SFDX Association Talk November 2nd 2011

Tower Safety, Coax & RF Fittings, Network Analyzers

Mark Lavallee

1. Tower Safety, Working at height
    1. Tower climbing, 100% tie off
    2. The most valuable asset.
    3. OSHA's view,
    4. Belt vs. climbing harness
    5. Tower rescues, things that are useful to know
    6. Some thoughts that run through your our head at height. Some are healthy some are counter productive.
    7. Fear vs Reason,
    8. Ground Crew Considerations
    9. Tools and hardware equal missiles that can kill.
2. How to select coaxial transmission line and RF Fittings
    1. What's best crimp or solder or both neither?
    2. Can you really use RG-58 on a 1.5 kilowatt Power Amplifier and run RTTY on HF?
    3. Solid center vs. stranded coax
    4. Times Microwave LMR cables Vs the RG or beldon coax
    5. Maximum Usable Frequency vs. cable diameter, it not entirely intuitive.
    6. RF bandwidth of coaxial cables
    7. Waveguide, why its so great!
    8. Link Budget and how it relates to your own cost budget.
3. Network analyzers (Best Antenna System Testers) and how they are used in commercial antenna systems for testing.
4. SWR and Return Loss a new way to think about forward and reflected power.

Tower Safety & Working at Height

1. The most valuable asset.
2. Tower climbing, 100% tie off.
3. Positioning belt or full body harness for fall arrest.
4. Ground crew considerations, drop zone & under the load?
5. Tools and hardware equal missiles that can kill.
6. Tower rescues, its important to know.
7. Some thoughts that run through a persons/my head at height. Some are healthy some are counter productive.
8. Fear vs. Reason, respecting height, understanding the danger.

FROM OSHA PUBLICATION

All fall protection products fit into four functional categories. 1. Fall Arrest; 2. Positioning; 3. Suspension; 4. Retrieval.

Fall Arrest

A fall arrest system is required if any risk exists that a worker may fall from an elevated position, as a general rule, **the fall arrest system should be used anytime a working height of six feet or more is reached.** Working height is the distance from the walking/working surface to a grade or lower level. A fall arrest system will only come into service should a fall occur. A full-body harness with a shock-absorbing lanyard or a retractable lifeline is the only product recommended. A full-body harness distributes the forces throughout the body, and the shock-absorbing lanyard decreases the total fall arresting forces.

Positioning

This system holds the worker in place while keeping his/her hands free to work. Whenever the worker leans back, the system is activated. However, the personal positioning system is not specifically designed for fall arrest purposes.

Suspension

This equipment lowers and supports the worker while allowing a hands-free work environment, and is widely used in window washing and painting industries. This suspension system components are not designed to arrest a free fall, a backup fall arrest system should be used in conjunction with the suspension system.

Retrieval

Preplanning for retrieval in the event of a fall should be taken into consideration when developing a proactive fall management program.

How to select coaxial transmission line and RF Fittings

1. Teaser- Can you use RG-58 @ 1.5 kilowatt and TX continuous RTTY on HF? Can you use RG-174 coax at 610kHz @ 1000 Watts power?
2. Link Budget; how it relates to your own cost budget and performance needs.
3. Attenuation per length, power handling capability, Coax Voltage vs. Current MUF, affordability
4. RF Fittings; what's best crimp, clamp, solder, or compression?
5. Solid center vs. stranded coax
6. How to choose; Hardline, Times Microwave LMR style, Beldon, Wireman?
7. Maximum Usable Frequency vs. cable diameter, it not entirely intuitive.
8. RF bandwidth of coaxial cables
9. Waveguide, why it's so great!
10. Answer to the RG-58 and RG-174 question

- Link Budget, how much signal do I really need, how much signal can I afford to loose?

- Chasing centibels, 10 centibels = 1 Decibel

- How Much Transmission Line Loss is too Much?

- What does the 0.5 dB of signal loss sound like in my RX? 1.0 and 2.0? How much did that 0.5 dB cost me?

- Where do I invest my antenna system money? The Coax, The Tower, or The Antenna?

