



# **“Using High Performance Multiplexer Technology to Improve Your HF Station Capability”**

**by Andrei Fedorishchev  
RA6LBS**

Dayton  
**Hamvention**  
Antenna forum **2017**

# Agenda

- A bit of history
- What is a multiplexer?
- Can I fry my radios?
- Specifications of multiplexers
- Why do we need additional filters?
- Multiplexer + Filter combo
- Relay switches
- Where is the right place for filters and a switch?
- The devil is in the details ...
- Interconnecting cables
- Some examples and ideas for transmit antennas
- Upside down!
- Can we have any benefits for receive antennas distribution?
- Q & A?

# A bit of history:

## P33W, WRTC-2010 and Multiplexers

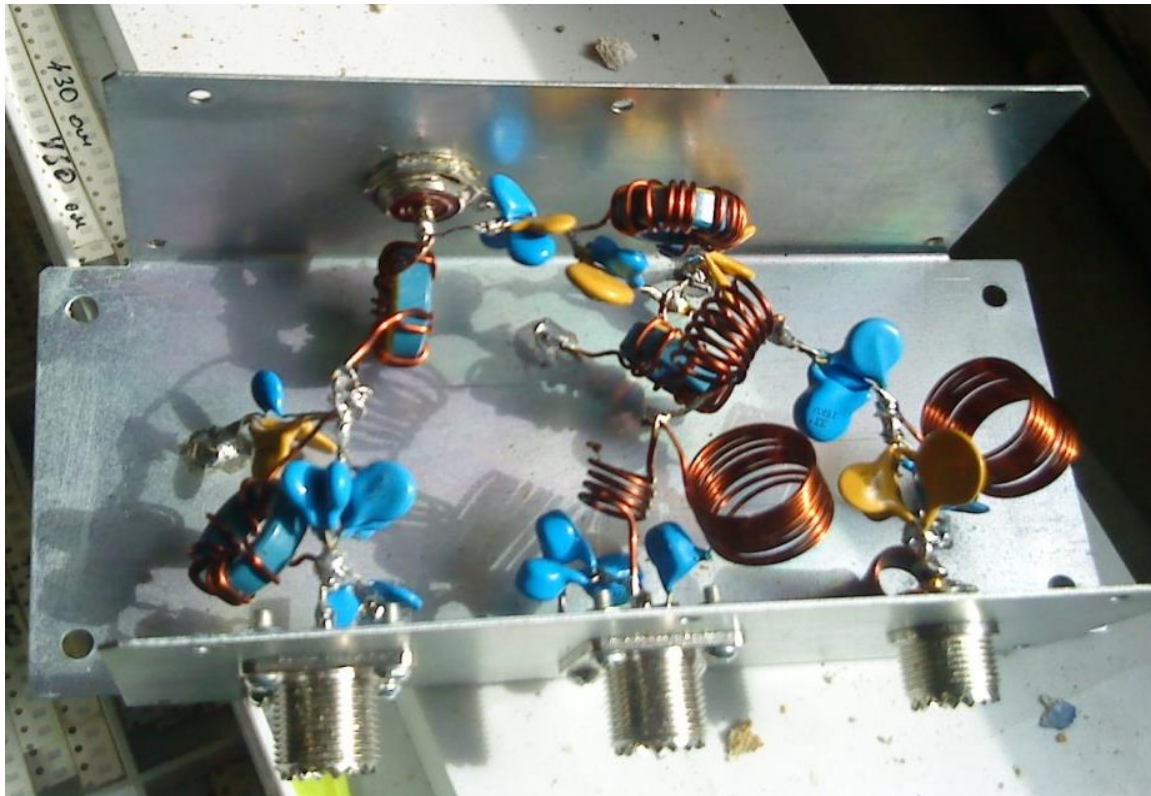
We implemented and used with great success an In-Band style of operation at P33W in 2008: WPX SSB, IARU, and latter WW contests.

After IARU-2008, which we won of course, Harry - RA3AUU asked me if I could suggest something innovative for Russian teams, in order to win WRTC-2010 in Moscow.

Inspired by P33W success with InBand, I was confident that the only place to improve the proposed WRTC setup would be a better utilization of TriBander on 14-28.

And no one could answer my question WHY don't we have same thing as Duplexers at VHF ...

# The very first HF triplexer, circa November 2008



# What is a multiplexer?

- **Used for decades by VHF–UHF guys!**
- Multiplexers enable multi-transceiver stations to share a single multi-band antenna;
- Multiplexers, by themselves, cannot provide the necessary isolation with 100W radios;
- Each transmitter must be connected to a multiplexer through a bandpass filter in order to keep them from interfering with each other;

# How does it work?

- **It`s a filter!**
  - Think of a triplexer as a low pass filter, a bandpass filter and a high pass filter with their outputs connected;
  - Triplexer is routing high, mid and low frequencies to three different input ports;

# Can I fry my radios?

- **YES!**
- **and NO!**
  - Hardware band switching lockout is a must!
  - Power consideration is a must!
  - All of this is easy to implement and to control.

# Part I

## Components of multiplexing technology



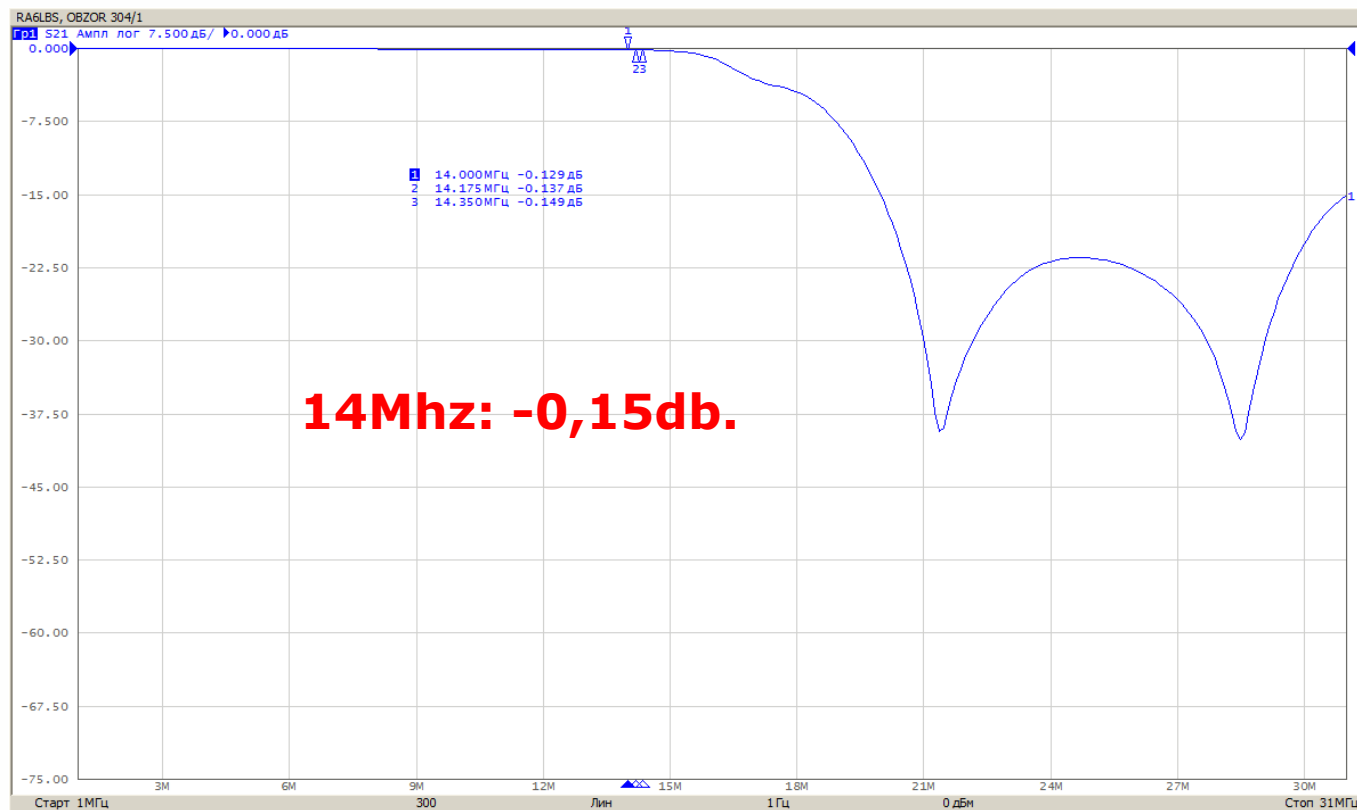
# Multiplexers vs Antennas

- Di-** Duo band antennas, simple dipoles feed in parallel with single coax  
**160/80, or 80/40, or 40/20**  
or ..... some exotics like **6/4** in Europe
  
- Tri-** Tribander gives three bands  
usually **20-15-10**
  
- Quad-** **4band** antennas, like  
OptiBeam OB12-4 and multiband Verticals!  
**40-20-15-10**
  
- Penta-** **5/6 band** antennas like Spiderbeam, Hexbeams  
and multiband Verticals!  
**20-17-15-12-10-6**

# Specifications of multiplexers

## #1 - Losses

Fractions of Decibel, typical average is  $\leq -0,2\text{db}$ .



# Specifications of multiplexers

## #1 - Losses

Decibel is a ratio of Input to Output Power

$$(dB) = 10 \log(P_{out}/P_{in})$$

Multiplexer`s Attenuation, db.	Transmitted power at 1500W TX Out	Transmitted power at 100W TX Out
-0,1	1465	98
-0,2	1432	95
-0,3	1399	93
-0,4	1368	91
-0,5	1336	89
-0,6	1306	87
-0,7	1276	85
-0,8	1247	83
-0,9	1219	81
-1,0	1191	79

# Specifications of multiplexers

## #1 - Losses

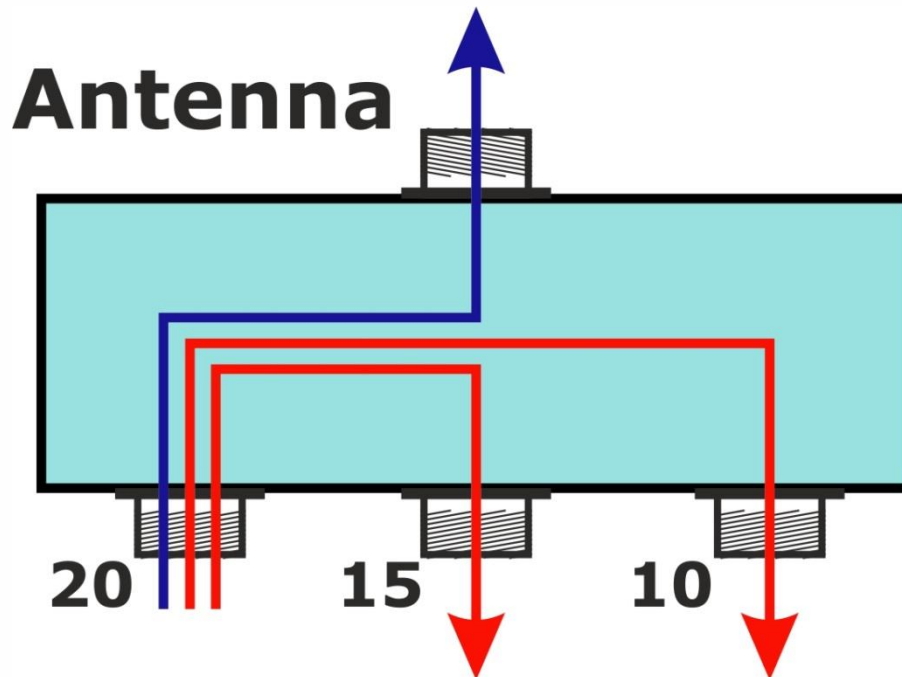
This is not a question of useful power losses, but more of heat dissipation!

Fortunately, this heat is spread among few of the plexer`s components.

Multiplexer`s Attenuation, db.	1500W TX Heat generation, Watts	100W TX Heat generation, Watts
-0,1	35	2
-0,2	68	5
-0,3	101	7
-0,4	132	9
-0,5	163	11
-0,6	194	13
-0,7	224	15
-0,8	253	17
-0,9	281	19
-1,0	309	21

