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**Test of E2V 650 MHz IOT efficiency and Ferrite 60 KW Circulator**

Attached are the test results from an efficiency test on the V2 E2V 30 KW IOT and transmitter plus Ferrite circulator. 480 VAC was monitored with a Fluke power energy analyzer directly attached to the mains input on the transmitter. AC power measured does not include power for the solid-state driver amplifiers, but does include fans, filaments, bias supplies, ion pump, controls, etc that are part of the main transmitter cabinet. RF power was measured with Agilent power meters. Calibrations of all couplers were done to an accuracy of 0.1 dB and these values were entered as offsets to the meters. An Agilent network analyzer was used to tune up the input and output cavities and coupling loops. Before the data was taken, an efficiency exceeding 50% AC to RF was tuned. Figure 1 shows a photo of the transmitter and circulator. At 30 KW, 6-1/8 inch coax is required. Initially loads are attached to both ports 2 and 3 of the circulator. A short circuit was then installed on port 2 of the circulator to reflect power to the load on port 3.

Trolley tuner settings:

| | |
|---|---|
| Input Cavity Counter: | 740 |
| Output Cavity 1 Counter: | 977.75 |
| Output Cavity 1 Loop: | 81 degrees |
| Output Cavity 2 Counter: | 951 |
| Output Cavity 2 Loop: | 80 degrees |

Figure 1. Comark IOT transmitter and Ferrite 650 MHz circulator. Loads installed on ports 2 and 3.

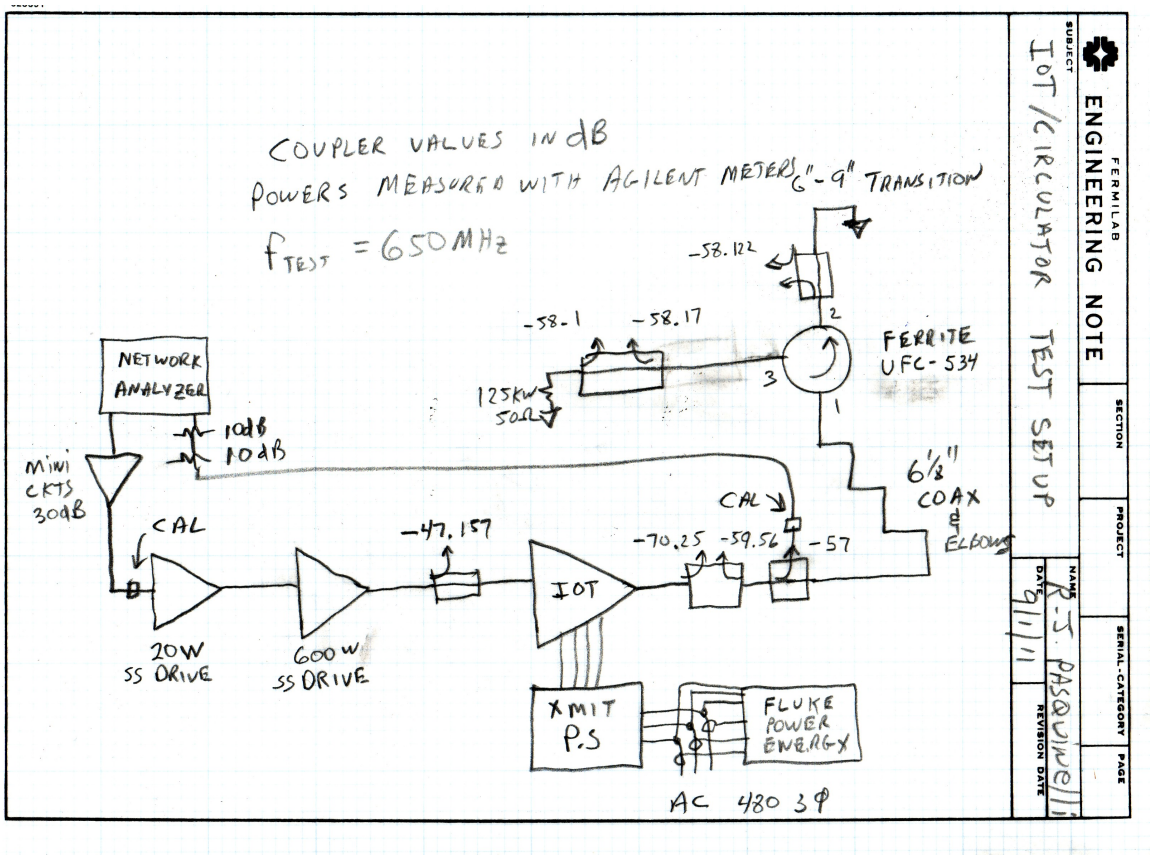


Figure 2. Block diagram of test set up.