COAXIAL CABLE - ATTENUATION & POWER HANDLING CALCULATOR

Coaxial Cable Data

Product:	LMR-400
Frequency (MHz):	29.5
Run Length (Feet):	100
Attenuation (db/100 feet):	0.671
Attenuation (db/100 mtrs):	2.204
Average Power (kW):	3.36
Total Run Attenuation(dB):	0.7
Efficiency (%):	85.7

COAXIAL CABLE - ATTENUATION & POWER HANDLING CALCULATOR

Coaxial Cable Data

Product:	LMR-400
Frequency (MHz):	14
Run Length (Feet):	100
Attenuation (db/100 feet):	0.461
Attenuation (db/100 mtrs):	1.513
Average Power (kW):	4.89
Total Run Attenuation(dB):	0.5
Efficiency (%):	89.9

COAXIAL CABLE - ATTENUATION & POWER HANDLING CALCULATOR

Coaxial Cable Data

Product:	LMR-400
Frequency (MHz):	54
Run Length (Feet):	100
Attenuation (db/100 feet):	0.912
Attenuation (db/100 mtrs):	2.994
Average Power (kW):	2.47
Total Run Attenuation(dB):	0.9
Efficiency (%):	81.0

COAXIAL CABLE - ATTENUATION & POWER HANDLING CALCULATOR

Coaxial Cable Data

Product:	RG-58
Frequency (MHz):	3.5
Run Length (Feet):	100
Attenuation (db/100 feet):	0.835
Attenuation (db/100 mtrs):	2.739
Average Power (kW):	1.63
Total Run Attenuation(dB):	0.8
Efficiency (%):	82.5

COAXIAL CABLE - ATTENUATION & POWER HANDLING CALCULATOR

Coaxial Cable Data

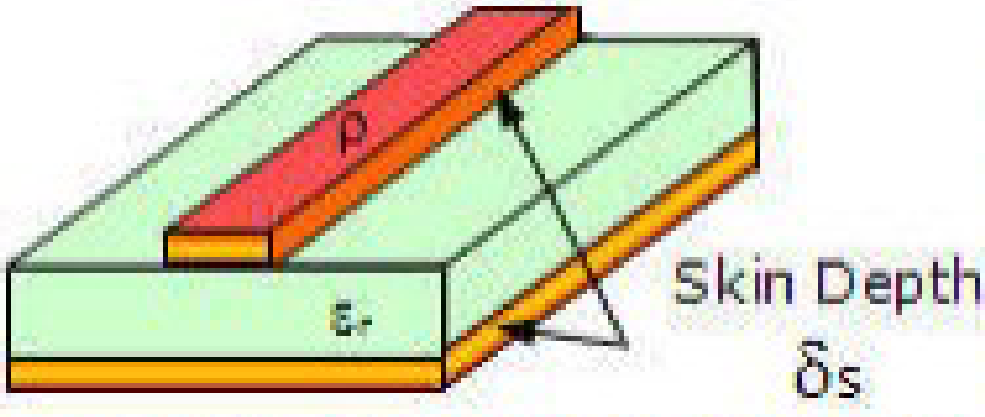
Product:	RG-58
Frequency (MHz):	.61
Run Length (Feet):	100
Attenuation (db/100 feet):	0.347
Attenuation (db/100 mtrs):	1.14
Average Power (kW):	3.91
Total Run Attenuation(dB):	0.3
Efficiency (%):	92.3

COAXIAL CABLE - ATTENUATION & POWER HANDLING CALCULATOR

Coaxial Cable Data

Product:	RG-174
Frequency (MHz):	.61
Run Length (Feet):	10
Attenuation (db/100 feet):	0.645
Attenuation (db/100 mtrs):	2.119
Average Power (kW):	1.35
Total Run Attenuation(dB):	0.1
Efficiency (%):	98.5

Skin Depth Equation Formula (aka Skin Effect)



As frequencies increase, conduction begins to move from an equal distribution through the conductor cross section toward existence almost exclusively near the surface. Depending on the conductor bulk

MACXLine® *MACX875B Series*

8 3/16 inch 75 Ohm Rigid Coaxial Line with Bellows

TV Channel	Frequency, MHz	Attenuation		Power	
		dB/100 ft	dB/100 m	Average, kW	Peak, kW
2	55.25	0.025	0.082	344.3	491.9
3	61.25	0.026	0.086	326.9	466.9
4	67.25	0.027	0.090	311.8	445.4
5	77.25	0.029	0.097	290.6	415.2
6	83.25	0.031	0.100	279.8	399.8
7	175.25	0.045	0.147	191.7	273.9
8	181.25	0.045	0.149	188.5	269.3
9	187.25	0.046	0.152	185.4	264.8
10	193.25	0.047	0.154	182.4	260.6
11	199.25	0.048	0.156	179.6	256.6
12	205.25	0.048	0.159	176.9	252.7
13	211.25	0.049	0.161	174.3	249.0
14	471.25	0.074	0.243	115.5	165.1
15	477.25	0.075	0.245	114.8	164.0

