Ferrite UFC3-540 SN2272 75 kW 162.5 MHz Circulator

Ralph J. Pasquinelli

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Transfer function measurements as a function of input water temperature

and power vs frequency test

or

How to get the water Just Right

This report shows the performance of the circulator under matched conditions and with shorted port 2. The first series of s parameters are made with a network analyzer at low powers. The water temperature is indicated and the system was allowed to reach equilibrium at each temperature. Without a heat source other than the pump, low level measurements were limited to 91 F. The circulator looks to be tuned at 95 F as specified.

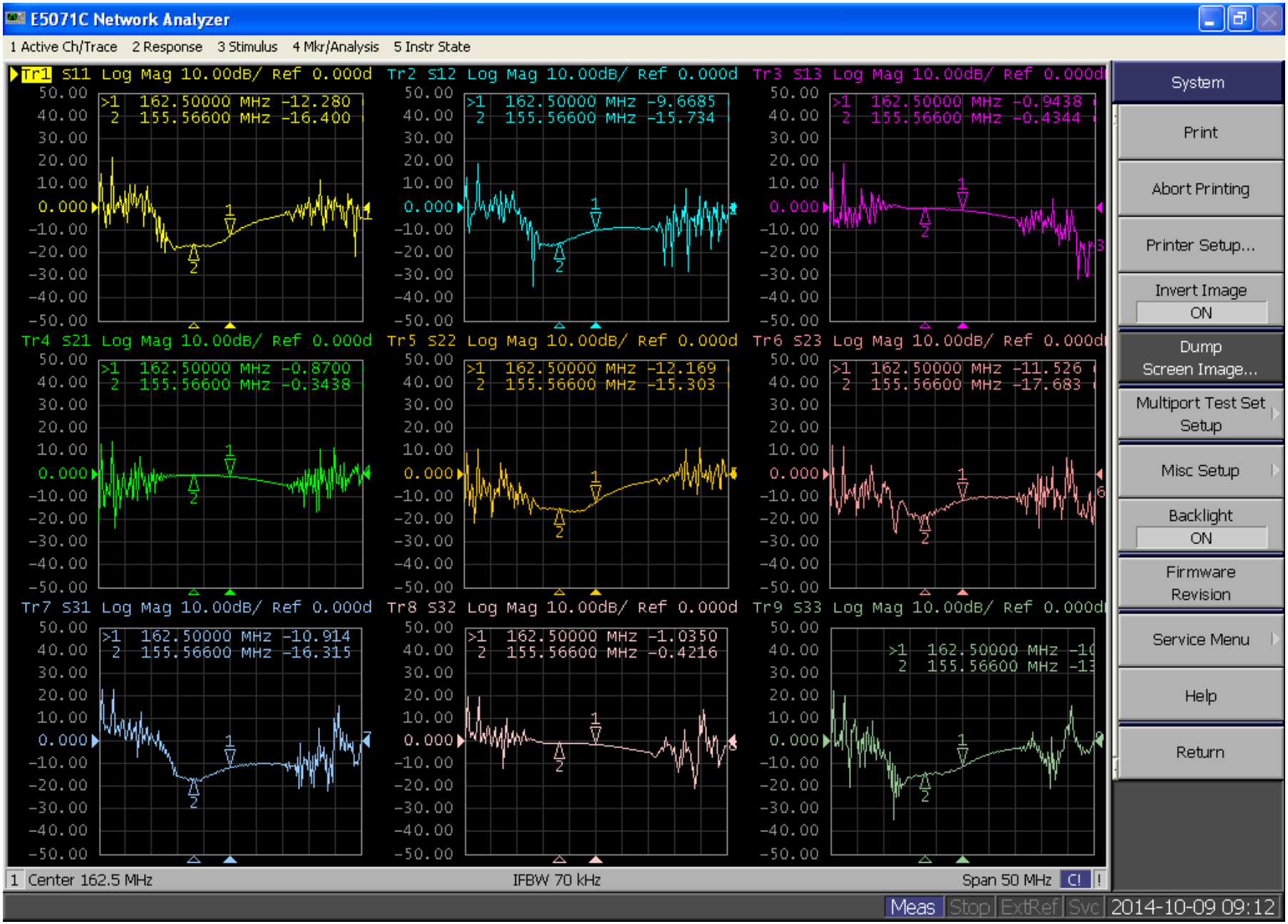
For the shorted test, the short was placed at two positions 1/8 wavelength apart with similar results for each position. Two tests at 70 F and 85 F input water temp measured. When power is applied, the frequency response changes dramatically. There is a clear difference in the input and output water temperature as expected.

The flow is only 4.1 GPM through the circulator.
A test was performed with a pressure difference of 110 psi and only 4.8 GPM was achievable.

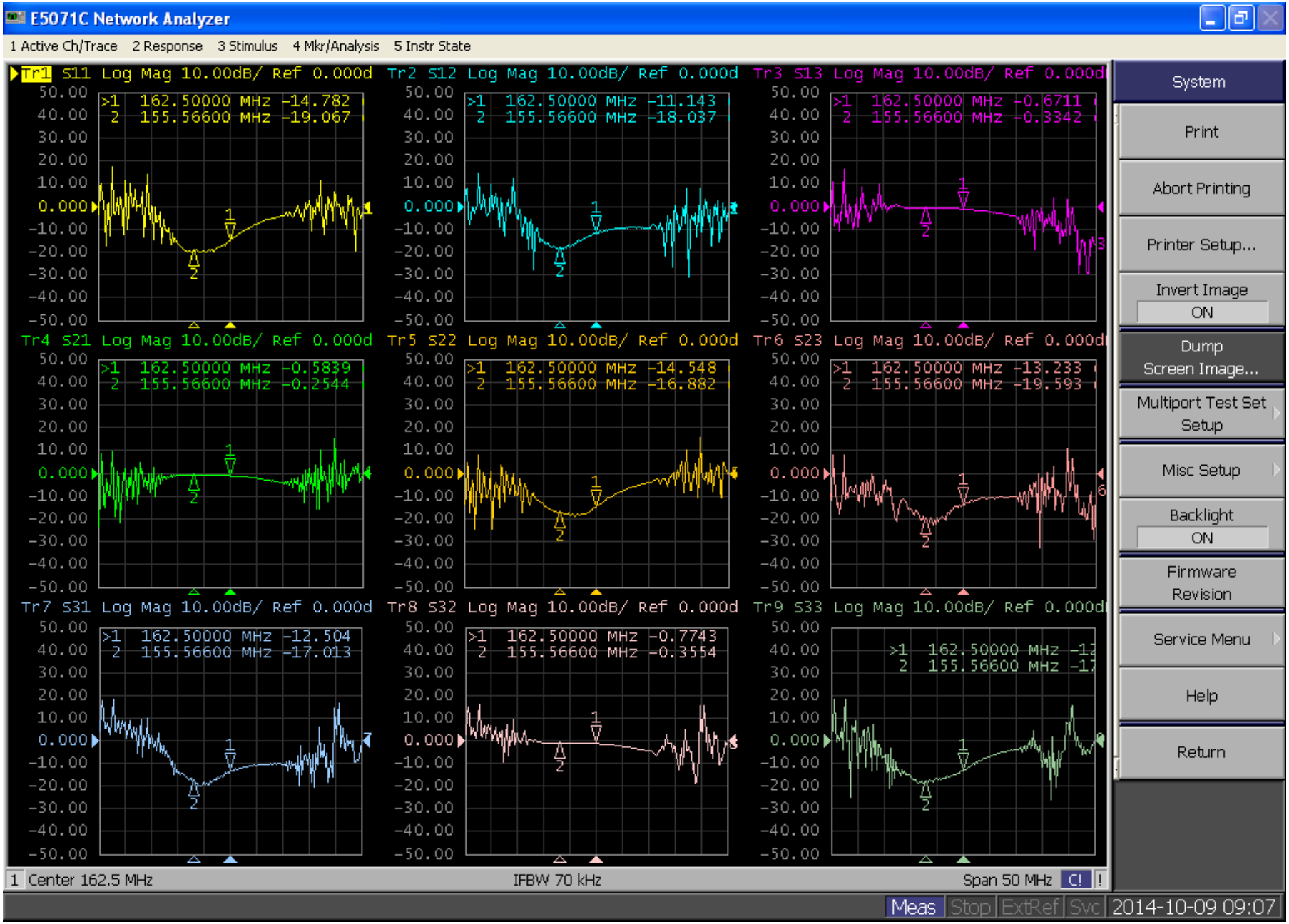
Load test was performed with loads on ports 2 & 3. Nominal operating power is expected to be 65 kW. At powers above 60 kW the best match occurs above 162.5 MHz. The final test was varying the water temperature set point at the water skid to tune the best match to 162.5 MHz with loads on ports 2 and 3.