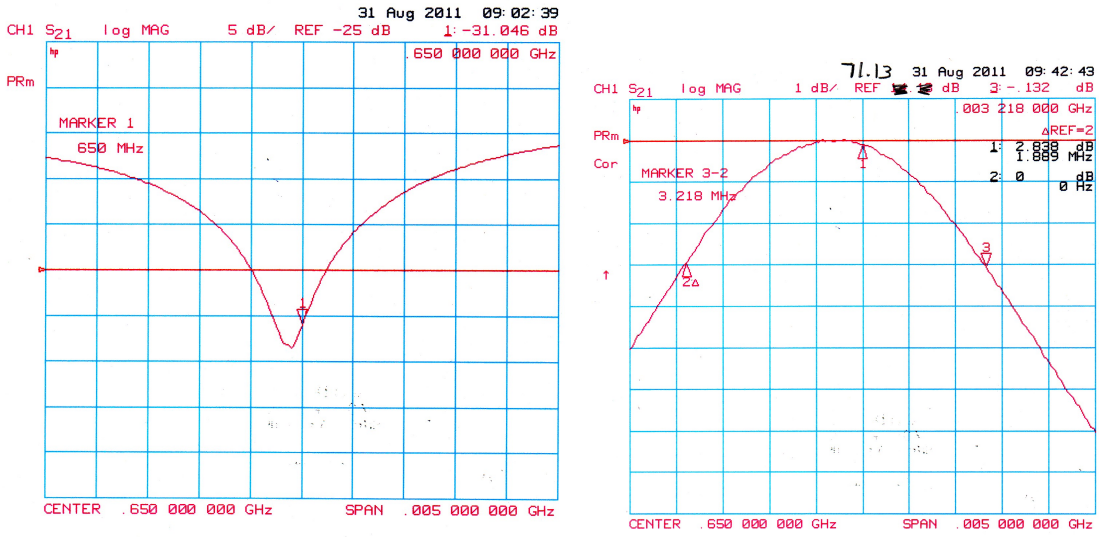


Figure 3. Left: Input match to the IOT. Right: System gain between cal points. Peak power is 30 KW mid band. Bandwidth is set to 3.2 MHz.