WR Waveguide *WR1800, WR1500,*

Standard Rectangular Waveguide

Thinwall (Unpressurized Only)

Channel Number	Visual Carrier MHz	Length, in (mm)	Attenuation, dB/100 ft	Type No.
14	471.25	143.62 (3648)	0.0474	WR1800-143.62
15	477.25	143.62 (3648)	0.0469	WR1800-143.62
16	483.25	143.62 (3648)	0.0464	WR1800-143.62
17	489.25	138.00 (3505)	0.0458	WR1800-138
18	495.25	138.00 (3505)	0.0453	WR1800-138
19	501.25	143.62 (3648)	0.0448	WR1800-143.62

Table I. Standard coax cable connector series and typical specifications.

Series	Frequency GHz	Power Watts*	Typ. Diameter inches	Relative Cost
BNC	0-4	80	0.6	Low
F	0-0.9	N/A	0.44	Low
N	0-11	300	0.8	Moderate
SMA	0-18	100	0.4	Moderate
TNC	0-11	100	0.6	Low
UHF	0-0.3	500**	0.85	Low
7-16 DIN	0-7.5	2,500	1.25	High

* At 1,000 GHz (See text) ** At 300 MHz

Vector Network Analyzers (VNA=best Antenna System Testers)

1. Bird watt meter lies, lies, and more damn lies
2. Return loss a new way to think about forward and reflected power, and SWR
3. Frequency vs. reflection amplitude is RL mode
4. Distance to fault mode
5. Cable insertion loss mode
6. My new antenna operates at 50KW I want to fully test it before I apply full power. I don't want to burn it up!
7. Ask me about commercial antenna fires, they are real and happen all the time…

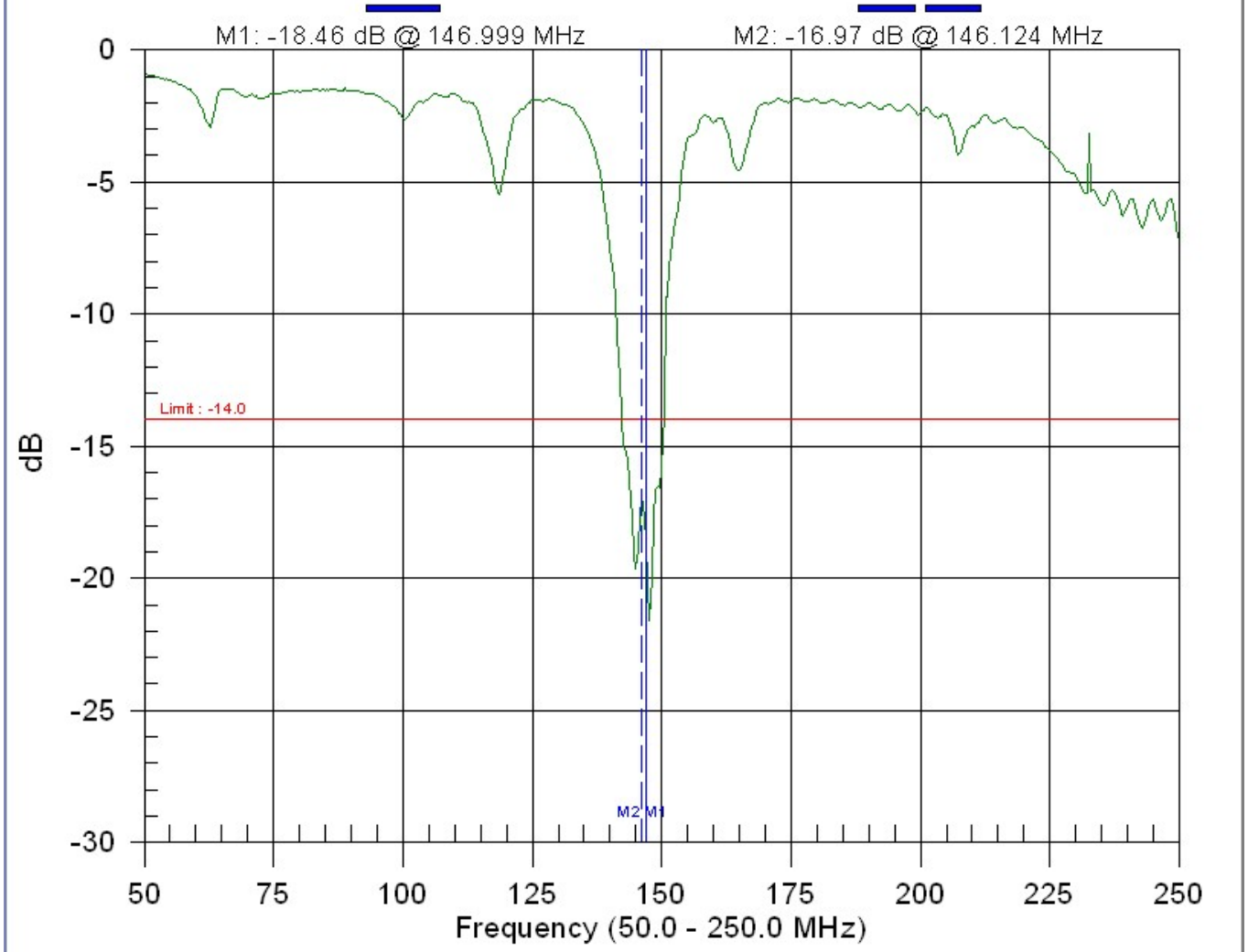
- Bird 43 requires a 50 Ohm System to provide accuracy in the Meter.
- When we have reflected power we have additional errors.
- The Bird is by it's dependence on the associated transmitter is a very narrow band device. Only looks at a small sliver of RF energy.
- Vulnerable to standing wave errors.
- Bird has an published specification accuracy of 5% of the slugs value.
- If you use a 2500 Watt Slug the measurement error could be 125 watts higher or lower, plus if there is reflected power, errors can be even higher, meter deflection errors, dirty contacts, etc.
- Bird is a pass fail meter, if it says the antenna is bad its likely bad, if it says its good it may be good or it may be bad.