Input Water Temperature = 68.6 F

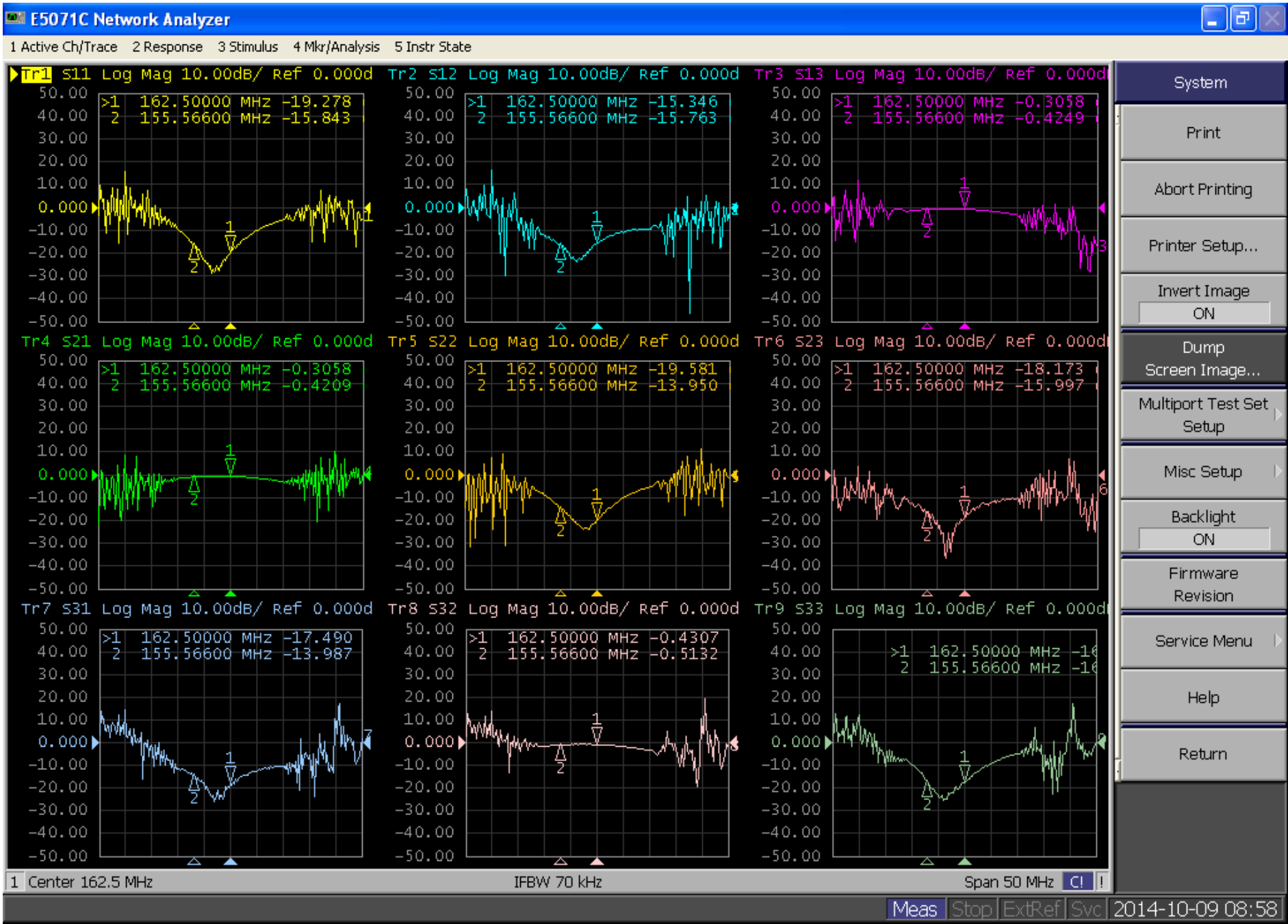
Input Water Temperature = 74.5 F



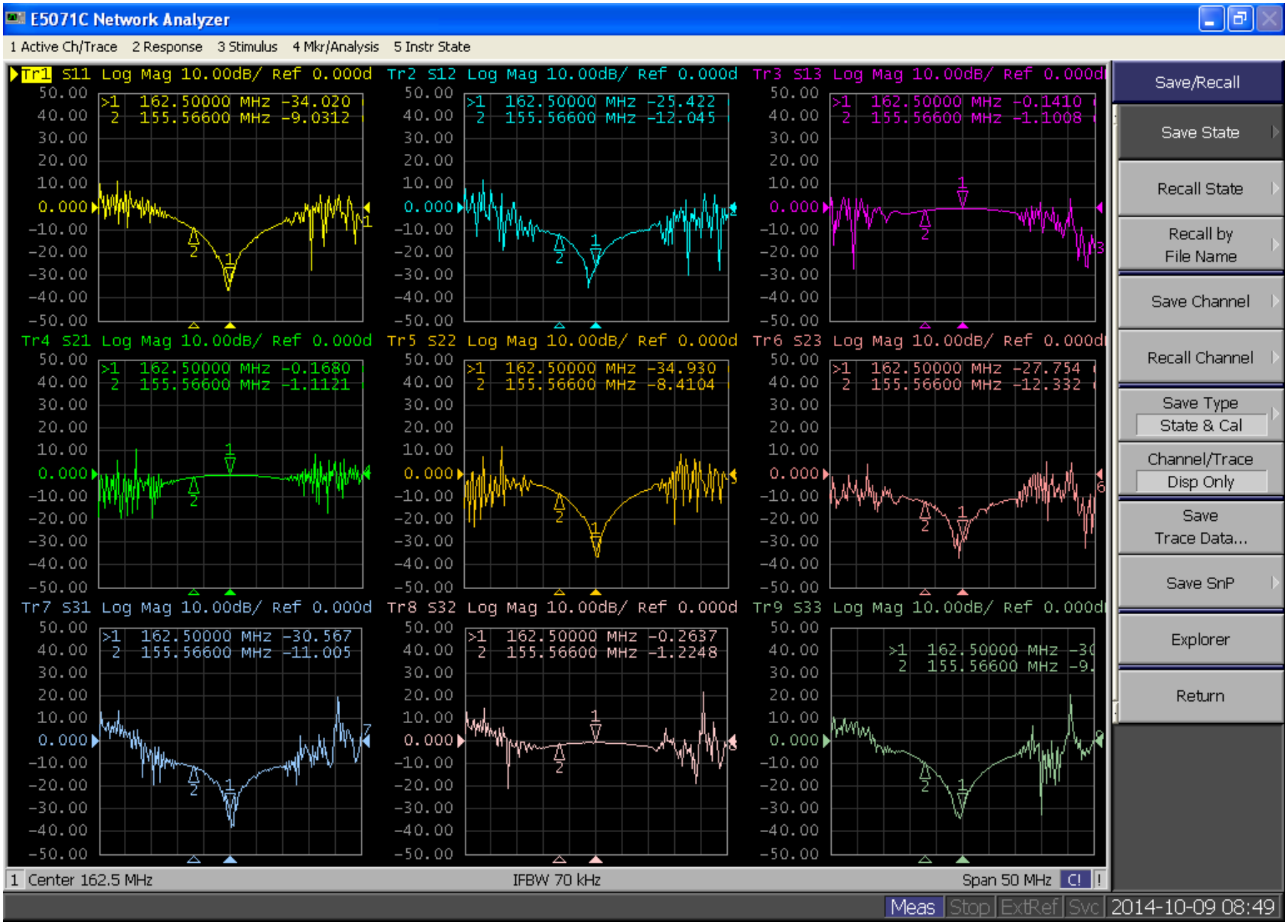
Input Water Temperature = 80.3 F



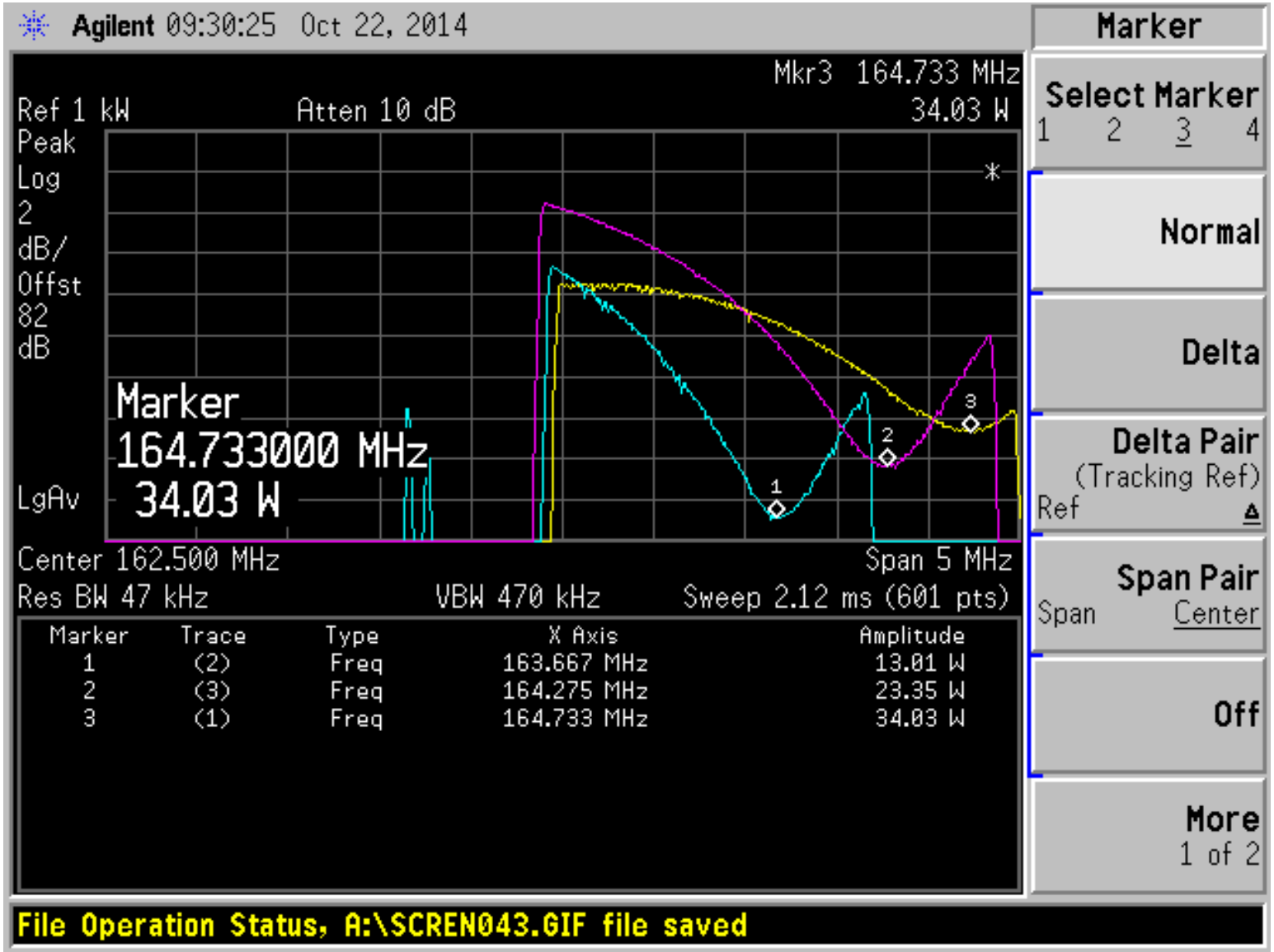
Input Water Temperature = 85 F



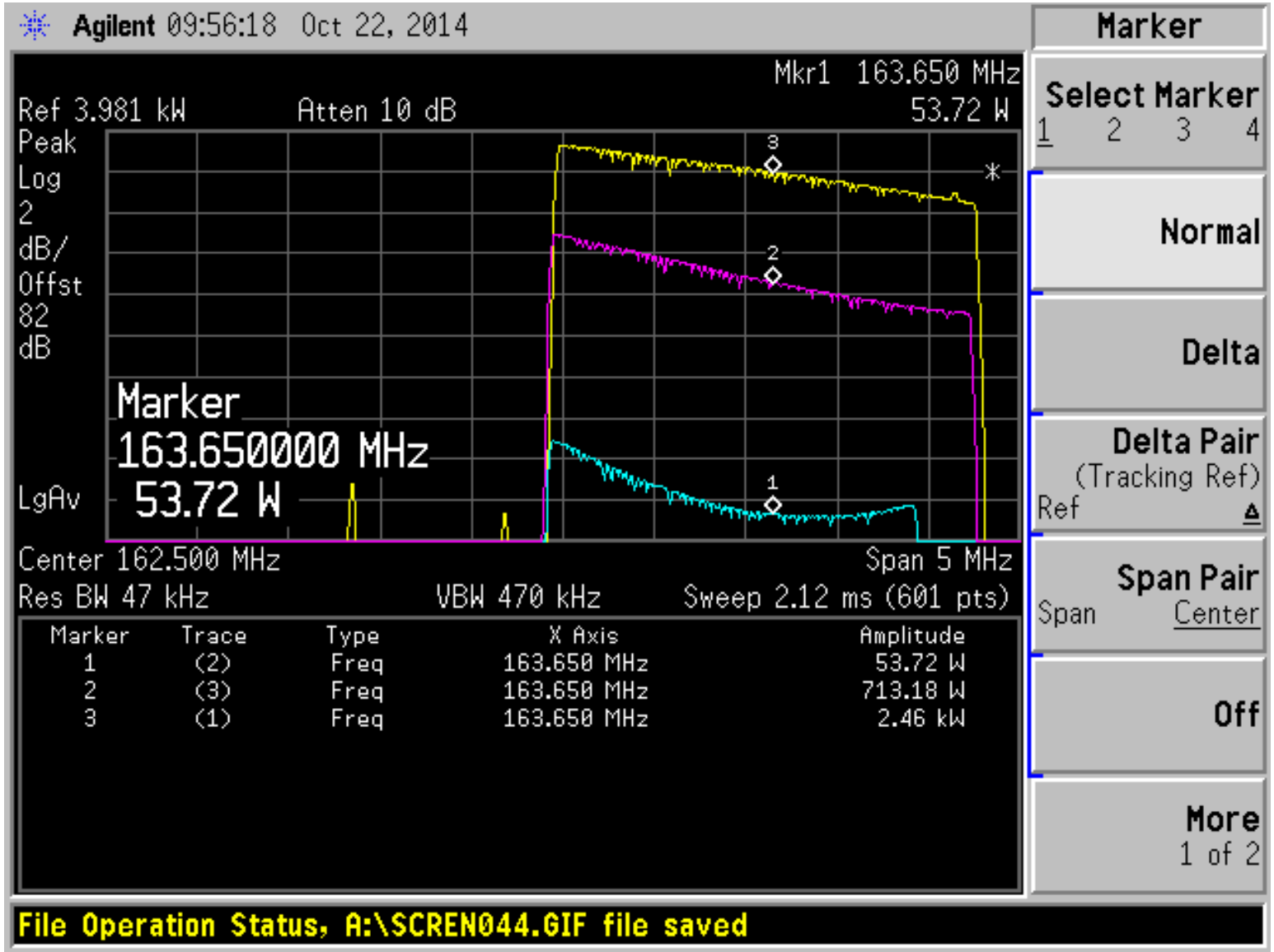
