JUST WHEN YOU THINK YOU'VE SEEN IT ALL

Microwave path failure at it's finest

By Gary A. Minker
Radio Works R.F. Consulting
June, 2017

When you get the call from an old customer for whom you have tried your best to keep from being their own worst enemy, you think you have seen it all but then you get reminded that not all old customers can or will learn new tricks.

THE SITUATION:
The microwave hop from the salty beach to an inland site has taken the last four years to digress to the point of less than 10dB fade margin and in the wet and rainy summer weather has become completely unreliable. As the rain and humidity wave through, that 10dB goes whizzing down the drain like a fresh can of Draino. Panic sets in since it is a public safety system and the Comm's manager is starting to freak out on a S.W.A.T. calibre scale. You get the call as their favorite Line Sweeper and when you arrive at the site, you are told that you are the third person over the last 4 steadily degrading years to try to diagnose this issue but now the feeling is that since the Commandant and the Sheriff are involved someone better call in the cavalry.

There you stand, face to face with Gold badges, white shirts, freaked out people with itchy trigger fingers and a tower crew that you have never worked with before, all to try to get a single line, non diversity hop to give up the story. Earlier in the ordeal the crew took photos of the dishes on each end and much to your dismay, a black and white Polaroid from 1962 would have taken better pictures than the pocket computer cell phones that the tower crew used. While trying to make heads or tails of the grainy blurred images with terrible shadows and corrosion, you just have to give up on the photos and get to the Sweeping part.

Cousin Murph always gets you to start on the end of the hop that is the most confusing and such was the case here. The 12 mile hop normally has a RSSI of about -34dBm. Over the past four years, the hop has degraded to a frighteningly fluctuating -68 dBm with a fade to fatal level of -75dBm. Things are bleak to say the least and the failure is symmetrical which rules out an electronic problem.

The first dance in to the system with the Vector Network Analyzer, the right fittings and all the cool toys shows a nominal high 20 something dBm Return Loss with a nearly perfect Time Domain. (See figure 1 and 2) This data is largely normal with the only fly in the ointment being a suspicious input connection to the dish that presents at -26dBm. This conclusion was arrived at with a full line characterization with a short and termination.

Ordinarily with new work, I would fail the system with such a connection value but this is certainly not new work, fatal, nor the big stinky cheese. In conferring with the Magna cum Laude guys on the tower, the radome is not in too bad of condition and the over all Time Domain of the four planes of the dish seem pretty good since I can indeed make out the input, the aperture of the feed, the parabola and the radome.

With the level of frustration rising rapidly with the Commo Commander(o) We break camp and cruise over to the other end of the hop. Similarly crummy photos are brought out that couldn't ID the difference between a Raccoon and an Ant Eater so once again, the Vector Network Analyzer is brought to bear on the system.

Remember,,, the system still runs but not so good:

The first pop up of trace data just happened to be a dual overlay of a split screen with Time Domain on the top half of the screen and the Return Loss on the bottom half of the screen. The frequency spread of the calibration is well within the range of the feed horn and the scary spike at the end of the Time Domain in concert with the 4dB Return Loss on the bottom half all spell only one thing. The antenna is "electrically" missing. While the system is still holding pressure and the dish is certainly still physically up there,,, the thing is just not home. If the line were open or the connector ripped off, the system would not hold pressure, the hop would be down and the Return Loss would be closer to -12dBm with an open air coupling to the ether.

Just like the starting first site, a full characterization of the line begins. We remove the trunk and flex line from the dish and begin with a short. The length of the line is established as is the insertion loss with a quick mental note of "divide by 2" to account for the "round trip". The precision termination is then placed on the line system which reveals a nearly -30dBm Return Loss, even with numerous minor dents and wrinkles in the elliptical. With both the Time Domain traces and the two Return Loss traces in agreement for the short and termination, we then go back to Mr. Dish. I call up to the tower crew and ask again what the visual is on the feed horn and the reply is very nebulous, just like the photos. Fortunately the crew had brought a gently used replacement feed horn with them. We brought the used replacement in to the shelter where we swept it hanging from a piece of rope in mid air and achieved a very nice high 20's Return Loss which was well within the prescribed band though it was an adjacent band split and not exactly like the ones in use.

