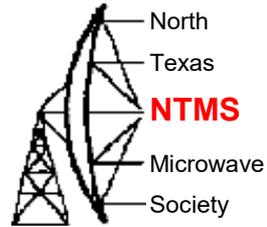


Dielectric Window Losses at 24 and 47 GHz

W5LUA

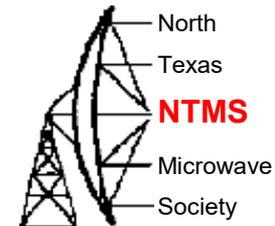
March 14, 2026

Introduction



- Part 1 will deal with dielectric window losses at 24 GHz in WR-42
- Part 2 will deal with dielectric losses as windows for 47 GHz Feedhorns

Various Commercial WR-42 Pressure Windows



Andrew #55000A-42

Unknown Mfg

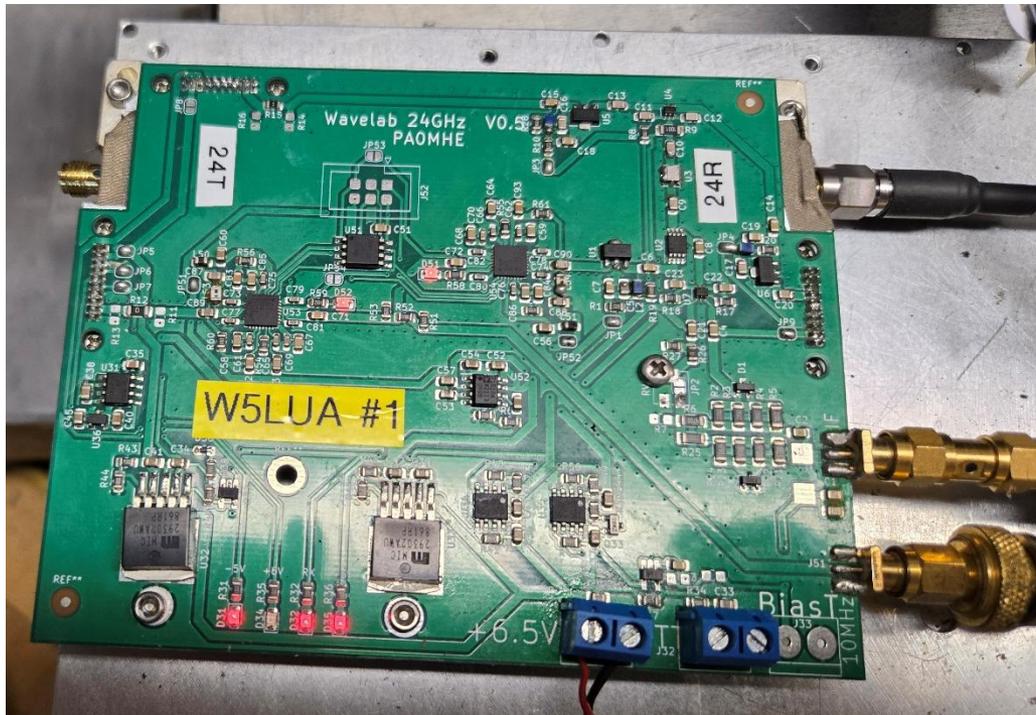
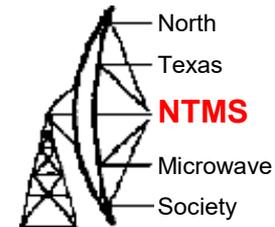


The Andrew unit is 2 pieces
 Could be a good test bed for
 evaluating other dielectric
 windows. Windows appear
 to be mylar



