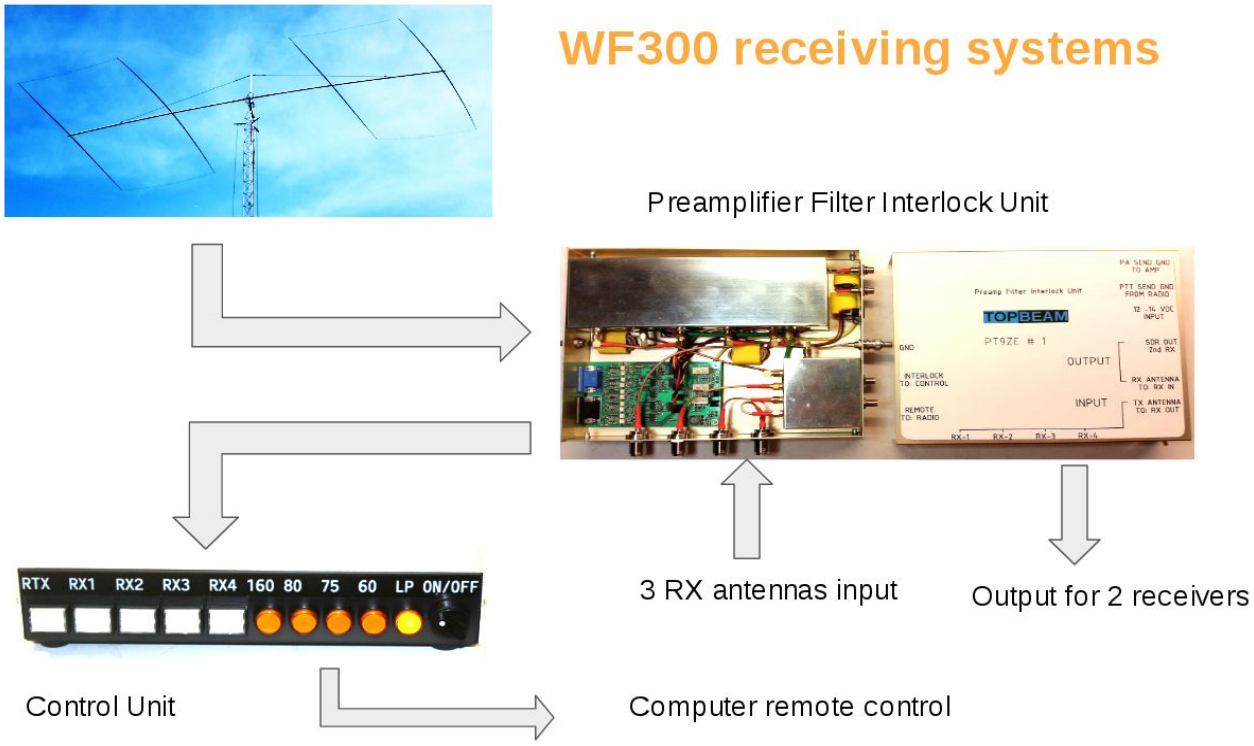


Introduction

What is the secret behind the fact that one station can work all the DXs on low bands while another station in the same area can't?

Both stations, even having equivalent equipment; receiving antenna, pre-amplifier, filter, and a good radio can get different results. Quite often both operators are really skilled DXer's on HF, but the truth is that one station just can't hear the DX as good as the other.

Why is that?

The ham radio station is indeed one unique system, buying equipment and plugging them together might seem a straightforward procedure but, far too often, they are just pieces of different puzzles that do not quite connect.

Every single component interacts with the other components like a sequence of boxes where the system performance depends on how each box interacts with one another. The unsuccessful station may have the same set boxes, but since the components were never designed as one system, they cannot reach their maximum performance.

Understanding how each component really interacts and impacts the overall performance, requires the same set of skills of a professional commercial station and most of us have no clue that this happening or how the receiving system should perform.

The idea behind a successful station is that its receivers, transmitters, pre-amplifiers, filters and all antennas work as one system designed for maximum expected performance.

Location, location, location… we always hear that, but, and here is the “but”, we live in our houses and that's our location, we can’t change that ,!! … location is the most important parameter to design a system. Your location!!!!

And that is where TOP-BEAM comes in… providing you with a receiving antenna system that brings you a solution able to figuratively transport your suburban location to the silence of a corn field.

We know how your receiver interacts with the TOP-BEAM pre-amp, feed line, and WF Receiving Antenna at your location so that it can work together as a *system* for maximum DX performance, At TOP-BEAM, we think of your station at a system level.

System level means we can customize the solution based on your needs, DXer, Contester. SO2R, Multi Multi, Multi Single and solutions for commercial application.

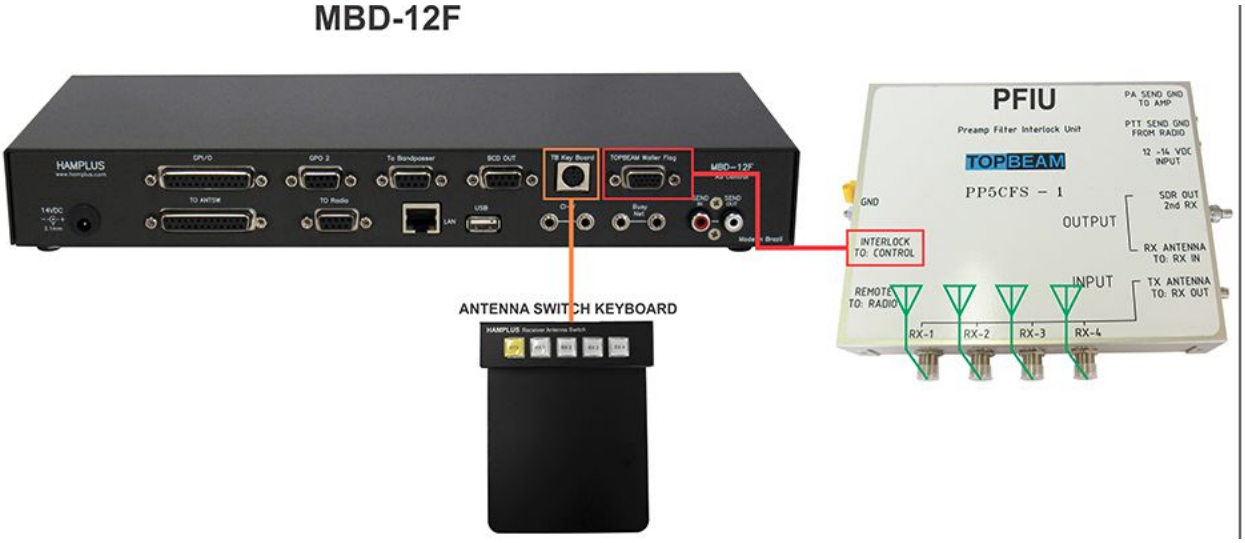
DXer system is optimized for best sensitivity or Noise Figure.

SO2R system is optimized for high isolation between bands allowing to use 160m 80m and 40m at same time on the same antenna per PFIU unit, minimum two PFIU is necessary, one for each receiver. Up to 4 Waller Flag antennas can be selected.

Multi Multi system with fixed station per band is optimized for maximum band performance Duplexer is used with high isolation to split the signal 160 and 80/40 m a second duplexer can be used to split 80 and 40m. The PFIU optimized and fixed for one band (optional switch 4 WF)

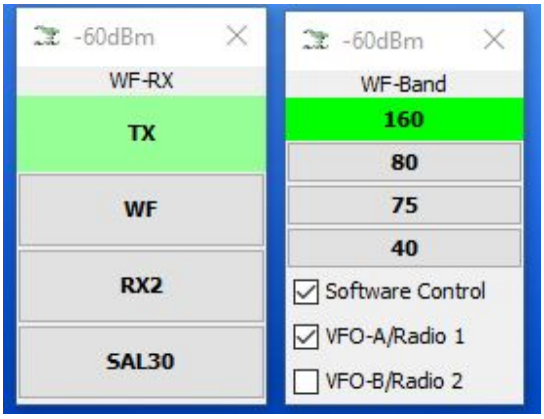
The band selection can be manual, fixed or automatic using external band decoder or the smart Automatic Antenna Switch Controller from Hamplus, MBD-8 F or MBD1-12F,

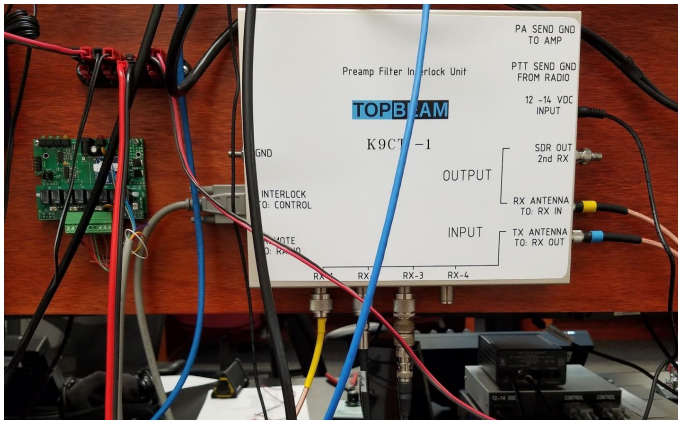
http://www.hamplus.com/mbd12f.htm http://www.hamplus.com/mbd8f.htm



The PFIU also can be connect directly to you PC remote control system, like the Green Heron Engineering remote system for example;

http://www.greenheronengineering.com/proddetail.php?prod=GHE_Remote





WF300 Receiving Systems Components

Waller Flag WF 300

The WF300 is a receiving antenna designed to filter vertical polarized signals and to improve signal to noise ratio receiving only sky wave horizontal propagated signals. There are two identical loops connect 180 degree out of phase. Two Identical loops provide the same output voltage; and when the outputs are connected with inverted polarity the result voltage should be ZERO.

The WF cancels all ground wave signals that are mainly man made noise. Ground wave signals are heavily attenuated making the ground wave signal output below the minimum detect signal or MDS of the receiver. For skywaves, the signal reaches one loop before the other and the signal output is not zero, this voltage is amplified by a high gain low noise preamplifier in the PFIU box.

Preamplifier Filter Interlock Unit

The PFIU is the heart of the TOP-BEAM System and it can be configured for different applications based on your location noise level. The concept is to adjust the sensitivity point to keep ground wave.

The preamplifier

An High Q input tuned filter with 0.2 db insertion loss at the input circuit can be selected up to four different bands. The preamplifier has a high impedance after the filter due the high Q of large inductor at the MOSFET gates. The gates are protected by 12 diodes back to back. The gain is very high and covers 100 KHz on 160m, 200 kHz on 80m and 400 Khz on 40 m.

The Filters

Four different filters with low loss and very sharp deep attenuation to reject adjacent bands strong signals and protect the preamplifier and or the radio RX input. For contesting location the filter is connected ahead of the preamplifier to reject signal from other bands, in this case, up to 3 PFIU's can be connected in parallel to one WF to feed up 3 radios in 3 different bands, 160 80 and 40 m at same time. For DX the best performance is connecting the filters behind the preamplifier. This configuration reduces reciprocal noise and intermodulation in the receiver, besides providing protection for the receiver front end.