Accuracy

CW (all models)	± 5% of full scale
Peak Power (43P only)	± 8% of full scale

Return Loss

W4AB @ 110 Tower



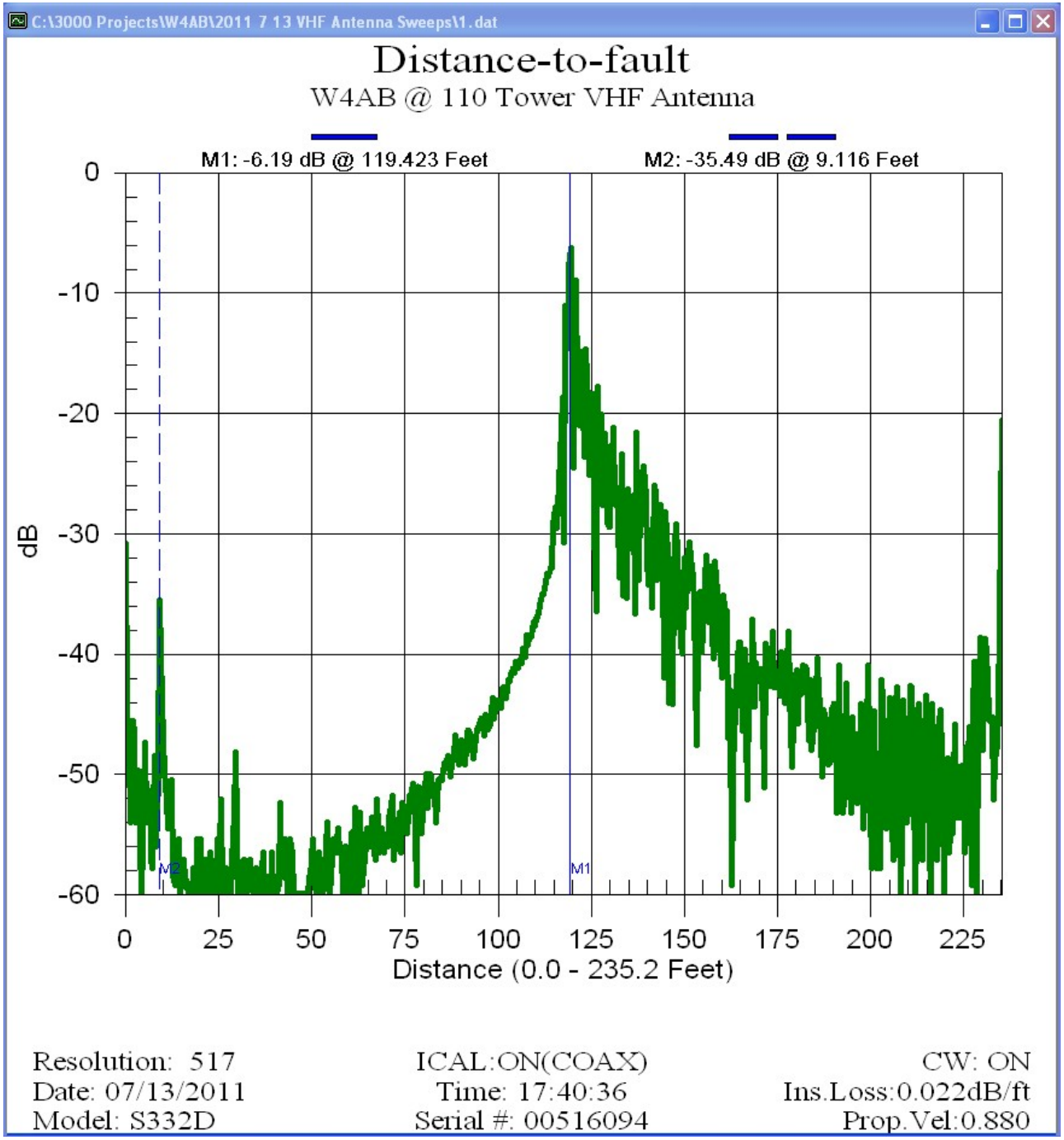
Resolution: 517
Date: 07/13/2011
Model: S332D

