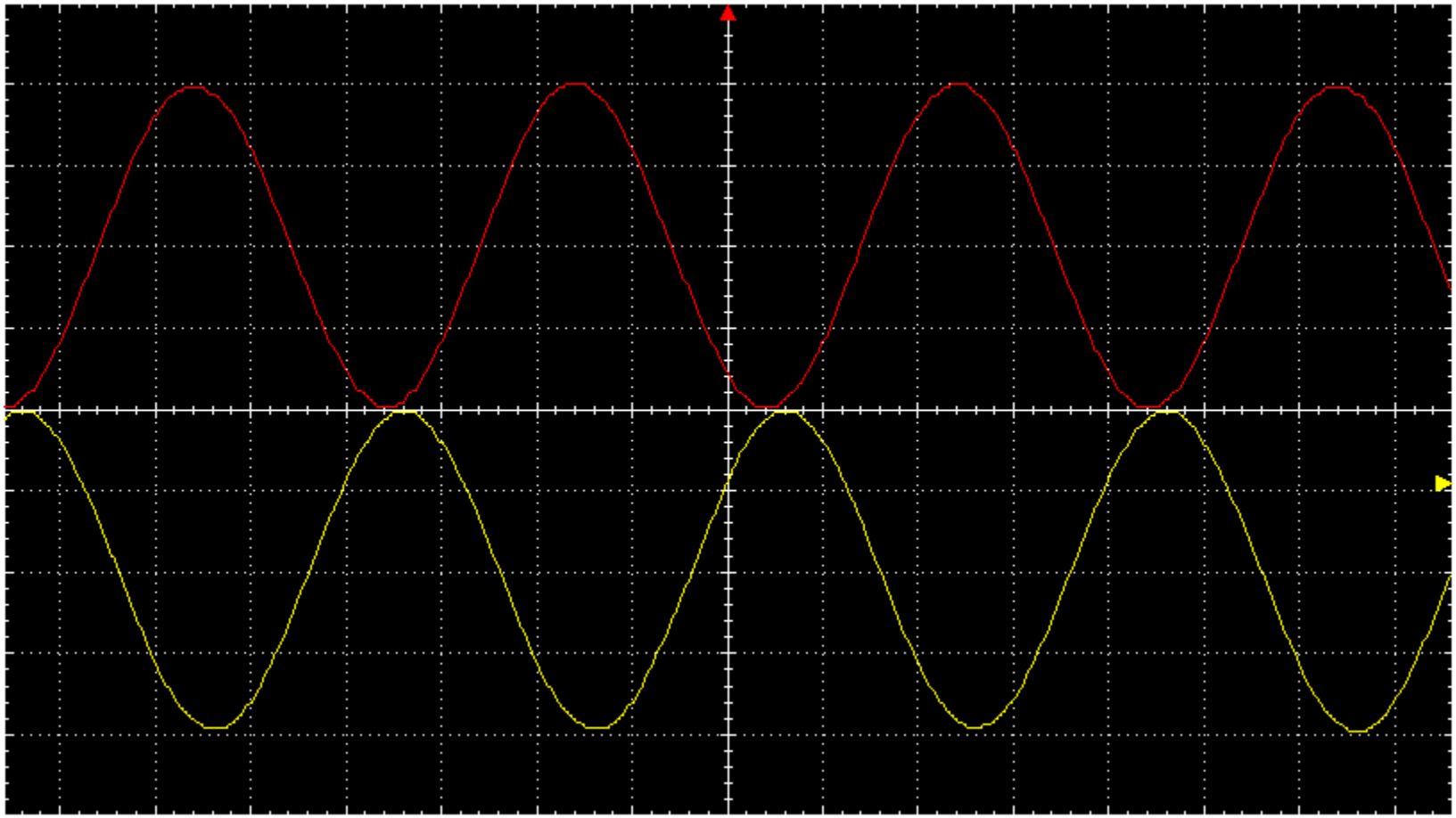
Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)