Input Water Temperature = 91 F



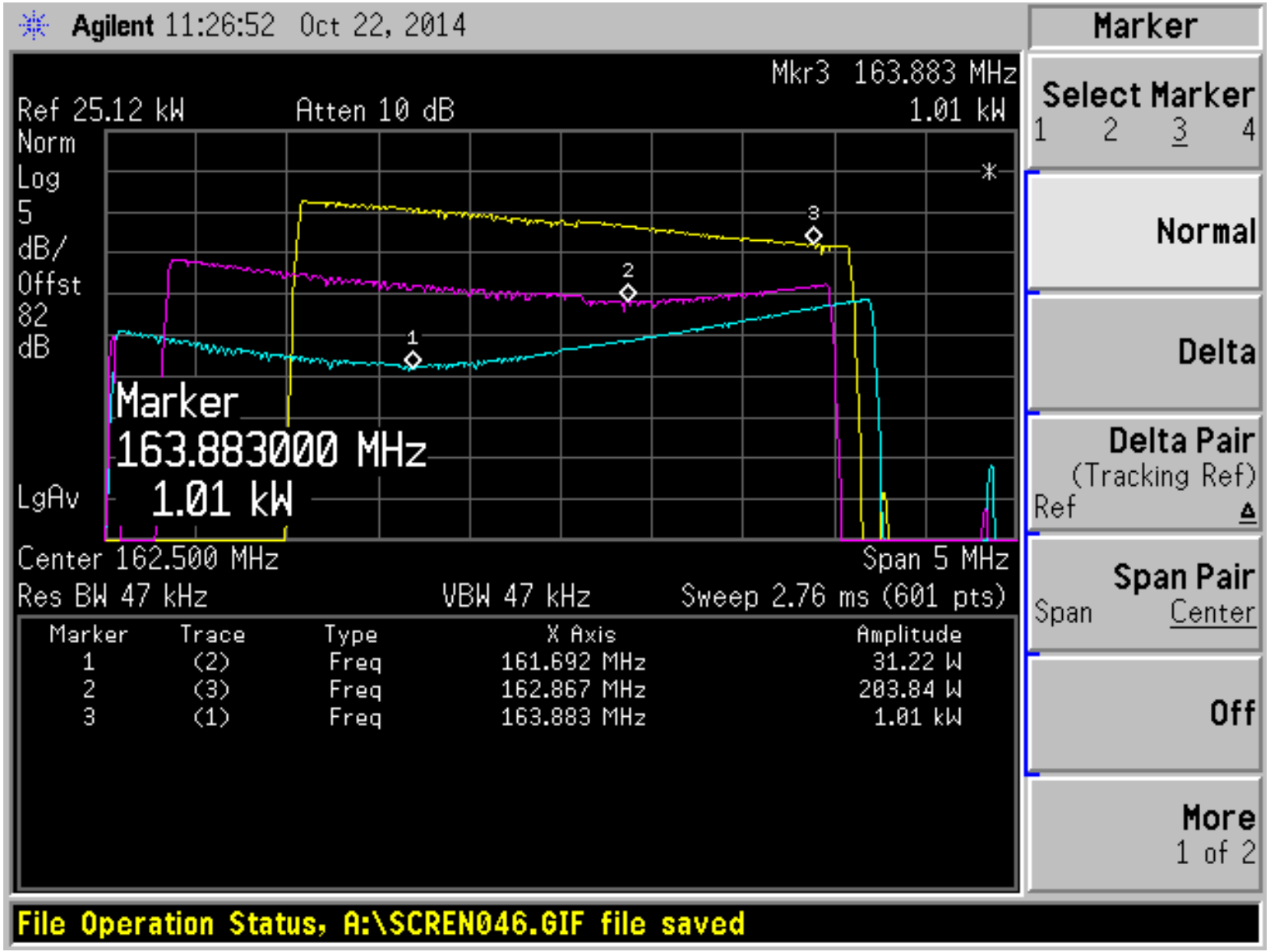
Input Water Temperature = 70 F, short circuit on port 2, amplifier reflected power vs freq
Blue 10 kW, Magenta 20 kW, Yellow 30 kW, markers indicate minimal power and freq