ICAL:ON(COAX)
Time: 17:46:46
Serial #: 00516094

CW: ON

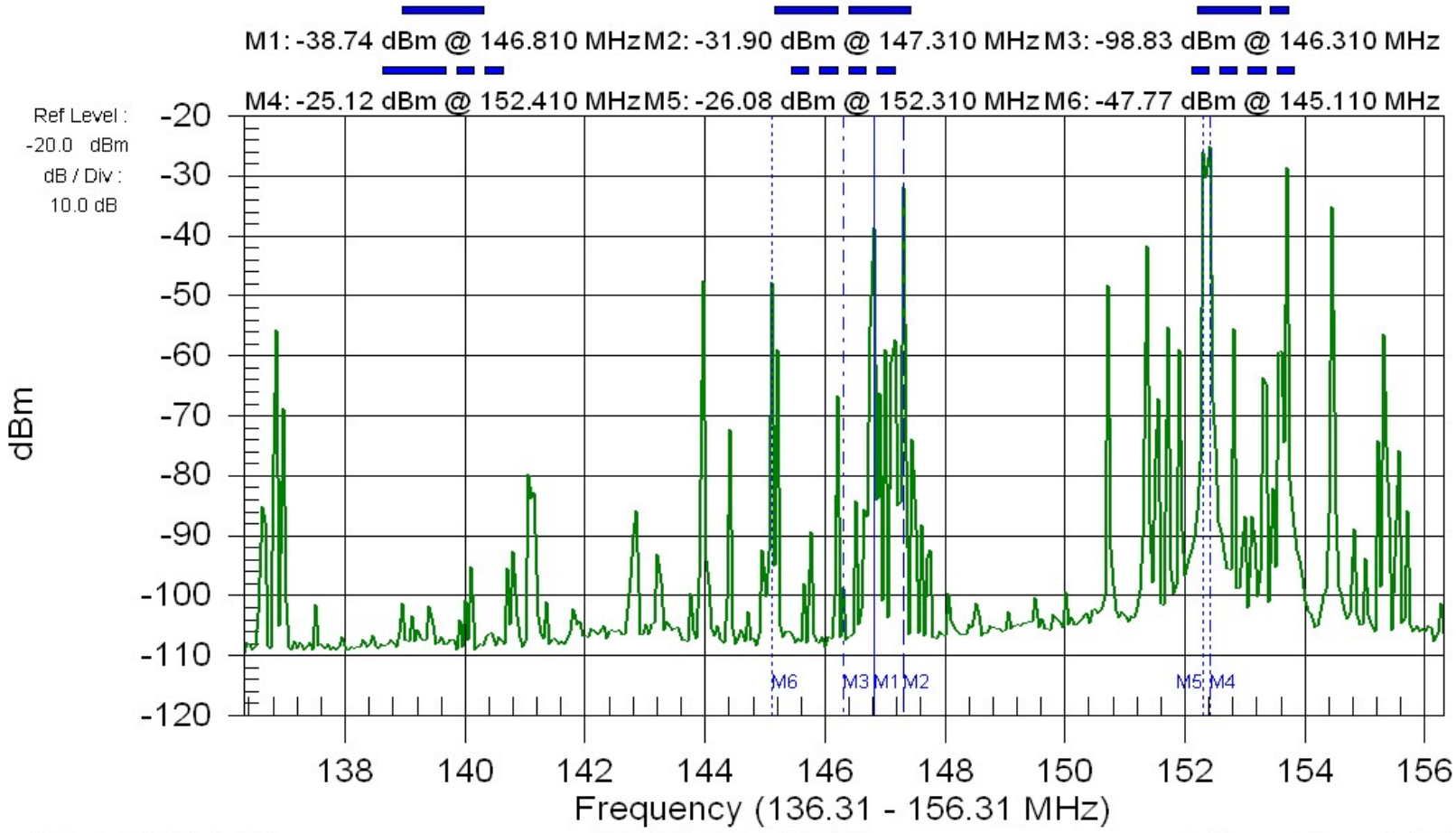
VSWR	Reflection coefficient	Return loss	Notes
1:1	0.00	infinity	a perfect match
1.1:1	0.05	26.44	
1.2:1	0.09	20.83	
1.3:1	0.13	17.69	
1.4:1	0.17	15.56	
1.5:1	0.20	13.98	A good rule of thumb: 1.5:1 = 14 dB
1.6:1	0.23	12.74	
1.7:1	0.26	11.73	
1.8:1	0.29	10.88	
1.9:1	0.31	10.16	A good rule of thumb: 1.9:1 = 10 dB
2.0:1	0.33	9.54	
3.0:1	0.50	6.02	A good rule of thumb: 3:1 = 6 dB
4.0:1	0.60	4.44	
5.0:1	0.67	3.52	
6.0:1	0.71	2.92	
10:1	0.82	1.71	
infinity:1	1.000	0.00	short or open circuit