3xFB-43-1020 @ 50MHz, 50ohm load

Symmetry measurement

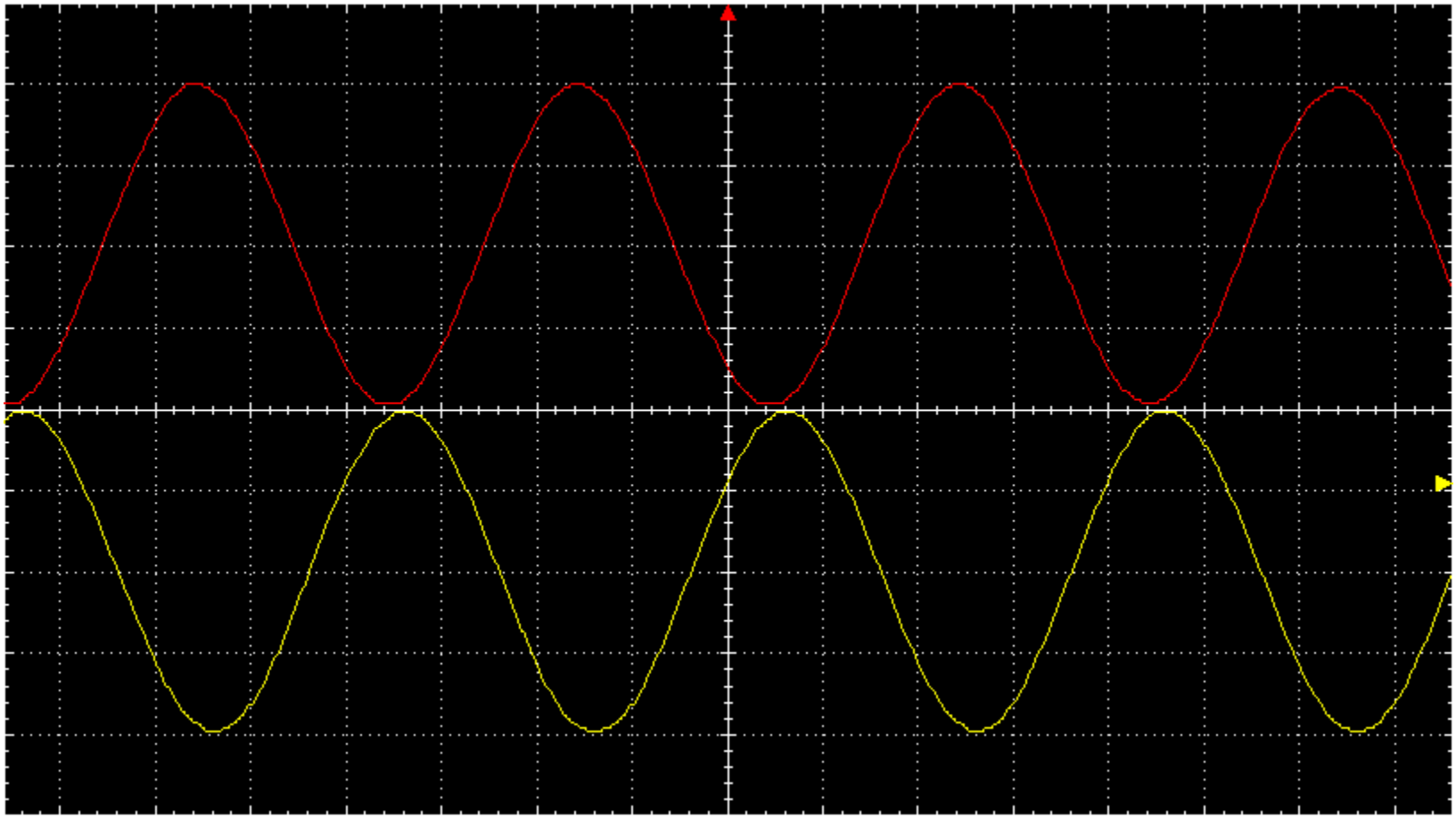
Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)



3xFB-43-1020 @ 50MHz, 150ohm load

Symmetry measurement

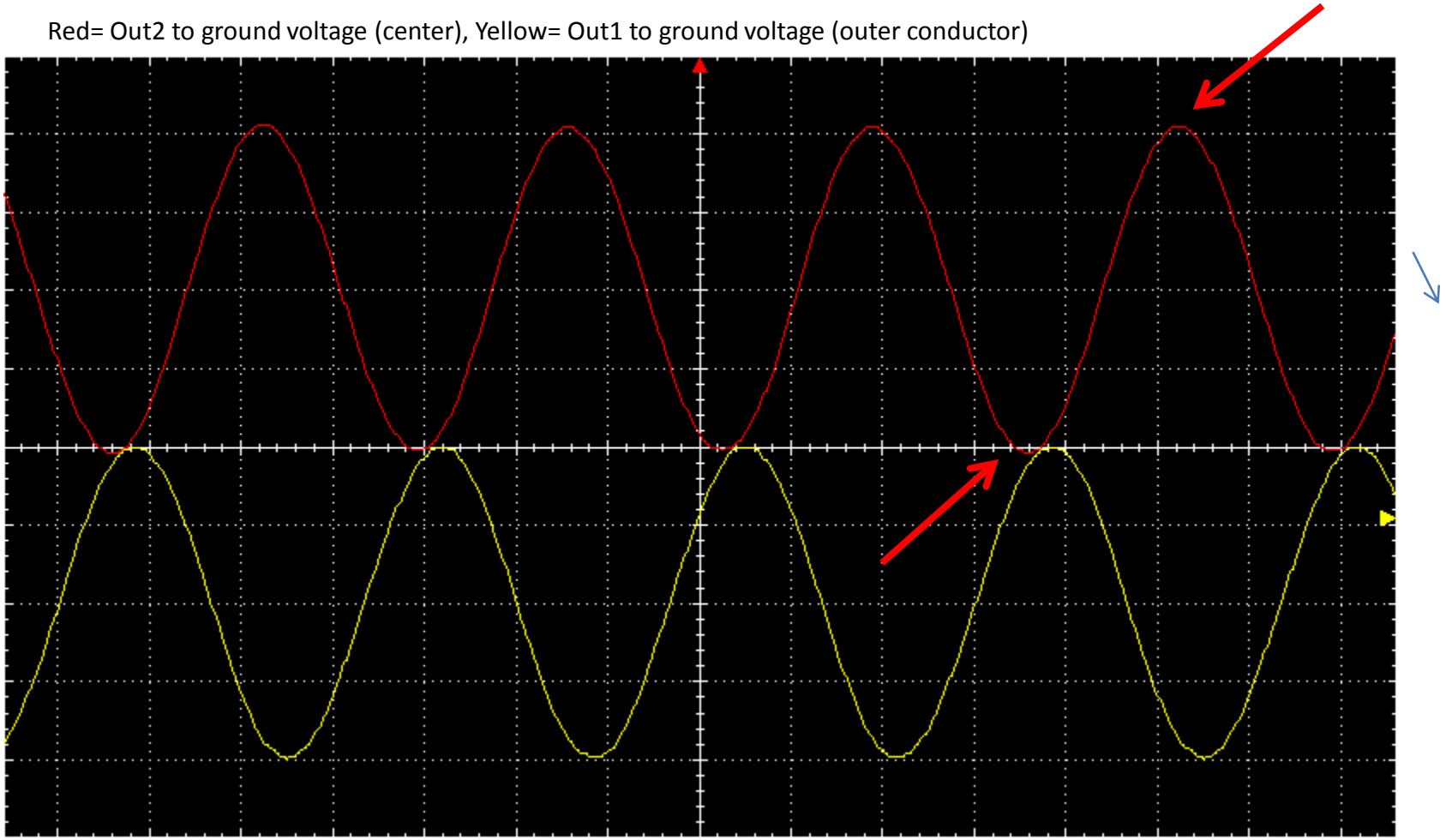
Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)