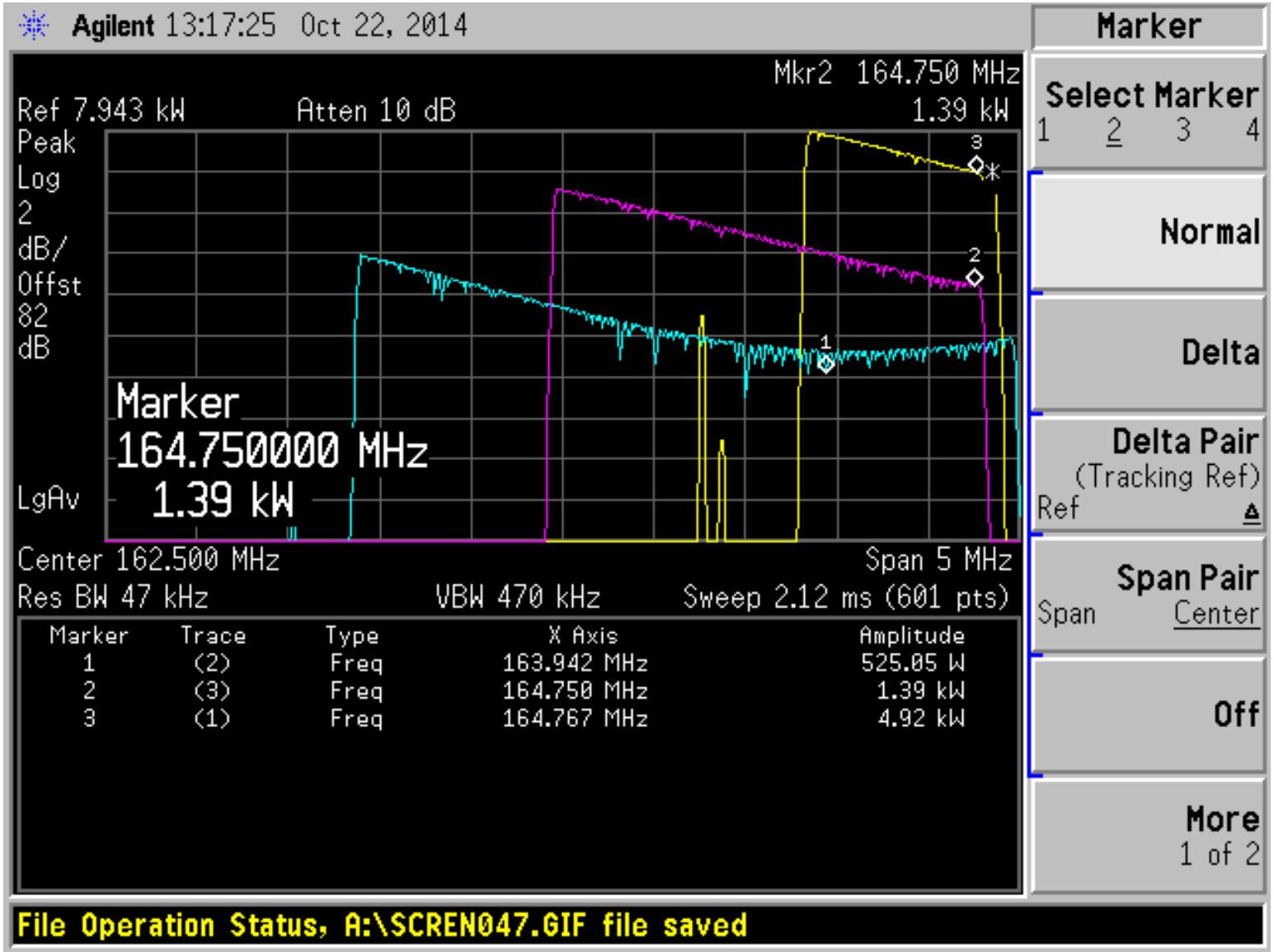
Input Water Temperature = 70 F, short circuit on port 2, amplifier reflected power vs freq
Blue 40 kW, Magenta 50 kW, Yellow 60 kW, markers indicate minimal power and freq.
note at these higher powers, minimum reflected is beyond the amplifier bandwidth (5 MHz)



