<u>Initiation Date:</u>

25 Apr 2018

<u>Participant(s):</u>

WB4GCS

<u>Initial Symptoms/Problem:</u>

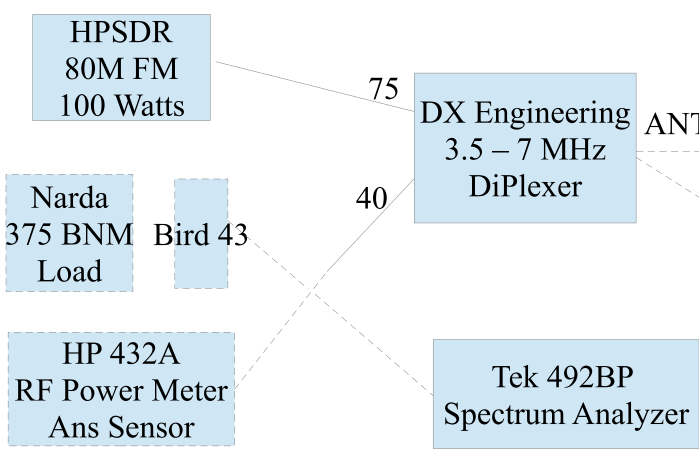
A question has arisen: Given that the diplexers perform OK, there is still the question – How much RF power will a 40M receiver see at the 40M port when an 80M transmitter is feeding 100 watts into a matched antenna or dummy load. This is important for two reasons:

1. Damage to receiver front end
2. Driving the receiver into non-linear performance (distortion and vulnerability to other nearby strong signals, degrading weak-signal performance)

<u>Actions:</u>

Run a test with a transmitter, one diplexer, dummy load, wattmeter, dummy load on "other" port and power meter on "other" port.

Test Setup:



The Bird 8833 Load is rated for 1KW.
The Narda 375 BNM Load is rated for 10 W – far more than we expect to see.
The HP 432A, which will replace the Bird and Narda load if apparently acceptable, will read down to -30 dbm (1 μW).

Procedure:

1. Connect equipment
2. Allow 30 minute warmup for all.
3. Calibrate HP432A.
4. Key transmitter, verify near 100 watts at diplexer common port output.
5. Unkey transmitter.
6. Move Bird 43 to 40m Port.
7. Key transmitter, measure power to Narda load, using lowest power slug available (50W). Based on earlier measurements, expect:

    100W = 50 dbm
    50dbm – 20 db = **30dbm = 1 W**
    This assumes a short at the antenna port and all power is reflected back into the diplexer. 1 W may or may not cause damage to a receiver; the best receivers designed for 40 M operation in Europe near the SW broadcast stations should handle this.

    Assuming 80 M antenna SWR of 1.43 (return loss of 15db)
    50 dbm – 15 db – 20 db = **15 dbm = 31.68mW**

The underlined, bold numbers above represent the amount of 80 M energy at the 40 M receiver. We also need to account for the 40 M energy (noise) from the 80 M transmitter reaching the 40 M receiver. Assuming that said noise is 30 db down (a really *dirty* transmitter) and that the connected 40 M antenna also has 15 db return loss, the 15 dbm becomes **-15 dbm, or .0316 mW or 31.6 µW.**

The above calculations take NO credit for any selectivity in the 40 M receiver. If the only selectivity is the transmit low-pass filter, then the above numbers state the case. If there is any bandpass filtering (expected, given the need to improve strong-signal handling characteristics), then the above numbers are improved by the attenuation of the 80 M energy by the 40 M receiver's input filter.

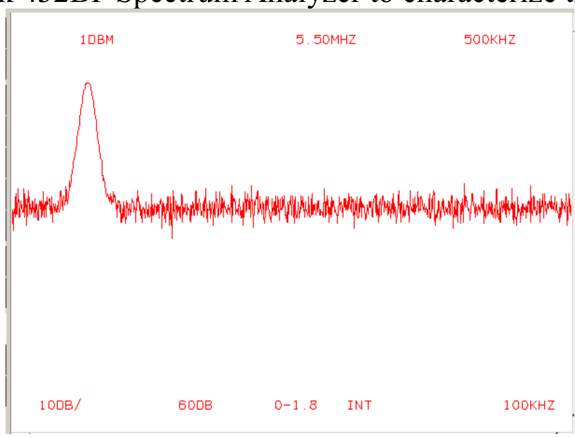
Assuming the 80 M energy doesn't damage the 40 M receiver or drive it into non-linear behavior, any respectable receiver should tolerate this situation. The anecdotal evidence clearly suggests this to be the case, or DX Engineering would not be selling so many of these units.