3xFB-43-1020 @ 60MHz, 50ohm load

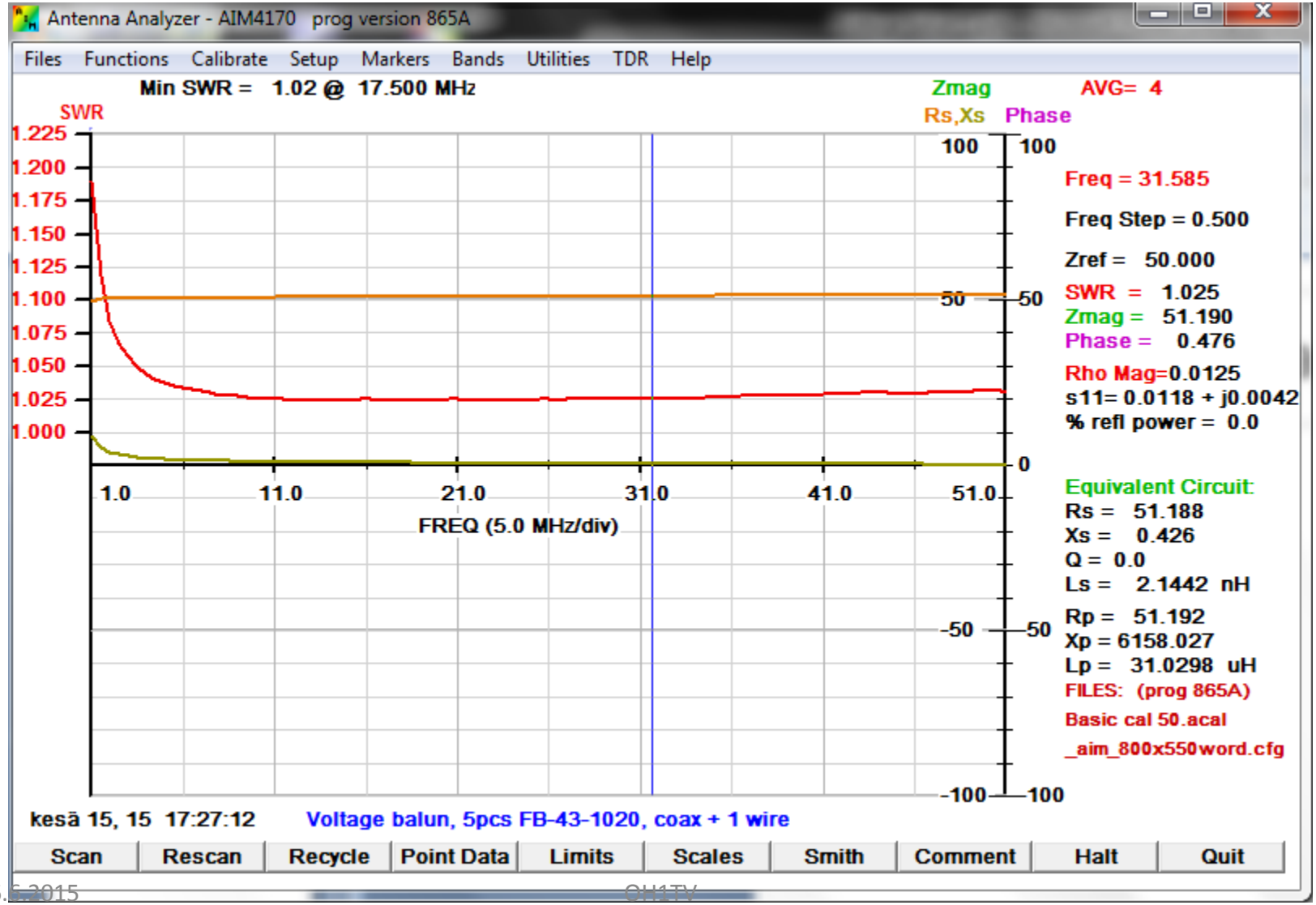
Symmetry measurement

Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)