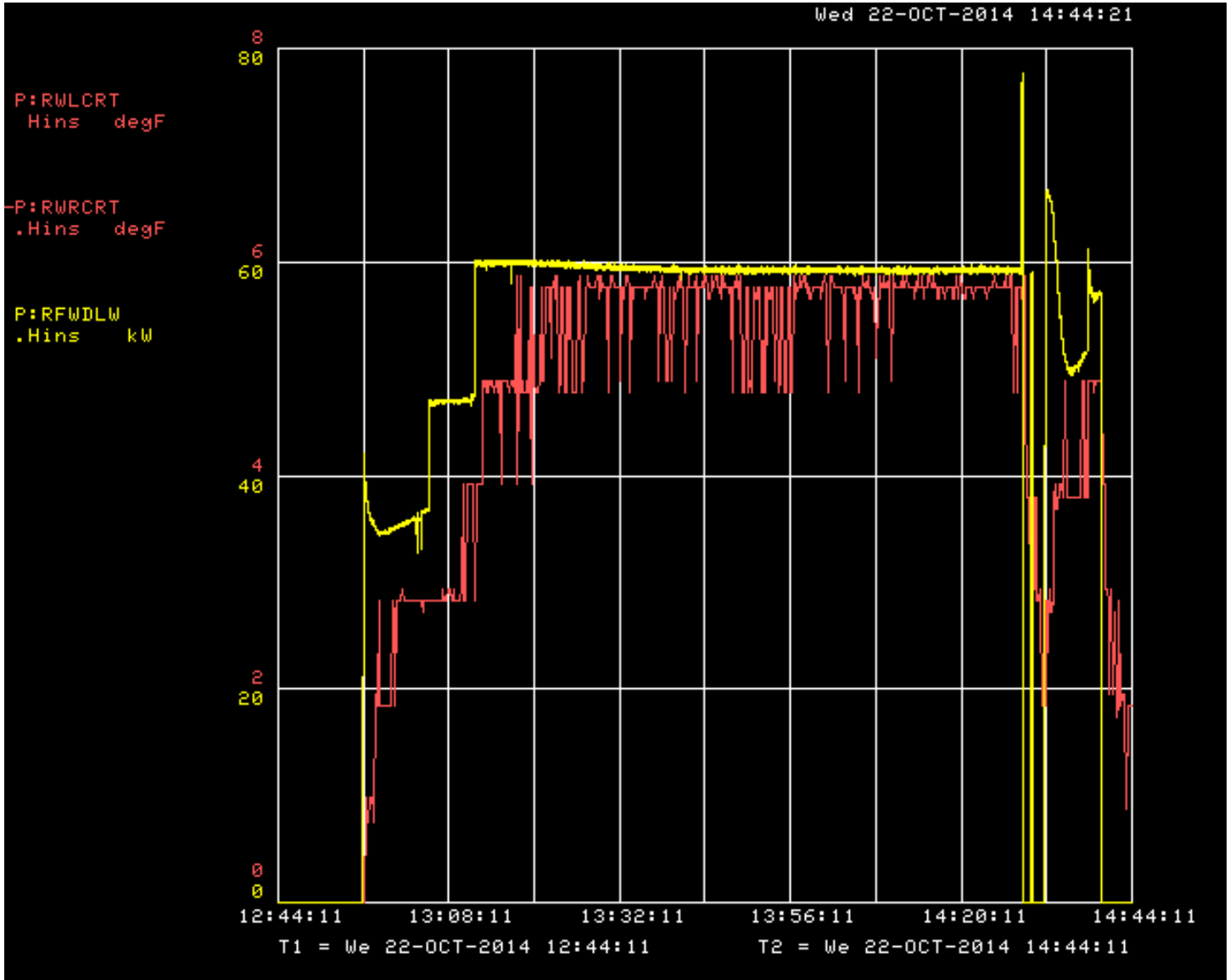
Input Water Temperature = 85 F, short circuit on port 2, amplifier reflected power vs freq
Blue 10 kW, Magenta 20 kW, Yellow 30 kW, markers indicate minimal power and freq.
Note there does not appear to be a sharp power minimum.



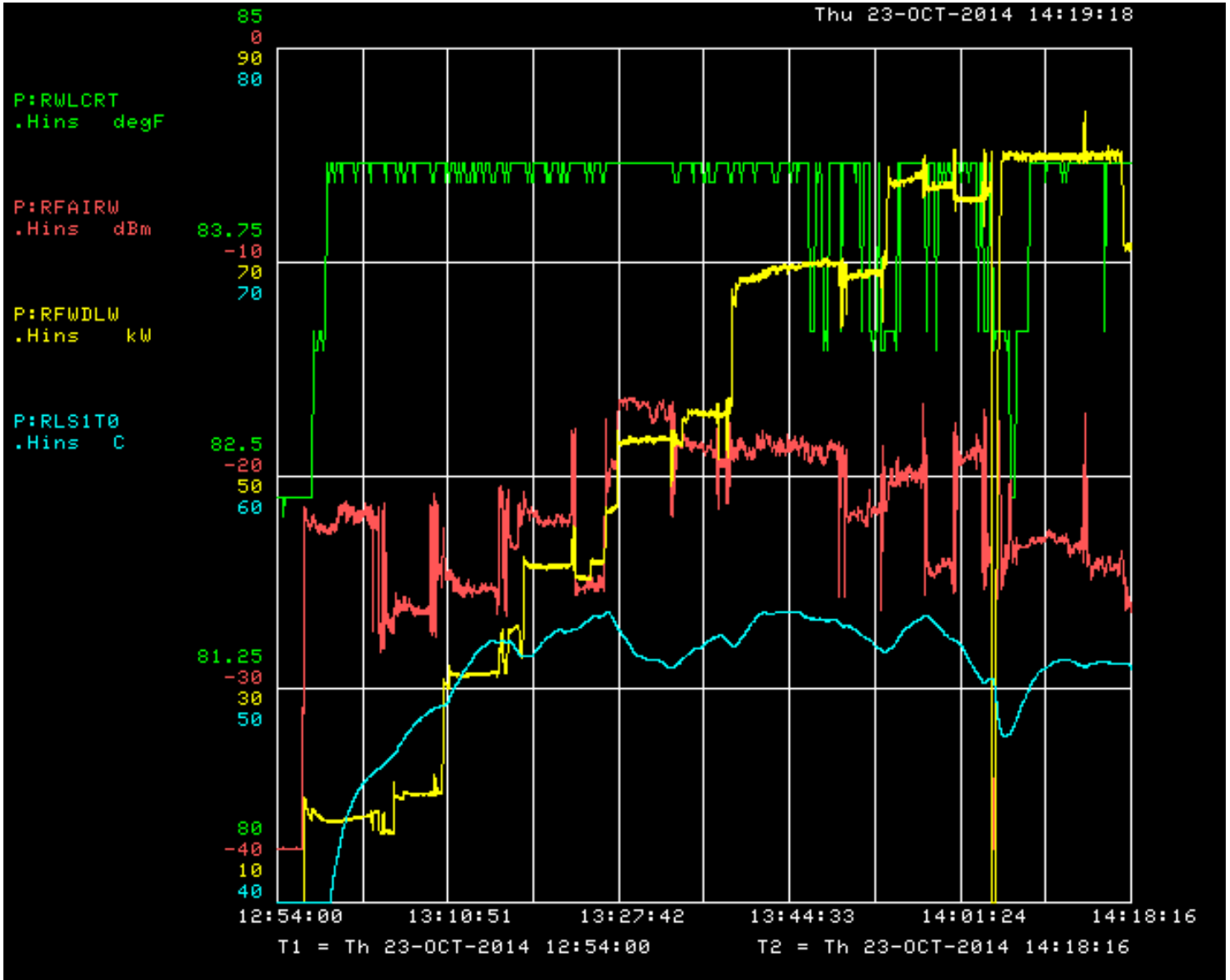
Input Water Temperature = 85 F, short circuit on port 2, amplifier reflected power vs freq
Blue 30 kW, Magenta 40 kW, Yellow 50 kW, markers indicate minimal power and freq.
note at these higher powers, minimum reflected is beyond the amplifier bandwidth (5 MHz)
return loss only 10 dB and minimum appears higher in frequency.