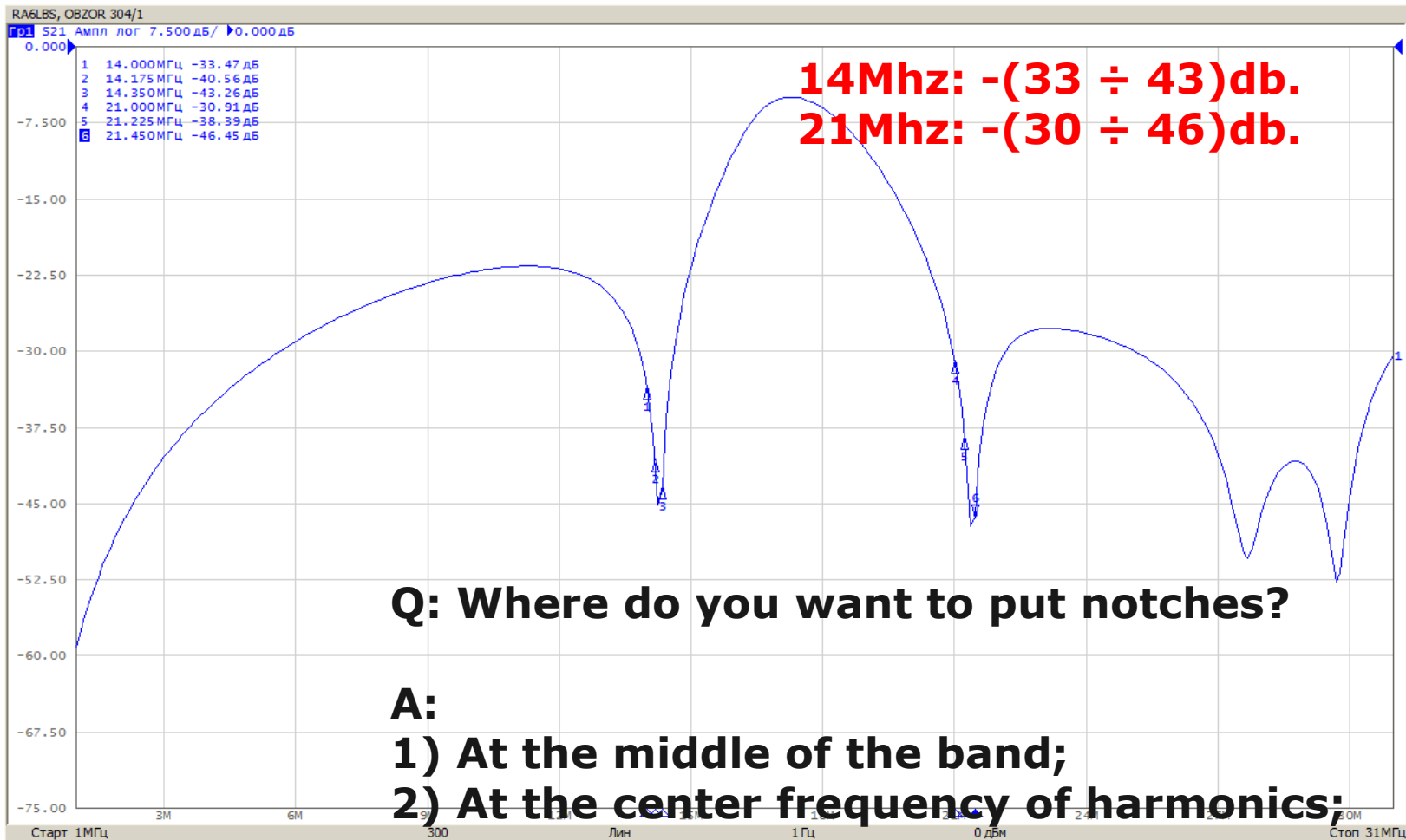
# Specifications of multiplexers

## #2 – Isolation, between it`s outputs!

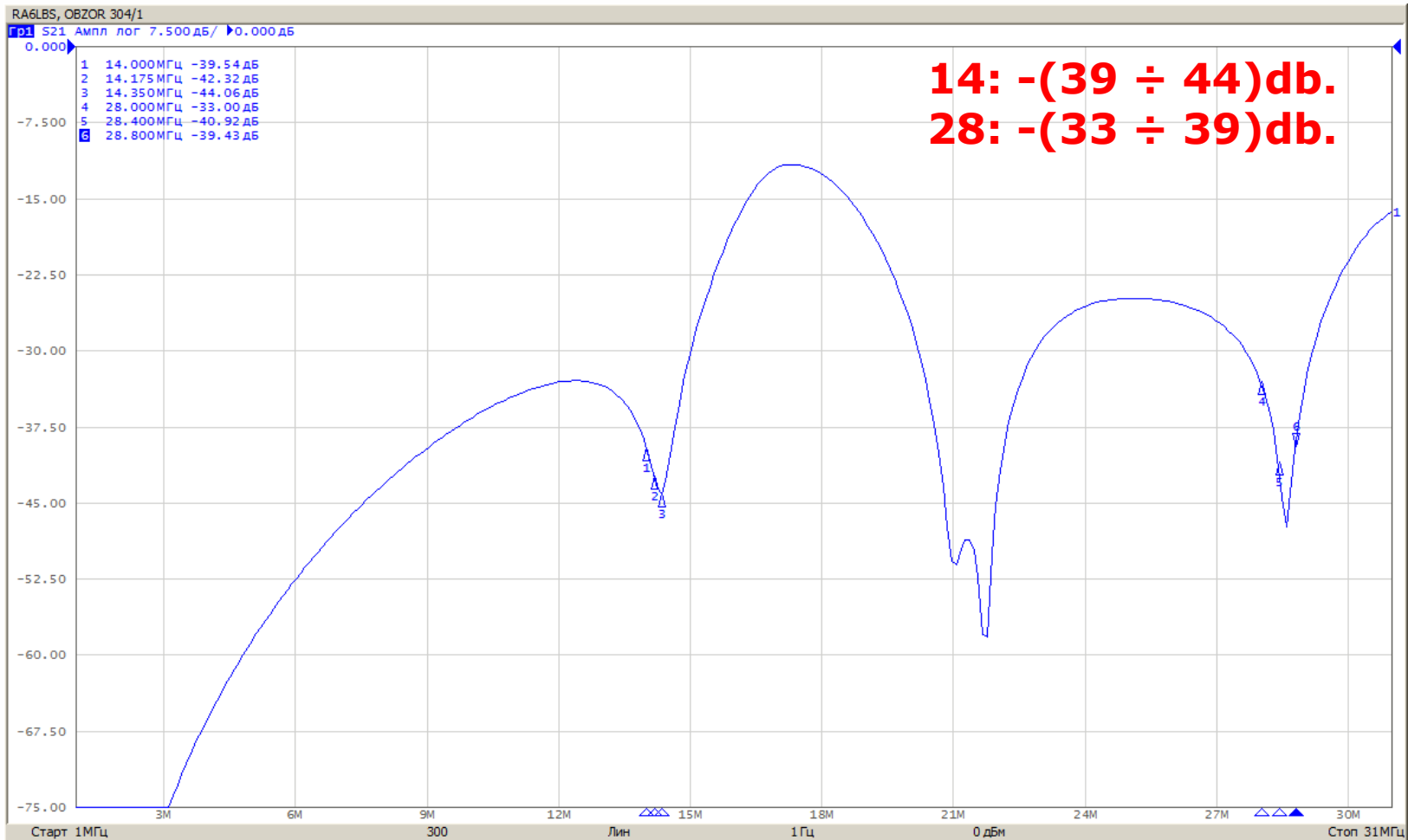


*Leakage from transmit port - 20,  
to receive ports - 15 and 10!*

# Isolation, measured, 14Mhz to 21Mhz, typical



# Isolation, measured, 14Mhz to 28Mhz, typical



# Specifications of multiplexers

## #2 - Isolation between its outputs!

Isolation	1500W TX, Leakage power	100W TX, Leakage power
-10 db.	150W	10W
-20 db.	15W	1W
-30 db.	1,5W	0,1W
-40 db.	0,15W	0,01W
-50 db.	0,015W	0,001W



# Why do we need ISOLATION?

## 2 issues:

- **Safety:**  
Unknown, and different level of damage to different radios
- **Interference:**  
Starting figures at around +10dbm may be,  
but again differs by radios and some other factors

# How many decibels of isolation do we need?

- **Think of DX pedition utilizing 2 or 3 or 4 station at the same time?**  
When sum of QRM from this multiple radios is going into play?
  
- **And what is the criteria of “QRM free” operation?**
  - Harmonics level? – NO
  - No any other signs of station transmission? - YES
  - Different band combination - different isolation requirements?  
Think of 10 meters noise level vs 80 meters ...

**We have now, 8 YEARS OF EXPERIENCE with 100 – 4500W power levels, different Rigs and Ops;**

**Observation:**  $-(80\div 100)$  db. should be fine for almost any condition.

## **Target figure is -90 db. of isolation for the complete system**

Neither the Triplexer alone, nor the band pass filters available in 2008 on the market, was close to this figure.

Best of the market, W3NQN design filters, has been modified with extra rejection sections, to satisfy tougher requirements.

# Triplexer + W3NQN BPF 14/21 isolation

2.521 Ампл. лог. (дБ)



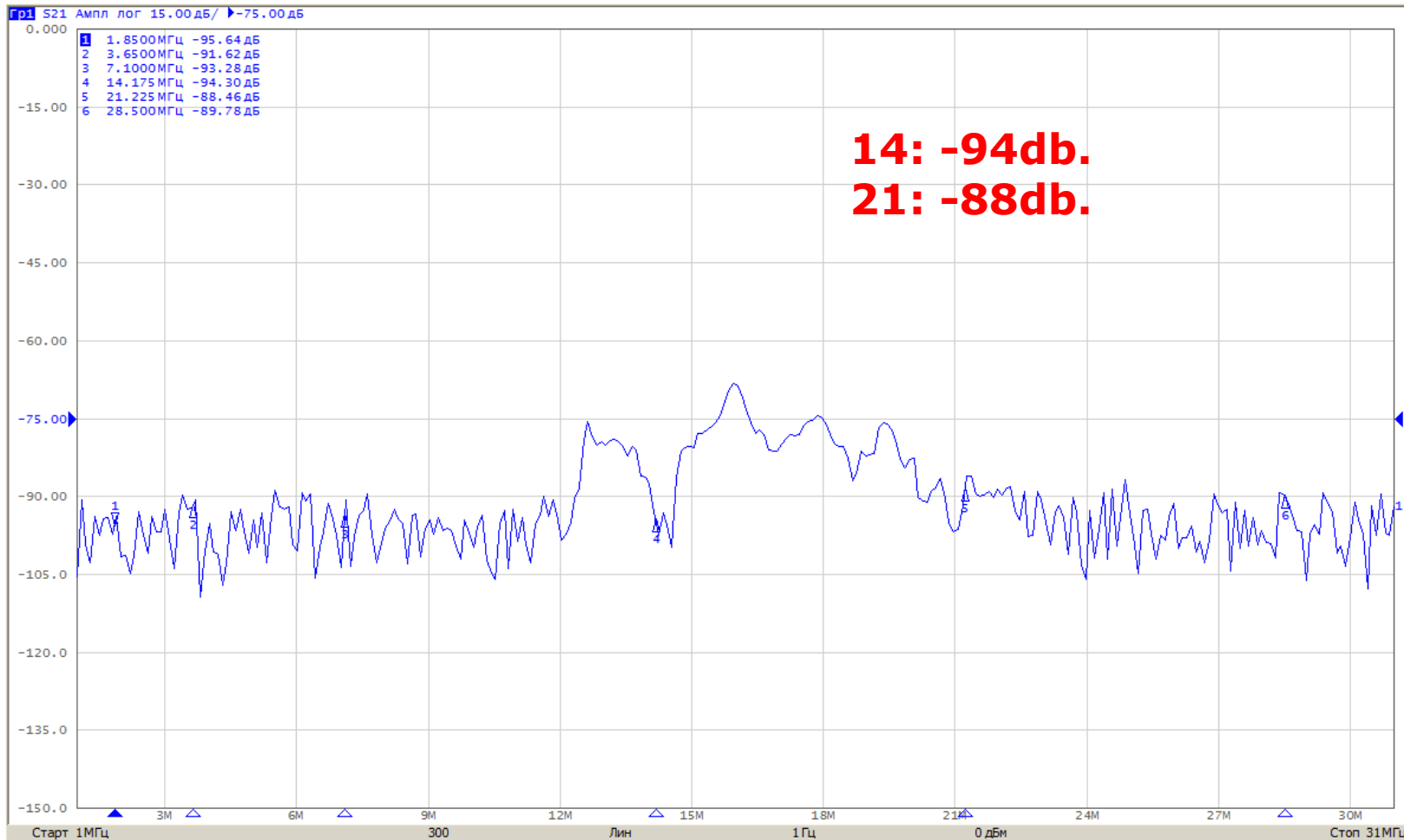
# Triplexer + modified W3NQN filter, 14/21 isolation:

2.S21 Ампл. лог. (дБ)



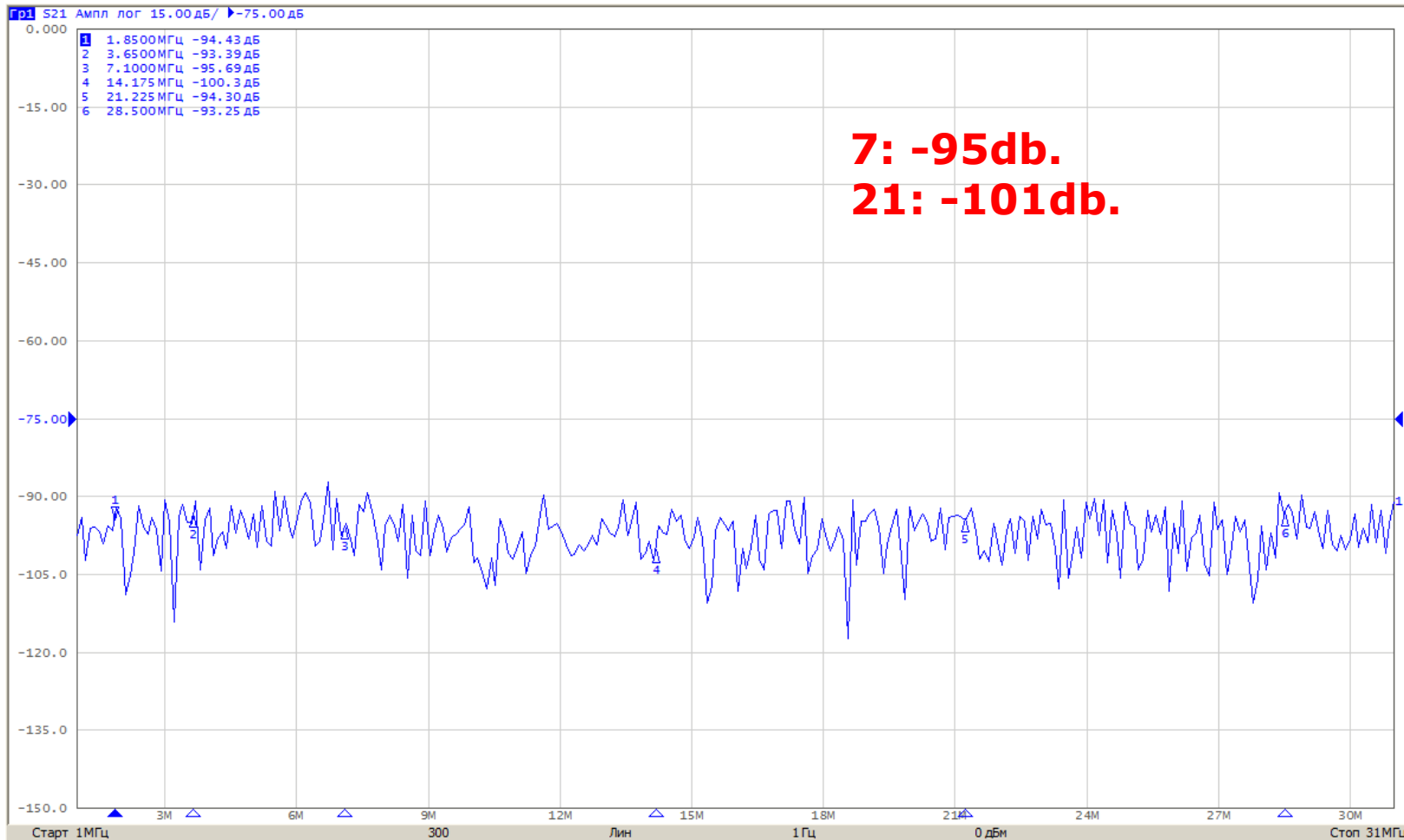
# Triplexer + PerfoBox filters, 1500W series, 14/21 isolation:

19.05.2017 8:21:57



# Quadplexer + PerfoBox filters, 1500W series, 7/21 isolation:

19.05.2017 8:24:57



# Interconnecting Cables

- **Shielding Effectiveness:**

- Messi & Paoloni >105db.
- Andrew LMR-240 >90db.