Observations:

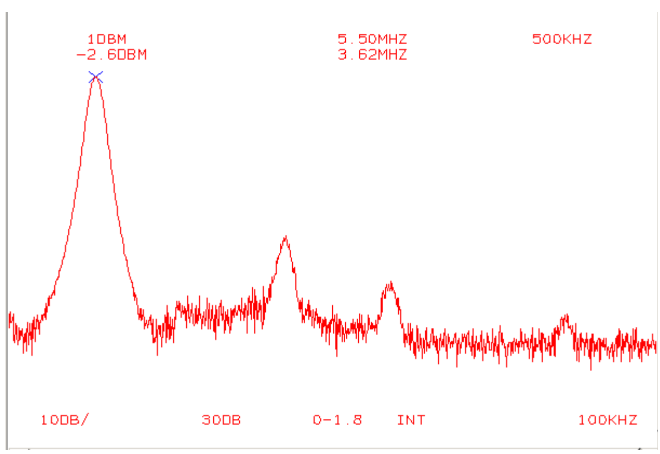
1. Ant port terminated with dummy load via Bird 43 Wattmeter and 40 M port terminated with load:
    TX Output 64 Watts
    Bird reading 58 Watts at Ant port
2. Ant port terminated with dummy load and 40 M port terminated with Bird 43 and load:
    TX Output 65 Watts
    Bird reading 0 Watts (no motion at all on meter)
3. Ant port terminated with dummy load and 40 M port terminated (via numerous attenuators) with HP 432A (zeroed and calibration checked immediately prior to measurement.)
    TX Output 65 Watts
    HP432A reading +2 to +3 dbm

The power at the HP 432A represents *all* power; 75 M, 40 M, and noise. Measurements were made on various scales and with various attenuation. All measurements were consistent. See appendix A for table of measurements and calculations.

Replace the HP432A with Tek 432BP Spectrum Analyzer to characterize the power.

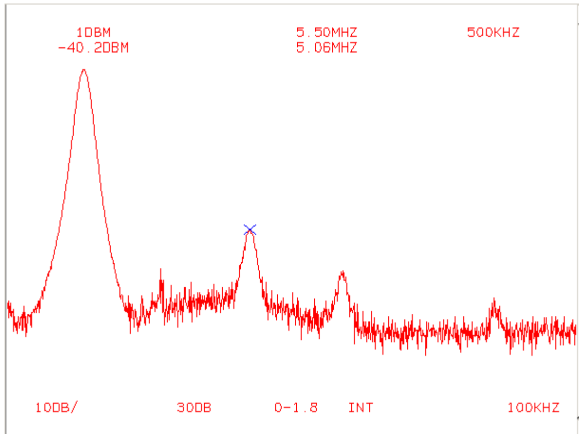


This shows that the majority of the energy is at 75 meters, and around 0 dbm. (10 dbm reference, 10 db per division, and -1 division.) HOWEVER, the spectrum analyzer has maximum attenuation cranked in for protection. Now that we know the power really is around 3dbm, which is less than the maximum 30 dbm input to the spectrum analyzer, we can remove some attenuation and see how much of the power is 40 M noise.

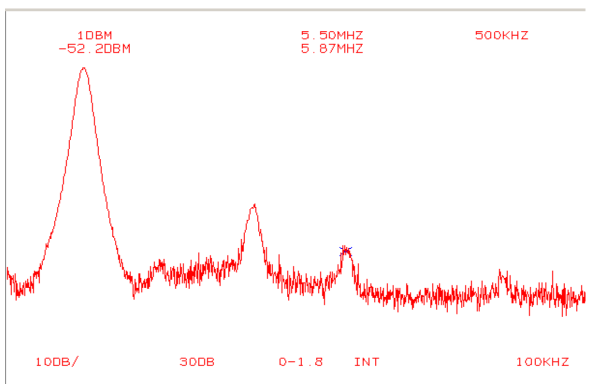


SO, the analyzer is seeing -2.6 dbm at the transmit frequency. Remember, there 6 db of high power attenuation ahead of the analyzer, so the real power is 3.4 dbm, consistent with what we measured on the HP432A power meter. This alone suggests that the bulk of the energy is at the 80 M transmit freqauency.