Voltage balun with 5 pcs Amidon FB-43-1020

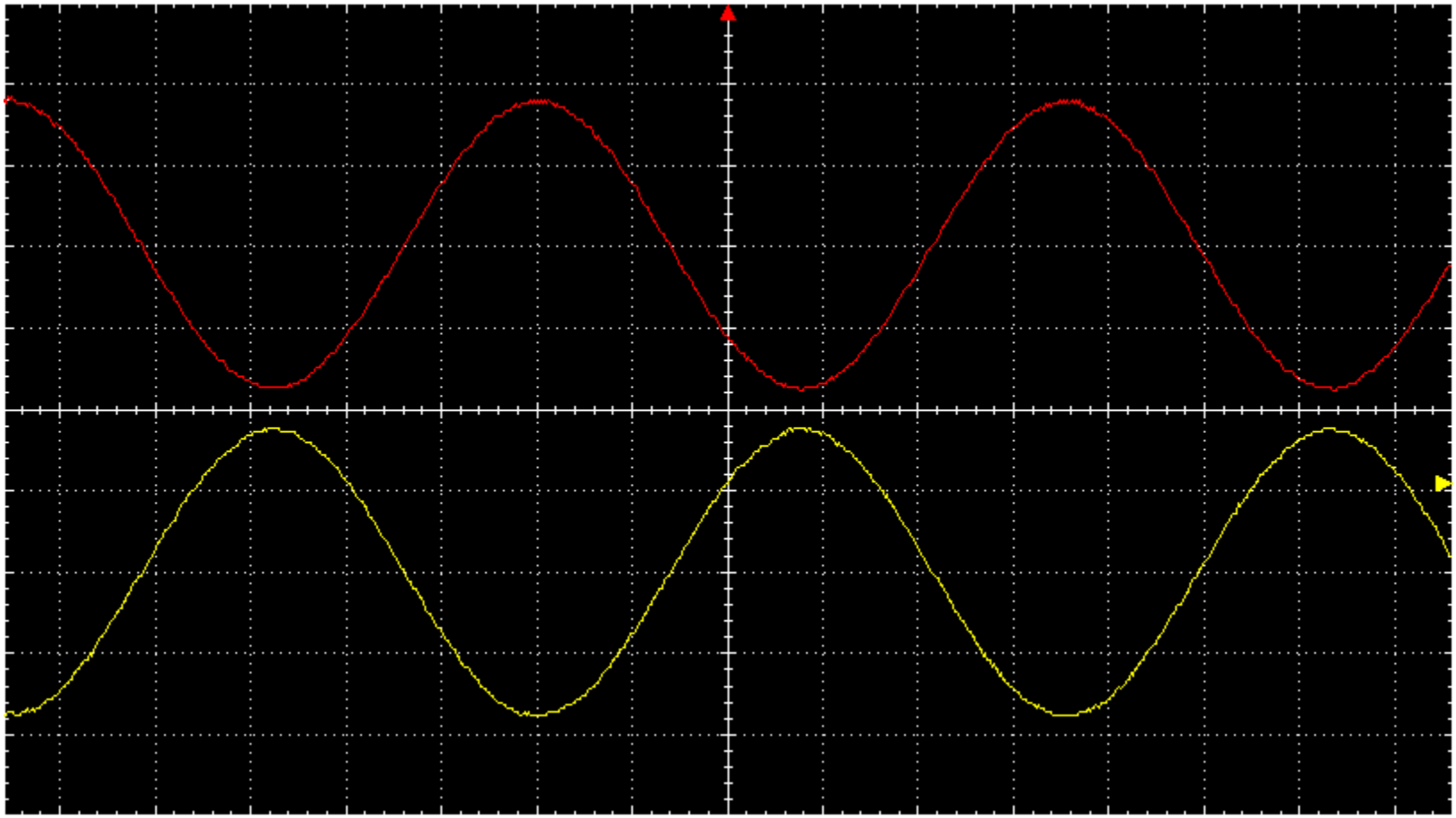
5xFB-43-1020, 50ohm: R,X,SWR measurement



5xFB-43-1020 @ 1.8MHz, 50ohm load

Symmetry measurement

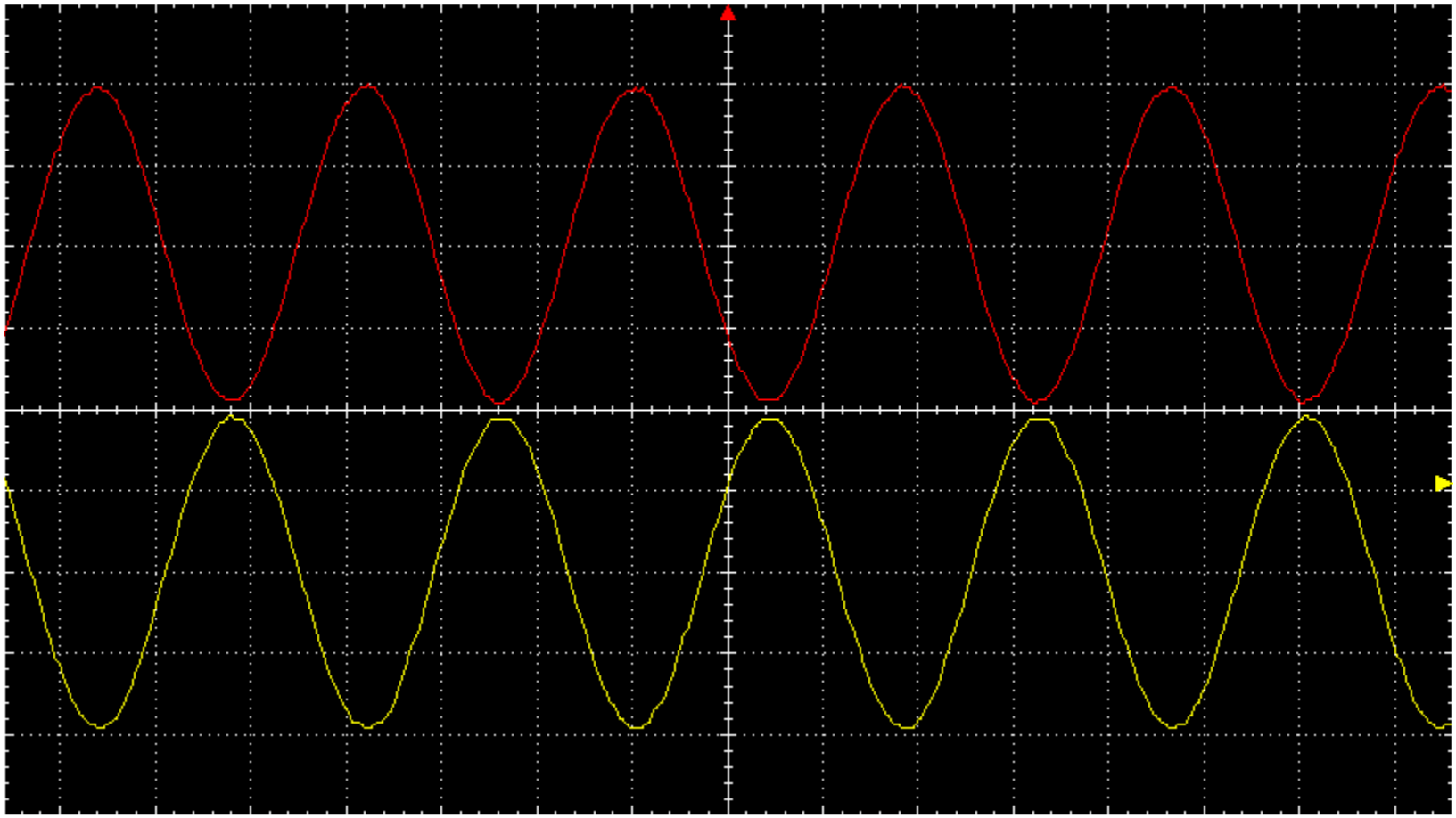
Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)