VSWR	Return Loss (dB)	% Power / Voltage Loss	Reflection Coefficient	Mismatch Loss (dB)
1	∞	0 / 0	0	0.000
1.15	23.1	0.49 / 7.0	0.07	.021
1.25	19.1	1.2 / 11.1	0.111	.054
1.5	14.0	4.0 / 20.0	0.200	.177
1.75	11.3	7.4 / 27.3	0.273	.336
1.9	10.0	9.6 / 31.6	0.316	.458
2.0	9.5	11.1 / 33.3	0.333	.512
2.5	7.4	18.2 / 42.9	0.429	.880
3.0	6.0	25.1 / 50.0	0.500	1.25
3.5	5.1	30.9 / 55.5	0.555	1.6
4.0	4.4	36.3 / 60.0	0.600	1.94
4.5	3.9	40.7 / 63.6	0.636	2.25
5.0	3.5	44.7 / 66.6	0.666	2.55
10	1.7	67.6 / 81.8	0.818	4.81
20	0.87	81.9 / 90.5	0.905	7.4
100	0.17	96.2 / 98.0	0.980	14.1
∞	.000	100 / 100	1.00	∞


C:\3000 Projects\W4AB\2011 7 13 VHF Antenna Sweeps\1.dat
Distance-to-fault
W4AB @ 110 Tower VHF Antenna
M1: -6.19 dB @ 119.423 Feet
M2: -35.49 dB @ 9.116 Feet
0
-10
-20
-30
-40
-50
-60
dB
M2
M1
0
25
50
75
100
125
150
175
200
225
Distance (0.0 - 235.2 Feet)
Resolution: 517
Date: 07/13/2011
Model: S332D
ICAL:ON(COAX)
Time: 17:40:36
Serial #: 00516094
CW: ON
Ins.Loss:0.022dB/ft
Prop.Vel:0.880

Spectrum Analyzer

W4AB Antenna System 110 Tower 450' AGL



CF: 146.31 MHz
SPAN: 20.00 MHz
Attenuation: 10 dB
RBW: 100 Hz
VBW: 1 MHz
Detection: Pos. Peak
MaxHold: ON
Std: AMPS / EIA 553
Min Sweep Time: 1.00 Milli Sec
Date: 07/13/2011
Time: 18:17:05
Model: S332D
Serial #: 00516094

Ask me about Broadcast Antenna fires, they are real and happen all the time…