That's good enough.

- **Connectors!**

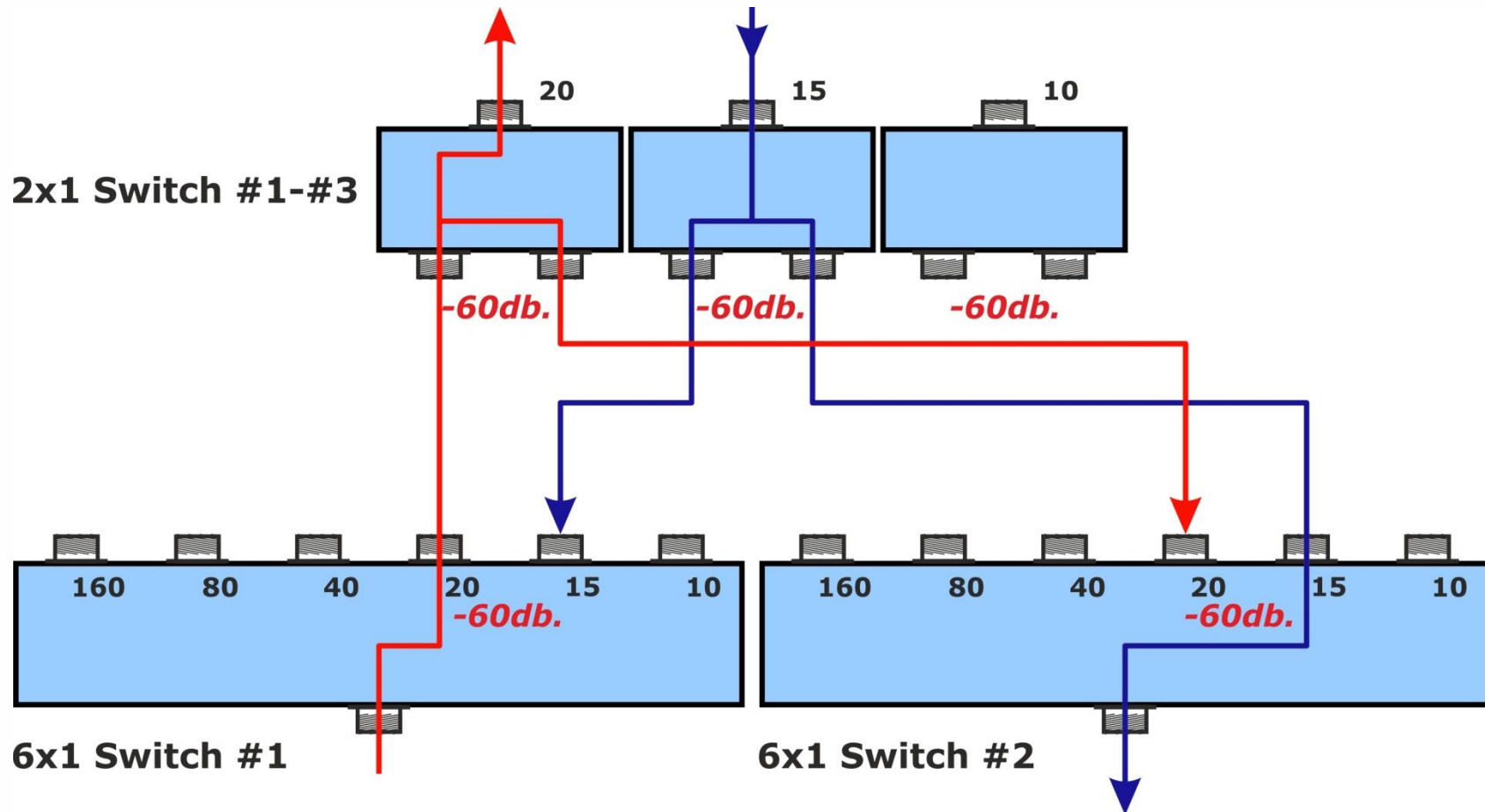
- Should always be clean and tighten well!
- Soldered cables braid to the body of connector!
- Bad connectors easily destroys low loss path;



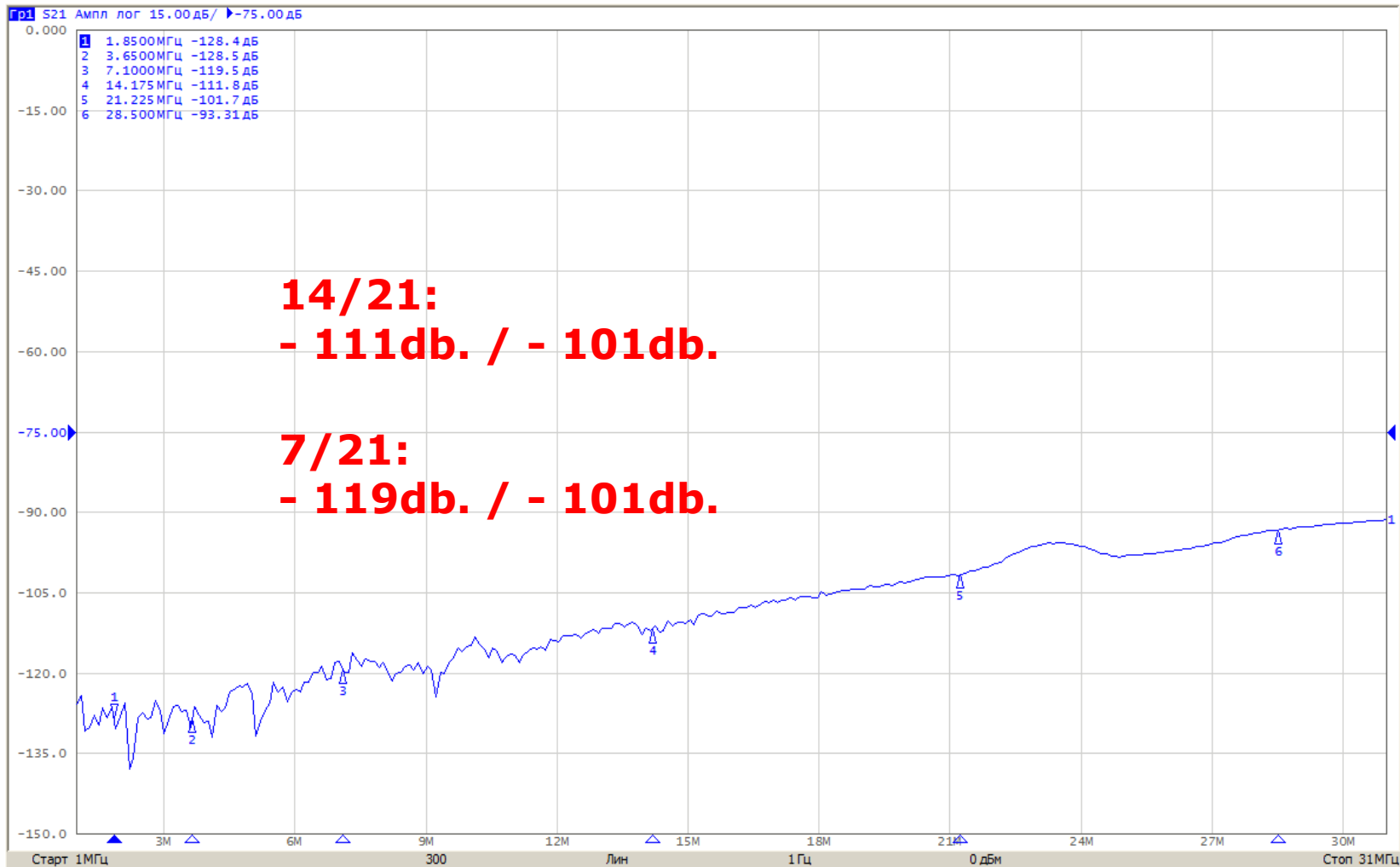
# Relay switches:

- **KK1L – entry level switch**
  - - *(85÷64)db. isolation, best case,*  
*not enough for this task*
  
- **RK-226 – good choice**
  - - *(90÷80)db. isolation, typical,*  
*(due to extra relay)*
  
- **Matrix switches – best of the best**
  - - *(125÷95)db. Isolation, typical*
  - *And any power levels!*

# Matrix switch, best of the best



# Isolation in Matrix Switch system, measured, 2008:

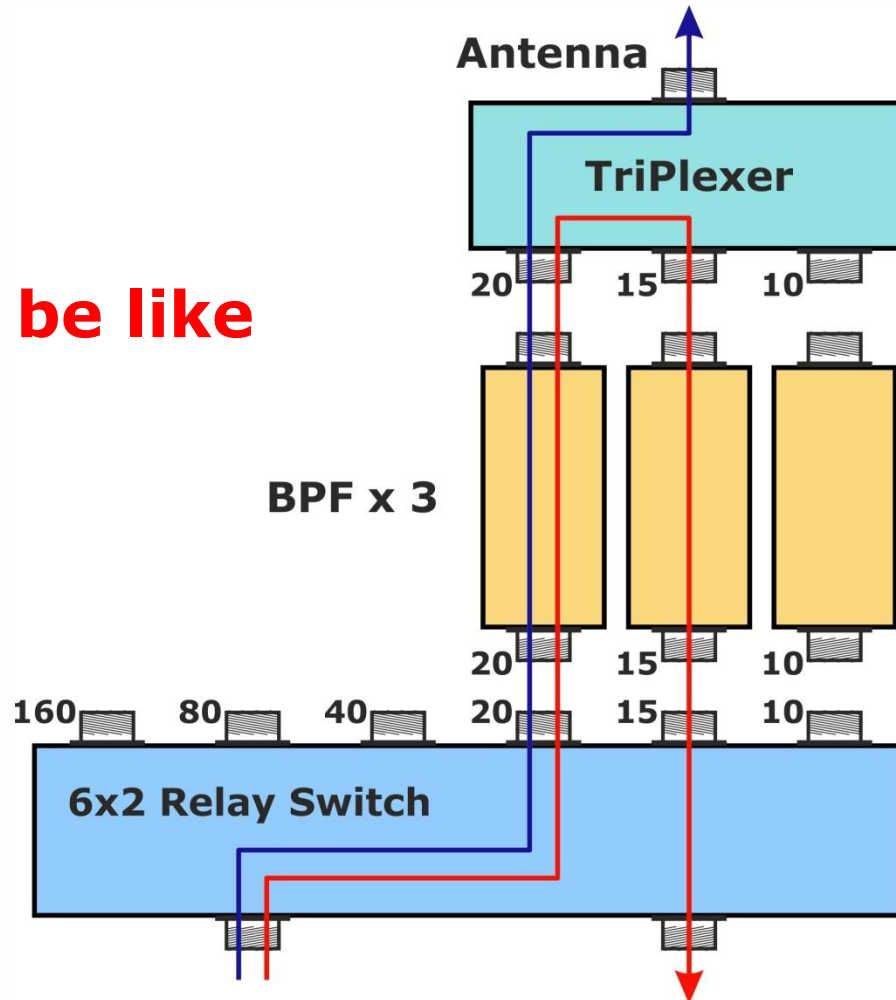


**Multiplexer +  
Filter +  
Relay switch**

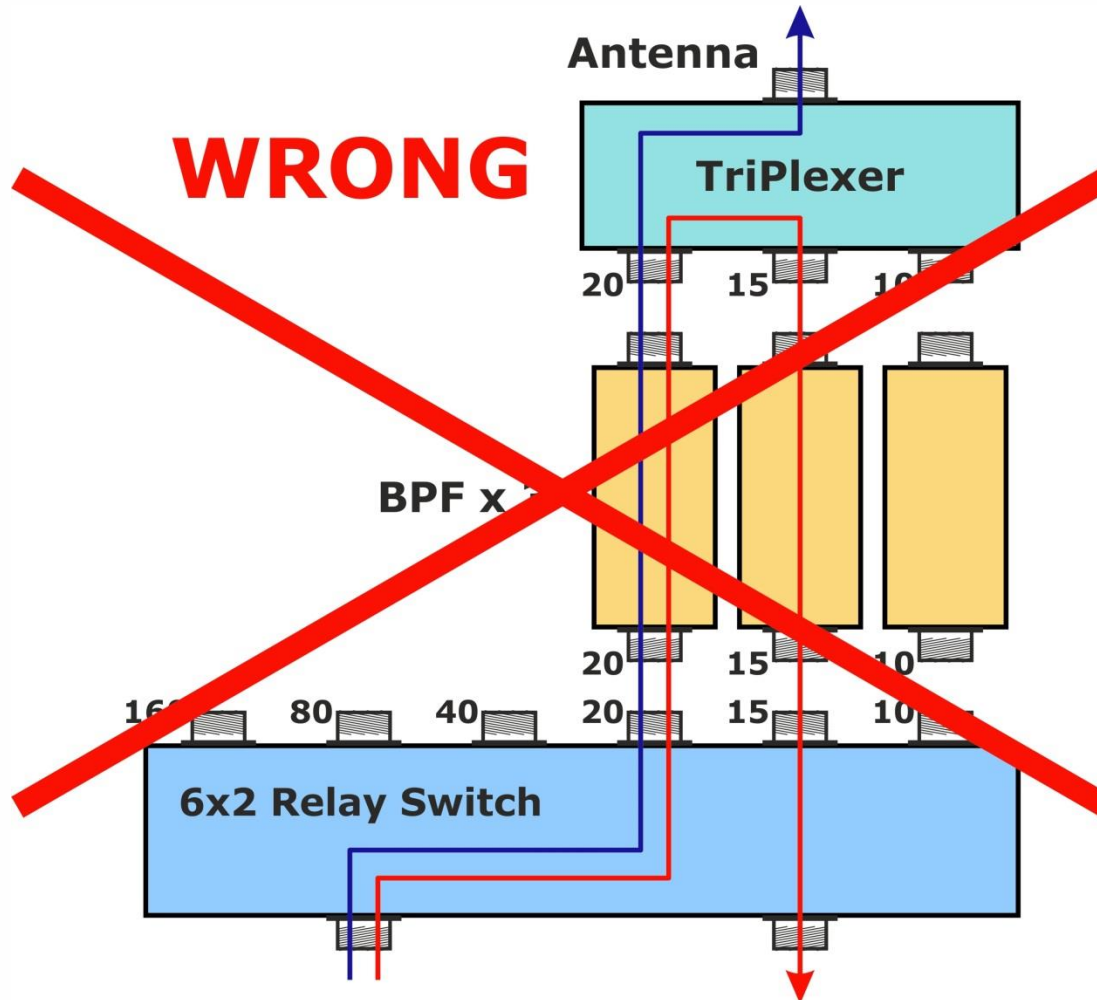
**Combos**

# Classic, 2x6 switch combo:

Great if  
it would be like  
this:



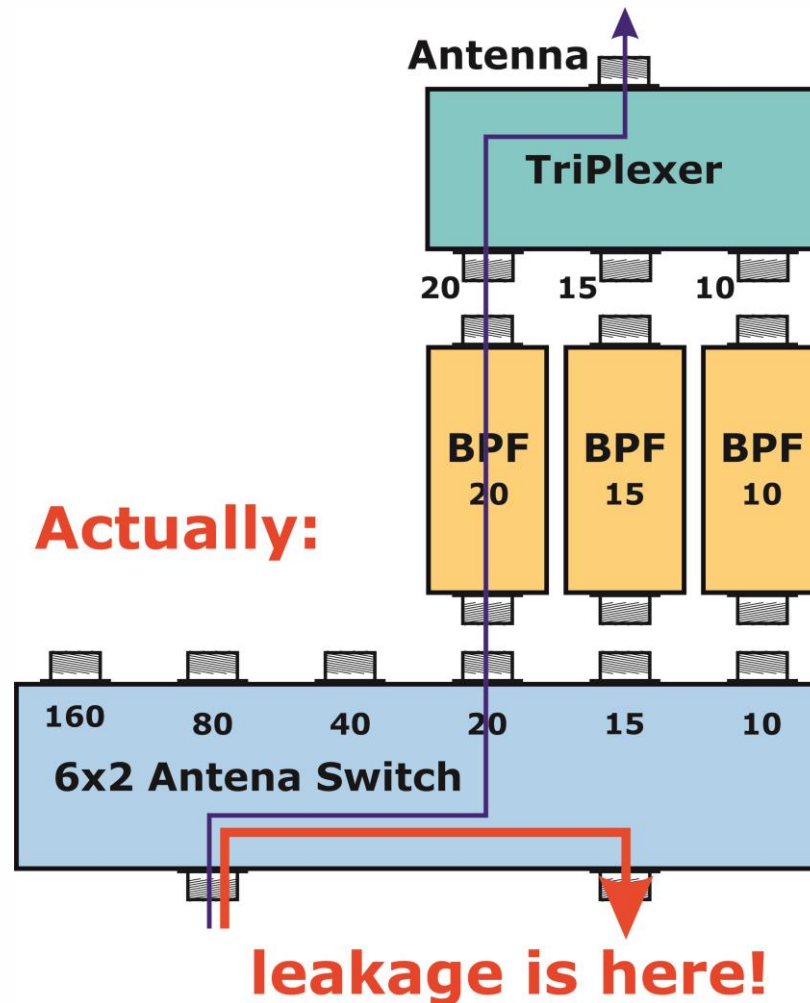
# Classic, 2x6 switch combo:



## **Classic, 2x6 switch combo:**

- **Leakage is determined by the switch!**
- **Not enough isolation in the switch can destroy performance of the best filters and Triplexer!**

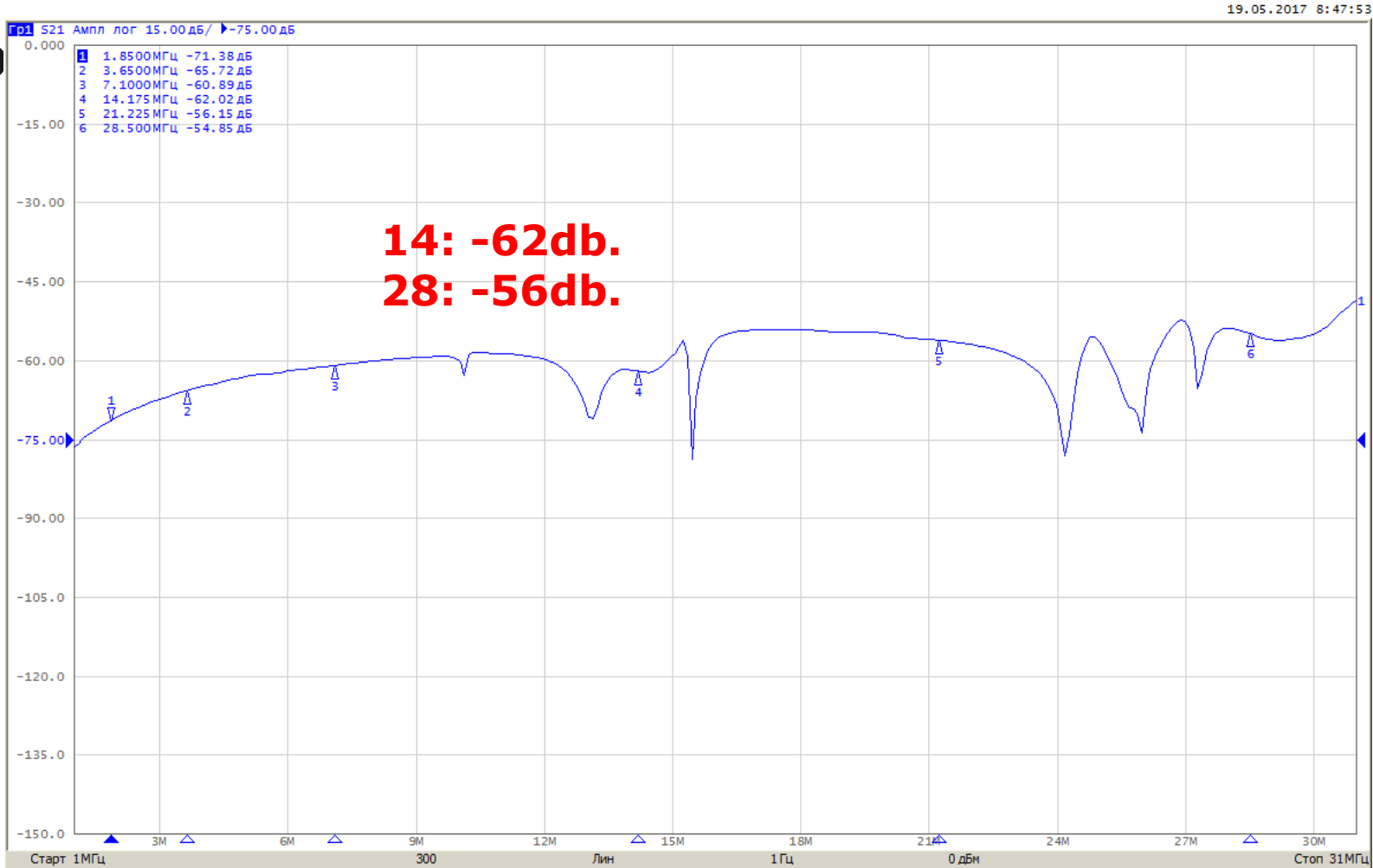
# Classic, 2x6 switch combo:





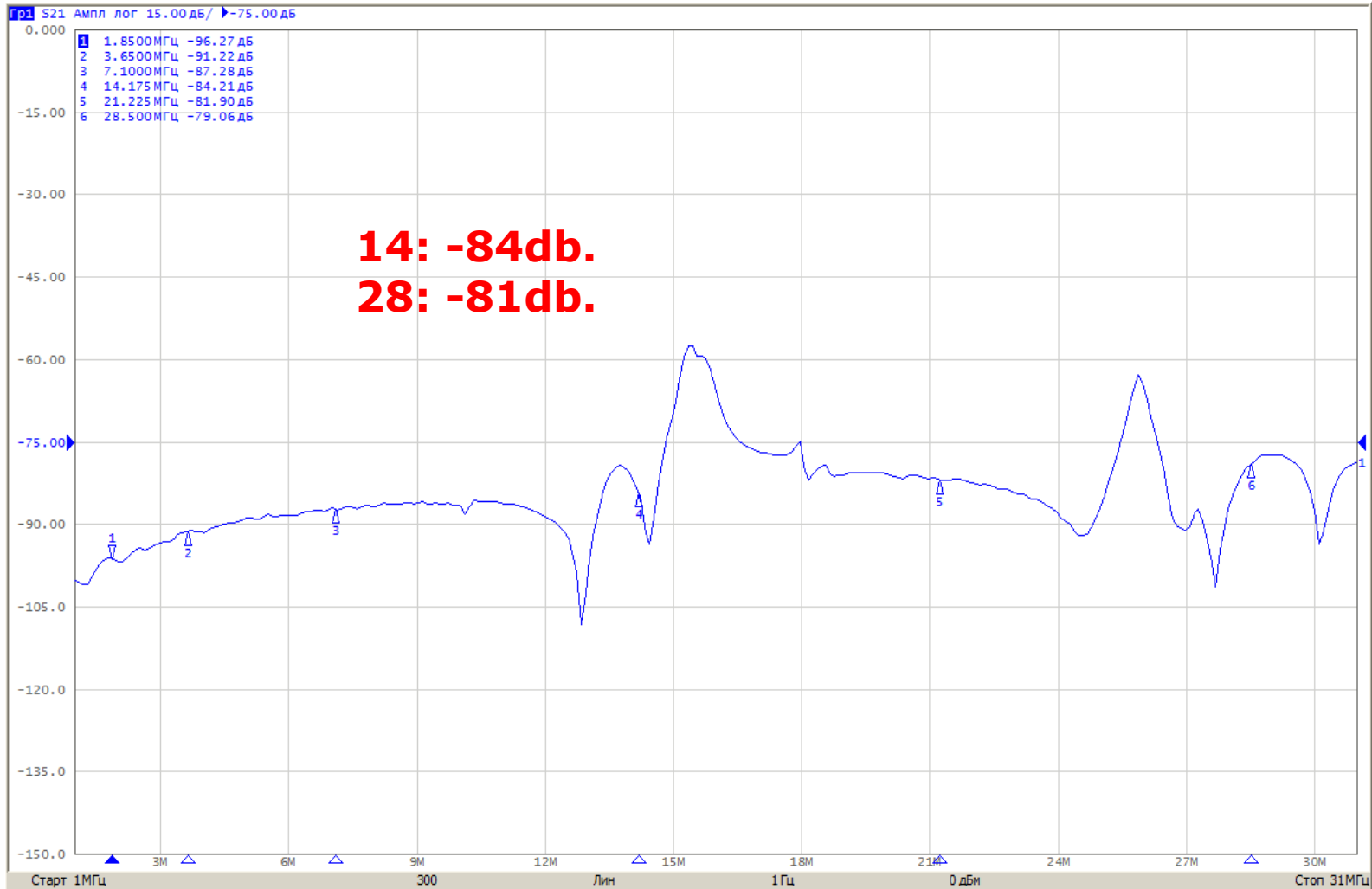
# with KK1L relay switch

P



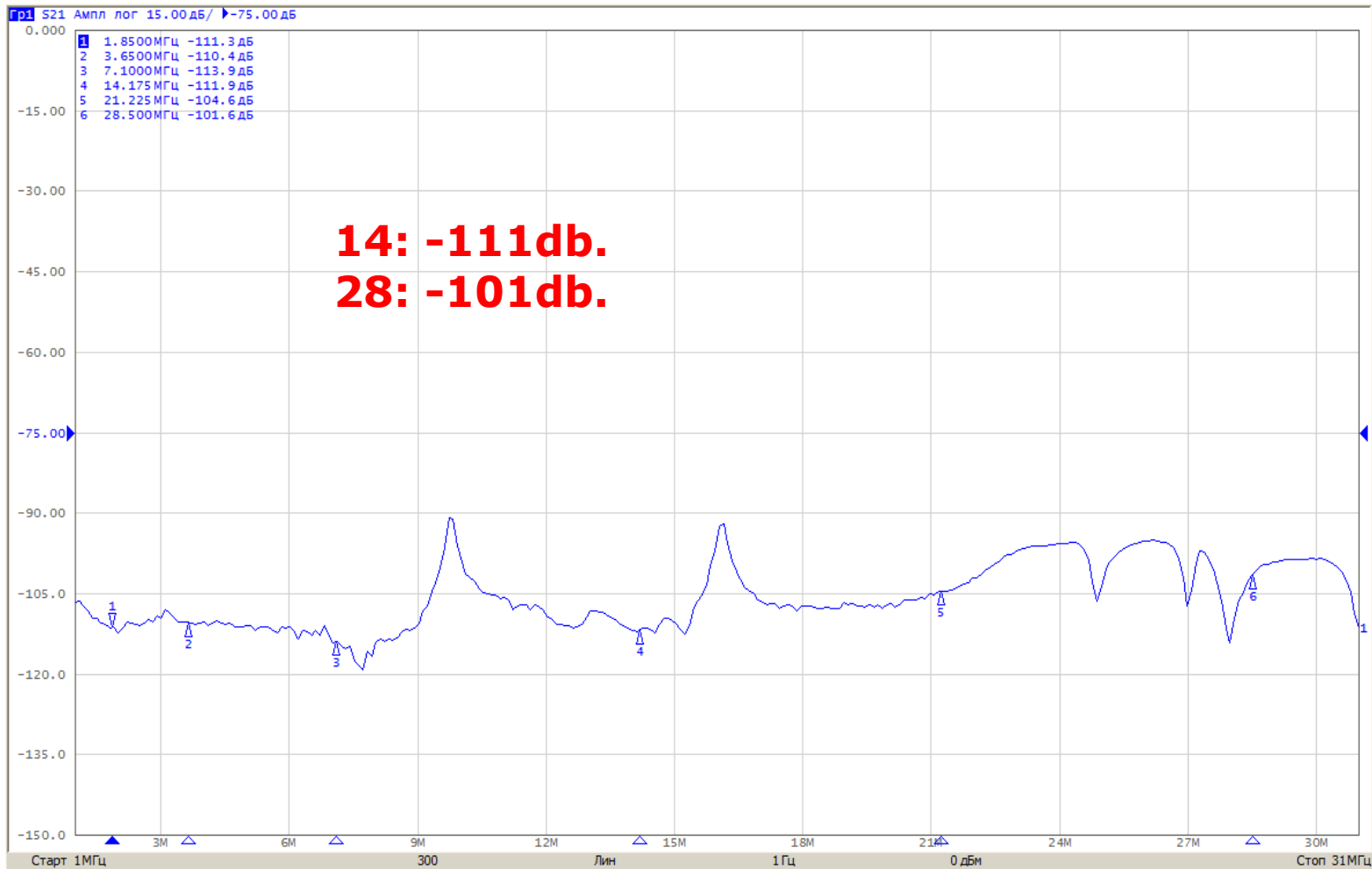
# with RK-226 relay switch

19.05.2017 8:49:06



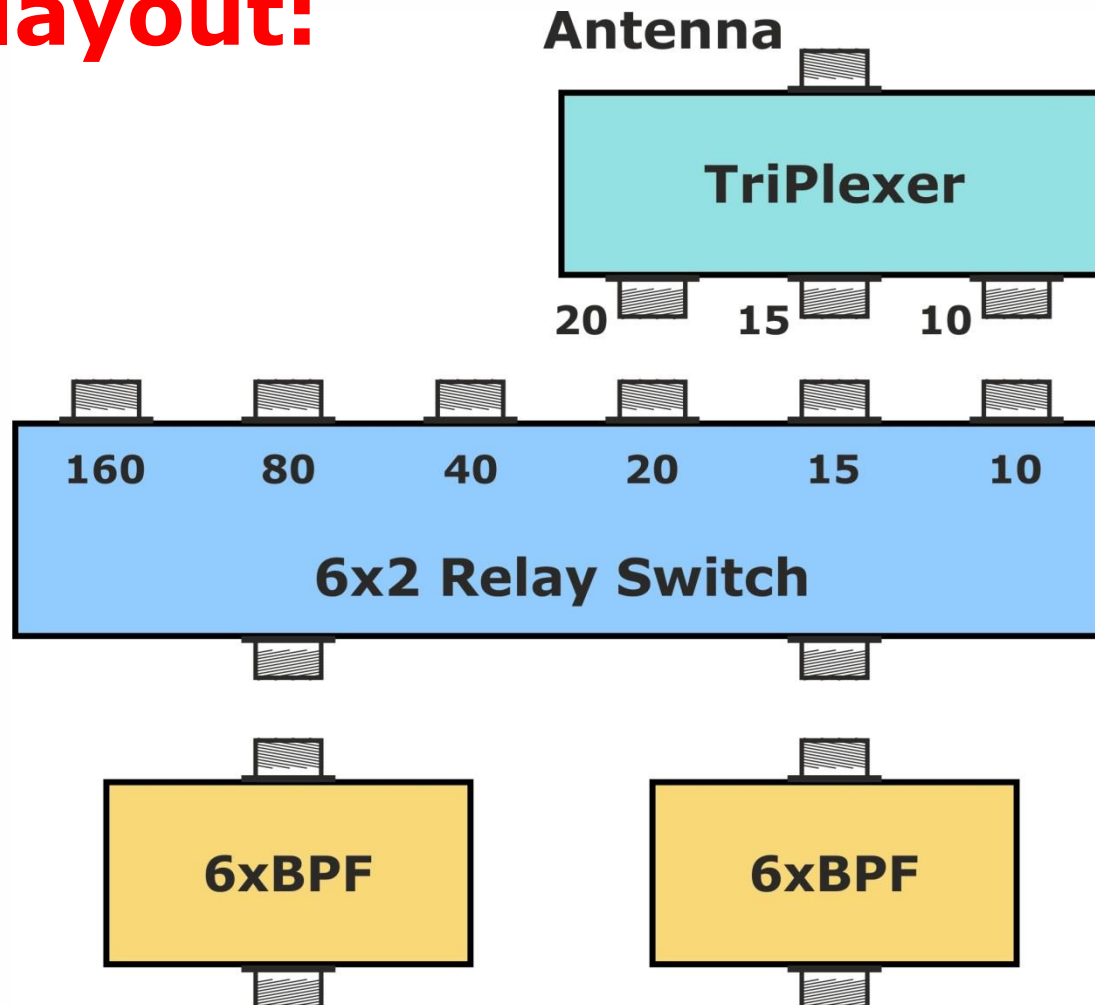
# with Matrix switch

19.05.2017 8:54:04



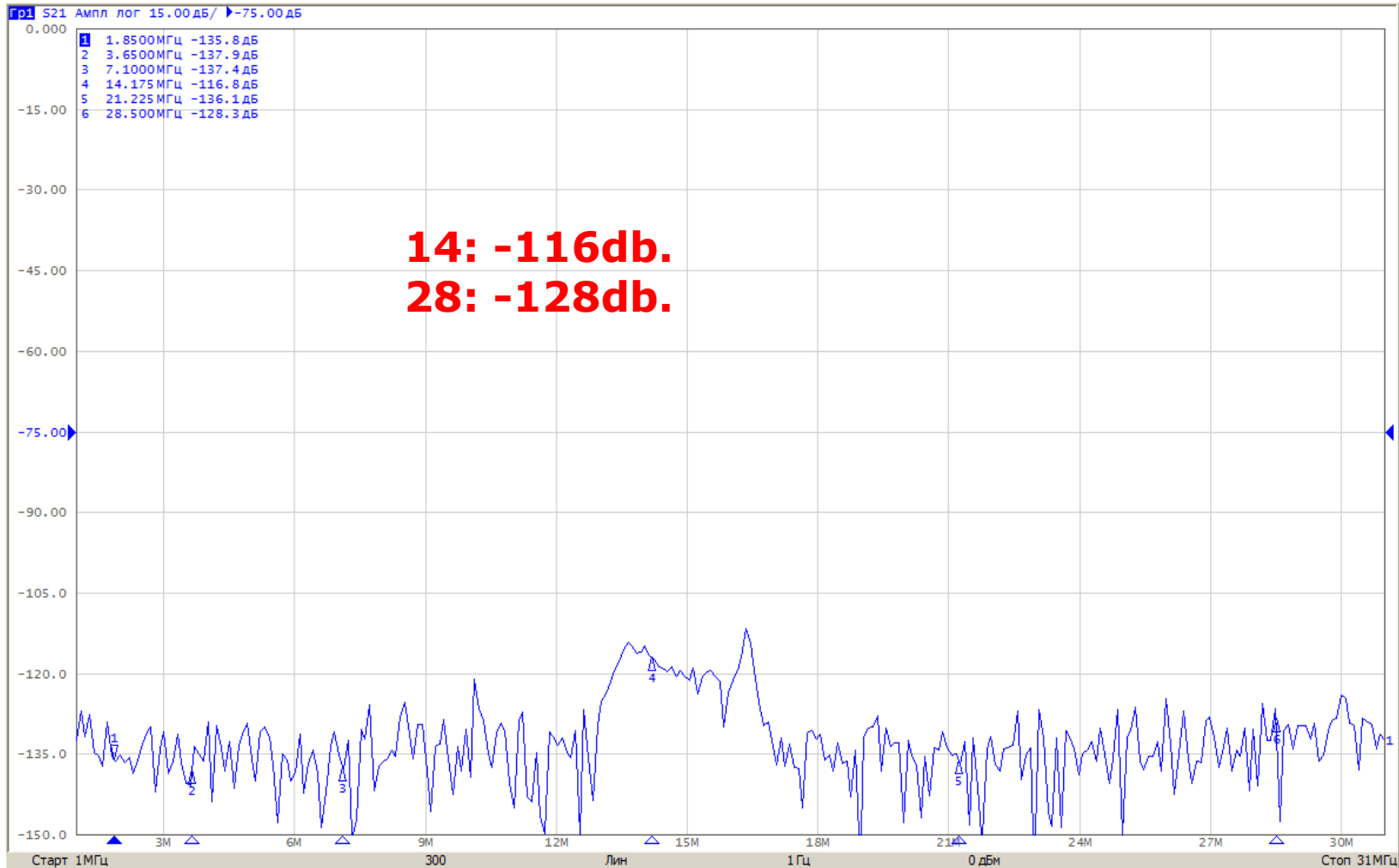
**Where is the **BEST** place for  
the filters and a switch?**

# Best layout:



# Isolation, THE BEST, MatrixSwitch and BPF ahead

19.05.2017 8:55:25



# Summary of isolation

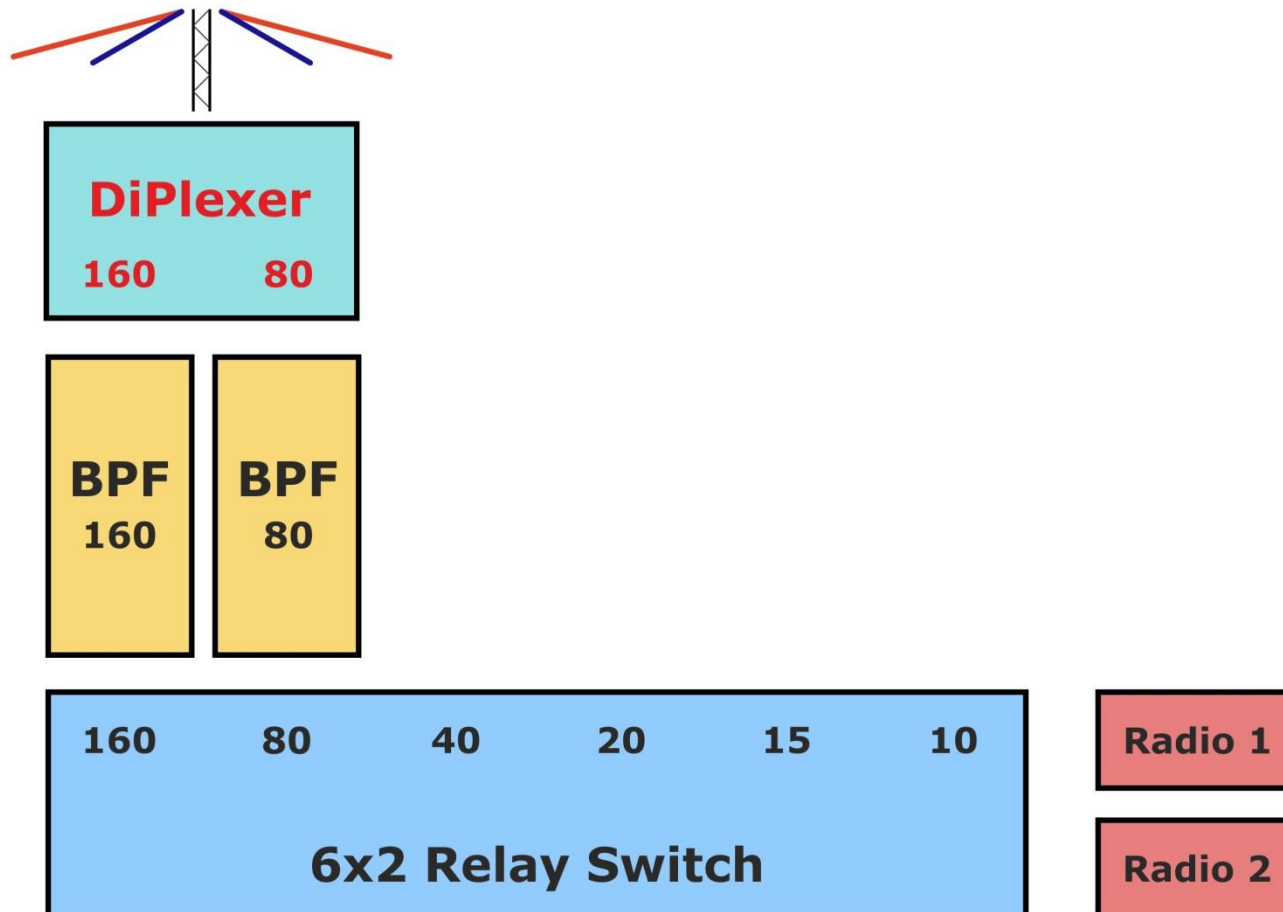
<b>Components:</b>	<b>14 to 28 isolation, as example</b>
<b>TriPlexer and Filters combos:</b>	
Triplexer 200W, minimum, db.	-40 / -34
Triplexer + Set of PerfoBox 200W filters	-96 / -103
Triplexer + Set of PerfoBox 1500W filters	-94 / -88
<b>Relay Switches:</b>	
2x6 Switch KK1L, best	- 85 / -64
2x6 Switch RK226, worst	-83 / -77
Matrix Switch	-111 / -98
<b>Complete SYSTEMS:</b>	
Triplexer + (3 x Filters) + KK1L	-62 / -64
Triplexer + (3 x Filters) + RK226	-73 / -79
Triplexer + (3 x Filters) + Matrix switch	-111 / -101
Triplexer + Matrix switch + Six pack of Filters ahead	-116 / -128