Up the tower goes the replacement feed horn. After nearly a hour of trying to snap corroded hardware and 2 cans of Kroil, the old feed was out and the replacement was installed. In the words of Gomer Pile, shazam and goollleee, the result on the analyzer was sheer joy.
(see figure 3) This data trace is a live look at the broken feed horn.

Just when you think that you have seen every crazy thing out there, you run in to a situation like this. With an inexperienced crew staring a failure in the face, they did not recognize that the failure and cause of the failure was right in front of them. Their eyes and training failed them and the customer, as did their pocket computer cell phone cameras.

WAIT FOR IT:

Looking backward at both sites, the obvious mode of failure found at the second site is the precursor to the start of the failure found at the first site. Figure 4 shows you what an old dish in the salt marsh can do if left with no maintenance and inspection people who do not know what they are looking at. The rigid copper feed guide of the button hook is completely crushed to the point of internal contact by the corroding pot metal of the aluminum casting of the polarizing flange. The growing crystal corrosion of the flange is not only splitting the massive reinforced casting apart and stretching the clamp hardware, it totally crushed the E plane walls of the rigid waveguide. Figure 5 shows an internal view of the rigid waveguide where the wall sides are actually touching.

Even with this incredible damage, and a Return Loss of only -4dB, the system was still on the air, albeit with a near zero fade margin. Examples like this stress the value of having competent and trained personnel with realistic technology and tools at their disposal. While mechanical inspection are super important, bringing in your Line Sweeper WITH the tower crew can often ward off Cousin Murph and his bag of evil spirits. No matter if the system is just a hop from pop to pop, or a critical remote Public Safety link, unless you don't mind egg on your face or being stood up in front of the firing squad, proper testing and inspections are the key to longer life of your system. After 38 years, I am pleased to learn a new trick.

FIGURE 1:

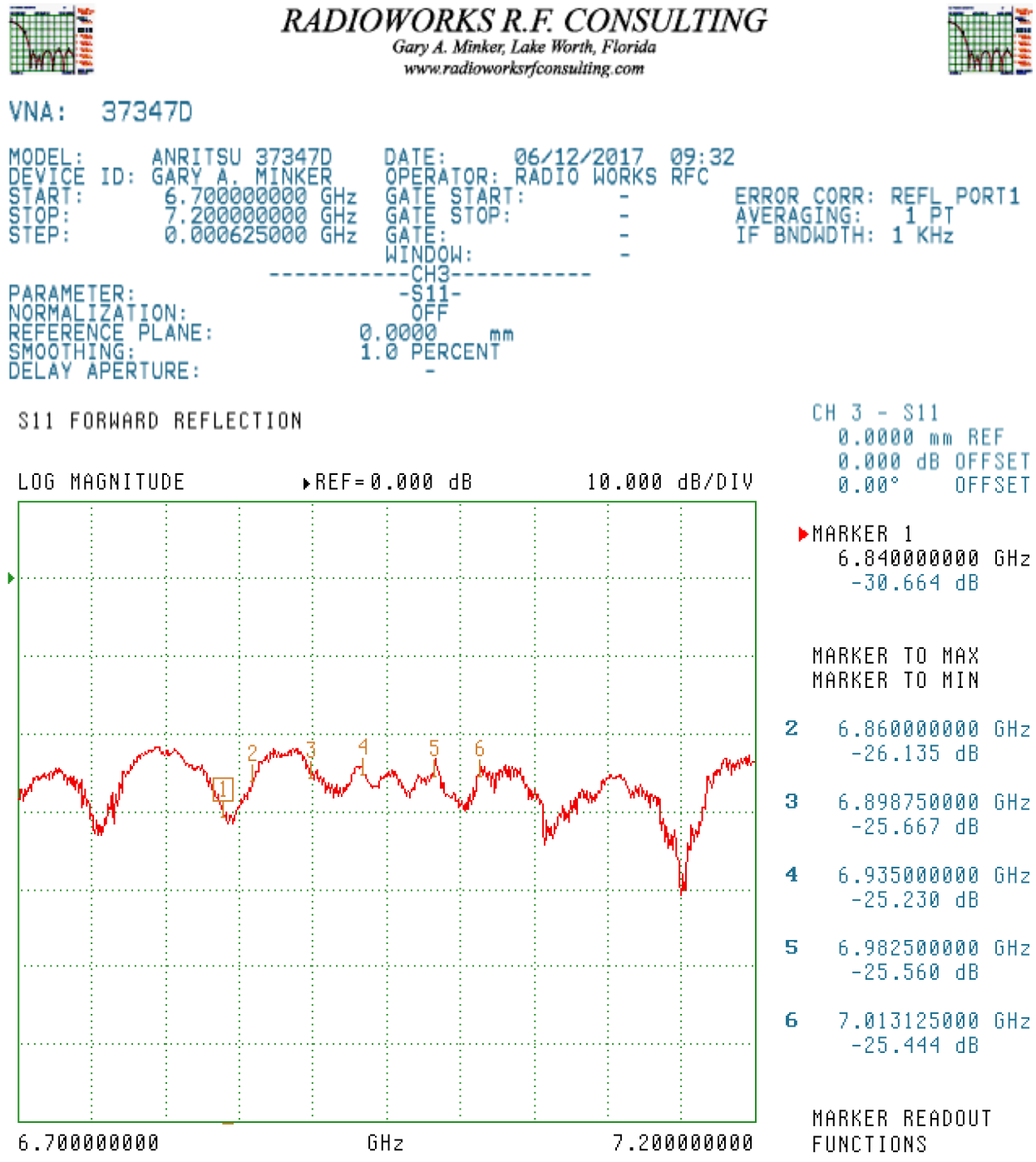

RADIOWORKS R.F. CONSULTING
Gary A. Minker, Lake Worth, Florida
www.radioworksrfconsulting.com
VNA: 37347D
MODEL: ANRITSU 37347D
DEVICE ID: GARY A. MINKER
START: 6.700000000 GHz
STOP: 7.200000000 GHz
STEP: 0.000625000 GHz
DATE: 06/12/2017 09:32
OPERATOR: RADIO WORKS RFC
GATE START: -
GATE STOP: -
GATE: -
WINDOW: -
ERROR CORR: REFL PORT1
AVERAGING: 1 PT
IF BNDWDTH: 1 KHz
CH3
PARAMETER: S11
NORMALIZATION: OFF
REFERENCE PLANE: 0.0000 mm
SMOOTHING: 1.0 PERCENT
DELAY APERTURE: -
S11 FORWARD REFLECTION
LOG MAGNITUDE
REF=0.000 dB
10.000 dB/DIV
6.700000000
GHz
7.200000000
CH 3 - S11
0.0000 mm REF
0.000 dB OFFSET
0.00° OFFSET
MARKER 1
6.840000000 GHz
-30.664 dB
MARKER TO MAX
MARKER TO MIN
2 6.860000000 GHz
-26.135 dB
3 6.898750000 GHz
-25.667 dB
4 6.935000000 GHz
-25.230 dB
5 6.982500000 GHz
-25.560 dB
6 7.013125000 GHz
-25.444 dB
MARKER READOUT
FUNCTIONS

FIGURE 2:

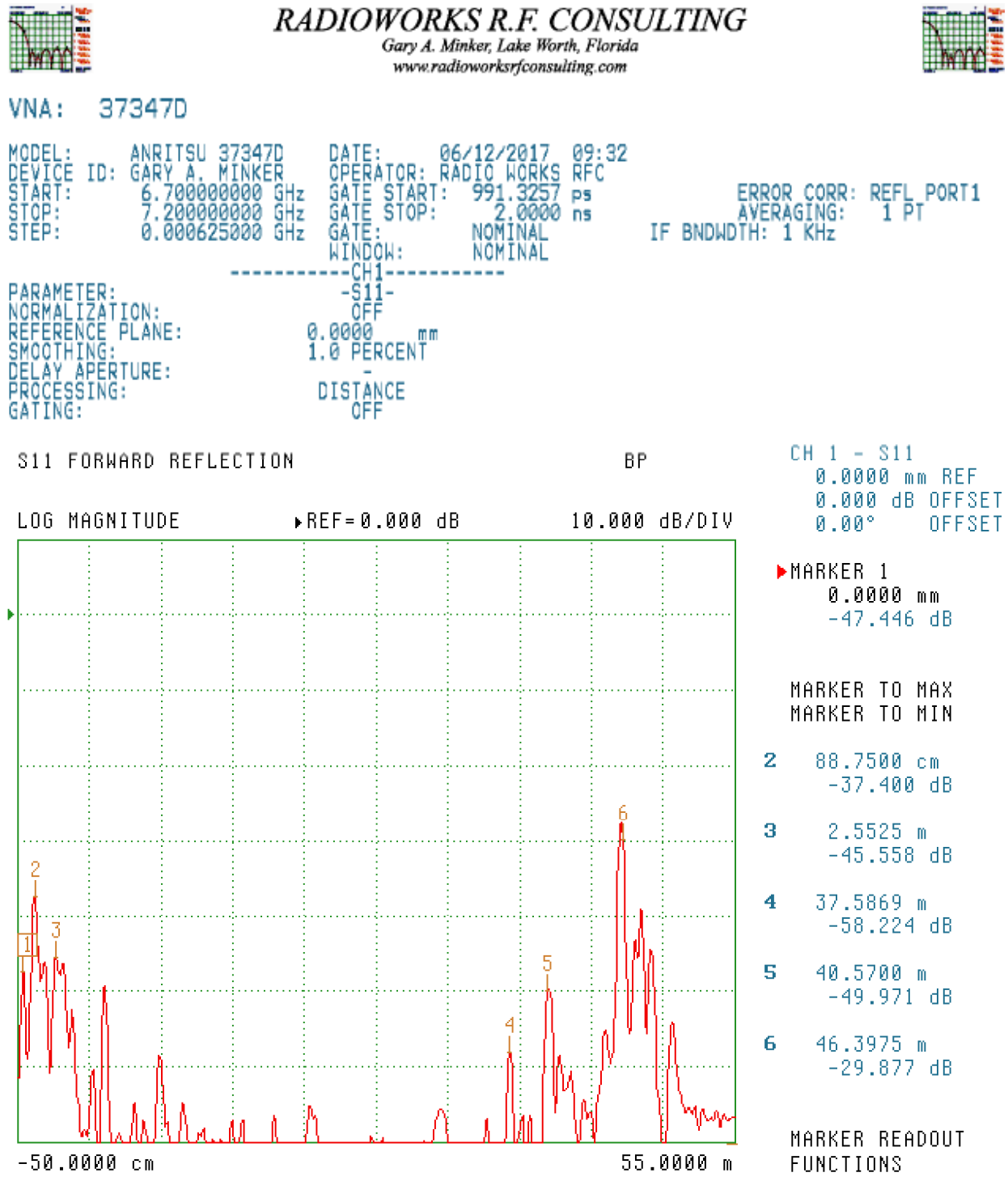

RADIOWORKS R.F. CONSULTING
Gary A. Minker, Lake Worth, Florida
www.radioworksrfconsulting.com
VNA: 37347D
MODEL: ANRITSU 37347D
DEVICE ID: GARY A. MINKER
START: 6.700000000 GHz
STOP: 7.200000000 GHz
STEP: 0.000625000 GHz
DATE: 06/12/2017 09:32
OPERATOR: RADIO WORKS RFC
GATE START: 991.3257 ps
GATE STOP: 2.0000 ns
GATE: NOMINAL
WINDOW: NOMINAL
ERROR CORR: REFL PORT1
AVERAGING: 1 PT
IF BNDWDTH: 1 KHz
CH1
PARAMETER: -S11-
NORMALIZATION: OFF
REFERENCE PLANE: 0.0000 mm
SMOOTHING: 1.0 PERCENT
DELAY APERTURE: -
PROCESSING: DISTANCE
GATING: OFF
S11 FORWARD REFLECTION
BP
LOG MAGNITUDE
REF=0.000 dB
10.000 dB/DIV
-50.0000 cm
55.0000 m
CH 1 - S11
0.0000 mm REF
0.000 dB OFFSET
0.00° OFFSET
MARKER 1
0.0000 mm
-47.446 dB
MARKER TO MAX
MARKER TO MIN
2 88.7500 cm
-37.400 dB
3 2.5525 m
-45.558 dB
4 37.5869 m
-58.224 dB
5 40.5700 m
-49.971 dB
6 46.3975 m
-29.877 dB
MARKER READOUT FUNCTIONS