Interlock board

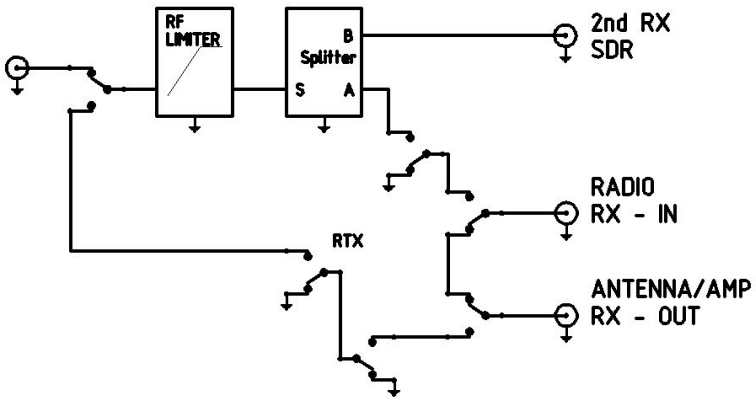
The interlock board has several functions

1. *Selects the preamplifier input tuning band frequency*
2. *Selects the filter for the same preamplifier band*
3. *Interlock band selection to protect from wrong selections or more than one band at same time. In this case no filter is selected and the preamplifier part on 40 m until the wrong selection is removed.*
4. *Interlock RX antenna select to avoid two antennas selected at the same time. If two antennas are selected at same time no selection is made and the last ground removed selects the RX antenna.*
5. *5 bands GPIO, ground pin input output. Each 5 input can be selected by a momentary contact to ground and stay at ground.*
6. *5 RX antenna GPIO ground pin input output. Each 5 input can be selected by a momentary contact to ground and stay at ground. You can listen to the TX antenna signal coming from RX out from the radio. Or select the WF system at RX1 and additional 3 other RX systems (RX2 RX3 RX4) that requires their own preamplifier.*
7. *All 10 GPIO are opto isolated and can have a separate digital ground from the analog ground to connect direct to a computer port.*
8. *Sequencer activated from the radio PTT to ground to protect the preamplifier and radio front end.*
9. *Control for an external relay for detuning relay to avoid interaction during RX.*
10. *TX to ground sequenced relay with isolated pin for the power amplifier relay ground to transmit.*
11. *Protected polarization for 12-14 Vdc input.*
12. *Electronic temperature resettable fuse to protect from overvoltage.*

13. *RX 12 Vdc switched voltage for external preamplifiers.*
14. *DB9 connector for direct cable for Radio PTT, 12Vdc, PA control .12Vdc during TX and detuning relay switch with isolated contacts.*
15. *HD15 connector for direct cable to TOP-BEAM control box or HamPlus MBD-8 or MBD-12.*

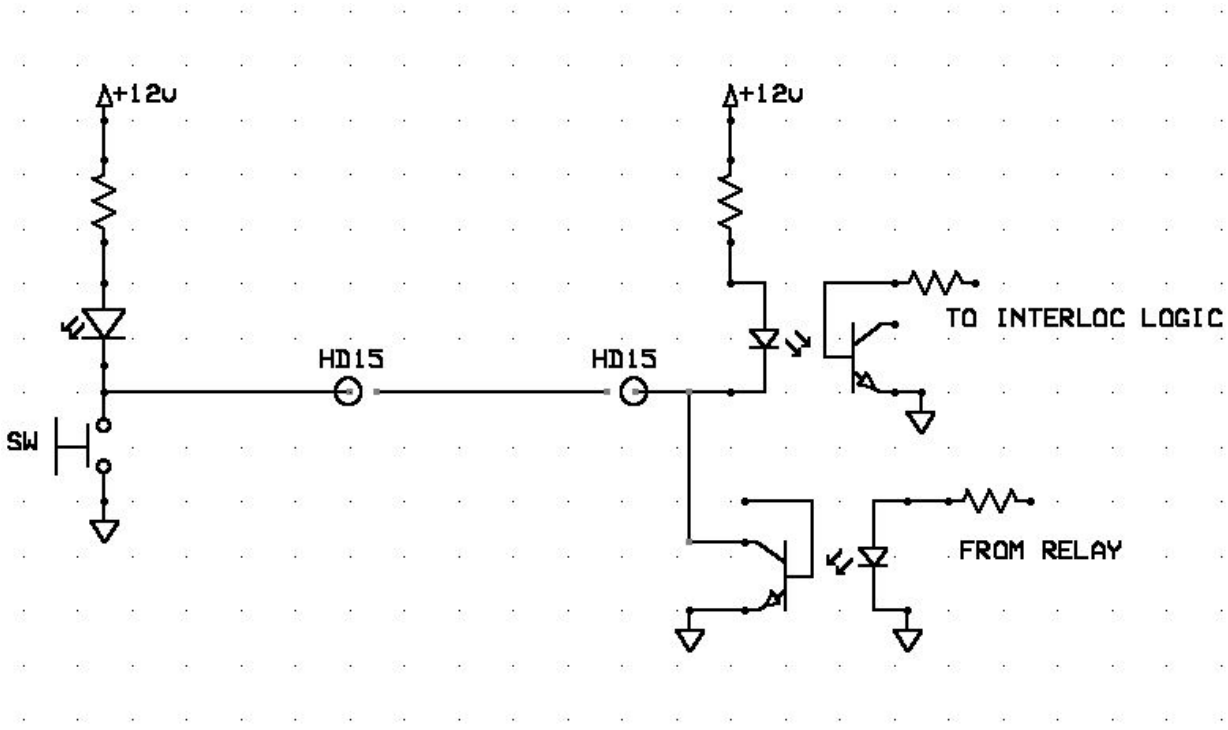
TX/RF High Isolation Switch

The TX/RX board has high isolation relay -100 db. Two mini UHF connectors can handle up to 200 W and it is very fast (2 ms).
The PFUI can be used between the radio and the power amplifier when your radio does not have a dedicated RX port, or the RX port in your radio has poor isolation from the antenna port in your radio.
The output is protected by a Mini-Circuits limiter, and offer excellent protection against a wide range of spikes and power surges where unwanted signals prevail – even in the harshest environments. The limiter reacts nearly instantaneously, as fast as 2 ns for response and 8 ns for recovery, to reduce +5 to +36 dBm inputs to as little as -0.5 dBm output power, with small signal insertion loss as low as 0.23 dB.



Control Box Unit (manual)

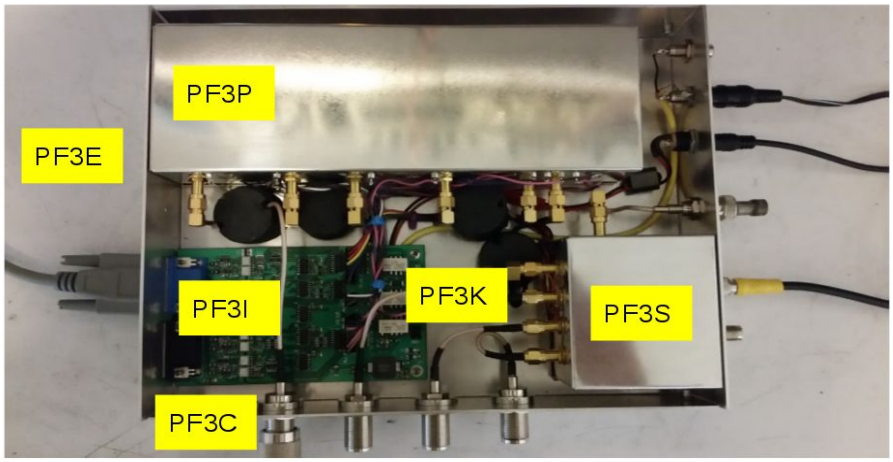
The control box has 10 LED illuminated push buttons to manually select bands and RX antenna switches, also a rotary on/off switch can disconnect the 12 Vdc front the radio to the PFUI unit. There are two mirror HD 15 connectors allowing the 10 GPIO pins to be controlled by a remote device or computer, in this case the LED will indicate band/ RX antenna selected. When PTT goes to the ground the selected push button LED turns OFF to indicate that the PFIU is in transmit mode.



PFIU Components Part Numbers

PFUI Preamplifier Filter Interlock Unit

Part # = PF3



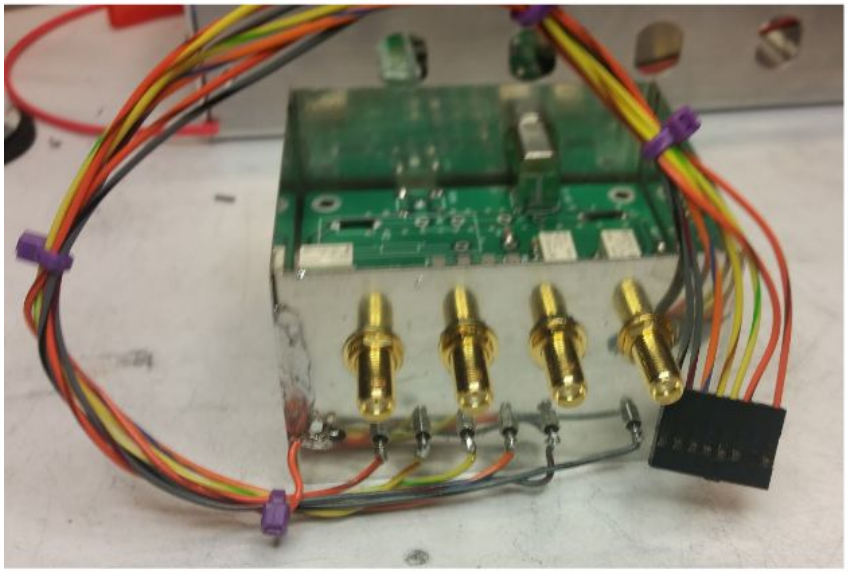
PF3P - Preamplifier unit
PF3S - TR/RX Switch
PF3E - Aluminium enclosure
PF3C - Connectors assemble
PF3K - Chokes assemble

PF3P Preamp filter unit

Filter 2 Filter 1 Preamp

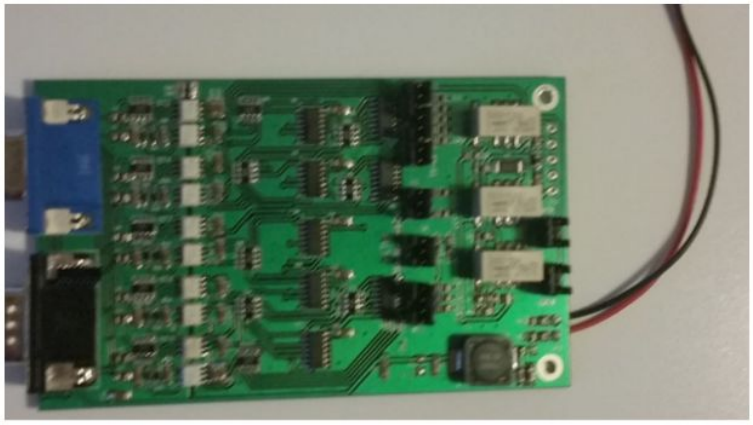
TBPT-0001 Preamplifier tuned 160/80/75/40
TBBP-0001 Passband Filter 160/80
TBBP-0002 Passband Filter 40/LP

PF3S Switch unit



TPRT-0001 Selector board

PF3I Interlock unit PCB



TPCB-0001 Interlock unit

PFIU Connectors

VGA CABLE CAN DAMAGE THE PFIU

HD15 (not a VGA, use only data cable pin to pin)

1. *160m*
2. *80m*
3. *75m*
4. *40m*
5. *30/LP/HP*
6. *12 Vdc from interlock board*
7. *12 Vdc from interlock board*
8. *Acc , PTT*
9. *Dig ground*
10. *Dig ground*
11. *RTX*
12. *RX1*
13. *RX2*
14. *RX3*
15. *RX4*

Recommend HD 15 cable Amphenol Cable CS-DSDHD15MM0-XXX

PIN 1	*160m*	*wire color black*
PIN 2	*80m*	*wire color brown*
PIN 3	*75m*	*wire color red*
PIN 4	*40m*	*wire color orange*
PIN 5	*HP*	*wire color yellow*
PIN 6	*12Vdc*	*wire color green*
PIN 7	*12Vdc*	*wire color blue*
PIN 8	*Acc PTT*	*wire color violet*
PIN 9	*Dig ground*	*wire color gray*
PIN 10	*Dig ground*	*wire color white*
PIN 11	*RTX*	*wire color pink*
PIN 12	*RX1*	*wire color light green*
PIN 13	*RX2*	*wire color black/white*
PIN 14	*RX3*	*wire color brown/white*
PIN 15	*RX4*	*wire color red/white*

PFIU Connectors (optional PAD) same on the MBD-8F or MBD12F

Mini Din 8 pin connector for computer pad

PIN 1 RTX
PIN 2 RX1
PIN 3 RX2
PIN 4 RX3
PIN 5 RX4
PIN 6 12Vdc
PIN 7 GND
PIN 8 GND

DB9 PFIU pins

This connector is a option for the RCA connector and the DB9 pins are connected to RCA and 12 V input, The Detune relay contact can carry 2 amps and the contact are isolated from ground , it can be used with vacuum relay with external voltage supply, example 26Vdc relay.