5xFB-43-1020 @ 7.1MHz, 50ohm load

Symmetry measurement

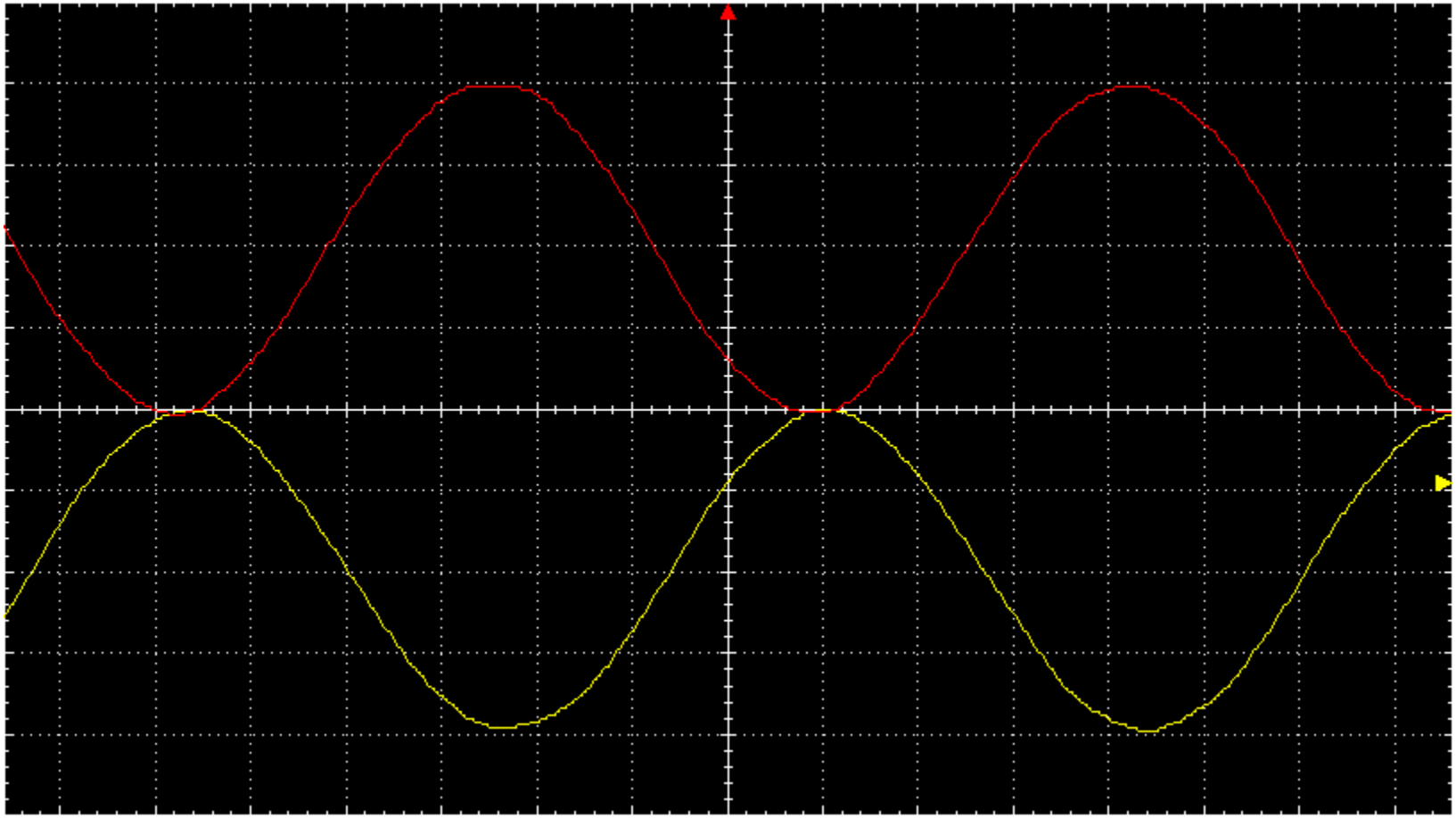
Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)