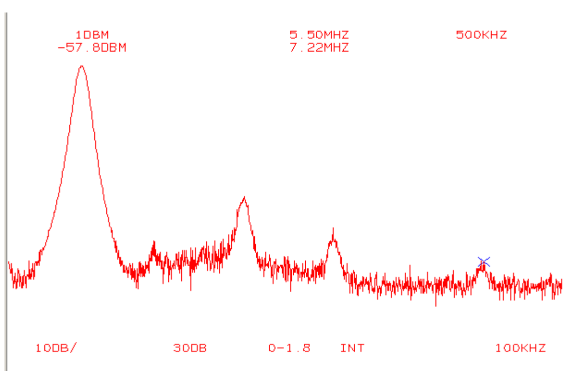
Let's look at the other responses.



This shows -34 dbm at just over 5 MHz. (Corrected for the high power attenuators in line.)



Here we see -48 dbm at 5.87 MHz. (Corrected)



AND, finally, -51 dbm at 7.22 MHz, *in the 40 meter band!*

Some notes:

1. The currently accepted definition of S-9 is -73 dbm, or 50 µVolts at the receiver antenna terminals.
2. We can expect the out of band signals to be attenuated somewhat by the 80 M transmitter

bandpass filter.
3. We can expect the 80 M signal to be attenuated somewhat by the 40 M bandpass filter in the line to the 40 M receivers.
4. We should account for 80 M antenna return loss.

Analysis:

Frequency (MHz)	Diplexer Out (dbm)	80 M TX Filter Attenuation (db)[1]	Antenna Return Loss (db)[2]	40 M RX Filter Attenuation (db)[3]	40 M Receiver input Power (dbm)	S-Meter Reading[4]
3.62	3.4	0	15	76	-87.6	S-7 -
5.06	-34	40	5	10	-89	S-6 +
5.87	-48	41	5	10	-104	S-4 -
7022	-51	69	0	0	-119	S-1+

Notes:
1. Read from graph of prior N3FB "cadillac" 80 M filter measurement (17 Sep 2016).
2. Estimated: 15db RL at resonance 5db at 5 MHz, 0db at 7 MHz.
3. Read from graph of prior N3FB "cadillac" 40 M filter measurement (17 Sep 2016).
4. At HF, S-9 is defined as -73 dbm; 6 db per S-unit.
5. Attenuation based on distance between antennas is neglected.
6. Effects of radiation from transmitting feedlines into receiver feedlines is also neglected.

Calculation: 40 M Rx Input Power = Diplexer Out Power – 80 M filter attenuation – Antenna RL – 40 M filter attenuation.

Hypothesis:
N/A

Plan:
As documented above.

Results:
See conclusisons.

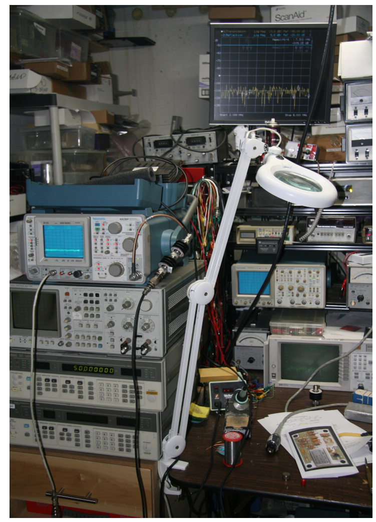
Conclusion:

1. We are probably not going to *damage* any receivers.
2. Mediocre receivers will probably see an elevated noise floor.
3. Even decent receivers may be driven close to non-linearity, increasing their vulnerability to adjacent strong signals, *such as the other transmitter on the same band.*

4. We will get more attenuation from the orthogonal antenna arrangements, as corrupted by reflections.
5. We will get some additional attenuation from the geographic separation.

Note: Spectrum Analyzer <u>Front-Panel setup</u> is saved in Memory 6. Minimum Attenuation set at 20 db.

Photos of the test setups



Left: SDR Transmitter, Diplexer and Bird 43.
Right: Spectrum Analyzer, Attenuators, HP432A barely visible, center right, next to oscilloscope.

Appendix A

Table of RF from 40 M port when diplexer is excited by 80 M with antenna port terminated in 50 Ohms.

TX Power (Watts)	HP432A Scale (dbm)	HP 432A Indication (db)	Power at Sensor (dbm)	Attenuation (db)	Power from Diplexer (dbm)
64	5	-9	-4	6	2
64	10	-10	0	3	3
65	5	-5	0	3	3
65	10	-10	0	3	3
65	5	-5	0	3	3
65	5	-9	-4	6	2
65	0	-3.5	-3.5	6	2.5

Calculation: Power from diplexer$_{(dbm)}$ = Scale$_{(dbm)}$ + Indication$_{(db)}$ + Attenuation$_{(db)}$