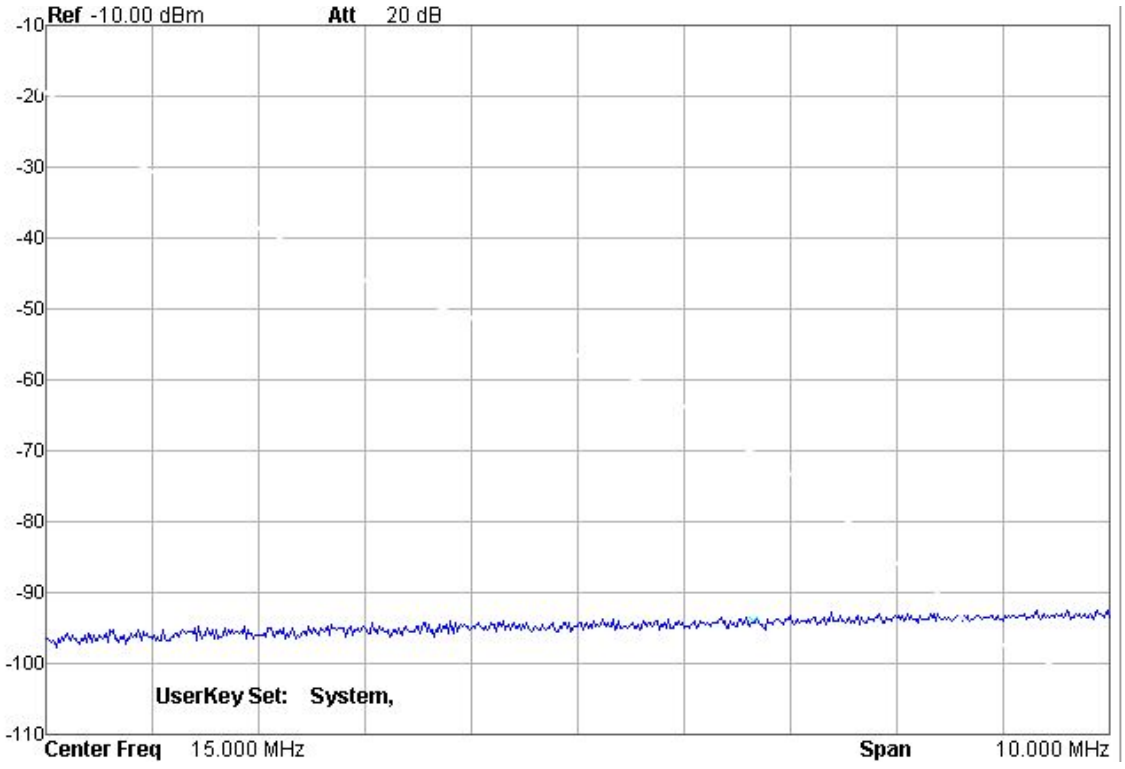
PIN 1 TX 12V
PIN 2 PTT IN
PIN 3 DETUNE RELAY
PIN 4 DETUNE RELAY
PIN 5 PA PTT
PIN 6 GND
PIN 7 GND
PIN 8 12 - 16 VDC
PIN 9 12 - 16 VDC

PFIU attenuation between bands

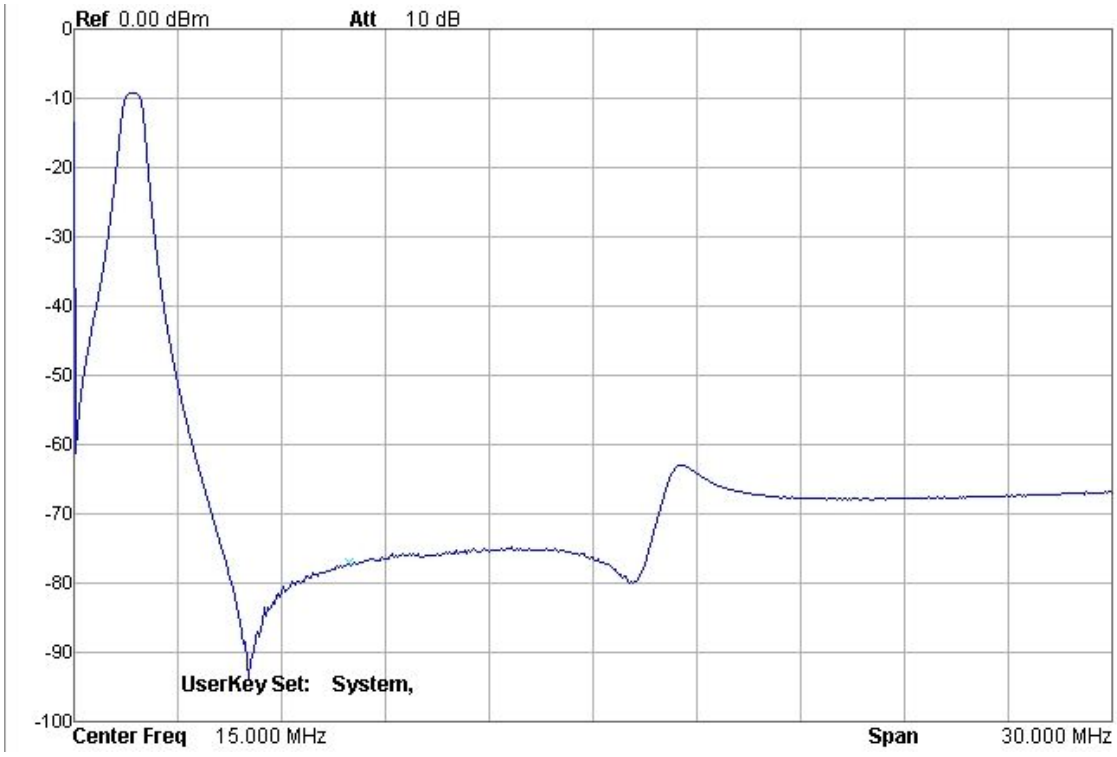
Attenuation Chart

All numbers dB	160	80	40	30	20	15	10
Filter insertion loss at pass band	-0.48	-0.76	-1.03	-0.3	-0.3	-0.3	-0.3
Filter 160m attenuation	0	-53.7	-60.6	-67.1	-66.3	-58.7	-58.2
Filter 80m attenuation	-37.2	0	-65.7	-67.6	-65.5	-60.7	-58.3
Filter 40m attenuation	-55.1	-43.8	0	-50.0	-68.16	-61.4	-59
High pass filter attenuation	-32.54	-0.04	-0.04	-0.21	-0.25	-0.35	-0.46
Preamp 160m gain	40	6.6	-1.4		-8.4	-12	-14
Preamp 80m gain	12.0	40	11.6		3.5	-0.1	-2.2
Preamp 40m gain	10.9	18	40		18.5	13.3	10.5