5xFB-43-1020 @ 30MHz, 50ohm load

Symmetry measurement

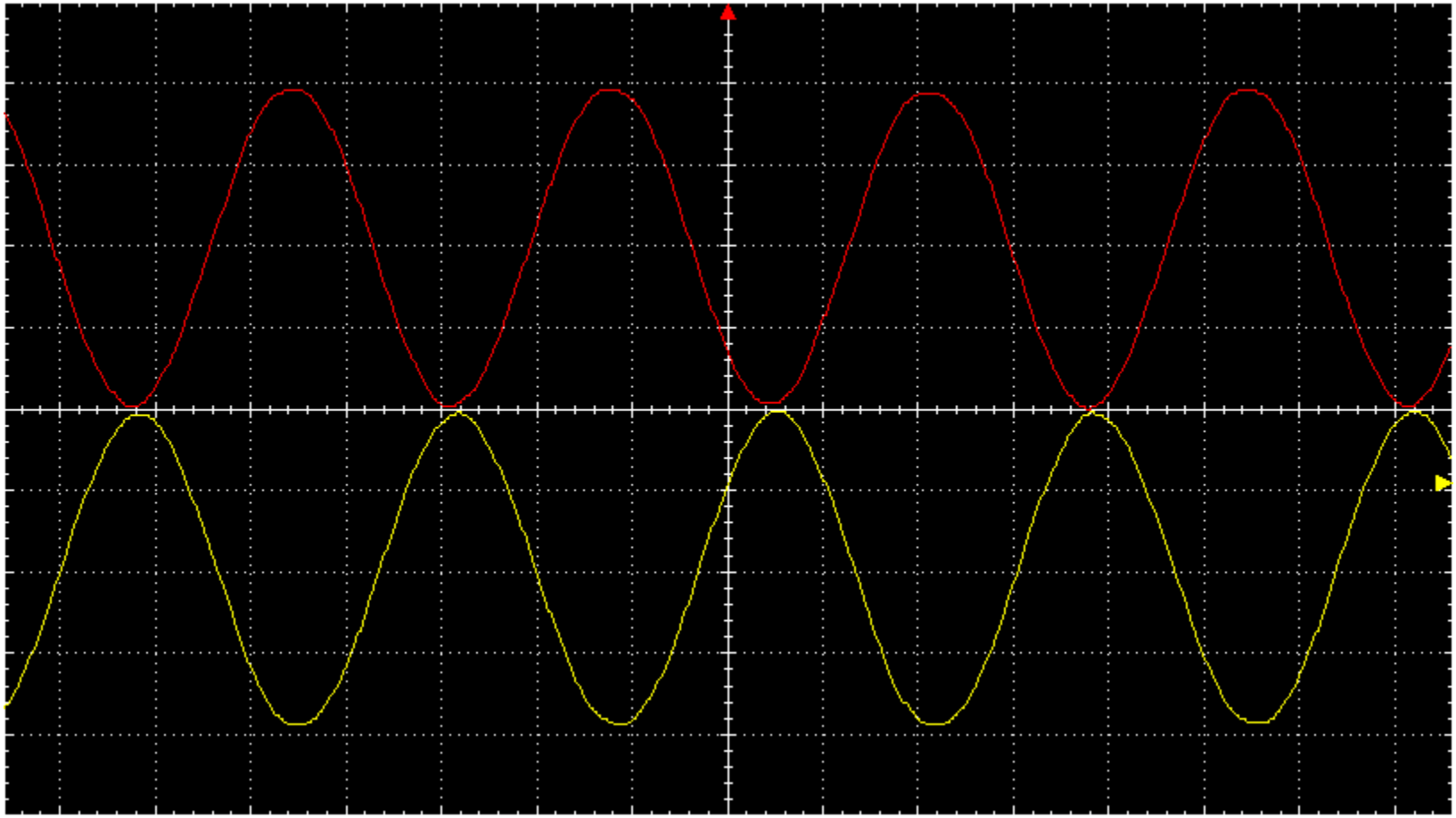
Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)