FIGURE 3:

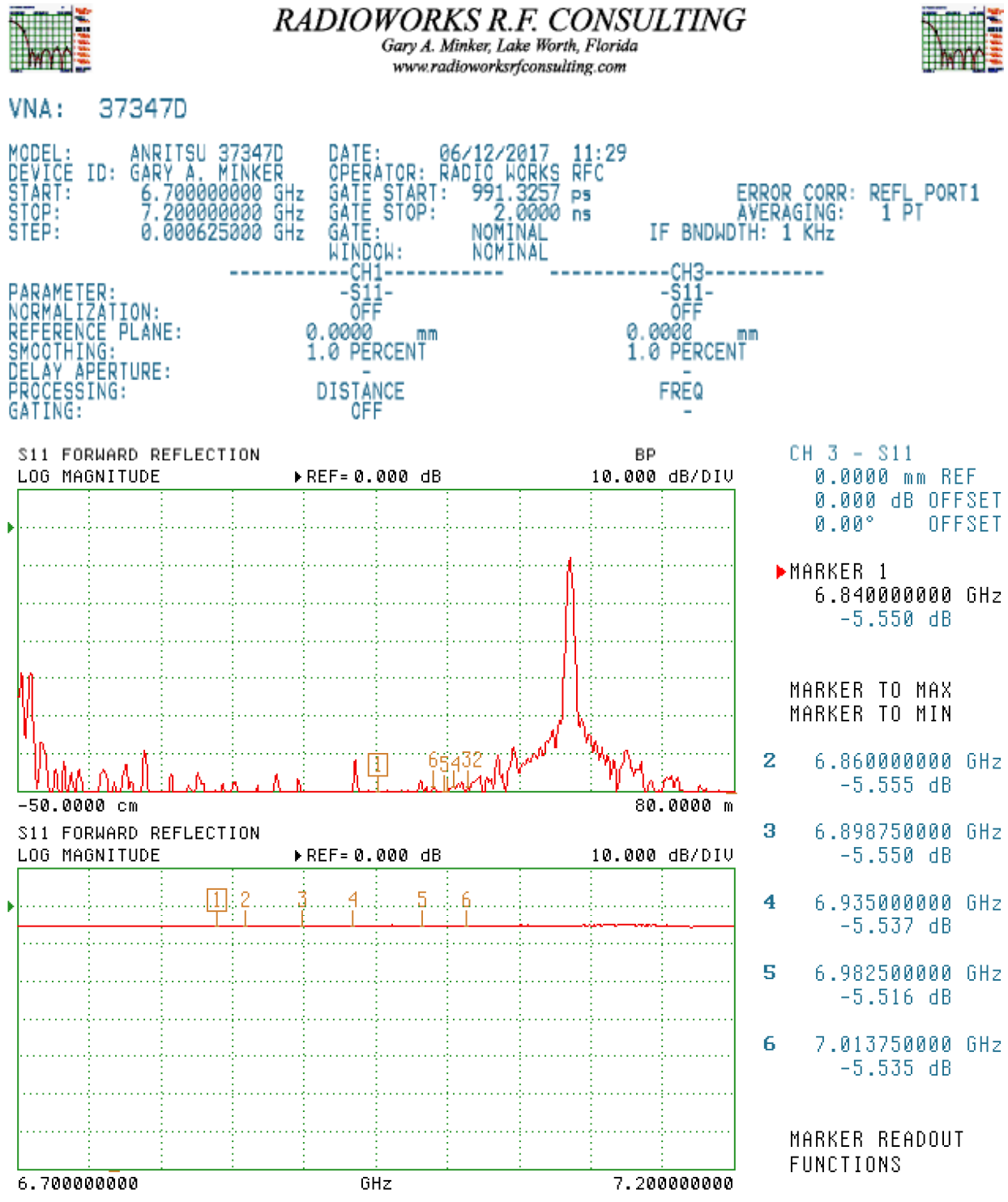