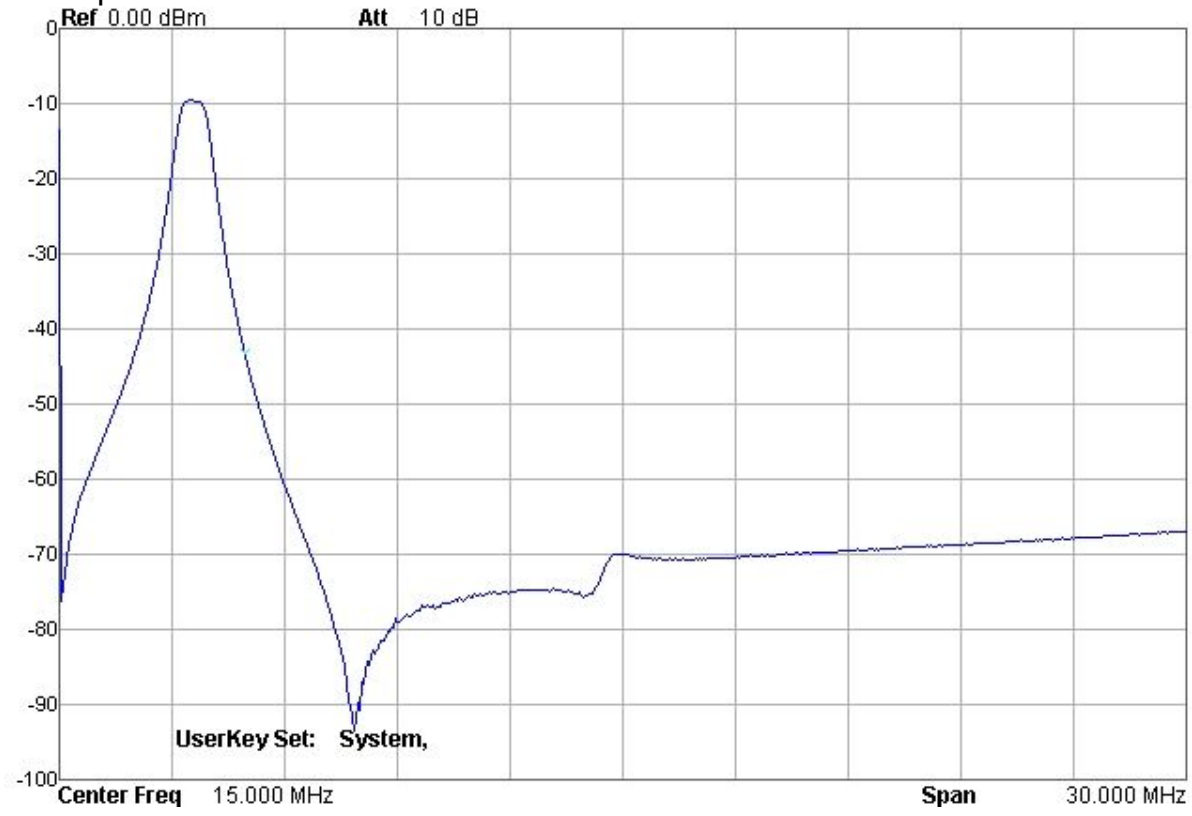
Typical Port Isolation



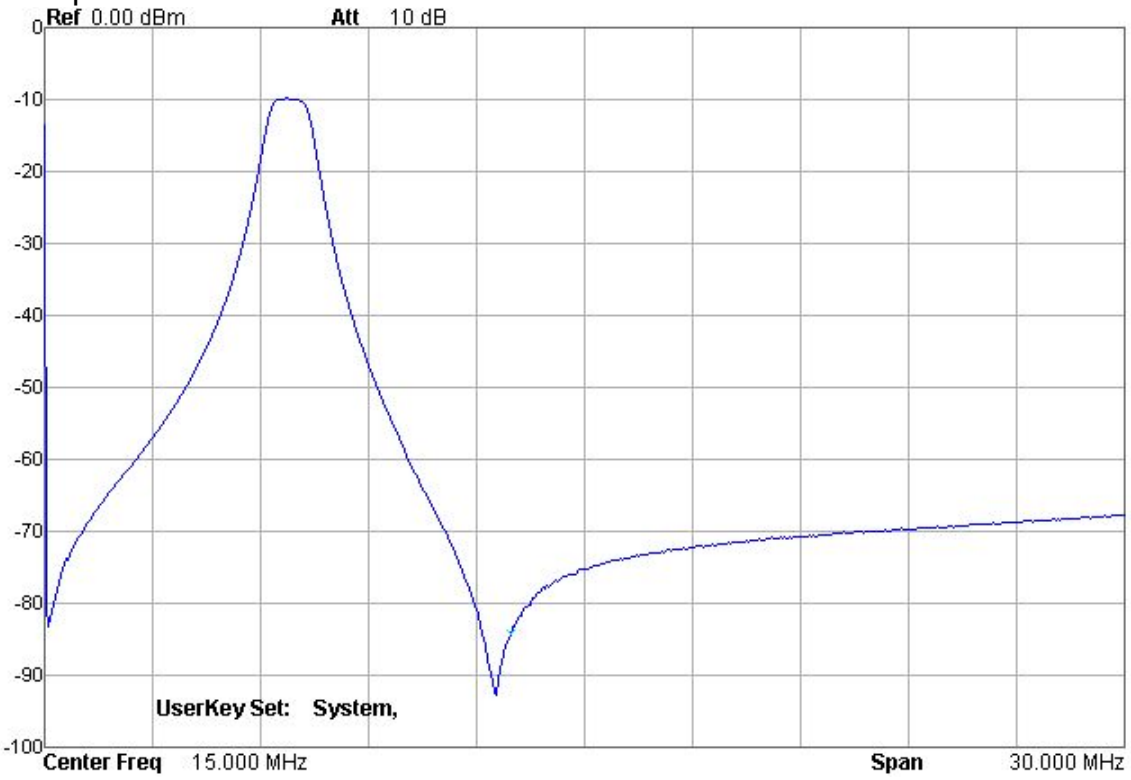
Band pass filter 160m



Band pass filter 80m

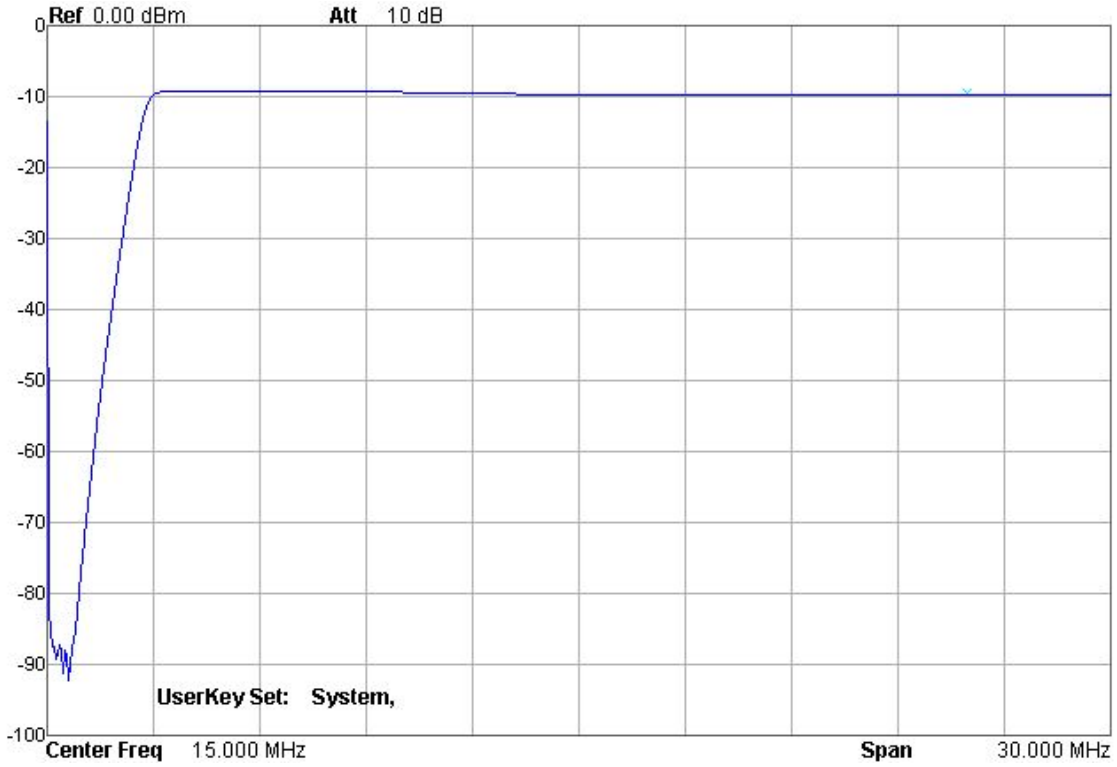


Band pass filter 40m

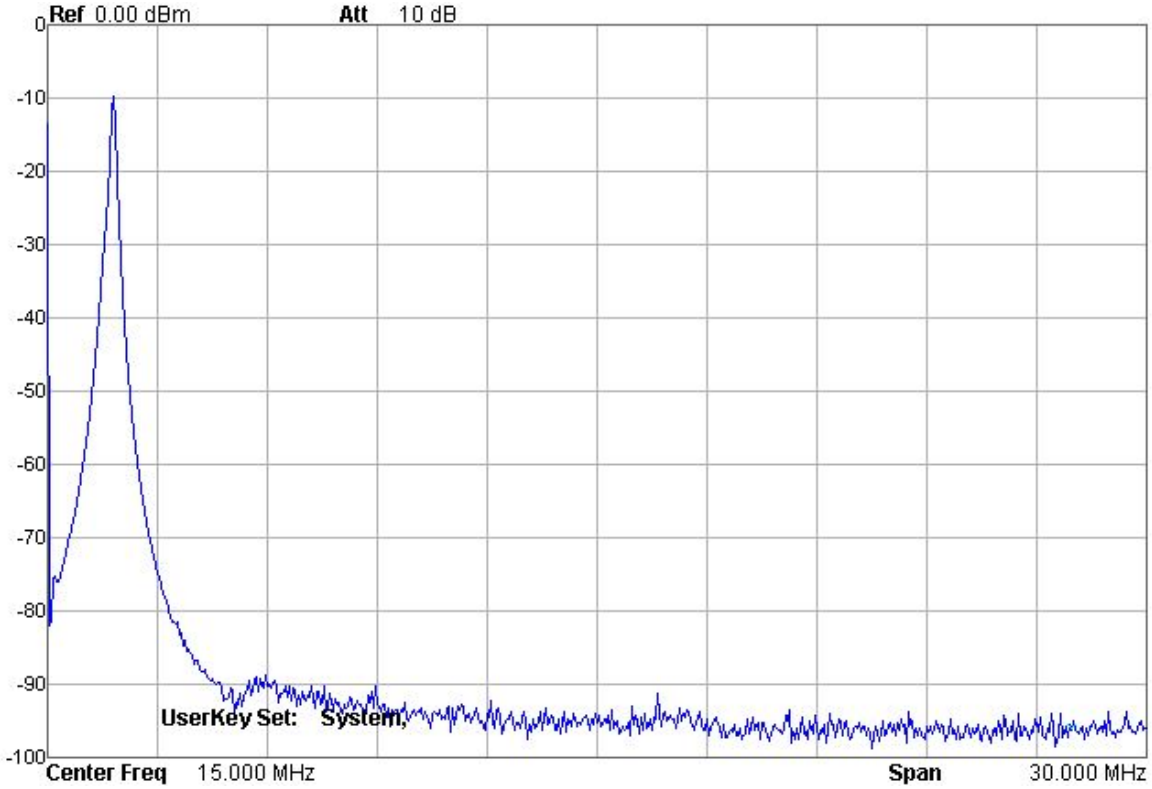


LOW PASS (Fc 10 MHz) filter position bypass the internal preamplifier. There is no need for amplification above 10 MHz, This position can be used on any frequency without the PFIU preamplifier gain, use the radio preamplifier if necessary,

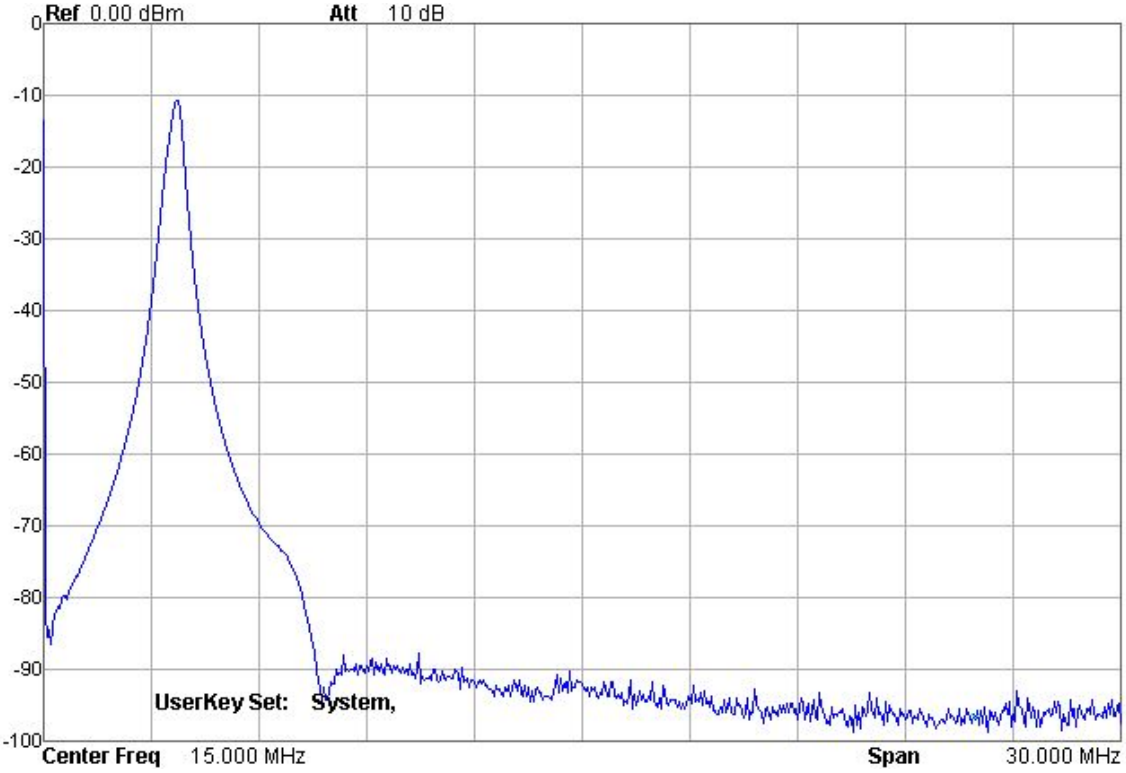
High pass filter 3 Mhz up. Some units does have a low pass filter below 10 MHz (optional HP for 1.8MHz. -25db at 1.7MH, 50 db attenuation 1.6M below.)