5xFB-43-1020 @ 30MHz, 150ohm load

Symmetry measurement

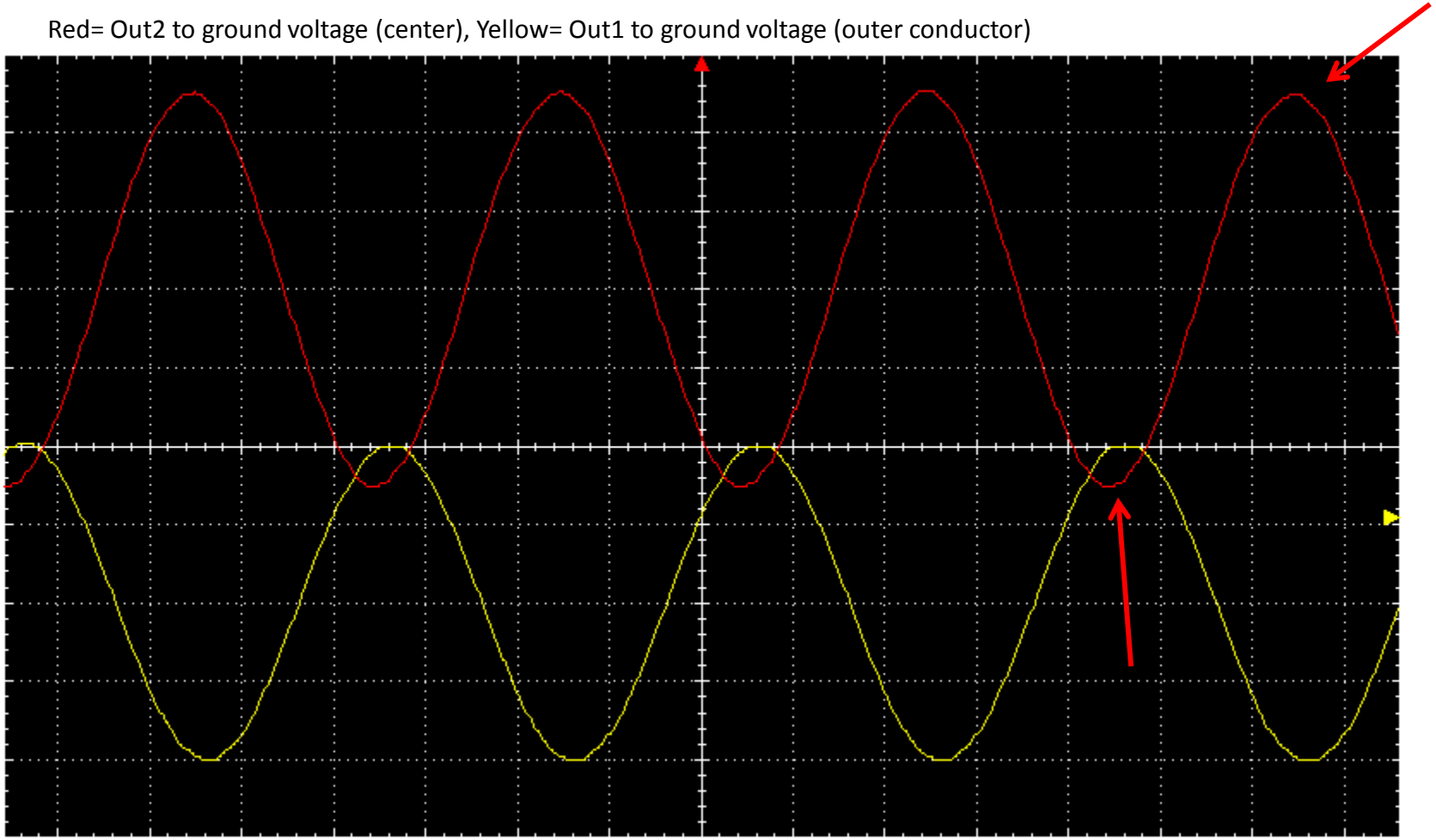
Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)



5xFB-43-1020 @ 50MHz, 50ohm load

Symmetry measurement

Red= Out2 to ground voltage (center), Yellow= Out1 to ground voltage (outer conductor)