Commercial 23 GHz Radio

24 GHz Wavelab Transverter used as test downconverter

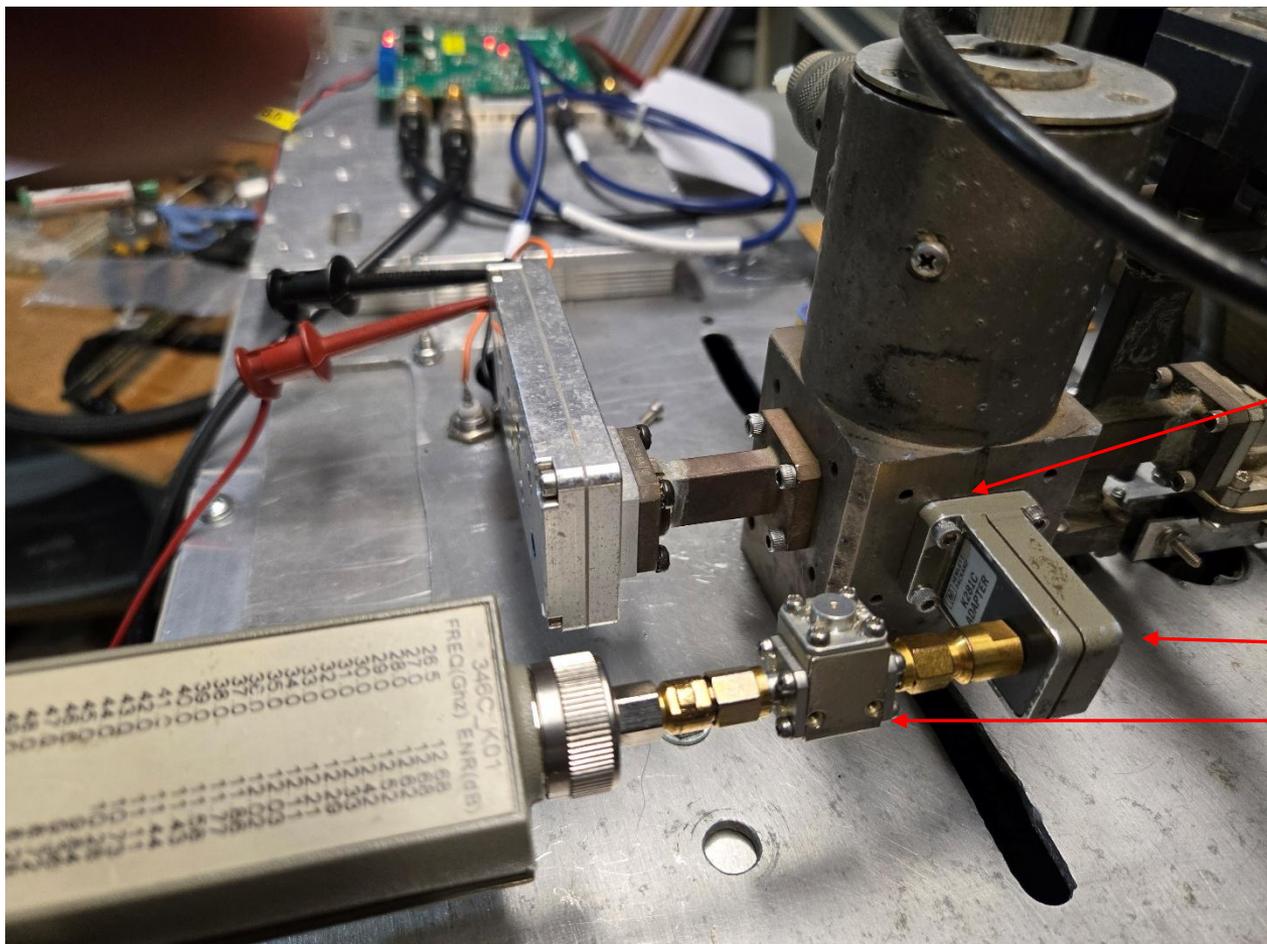
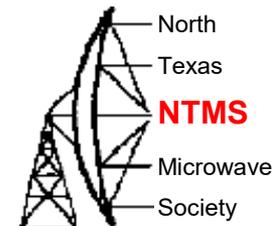


RF input
through 2.5 dB
cable loss to
LNA

144 MHz IF

10 MHz Ref Input

DU3T LNA & WR-42 W/G Relay



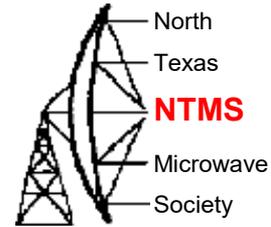
DU3T LNA & W/G
Relay measures 27.8
dB gain and 1.74 dB
NF @ 24.192 GHz

Install window being
measured here. The
increase in NF
corresponds to the
loss of the window.