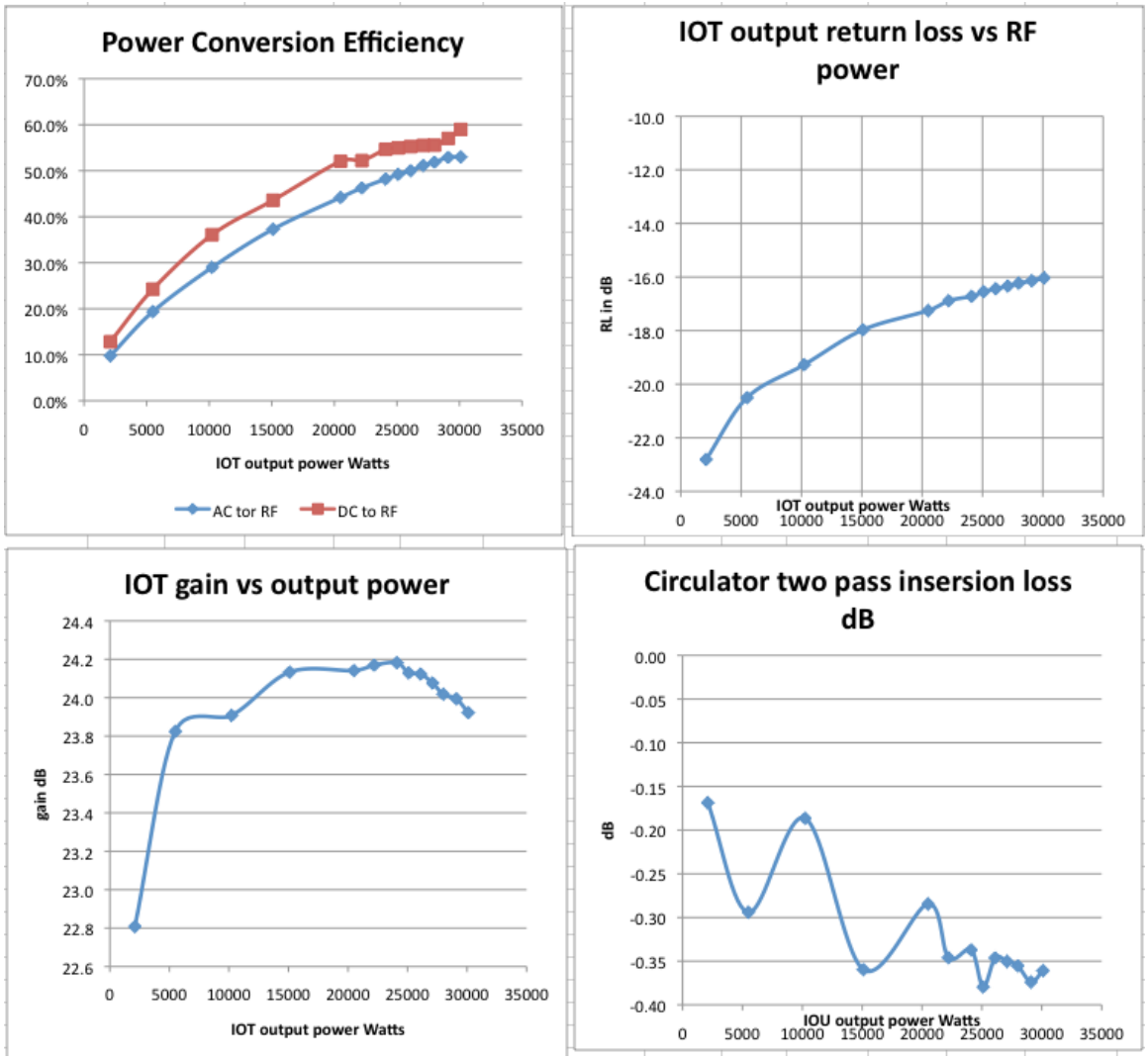


Figure 4. Efficiency, IOT output match, gain, two pass insertion loss of circulator.

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**Test of IOT gain, efficiency, Ferrite circulator UFC3-534-CIRC#H5616**

**IOT V2 installed in transmitter V1 Test Frequency 650 MHz**

Note that power on circulator port 2 is higher than incident. This is because the short circuit provides a high VSWR that affects the coupling constants of the bidirectional coupler.

| IOT Pfwd RF Watts | IOT Prev RF watts | IOT out RL dB | Pdrive RF Watts | port 3 rev | Pfor circ port 2 | Pfor circ port 3 | gain IOT dB | Circ s31 IL dB | | IOT Pfwd RF Watts | IOT Prev RF watts | IOT out RL dB | Pdrive RF Watts | port 3 rev watts | Pfor circ port 2 watts | Pfor circ port 3 watts | gain IOT dB | Circ s31 IL dB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| idle no HV | | | | | | | | | | idle no HV | | | | | | | | |
| HV no RF | | | | | | | | | | HV no RF | | | | | | | | |
| 2100 | 11 | -22.8 | 11 | 6 | 2500 | 2020 | 22.8 | -0.17 | | 2100 | 11 | -22.8 | 11 | 6 | 2500 | 2020 | 22.8 | -0.17 |
| 5500 | 49 | -20.5 | 22.8 | 14.8 | 6170 | 5140 | 23.8 | -0.29 | | 5500 | 49 | -20.5 | 22.8 | 14.8 | 6170 | 5140 | 23.8 | -0.29 |
| 10230 | 121 | -19.3 | 41.6 | 28 | 11500 | 9800 | 23.9 | -0.19 | | 10230 | 121 | -19.3 | 41.6 | 28 | 11500 | 9800 | 23.9 | -0.19 |
| 15100 | 241 | -18.0 | 58.3 | 41 | 1600 | 13900 | 24.1 | -0.36 | | 15100 | 241 | -18.0 | 58.3 | 41 | 1600 | 13900 | 24.1 | -0.36 |
| 20500 | 386 | -17.3 | 79 | 56 | 22600 | 19200 | 24.1 | -0.28 | | 20500 | 386 | -17.3 | 79 | 56 | 22600 | 19200 | 24.1 | -0.28 |
| 22200 | 455 | -16.9 | 85 | 60 | 24000 | 20500 | 24.2 | -0.35 | | 22200 | 455 | -16.9 | 85 | 60 | 24000 | 20500 | 24.2 | -0.35 |
| 24100 | 513 | -16.7 | 92 | 65 | 26100 | 22300 | 24.2 | -0.34 | | 24100 | 513 | -16.7 | 92 | 65 | 26100 | 22300 | 24.2 | -0.34 |
| 25100 | 556 | -16.5 | 97 | 68 | 27000 | 23000 | 24.1 | -0.38 | | 25100 | 556 | -16.5 | 97 | 68 | 27000 | 23000 | 24.1 | -0.38 |
| 26100 | 593 | -16.4 | 101 | 71 | 28400 | 24100 | 24.1 | -0.35 | | 26100 | 593 | -16.4 | 101 | 71 | 28400 | 24100 | 24.1 | -0.35 |
| 27100 | 630 | -16.3 | 106.0 | 75 | 29200 | 25000 | 24.1 | -0.35 | | 27100 | 630 | -16.3 | 106.0 | 75 | 29200 | 25000 | 24.1 | -0.35 |
| 28000 | 667 | -16.2 | 111.0 | 78 | 30.2 | 25800 | 24.0 | -0.36 | | 28000 | 667 | -16.2 | 111.0 | 78 | 30.2 | 25800 | 24.0 | -0.36 |
| 29100 | 708 | -16.1 | 116.0 | 79 | 31.4 | 26700 | 24.0 | -0.37 | | 29100 | 708 | -16.1 | 116.0 | 79 | 31.4 | 26700 | 24.0 | -0.37 |
| 30100 | 750 | -16.0 | 122.0 | 84 | 32600 | 27700 | 23.9 | -0.36 | | 30100 | 750 | -16.0 | 122.0 | 84 | 32600 | 27700 | 23.9 | -0.36 |