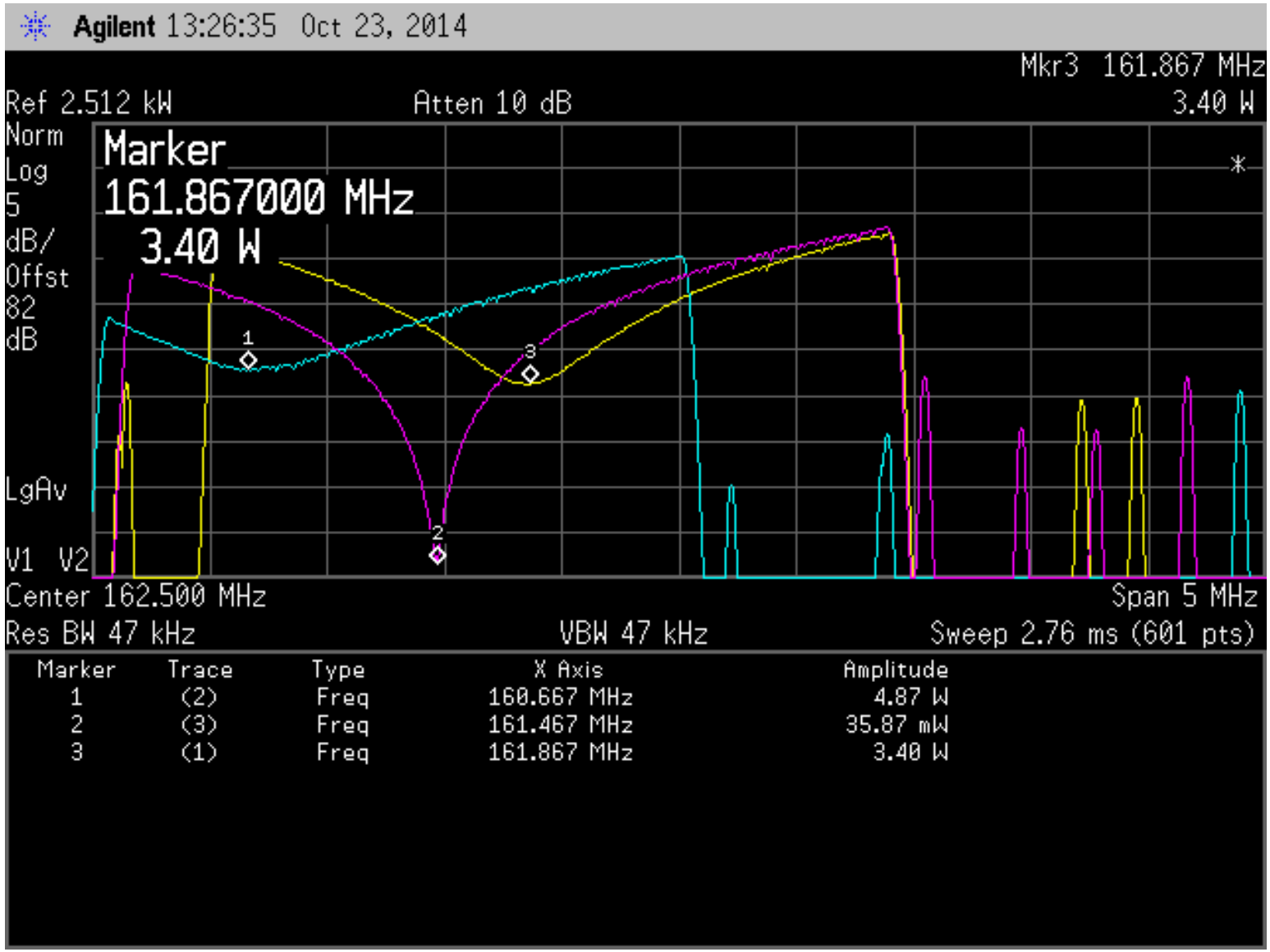
Input Water Temperature = 85 F, red is the difference between input and output water temp yellow is the forward power out of the amplifier. Water flow is 4.1 GPM. At 60 kW, the delta T is approximately 6 deg F. The thermal impedance between the water channels and the ferrite disc requires this lower operating water temperature.