HP K281C Adapter
SMT 1CY63 Isolator

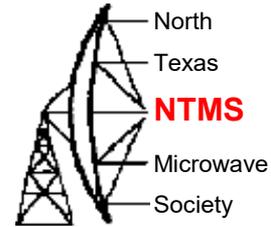
Agilent 346C-K01 50 GHz Noise Source

Measured Loss at 24 GHz

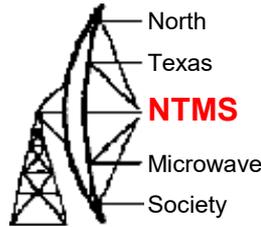


Loss	Window Thickness	Details			
0 dB	No window	Reference			
.05 dB	.0005"	Saran Wrap			
.06 dB	.002"	Kapton			
.10 dB	.0035"	Andrew pressure window #55000A-42			
.15 dB	.0015"	Pressure window - unknown origin			
.16 dB	.007"	Kapton			
.20 dB	.0035"	mica insulator			
.25 dB	.007"	Feed through guide for 23 GHz, opaque			

Part 2

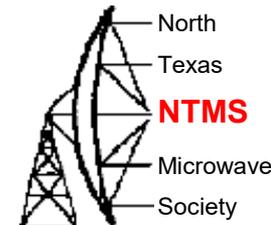


- Jim KM5PO has built several beacons for 24 and 47 GHz and the question about losses of dielectric windows came up.
- I decided to build up a test range using two identical horns and a small range in my shop.



Far Field

- Far field is the minimum distance to the receive antenna that guarantees it acts like a plane wave regardless of distance
- $R > \text{or} = \frac{2 D^2}{\lambda}$
- λ
- $D = \text{Diameter} = 1.375''$ and λ should be in the same units. Wavelength $\lambda = .25''$ at 47 GHz
- $R \text{ min} = 15.125''$



Notes:
Vamp=+3.5V
8340 +4.9 dBm

W1GHZ Horn

WR-22
to 2.4 mm

14"

35.5"

Test Platform

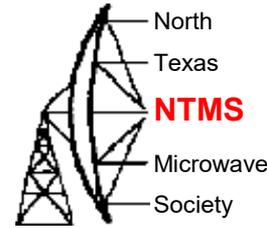
W1GHZ 47 GHz Horn

HP 8487A Power Sensor

Wiltron 13-20 GHz Amplifier

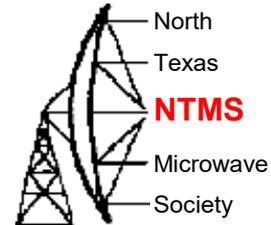


Next step is to analyze the path



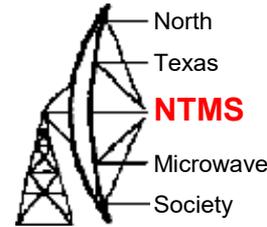
- Do we have enough signal to run a test?
- Multiplier puts out about -2 dBm at 47 GHz
- Received signal about -24 dBm which is over 20 dB over the noise on the E4419B power meter
- Make relative loss measurement by placing the dielectric under test at the mouth of the transmit horn and compare to no window. Results to follow