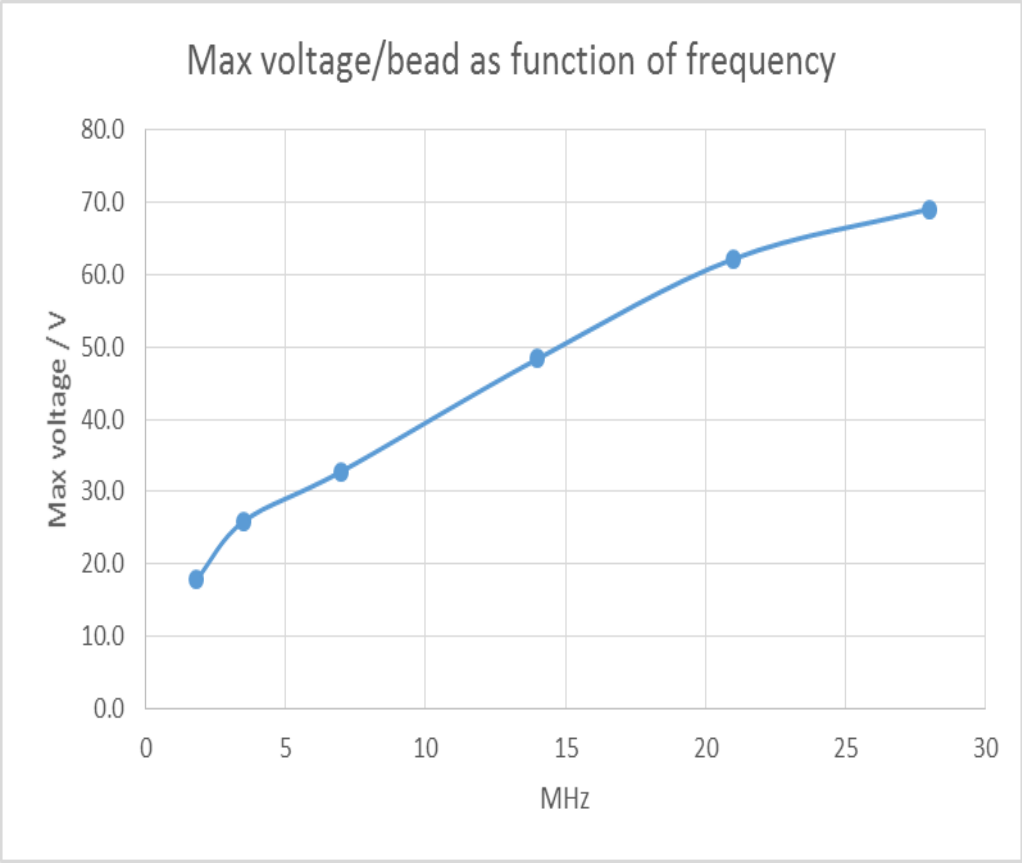


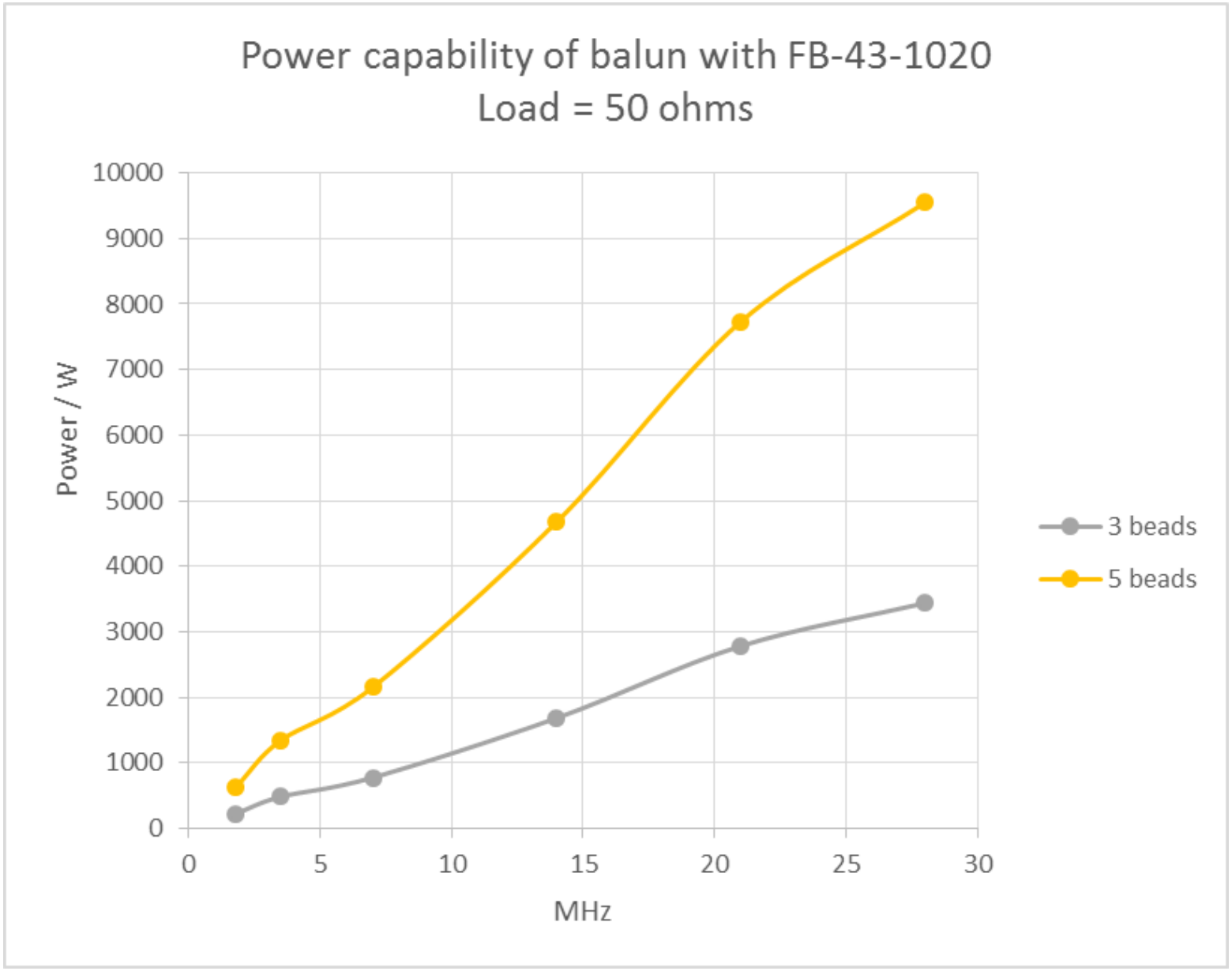
Power consideration

- Based on Amidon data I have calculated max acceptable voltage across one FB-43-1020 ferrite bead on different frequencies, see curve on the right
- Let's assume that input voltage to balun is 300V. This corresponds to 1800W to 50 ohm load.
- Half of this voltage, 150V is over the ferrite beads.

- The 3 bead version would have 50V over each of them.
  - Operation from 14 to 30 MHz would be ok.
  - Below 14MHz power should be lowered.

- The 5 bead version would have 30V over each of them
  - Operation from 7MHz and above would be fine
  - 160m and 80m would need more beads or lower power.




Power capability of balun with FB-43-1020
Load = 50 ohms
Power / W
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
MHz
3 beads
5 beads

Conclusions ..

- Voltage symmetry was very good in both baluns. On low HF symmetry was still good when SWR was already getting bad.
  - 3 bead version was good up to 50MHz. On 60MHz some imbalance was noticed. Amplitude via center conductor was stronger. Some phase delay was also visible on outer conductor.
  - 5 bead version was good up to 30MHz. On 50MHz imbalance in amplitude was clearly visible. There was also small phase delay on outer conductor.
  - Voltage symmetry is not sensitive to load impedance variations, if SWR<3
- Impedance matching was better all the way with 5 beads but acceptable also with 3 beads. Lower frequency limit is dictated by impedance across the load.
  - If we keep 1.05 as the max acceptable SWR, 7MHz is the lower limit for 3 bead balun and 3.5MHz for the 5 bead balun

..Conclusions

- Power capability depends on frequency. Higher power tolerance is on higher frequencies.
  - The following max powers were calculated for 50 ohm load, based on Amidon data
    - It is assumed that SWR is too high on the low bands where the box is empty
    - As load impedance is newer exactly 50 ohm, it is better to be conservative in power dimensioning

	160m	80m	40m	20m	15m	10m
3 bead			775W	1684W	2784W	3437W
5 bead		1343W	2154W	4678W	7733W	9547W

- Current in the balancing wire is much lower than in the coax.
  - This current is even lower on higher frequencies as forcing over higher impedance is easier
- If the beads are used as a current balun only, required number of beads is still the same. To achieve the same symmetry, current balun probably needs more beads.