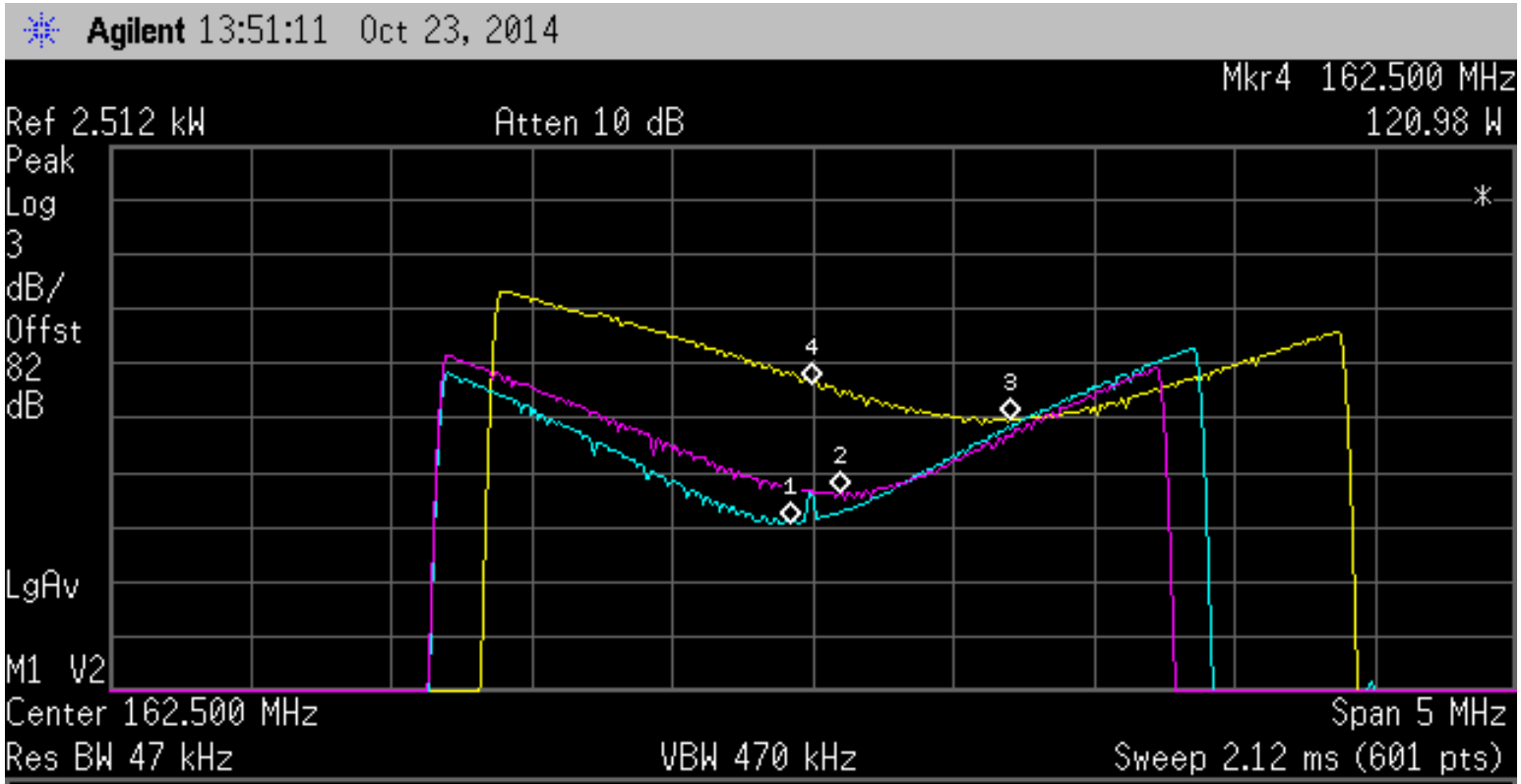
Plot of running conditions for testing the circulator with loads on ports 2 & 3. Green water temp deg F with one degree resolution, red is radiated power into the room antenna in dBm, Yellow is the forward power in kW, blue is the transistor temperatures of one of the amplifier modules in deg C. Trip level is 70 C.



Input Water Temperature = 85 F, blue 20 kW, magenta 30 kW, yellow 40 kW amp reflected power into a 50 ohm load. Of all the measurements only at 30 kW is such a pronounce match visible. Tends to be broader at all other powers. Spikes are generated by the stepping of the signal generator.

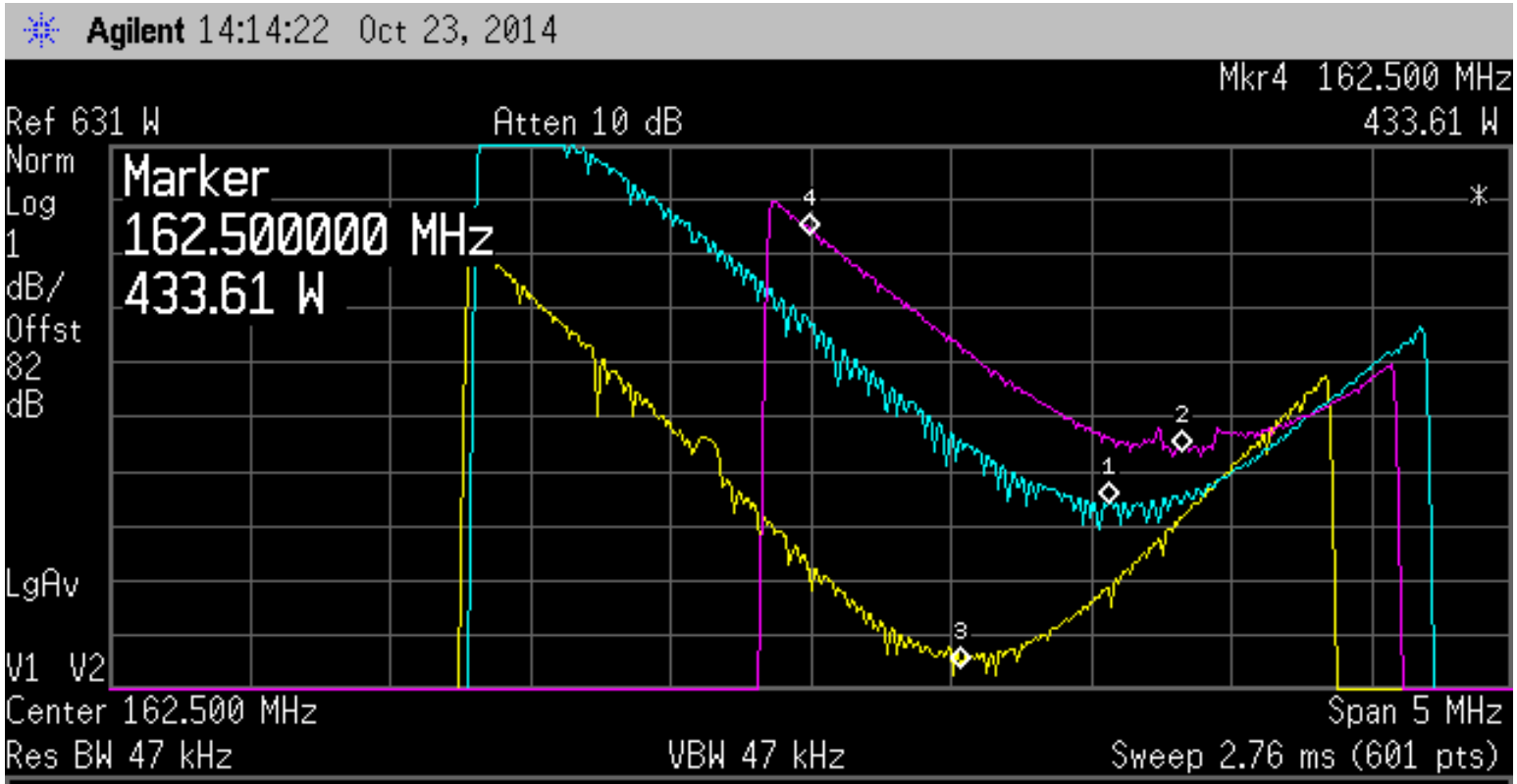


Input Water Temperature = 85 F, blue 50 kW, magenta 60 kW, yellow 70 kW amp reflected power into a 50 ohm load.