47 GHz Dielectric Loss



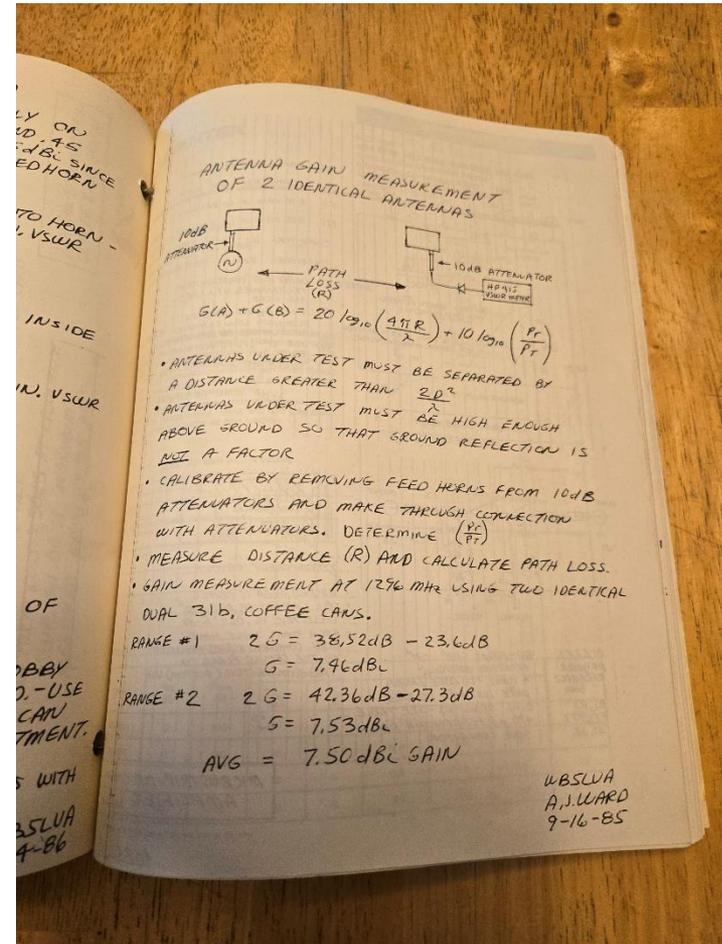
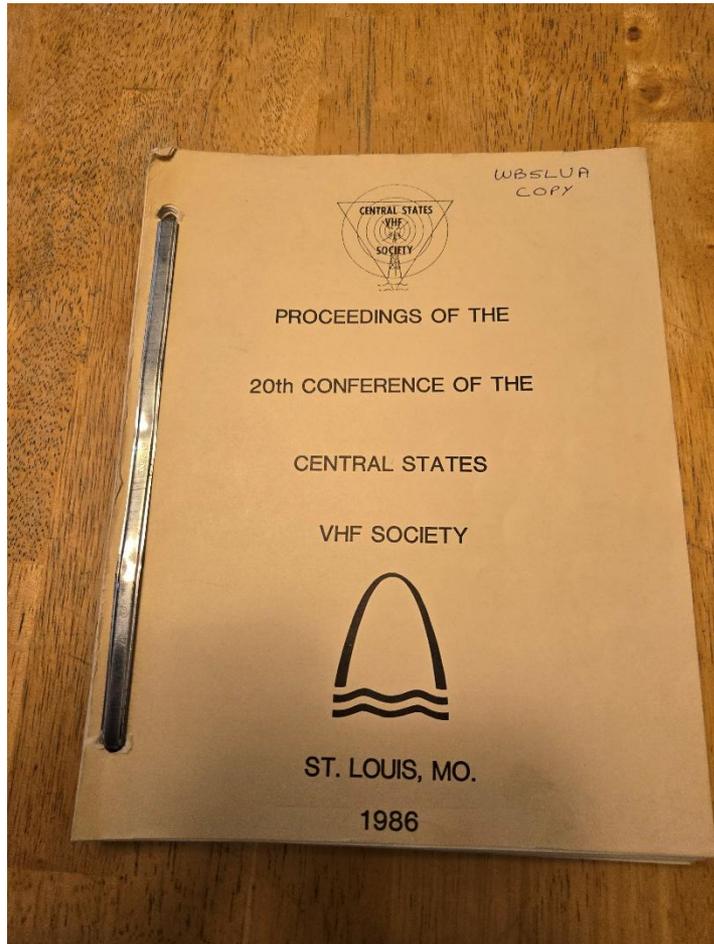
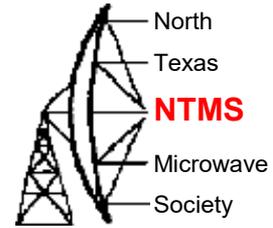
Dielectric Window loss at 47 GHz		
Loss	Window Thickness	Details
0 dB	No window	Reference
.05 dB	.0005"	Saran Wrap
.07 dB	.002"	Kapton
.12 dB	.010"	Teflon
.14 dB	.003"	Plastic painter's drop cloth
.27 dB	.007"	Kapton
.4 dB	.007"	mylar?
.62 dB	.060"	Sterilite 6qt container

Why not measure the Horn Gain?