# Part II

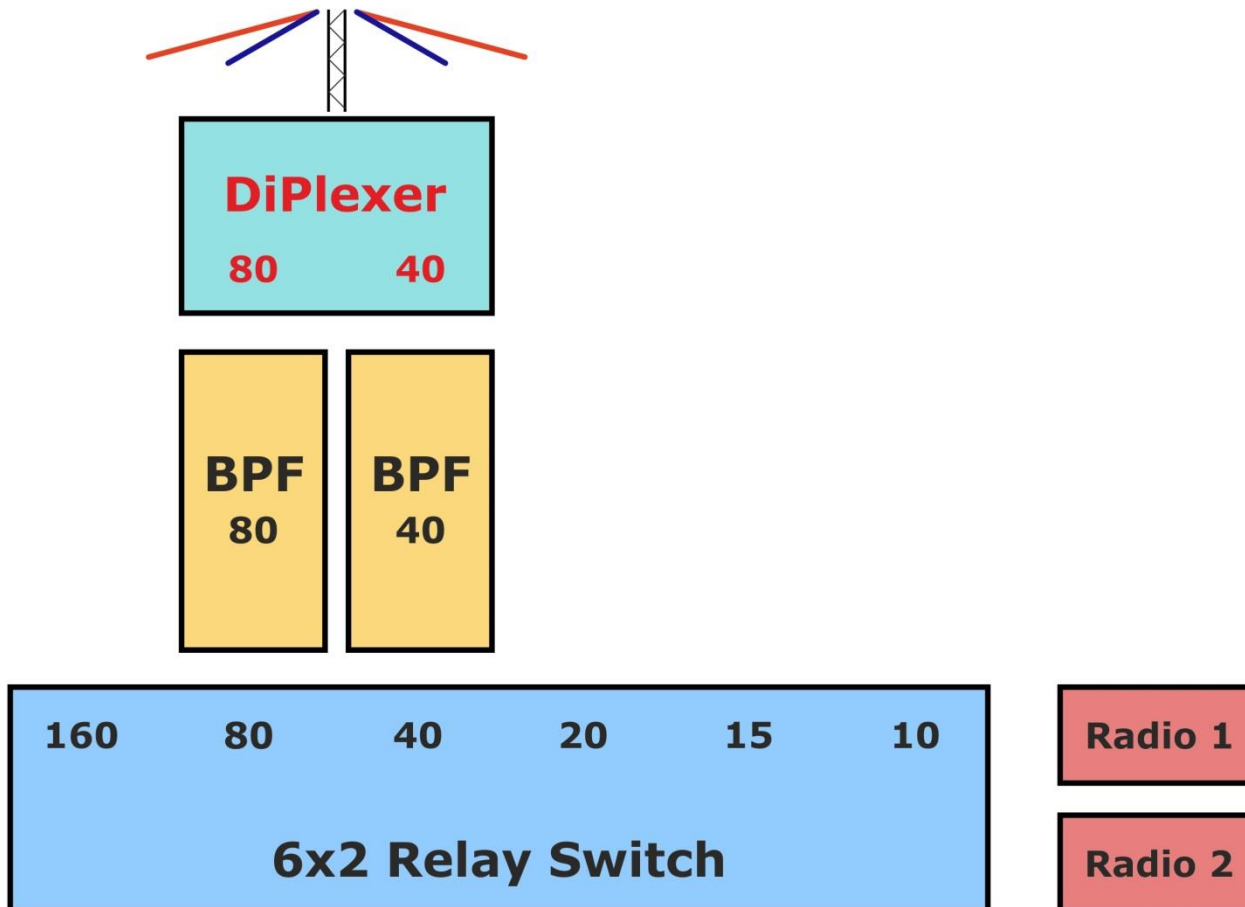
## MULTI BAND antennas



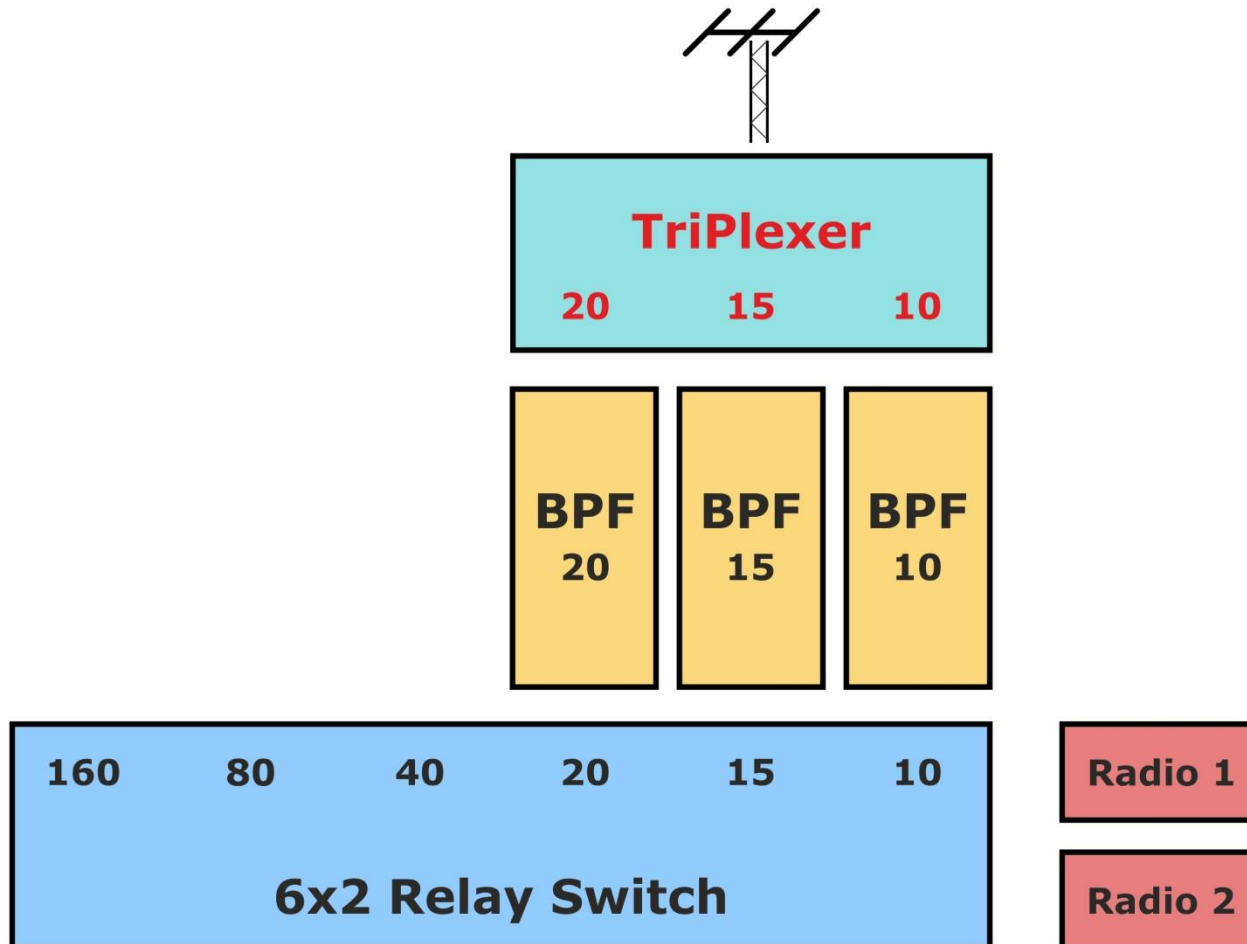
# Some examples for multiband antennas



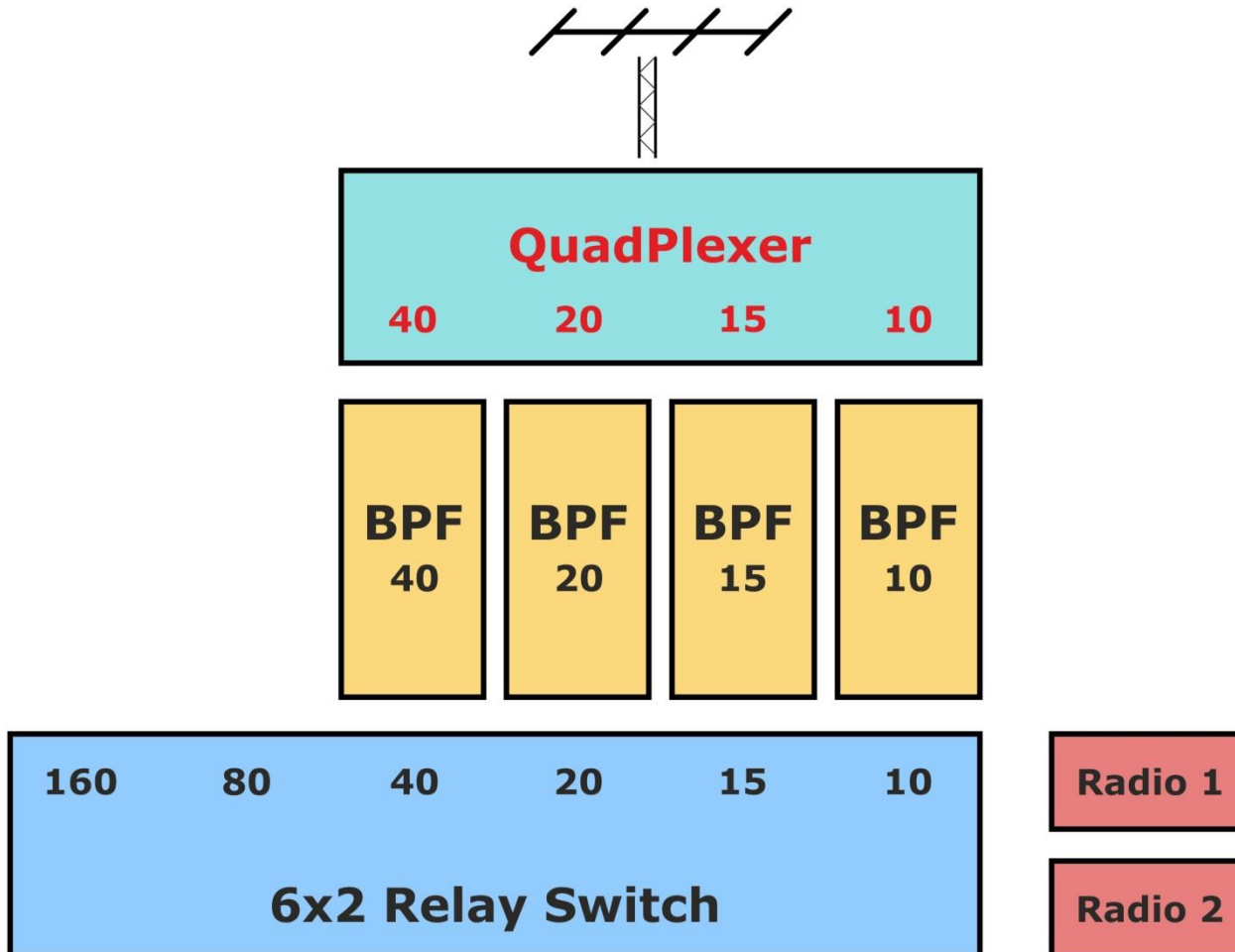
# Some examples for multiband antennas



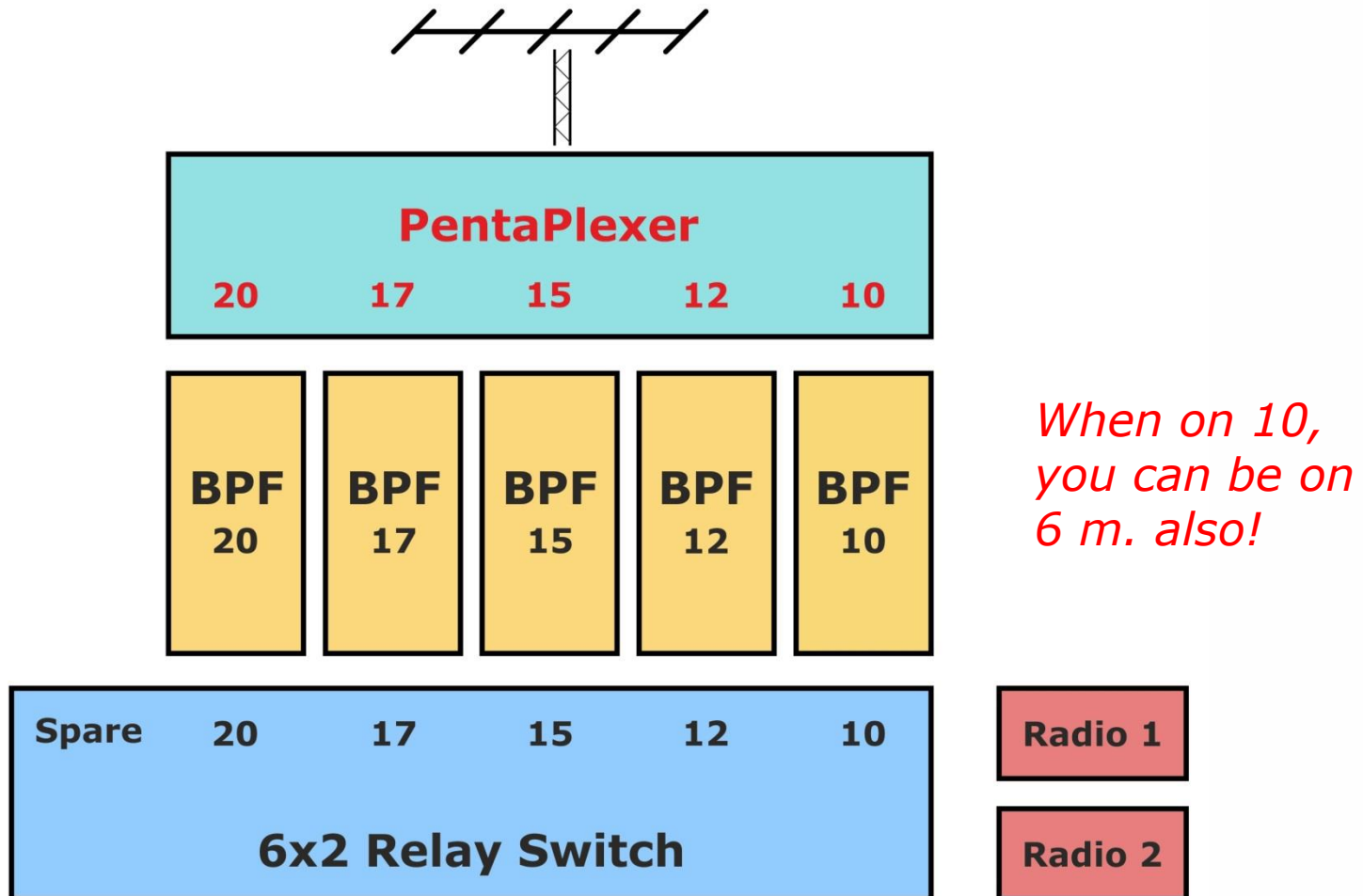
# Some examples for multiband antennas



# Some examples for multiband antennas



# Some examples for multiband antennas



# **Part III.**

## **Upside Down ?**

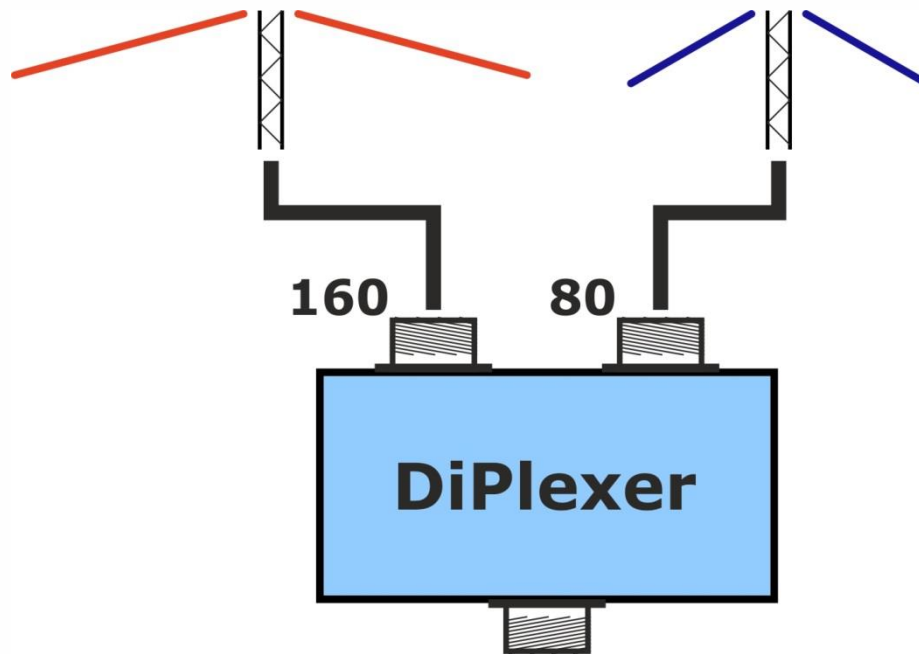
**YES!**

# Benefits:

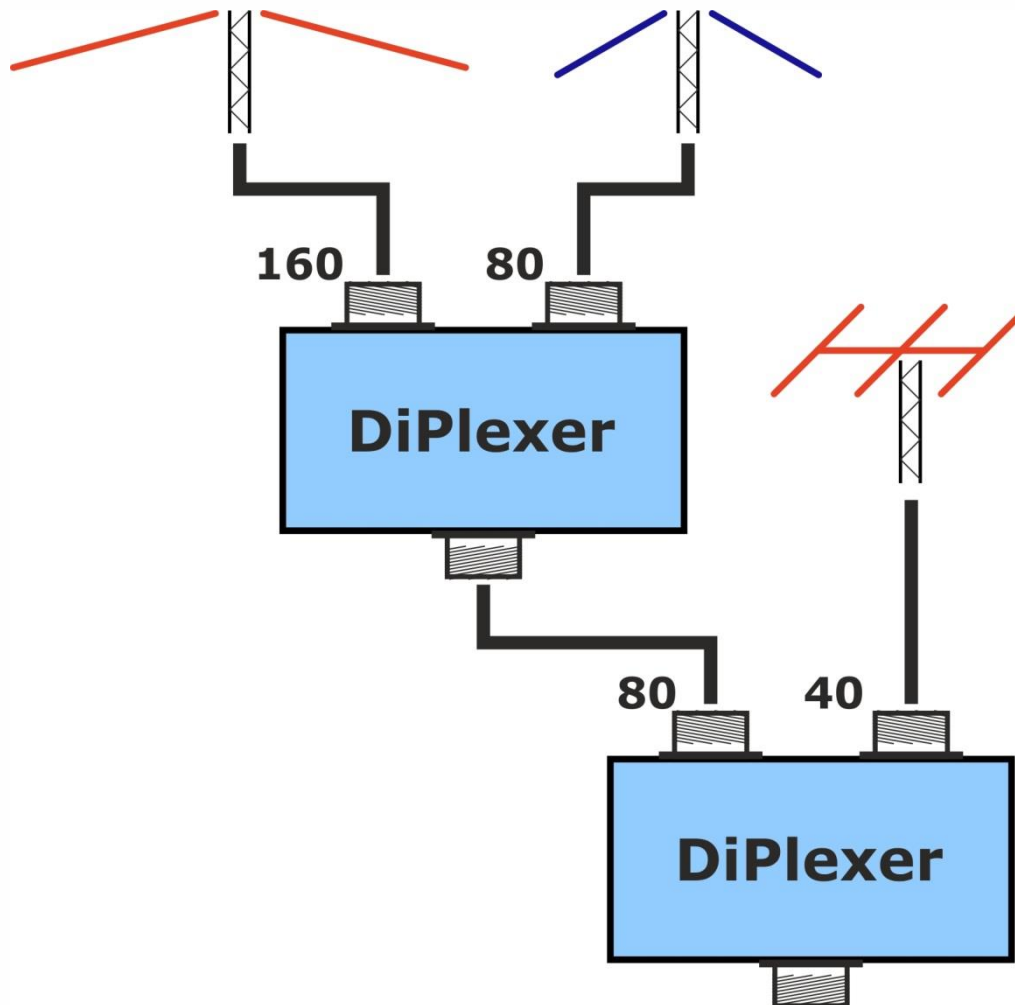
- **For in-band remote sites**
- **Hardline and installation time saving solutions**



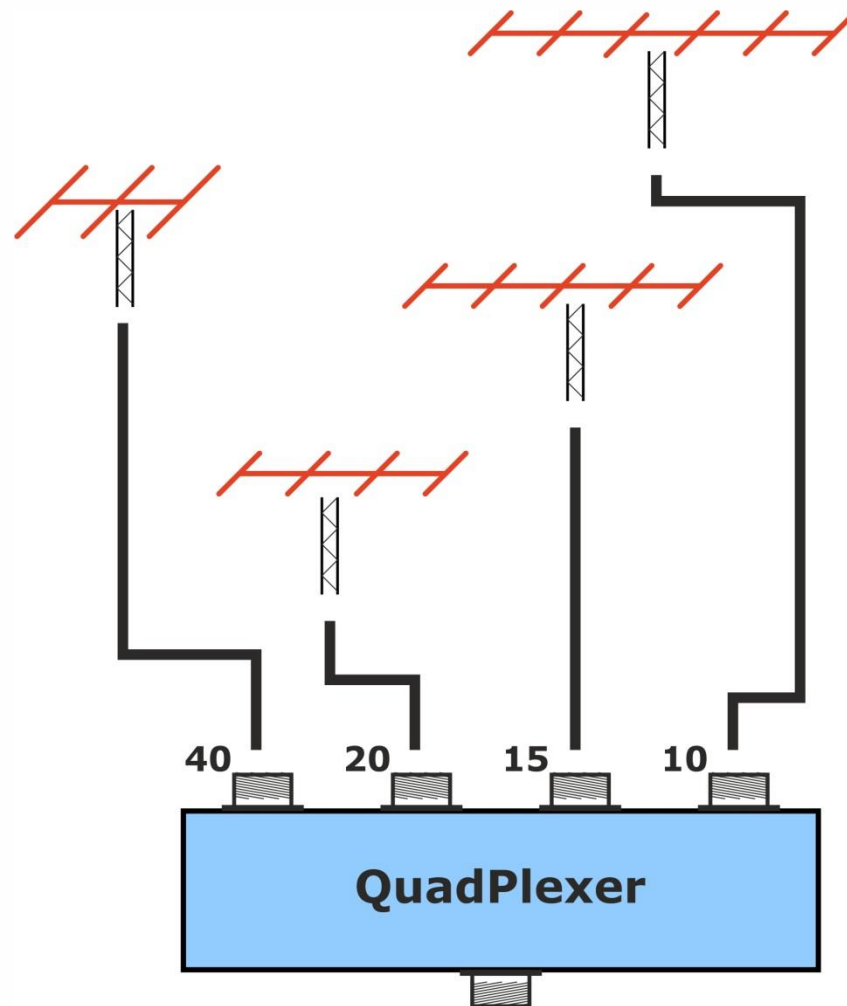
# Upside down "bricks"



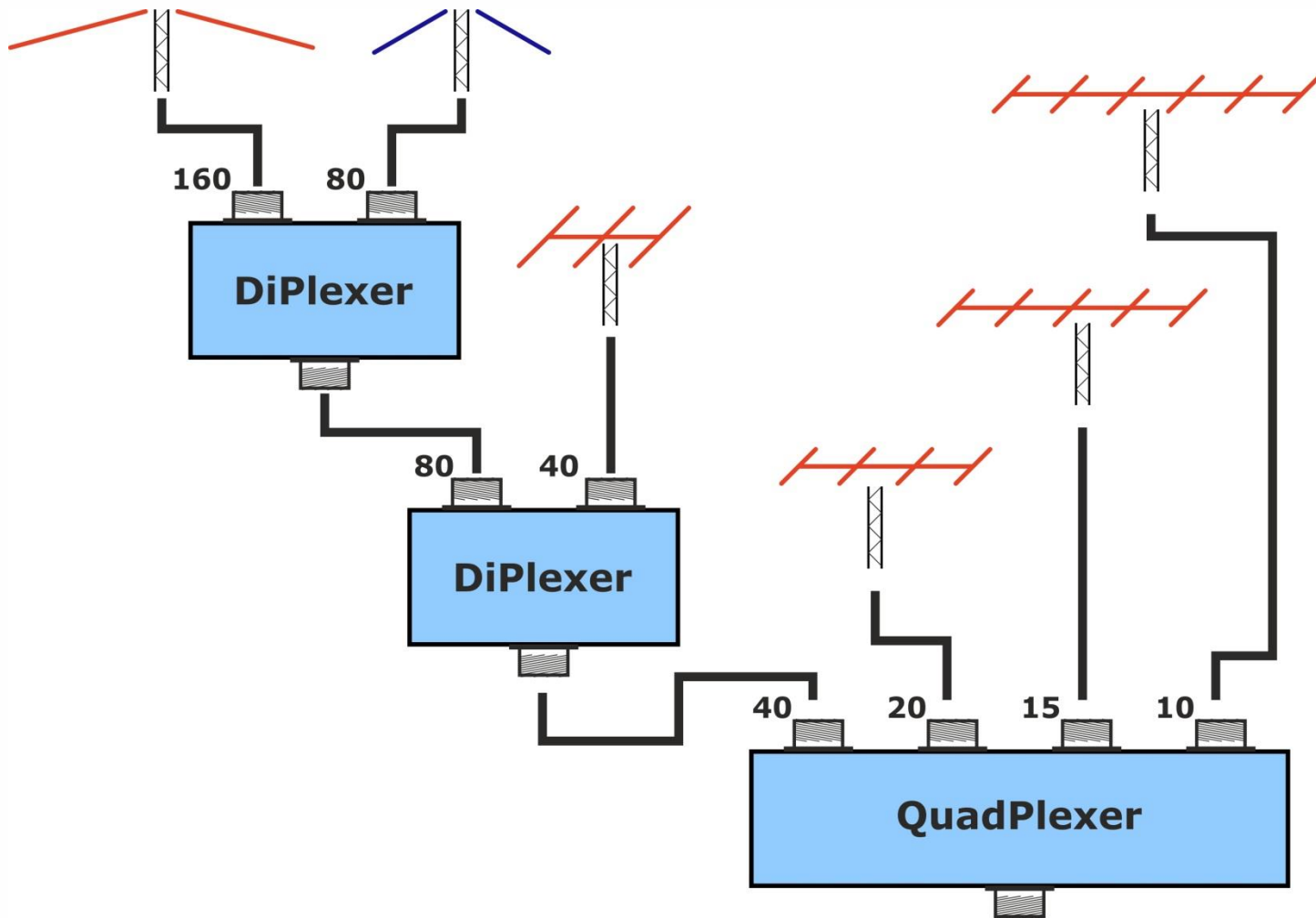
# Upside down "bricks"



# Upside down "bricks"



# Upside down summary:



# Part IV

- **RECEIVE ONLY APPLICTIONS**