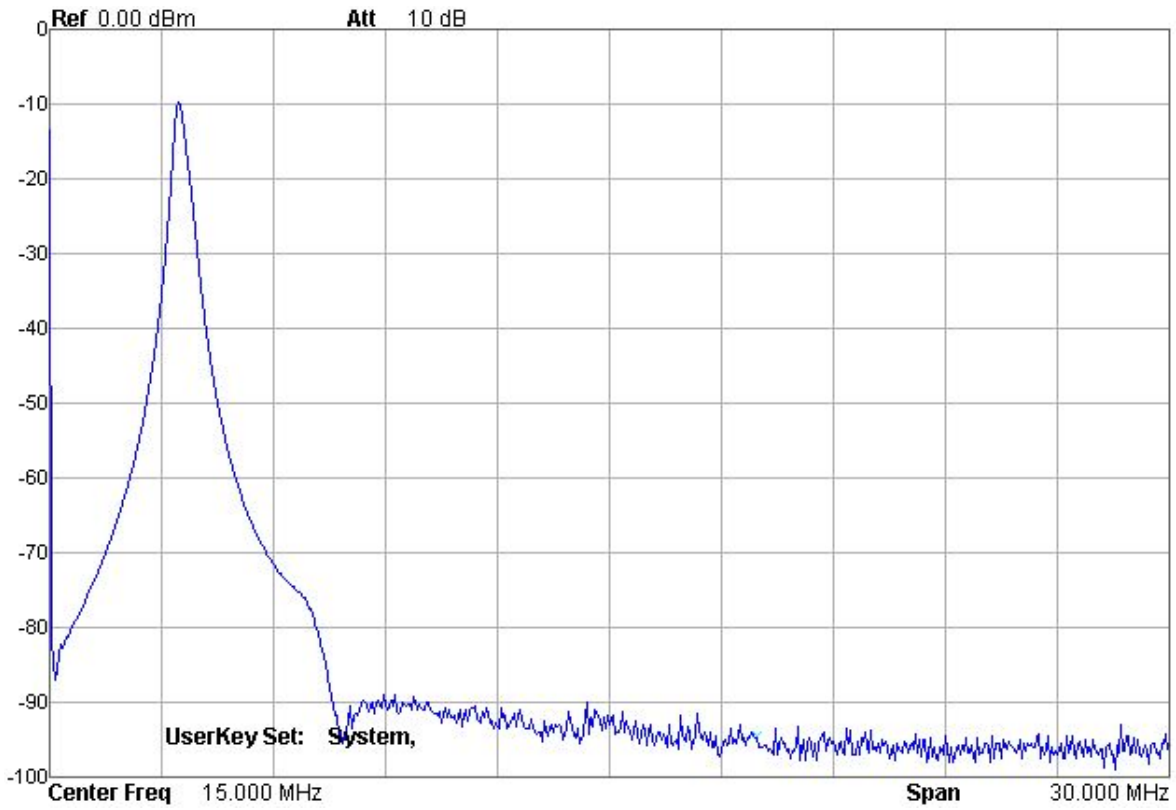
PFIU 160m preamplifier filter combo



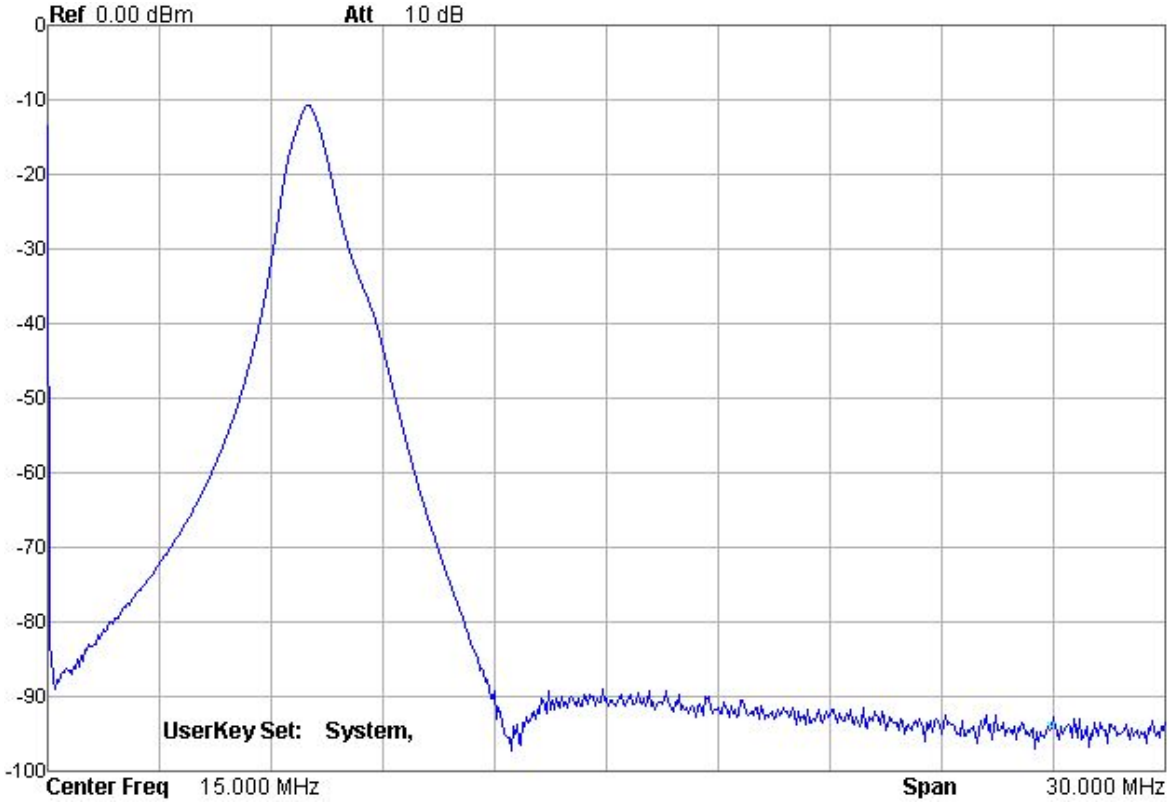
PFIU 75m preamplifier 80m filter combo



PFIU 80m preamp 80m filter combo

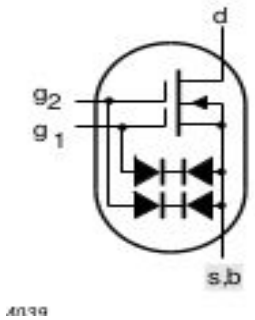


PFIU 40m preamp 40m filter combo



PFIU compression gain P1 and IP3

The TOP-BEAM preamplifiers have 6 devices BF966s in parallel to achieve very low Noise Figure , typical **NF = 0.5 db.** Paralleling devices not only increase the IP3 but also increase the input protection, Each BF996s have 2 back to back diodes on each gate, The max current is 10 ma per gate and the voltage knee is around 2 V, this mean the 6 devices can support 120mW or **+ 20.8 dBm** input signal.



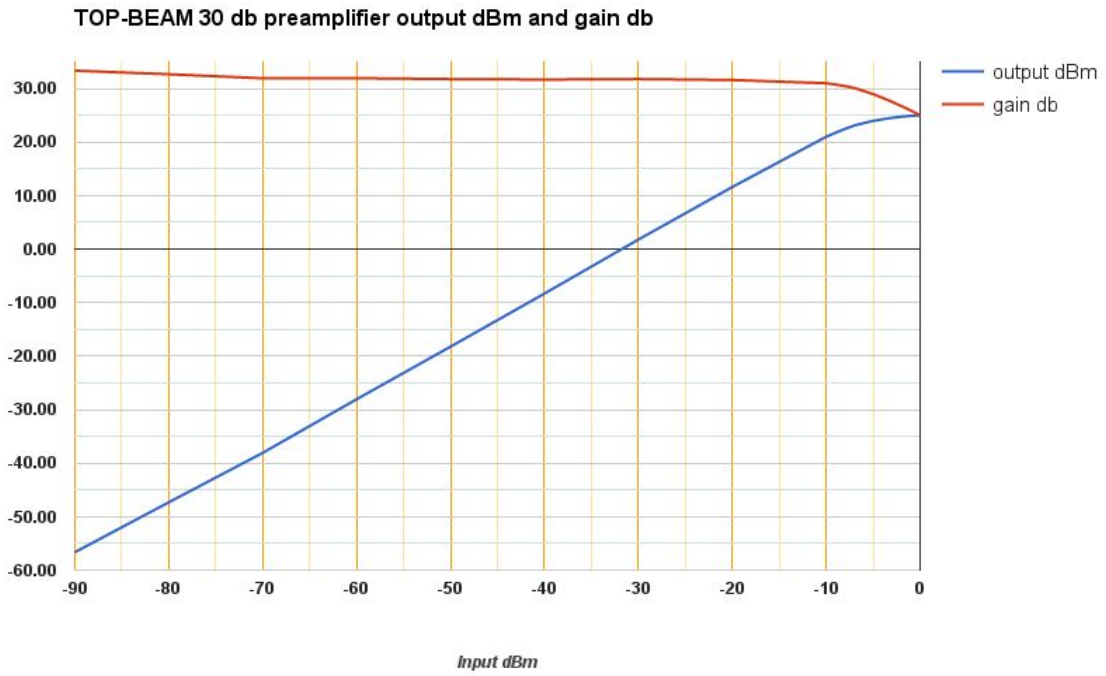
TOP-BEAM preamplifiers are configured for different tuned input frequency and also for different gain. For the WF 300 the gains on 160m is +40 db and for 80/75m it is +30 dbm.

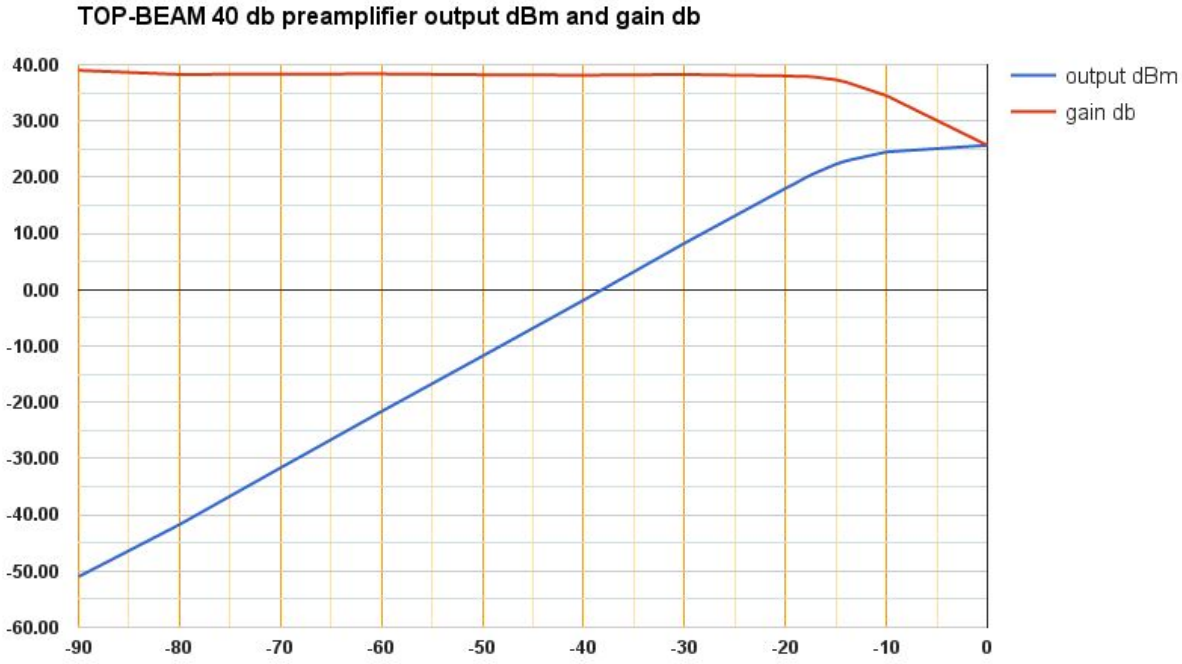
The P1 compression point is very high.