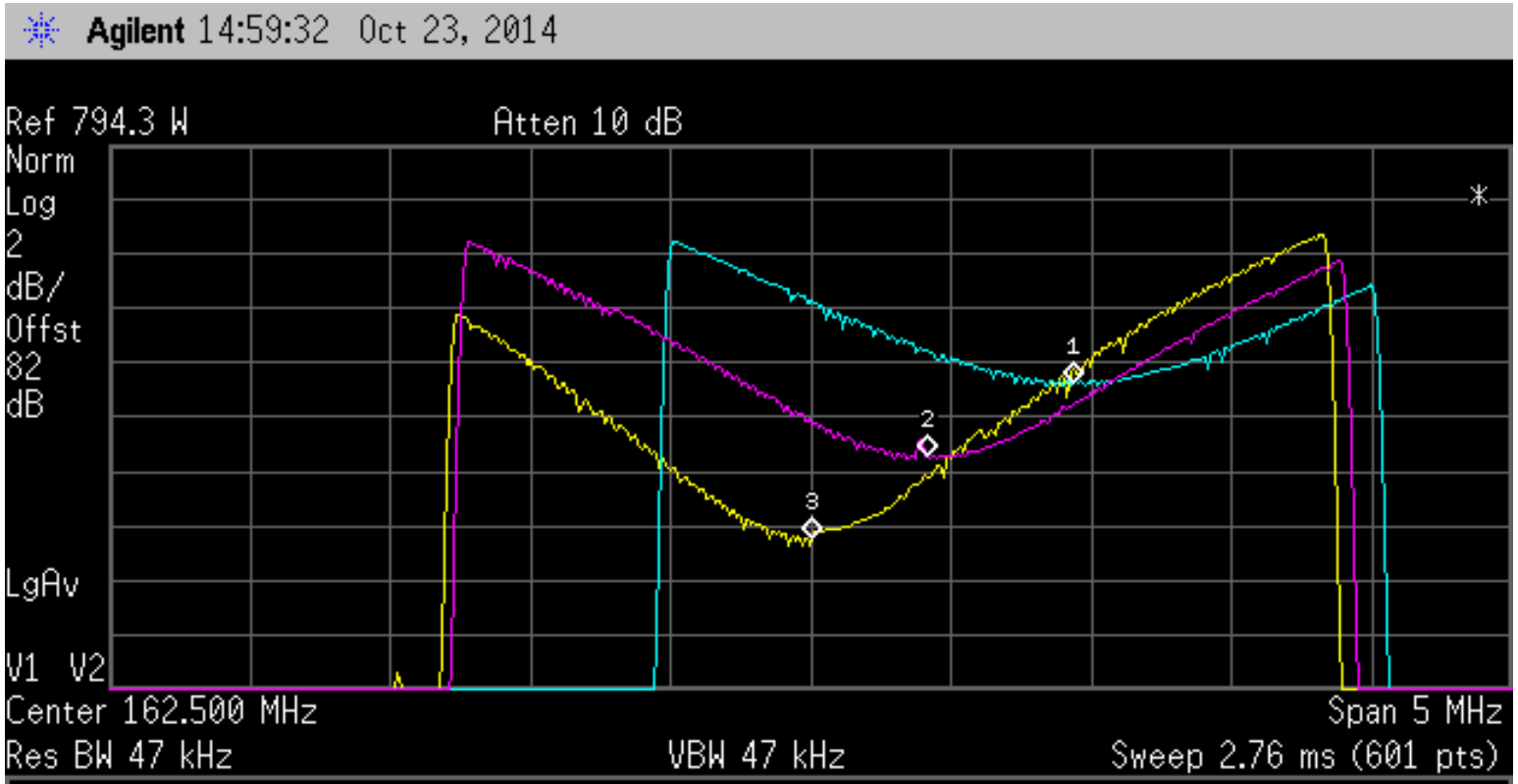
Marker	Trace	Type	X Axis	Amplitude
1	(2)	Freq	162.417 MHz	20.86 W
2	(3)	Freq	162.600 MHz	31.00 W
3	(1)	Freq	163.200 MHz	78.49 W
4	(1)	Freq	162.500 MHz	120.98 W

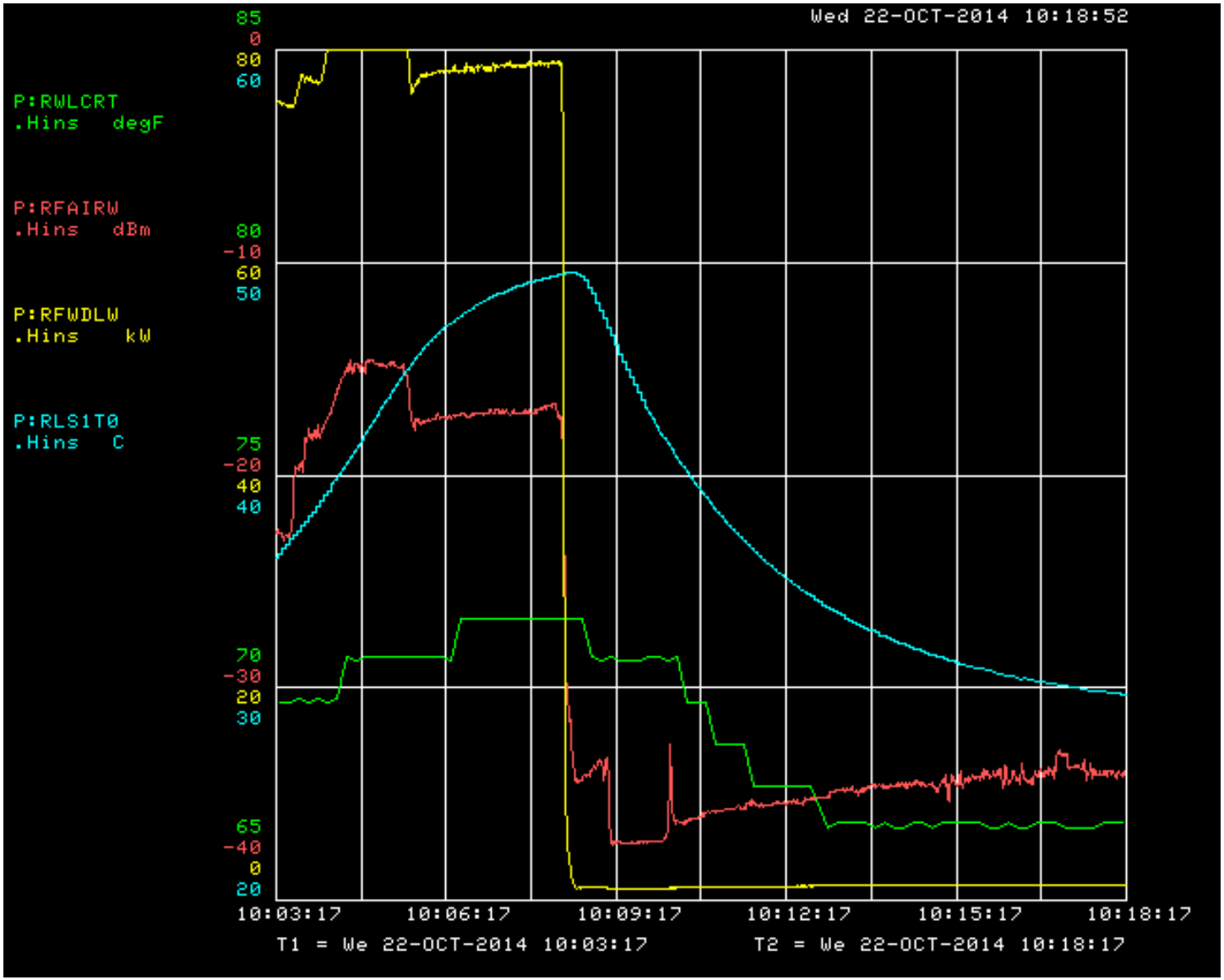
Input Water Temperature = 85 F, yellow 60 kW, blue 70 kW, magenta 75 kW amp reflected power into a 50 ohm load. (note color scheme different from previous plots due to operator, i.e.me)



Marker	Trace	Type	X Axis	Amplitude
1	(2)	Freq	163.567 MHz	138.23 W
2	(3)	Freq	163.825 MHz	172.50 W
3	(1)	Freq	163.033 MHz	69.07 W
4	(3)	Freq	162.500 MHz	433.61 W

Measurement of reflected power as a function of the set point on the water skid at 65 kW amp power. Blue is 85 F, magenta is 84 F, yellow is 82.5 F and the sweet spot. This is with only one amp running and the LEBT energized.
As more loads are added, the temperature at the circulators may vary and adjustments made.



Marker	Trace	Type	X Axis	Amplitude
1	(2)	Freq	163.433 MHz	105.10 W
2	(3)	Freq	162.917 MHz	56.77 W
3	(1)	Freq	162.508 MHz	28.62 W

Running at 74 kw (yellow), temperature of transistors in C (blue), radiated power dBm into room antenna (red), cooling water temperature (green). Abrupt turn off of power to see time constant, about ten minutes to stabilize transistor temp, six minutes for the water loop.