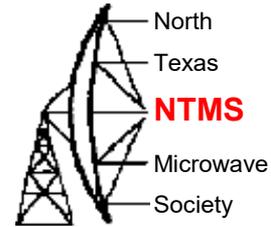


- If we know input power, output power, and we can calculate path loss and we have 2 identical horns, then we can calculate the gain of a single horn.
- I first talked about this sort of test at the Central States VHF Society in St. Louis, MO in 1986.

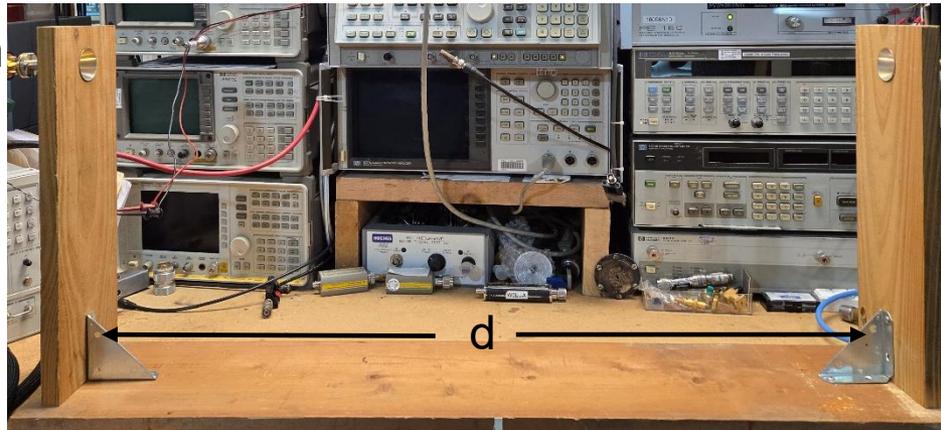
Before the ARRL was publishing our Proceedings



Test Method



$P_{in} = -2.1 \text{ dBm}$



$P_{out} = -24.5 \text{ dBm}$

$D = 35.5''$

$\lambda = .25'' \text{ at } 47 \text{ GHz}$

Horn

Path Loss

Horn

$$P_{in} + G_{\text{Horn}} - \text{Path loss} + G_{\text{Horn}} = P_{out}$$

$$\text{Path Loss} = 10 \log (4\pi d/\lambda)^2 = 65 \text{ dB}$$

$$\text{Horn Gain} = (\text{Path loss} + P_{out} - P_{in}) / 2 = 21.3 \text{ dBi}$$

Aperture Gain

$$A = 1.375''$$

$$\lambda = .25'' \text{ at } 47 \text{ GHz}$$

Gain (directivity) = $10 \log (4\pi A / \lambda^2) = 24.4 \text{ dBi}$ calculated

Measured Gain = 21.3 dBi

Paul Wade said he simulated about 22 dBi

Efficiency possibly 50% or maybe better?

Maybe close...

Could be low due to...

Antenna range reflections?

Range could be longer outside.

Test equipment variations

But you get the idea...

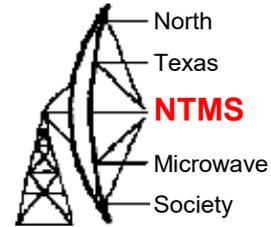
2.9507148?

- $2.9507148 / F_{\text{(GHz)}} = \lambda/4$ in inches
- i.e. $2.9507148 / 47.088 = .06266'' \frac{1}{4} \lambda$
- Wavelength = $.25065''$ at 47.088 GHz

2.9507148

- $\lambda = c / f = \frac{2.99792458 \times 10^8 \text{ m/sec}}{\text{Frequency c/sec}}$
- 1m = 39.3701”
- Converting to inches and GHz
- $\lambda = 11.8028590507 / F \text{ (GHz)}$
- Therefore $\lambda/4 = 2.95071476268 / F \text{ (GHz)}$
- Why not just remember a short cut?

Summary



- I do not pressurize my EME system on 24 GHz – Just trying to keep insects out of my Feedhorn and Relay. For my application, the .0005” Saran Wrap is the lowest loss.
- Saran Wrap also works fine at 47 GHz.
- .002” Kapton would be my choice for a pressurized system where Saran wrap won’t handle the pressure.
- Losses at 10 GHz should be even lower.
- My gain goal of this project was to measure dielectric losses at 24 and 47 GHz.
- Hopefully covering the other subjects was also beneficial.
- Any Questions?