30 db gain >> P1 out = +21.75 dBm P1 in = -9 dBm

40 db gain >> P1 out = **+22 dBm** P1 in = -15 dBm

IP3 in average is 15 db above P1, for both preamplifiers **IP3 out OIP3 = +37 db**





The PFIU preamplifier for 40 and higher bands can be configured with a Norton type preamplifier

Typically the **P1** output is **+30 dBm** and **IP3 + 45 dBm** with +11 db gains and **NF= 1.5 db**

Typical WF300 isolation in-band

The WF300 can perform very well on sites with multiple transmitter antennas, The isolation between bands is very high For contest stations when the filters are configured ahead the preamplifier, the isolation is better than **-70 db** and for PFIU DX configuration with the filter behind the preamplifier the isolation is better than **-90 db.** However when there are more than one station transmitting at same time on the same band, (N-BAND) the isolation between the RX antenna and the TX antenna needs a special attention.

Let' s consider a case when the TX antenna is a 4 square and the WF300 is 100 Ft apart.

Typical isolation

1- Worst case when the WF300 is facing the 4 square.

160 m 4 square TX direction	isolation 160m
SW	-83 dBm
NW	-86 dBm
NE	-87 dBm
SE	-85 dBm

2- WF300 is 45 degree off the 4 square.

160 m 4 square TX direction	isolation 160m
SW	-83 dBm
NW	-86 dBm
NE	-88 dBm
SE	-82 dBm

3- Worst case when the WF300 is facing the 4 square.

80 m 4 square TX direction	isolation 80 m
SW	-62 dBm
NW	-76 dBm
NE	-79 dBm

SE	-70 dBm

4- WF300 is 45 degree off the 4 square.

160 m 4 square TX direction	isolation 80 m
SW	-69 dBm
NW	-83 dBm
NE	-86 dBm
SE	-69 dBm

5- 40 3 elements yagi facing the WF300 does not have the polarization isolation like the vertical 4 square transmitting into the WF300 horizontal loops.

40m yagi	facing	the WF300	**-34 db**
40m yagi	side	the WF300	**-48 db**
40m yagi	back	the WF300	**-51 db**

Typical WF300 safe signal level in-band

Maximum input level Isolation for damage (NOT SAFE) > 43 dBm

Considering a TX level of 2000 W peak or **+63 dBm** transmit signal. The WF 300 and take 900 joules, it means 1 KW peak during one second or 100W for 10 seconds or 10W for 100 seconds. The signal necessary to damage the **PFUI is + 20 dBm on 120 mW .** The minimum isolation between the TX antenna and the WF300 should be better than **43 db**, iIf the isolation is 43 or lower it is necessary to use a RF liliter like the DX Engineering Receiver Guard Electronic RF Limiters.

Max Output Level: RG-5000HD: +14 dBm at 10 W input. RG-5000: +10 dBm at 10 W input

Max Input Level RG-5000HD (50W) and DXE-RG-5000 (10W)

Maximum input level Isolation for linearity P+1 point

Considering a TX level of 2000 W peak or **+63 dBm** transmit signal. The PFIU preamplifier P+1 compression point represent the maximum input signal to operate in the preamplifier linear region

Gain:

40 db preamp P1 = -15 dBm minimum isolation = **-78 db.** **(160m)**

30 db preamp P1 = - 9 dBm minimum isolation = **-72 db** **(80 m)**

22 db preamp P1 = +8 dBm minimum isolation = **-55 db.** **(40 m)**

11 db preamp P1 = +29 dBm minimum isolation = **-34 db.** **(40m)**

Output level consideration.

The 40 and the 30 db preamplifiers have an output level for **P1 = + 22 dBm.**

The Norton preamplifier with 11 db gain has an output level for **P1 = + 30 dBm**

Two cascade Nortons are used for 22 db gain.

Maximum input level for operation in-band

Considering a TX level of 2000 W peak or **+63 dBm** transmit signal. The PFIU preamplifier output signal near the P+1 point is very high and can damage the Radio receiving port and additional protection is necessary. The RF limiter from DXE protect (10 to 14 dbm) from damage but not from overload the RX input,

The PFIU has an RF limiter after the preamplifier output option, The Mini-Circuit RLM-521-2WL+ limit the signal output from the PFUI to **0 dBm**

Several radios can operate at 0 dBm level, some SDR can handle signals near +10 dBm, However the preamplifier gain must be taken in consideration to calculate the isolation necessary for in-band transmit signal.

To select the receiver input signal necessary for an acceptable operation in band we can use the Noise Power Ratio (NPR) Testing of HF Receivers - Using notched noise to evaluate dynamic receiver performance by Adam Farson, VA7OJ/AB4OJ.

http://www.ab4oj.com/test/docs/npr_test.pdf

Basically NPR measure the power necessary to raise the noise floor by 3db . Lets use the NPR power level as reference. All PRE OFF and ATT OFF (0 db)

Flexradio 6700 -5dBm 160m and 0 dBm for 80m and up

K3 -15 dBm

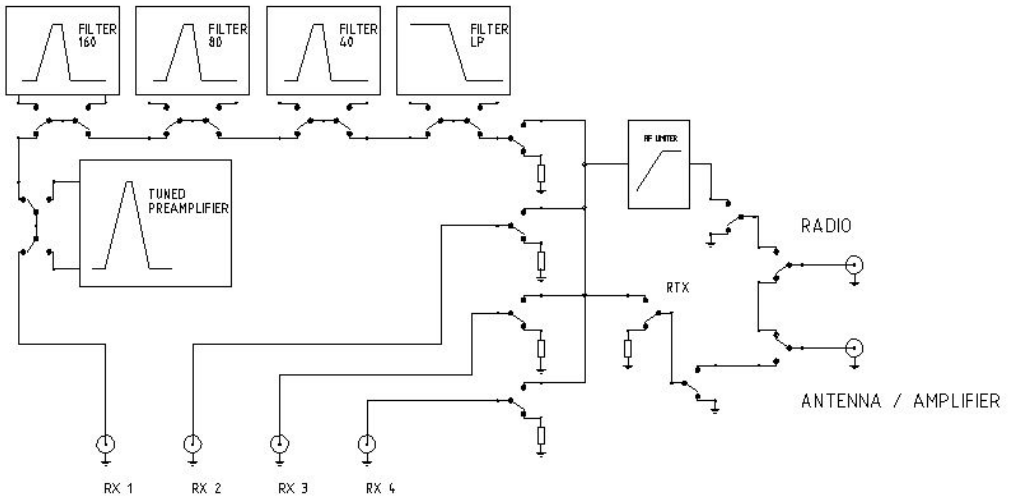
ICOM 7851 -5 dBm

Pre Gain	Out dBm	In dBm	Isolation		Out dBm	In dBm	Isolation
0	-5	-5	**-68**		0	0	**-63**
11	-5	-16	**-69**		0	-11	**-74**
22	-5	-27	**-90**		0	-22	**-85**
30	-5	-35	**-98**		0	-30	**-93**
40	-5	-45	**-108**		0	-40	**-103**

Adding 10 db attenuation at the RX input decrease the isolation necessary by 10 dBm.

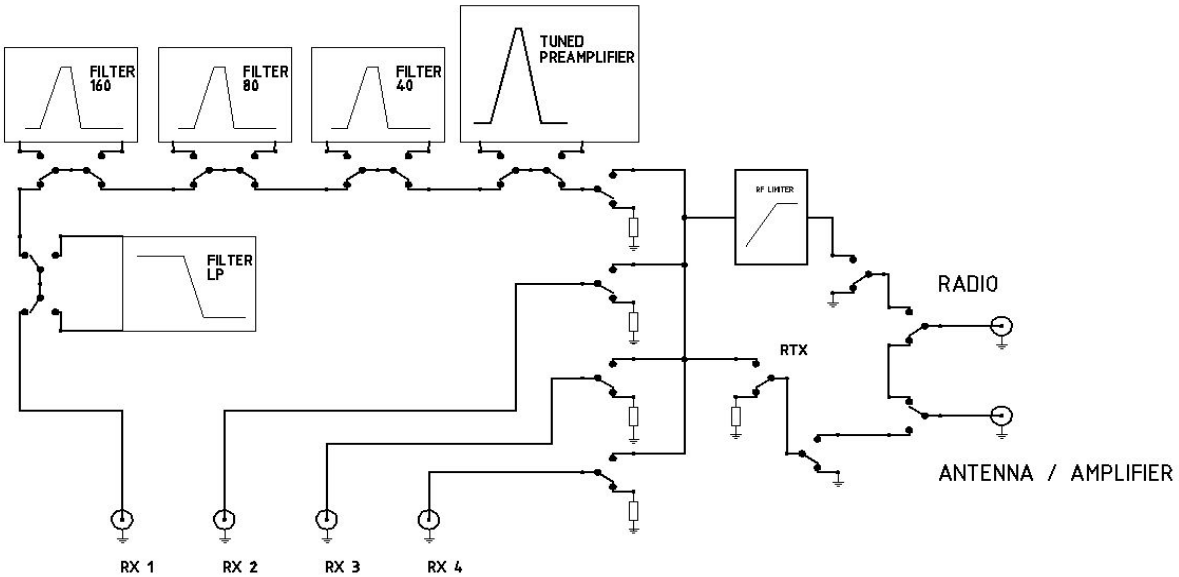
PFIU DX optional configurations

For DXers the tuned preamplifier is followed by the band pass filters and the gain is adjusted per band on each filter.