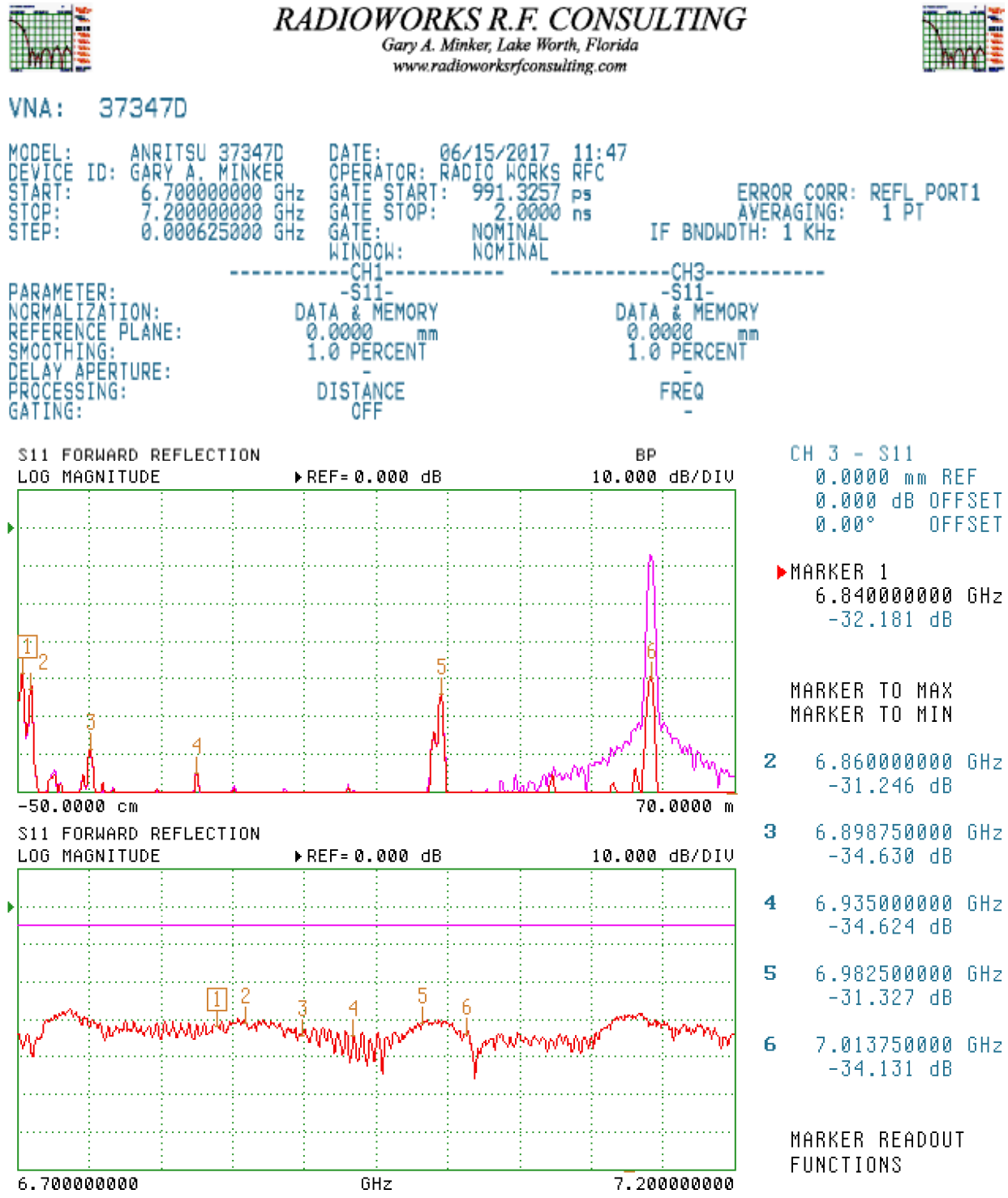