| IOT RF Pfwd Watts | Current A | Current B | Current C | AC power watts | AC power KVA | power factor | AC volts nom | AC to RF efficiency | DC beam current Amps | DC beam kV | DC beam pwr watts | AC to DC eff | DC to RF eff |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| idle no HV | 5 | 5 | 1 | 2000 | 3400 | 0.6 | 480 | | | | | | |
| HV no RF | 30 | 30 | 24 | 19400 | 23700 | 0.82 | 480 | | 0.37 | 32 | 11840 | 61.0% | |
| 2100 | 34 | 33 | 27 | 21500 | 26100 | 0.83 | 480 | 9.8% | 0.52 | 31.5 | 16380 | 76.2% | 12.8% |
| 5500 | 42 | 42 | 35 | 28400 | 32900 | 0.87 | 480 | 19.4% | 0.72 | 31.5 | 22680 | 79.9% | 24.3% |
| 10230 | 51 | 50 | 43 | 35300 | 39800 | 0.89 | 480 | 29.0% | 0.9 | 31.5 | 28350 | 80.3% | 36.1% |
| 15100 | 58 | 57 | 49 | 40500 | 45200 | 0.9 | 480 | 37.3% | 1.1 | 31.5 | 34650 | 85.6% | 43.6% |
| 20500 | 65 | 65 | 56 | 46400 | 51200 | 0.91 | 480 | 44.2% | 1.25 | 31.5 | 39375 | 84.9% | 52.1% |
| 22200 | 67 | 66 | 58 | 48000 | 52800 | 0.91 | 480 | 46.3% | 1.35 | 31.5 | 42525 | 88.6% | 52.2% |
| 24100 | 69 | 69 | 60 | 50000 | 54600 | 0.91 | 480 | 48.2% | 1.4 | 31.5 | 44100 | 88.2% | 54.6% |
| 25100 | 71 | 70 | 62 | 51000 | 56000 | 0.91 | 480 | 49.2% | 1.45 | 31.5 | 45675 | 89.6% | 55.0% |
| 26100 | 72 | 72 | 63 | 52200 | 57300 | 0.91 | 480 | 50.0% | 1.5 | 31.5 | 47250 | 90.5% | 55.2% |
| 27100 | 74 | 74 | 64.0 | 53000 | 58300 | 0.91 | 480 | 51.1% | 1.55 | 31.5 | 48825 | 92.1% | 55.5% |
| 28000 | 75 | 75 | 66.0 | 54000 | 59200 | 0.91 | 480 | 51.9% | 1.6 | 31.5 | 50400 | 93.3% | 55.6% |
| 29100 | 77 | 76 | 67.0 | 55000 | 60500 | 0.91 | 480 | 52.9% | 1.62 | 31.5 | 51030 | 92.8% | 57.0% |
| 30100 | 78 | 78 | 69.0 | 56800 | 62100 | 0.92 | 480 | 53.0% | 1.62 | 31.5 | 51030 | 89.8% | 59.0% |

Figure 5. Data taken for the test.