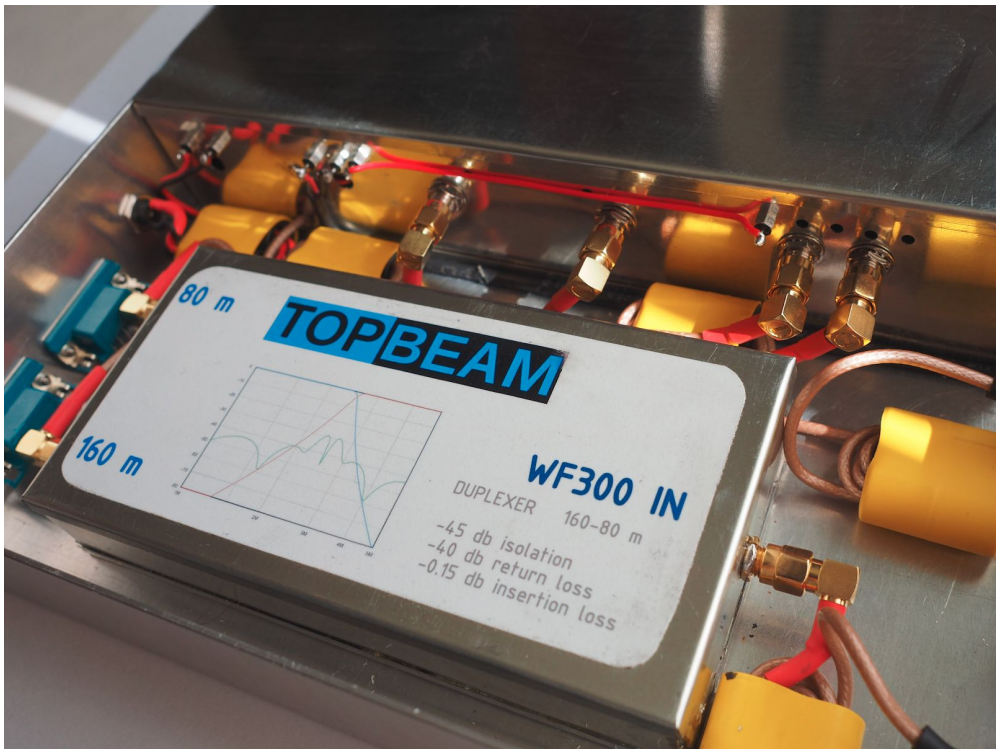


PFIU contest configuration

For contesters, the band pass filters is connected ahead of the tuned preamplifier and the gain is maximum per band, a input attenuation in the radio should be used to adjust band conditions.



PFIU contest configuration options

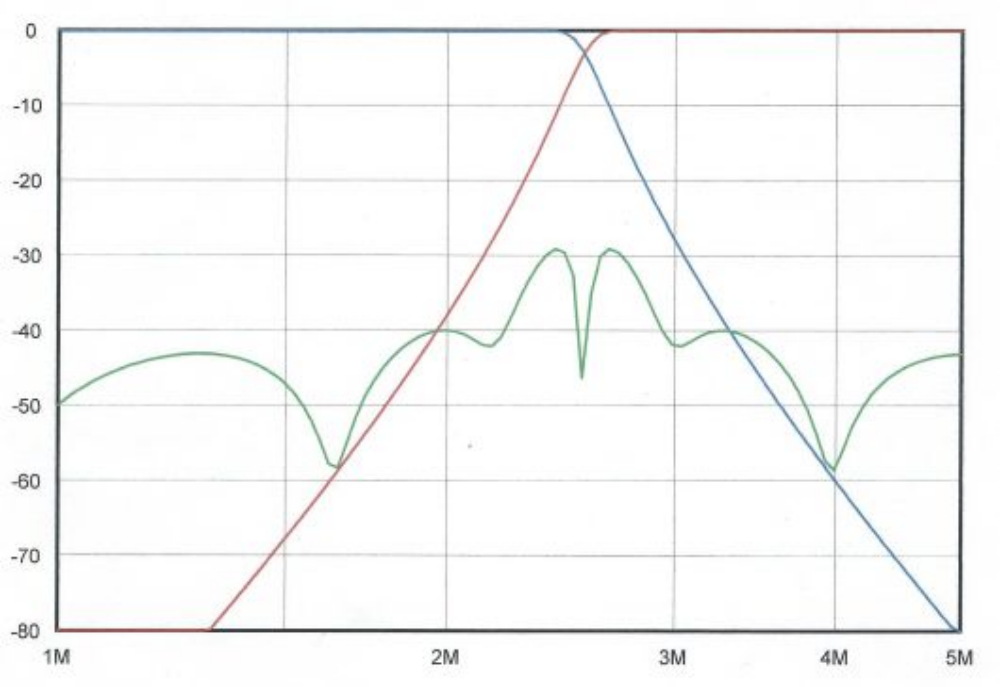


Introduction

Top-beam PFIU can be configured to optimize performance based on the contest station configuration, like Multi / Multi station that needs to receive on different bands at the same time using one radio per band. The WF300 antenna is broadband and can be used on several bands at the same time. When the station use one radio for different bands, like in the SO2R contest station , or a DX station using two receivers at same time on different bands, the WF 300 can be connected to the preamplifier unit using “T”, paralleling up to 3 units , however on 3 different bands. The input filters can be connected in parallel because the impedance out of band is high and the inband filter impedance is 50 ohms. The PFIU also can have a optional Splitter to feed a second receiver sharing the same signal from the PFIU.

Station with a fixed radio per band can share the same WF300 in several bands using TRIPLEXER (160m, 80m,and 40m) or DUPLEXER,(160m and 80m). Duplexer has very low insertion loss and avoid the 3 db increase on Noise Figure when splitter is used, in addition the duplexer adds more isolation between bands.

The TB160-80m duplexer was designed for very low insertion loss **-0.15 db** and < 0.5 db ripple. The isolation is **45 db** worst case, and the return loss is **-40 db** or SWR **1 : 1.02.**

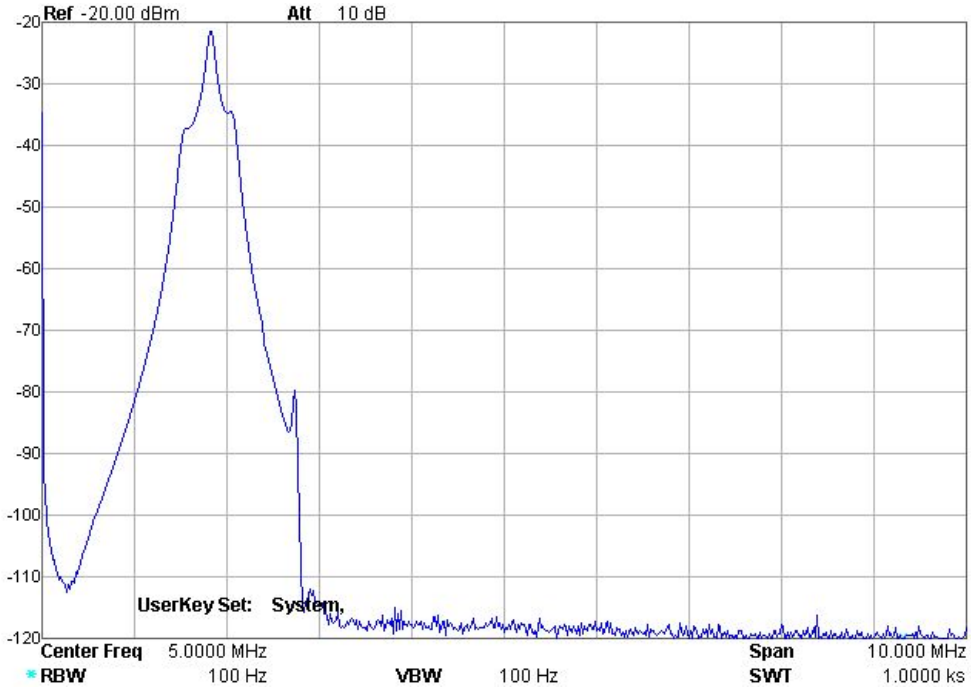


The TB160-80 duplexer has 90 db isolation between 80 and 160m output, and including the preamplifier gain the total unit gain is;

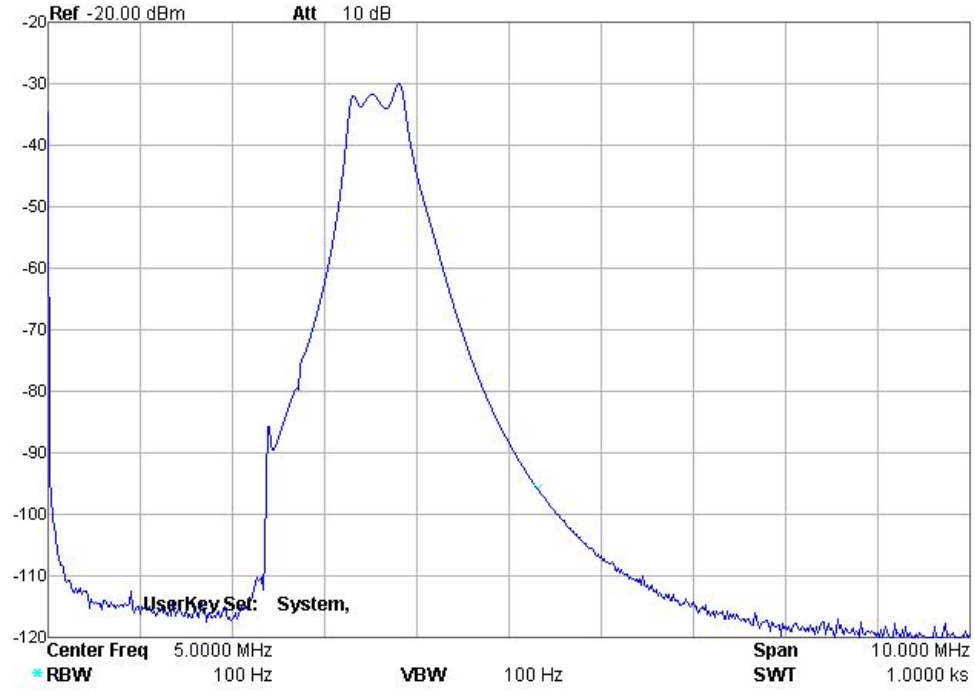
160 m Unit	160m	+ 38 db
	80m	< -75 db
	40m	< -75 db
80 m Unit	160m	< -75 db
	80m	+ 30 db
	40m	< -65 db
	20m	< -75 db

The unit gain outside the band is very low and cannot be displayed because exceed the 100 db dynamic of my spectrum analyser, The measurements above used a offset function to be able to measure the gains outside the band. The two images below shows the gain but limited on the lower side by the spectrum analyzer dynamic.