RADIOWORKS R.F. CONSULTING
Gary A. Minker, Lake Worth, Florida
www.radioworksrfconsulting.com
VNA: 37347D
MODEL: ANRITSU 37347D
DEVICE ID: GARY A. MINKER
START: 6.700000000 GHz
STOP: 7.200000000 GHz
STEP: 0.000625000 GHz
DATE: 06/12/2017 11:29
OPERATOR: RADIO WORKS RFC
GATE START: 991.3257 ps
GATE STOP: 2.0000 ns
GATE: NOMINAL
WINDOW: NOMINAL
ERROR CORR: REFL PORT1
AVERAGING: 1 PT
IF BNDWDTH: 1 KHz
CH1
CH3
PARAMETER: -S11- -S11-
NORMALIZATION: OFF OFF
REFERENCE PLANE: 0.0000 mm 0.0000 mm
SMOOTHING: 1.0 PERCENT 1.0 PERCENT
DELAY APERTURE: - -
PROCESSING: DISTANCE FREQ
GATING: OFF -
S11 FORWARD REFLECTION
LOG MAGNITUDE
REF= 0.000 dB
10.000 dB/DIV
BP
-50.0000 cm
80.0000 m
S11 FORWARD REFLECTION
LOG MAGNITUDE
REF= 0.000 dB
10.000 dB/DIV
6.700000000
GHz
7.200000000
CH 3 - S11
0.0000 mm REF
0.000 dB OFFSET
0.00° OFFSET
MARKER 1
6.840000000 GHz
-5.550 dB
MARKER TO MAX
MARKER TO MIN
2 6.860000000 GHz
-5.555 dB
3 6.898750000 GHz
-5.550 dB
4 6.935000000 GHz
-5.537 dB
5 6.982500000 GHz
-5.516 dB
6 7.013750000 GHz
-5.535 dB
MARKER READOUT
FUNCTIONS

FIGURE 4:

FIGURE 5:

FIGURE 6:


RADIOWORKS R.F. CONSULTING
Gary A. Minker, Lake Worth, Florida
www.radioworksrfconsulting.com
VNA: 37347D
MODEL: ANRITSU 37347D
DEVICE ID: GARY A. MINKER
START: 6.700000000 GHz
STOP: 7.200000000 GHz
STEP: 0.000625000 GHz
DATE: 06/15/2017 11:47
OPERATOR: RADIO WORKS RFC
GATE START: 991.3257 ps
GATE STOP: 2.0000 ns
GATE: NOMINAL
WINDOW: NOMINAL
ERROR CORR: REFL PORT1
AVERAGING: 1 PT
IF BNDWDTH: 1 KHz
CH1
CH3
PARAMETER: -S11- -S11-
NORMALIZATION: DATA & MEMORY DATA & MEMORY
REFERENCE PLANE: 0.0000 mm 0.0000 mm
SMOOTHING: 1.0 PERCENT 1.0 PERCENT
DELAY APERTURE: - -
PROCESSING: DISTANCE FREQ
GATING: OFF -
S11 FORWARD REFLECTION
LOG MAGNITUDE
REF= 0.000 dB
10.000 dB/DIV
BP
-50.0000 cm
70.0000 m
S11 FORWARD REFLECTION
LOG MAGNITUDE
REF= 0.000 dB
10.000 dB/DIV
6.700000000
GHz
7.200000000
CH 3 - S11
0.0000 mm REF
0.000 dB OFFSET
0.00° OFFSET
MARKER 1
6.840000000 GHz
-32.181 dB
MARKER TO MAX
MARKER TO MIN
2 6.860000000 GHz
-31.246 dB
3 6.898750000 GHz
-34.630 dB
4 6.935000000 GHz
-34.624 dB
5 6.982500000 GHz
-31.327 dB
6 7.013750000 GHz
-34.131 dB
MARKER READOUT
FUNCTIONS