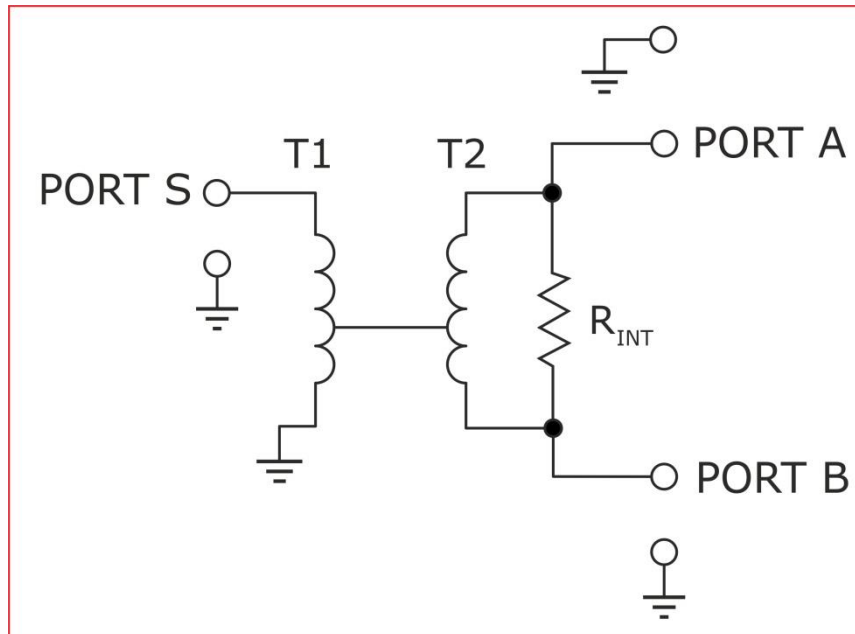
**Can we have any benefits with  
Multiplexer technology for  
receive only applications?**

**Yes!**

# Lets compare with the classic of the distribution:

## Wide band splitters:

SPLITTER/COMBINER, know also as a "Magic T" or "-3db."



# Wideband splitters:

## The weak point is internal losses:

- **-3,1db.** in a 2 way splitters;
- **-6,3db.** in a 4 way splitters;
- **-9,5db.** in a 6-8 way splitters;

*Plus losses in a feedline.*

*For 1000 feet of RG6 size cable it is -3÷4db.*

**Total losses may be over -12db. in a 6 way splitting!**

**And 6 way splitting is a must for Winning size Multi stations!**

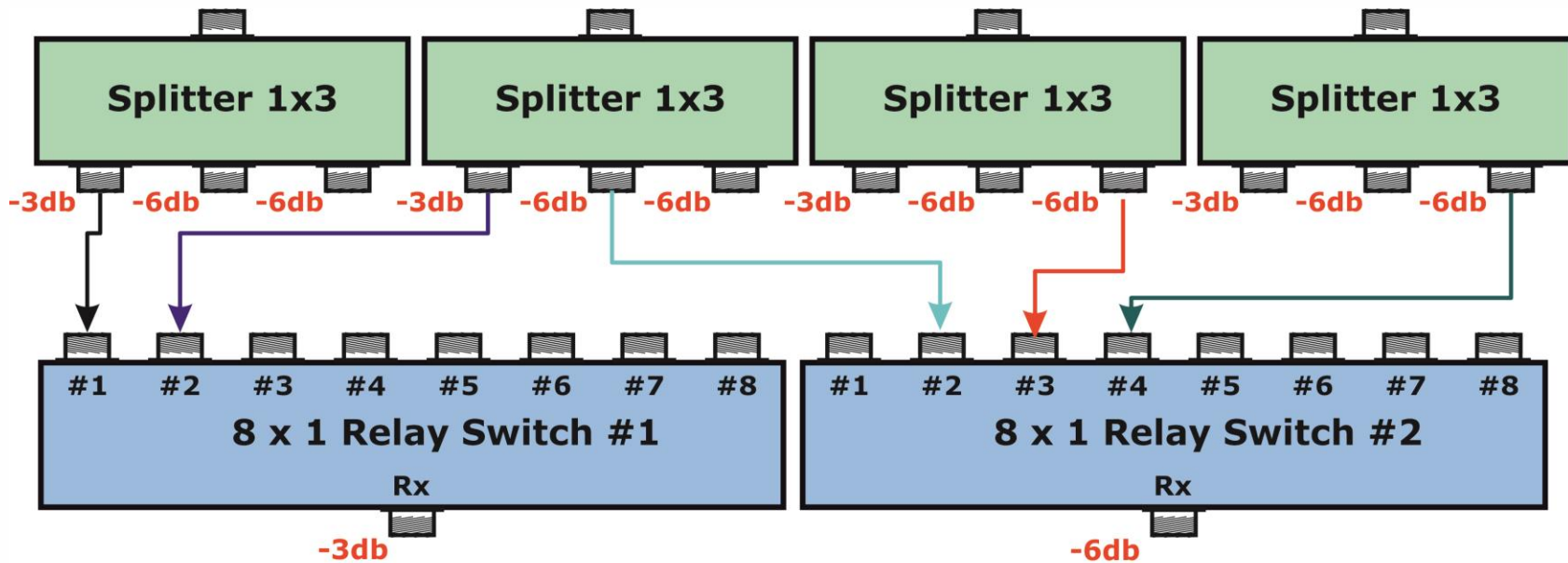


# CLASSIC LAYOUT:

Receive signal distribution for 3 station only,  
(small M/S), with wideband splitters:

*Number of receive antennas is always limited due to the lack of space ...*

*But now we have limitation on screen ...*



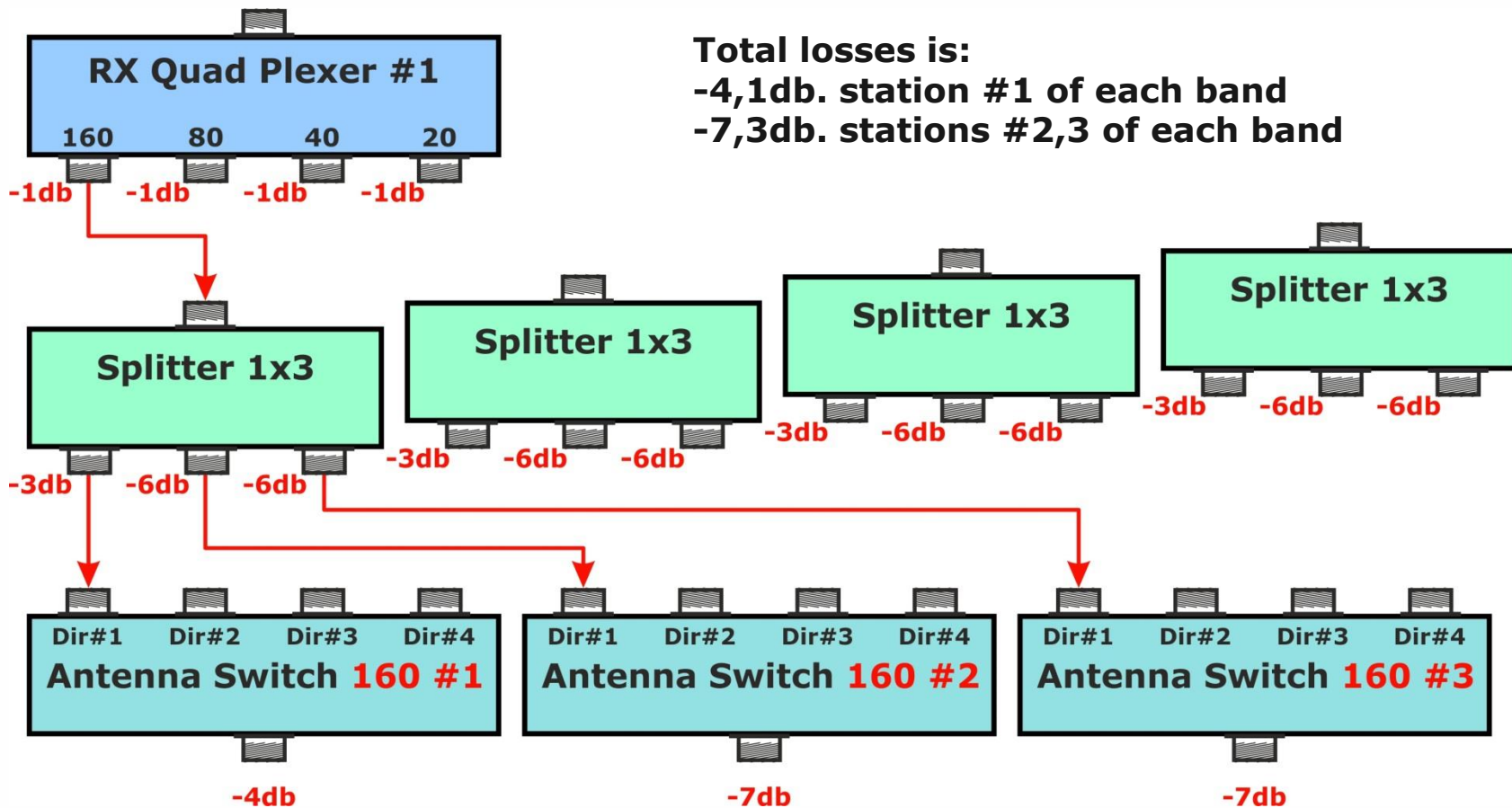
**8 x 1 Relay Switch #3 is not shown for simplicity**

*Losses is determined by nature of wideband splitters*

**Can we overcome this loss-  
related problem in a larger size  
stations  
with the MultiPlexer  
technology?**

# Advanced receive signal distribution for M/M, big M/S:

**Unlimited number of directions,  
Up to 4 bands, 3 station on each band!**



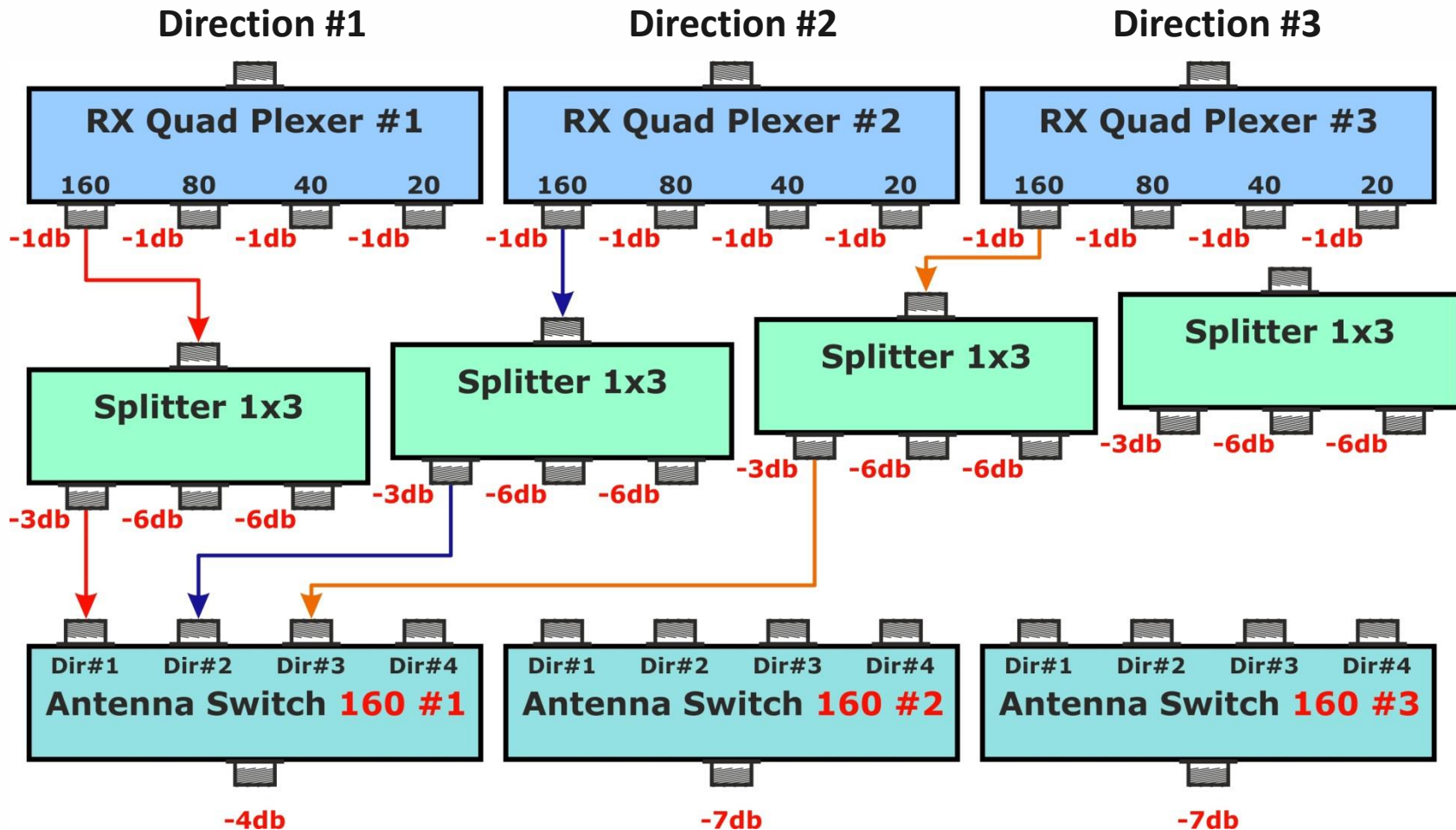
Total losses is:

-4,1db. station #1 of each band

-7,3db. stations #2,3 of each band

# Advanced receive signal distribution for M/M, big M/S:

**Unlimited number of directions,  
Up to 4 bands, 3 station on each band!**

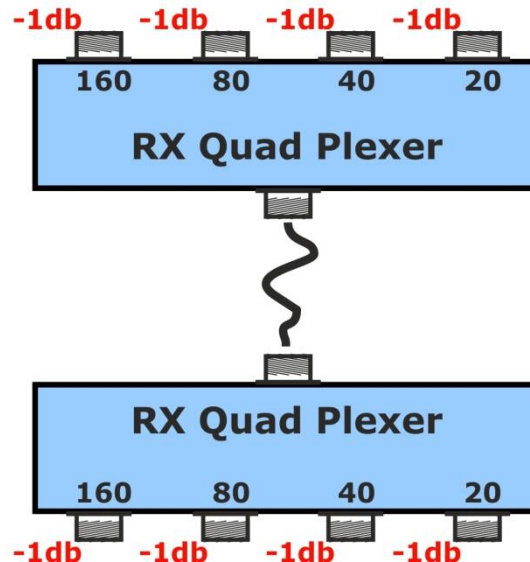


# **For DX pedition:**

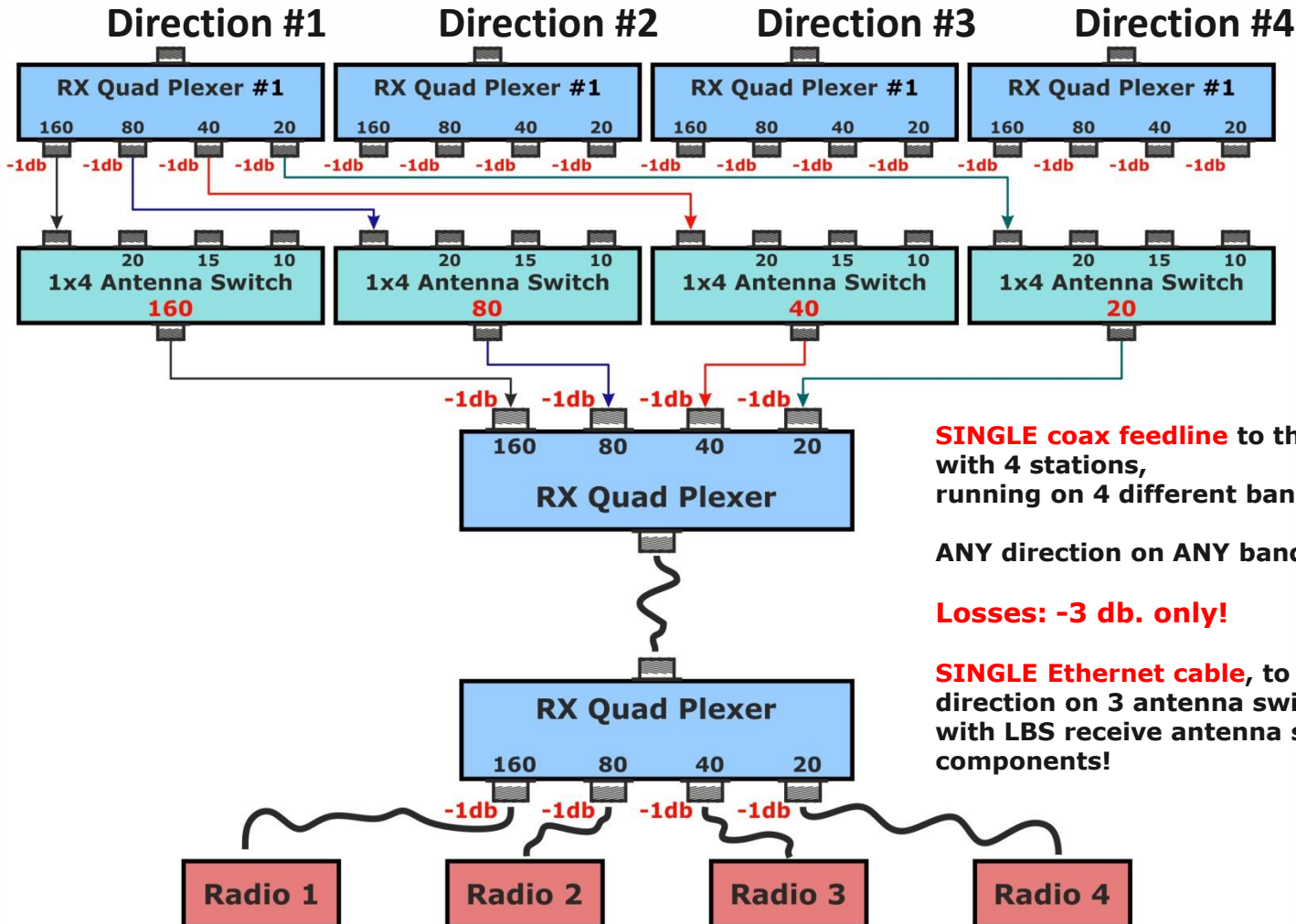
## **Coax and installation time saving solutions!**

# DX pedition advanced layout:

**You can first combine (*into single feedline*),  
and then split (*at the radios* )  
different band signals!**



# DX pedition advanced layout:



**SINGLE coax feedline** to the tent with 4 stations, running on 4 different bands!

ANY direction on ANY band!

**Losses: -3 db. only!**

**SINGLE Ethernet cable**, to control 4 direction on 3 antenna switches with LBS receive antenna systems components!

# Q & A?

- [LowBandSystems, of Russia](#)
- [DX Engineering - USA distribution](#)