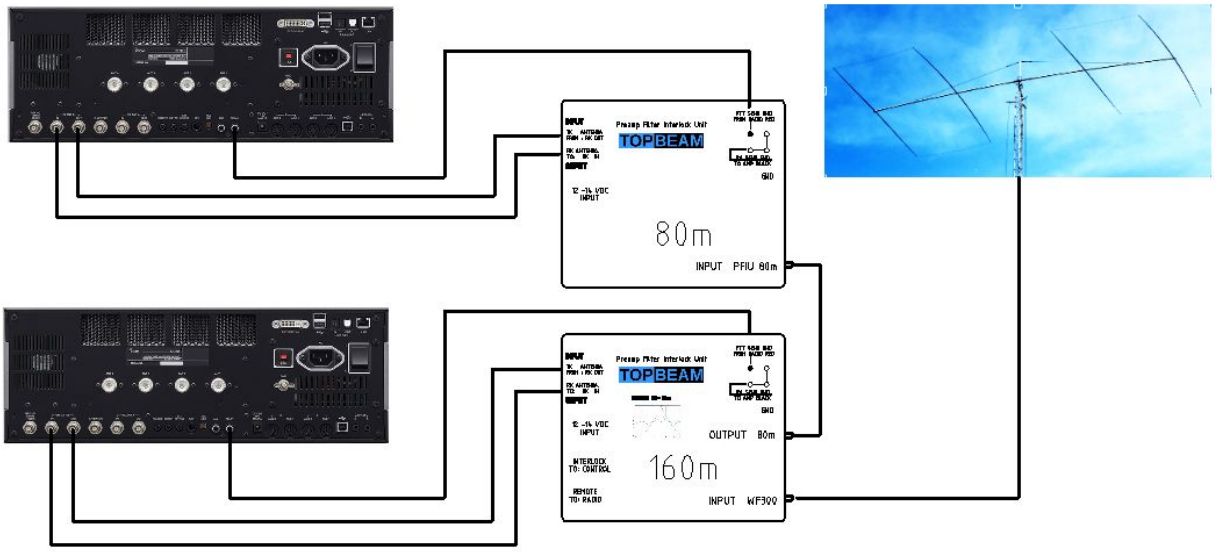
160 m unit (38db gain)



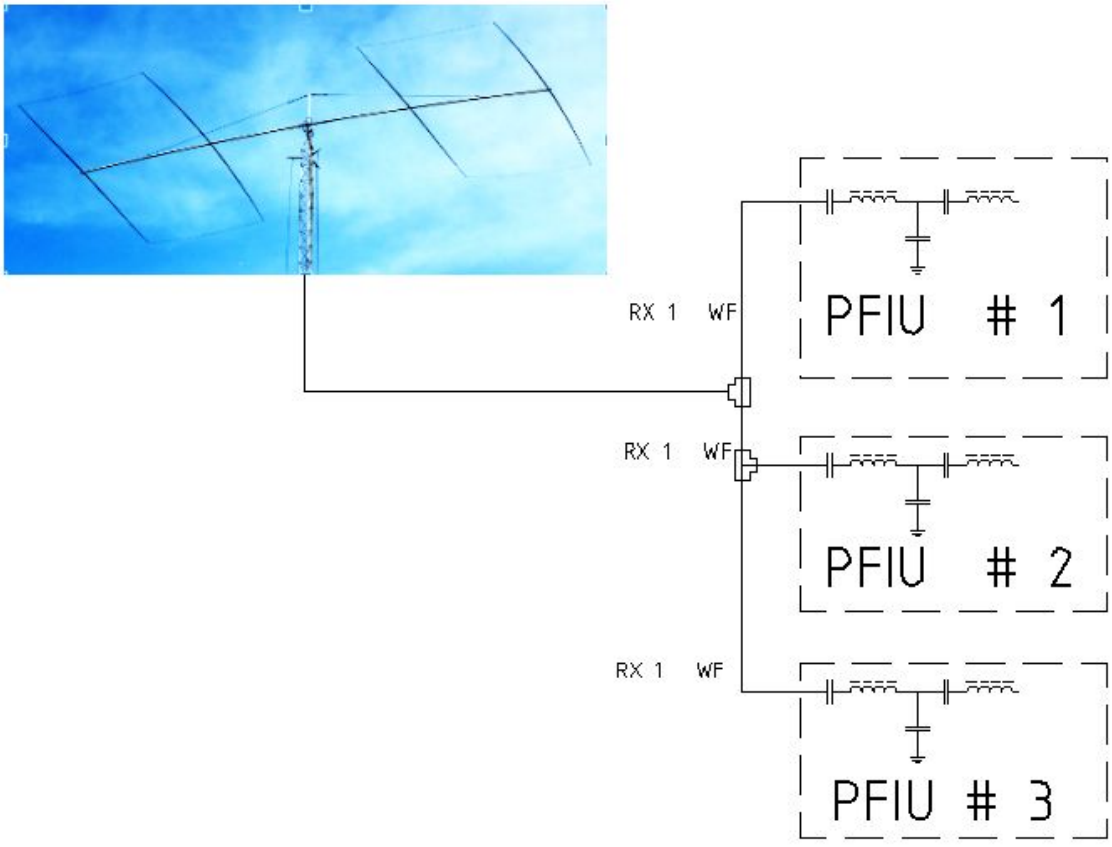
80 m unit (30 db gain)



PFIU Multi Multi with fixed station per band

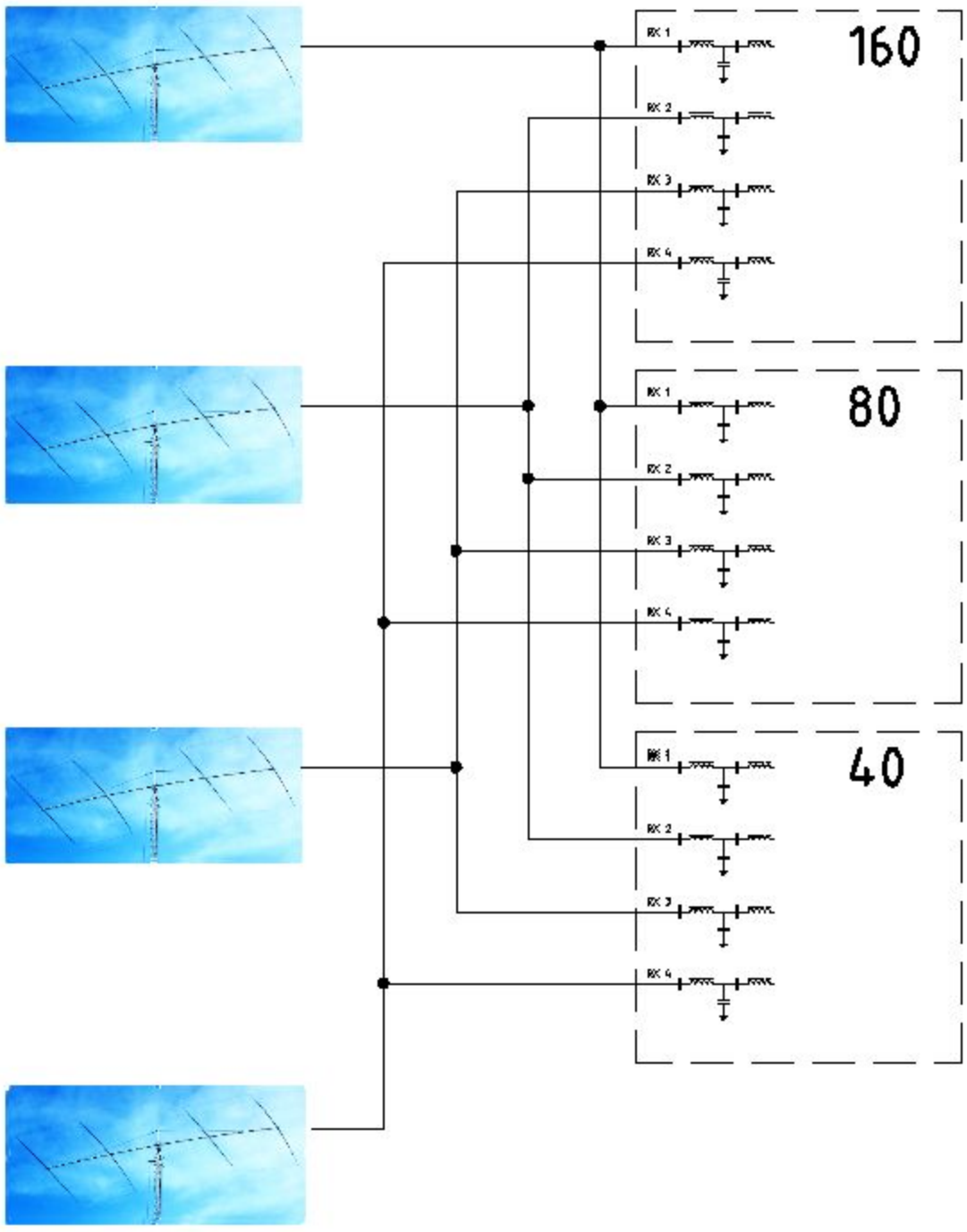


PFIU SO2R or Multi Multi with station multiband



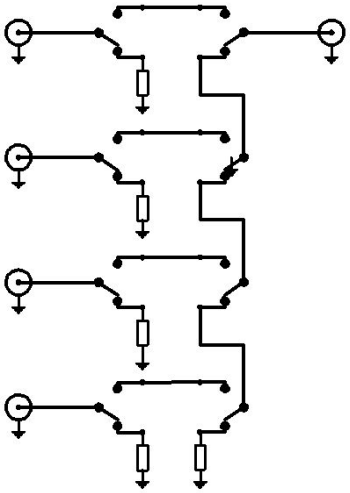
PFIU SO2R or Multi Multi with station multiband and 4 WF's

Each PFIU can select 160 or 80 or 40m but PTT control is necessary for "IN-BAND"



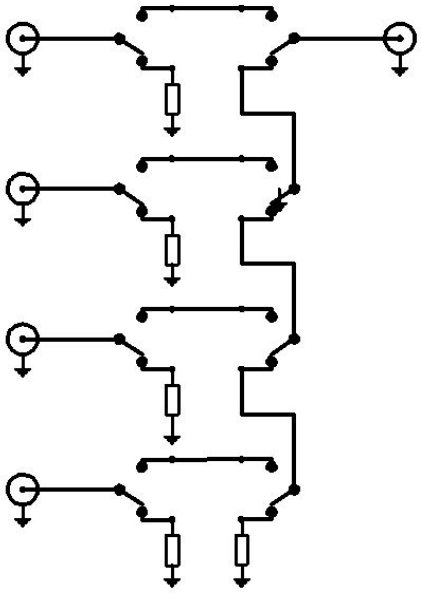
PFIU antenna switch for Waller Flag input

The PFIU can configured selected at the input up to 4 WF's

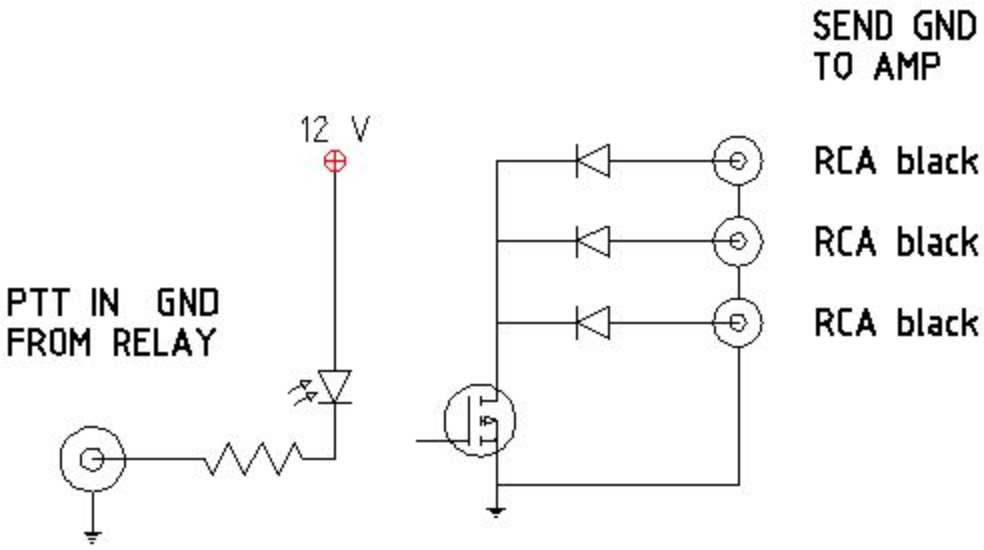


PFIU antenna switch output

The PFIU can configured selected other RX systems using their own preamp and filters.



PTT control



The PTT input coming from the SEND or RELAY on the IC-7851 and a optocoupler drives a 1 Amp. MOSFET switch. There are 3 RCA (black center) to sink to ground using a diode to isolate the 3 lines.