

Basics of “Snow Flaking”

Modifying and Tuning Microstrip Circuits

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March 2016



Tuning Microwave Circuit Boards

- The physical behavior of electricity changes with frequency.
- At DC and low frequencies, wires are adequate to convey electrical power.
- At radio frequencies, specially designed transmission lines (T/Ls) are necessary.
- At microwave frequencies, more sophisticated T/Ls are required.

A Ku-Band LNB for TV:

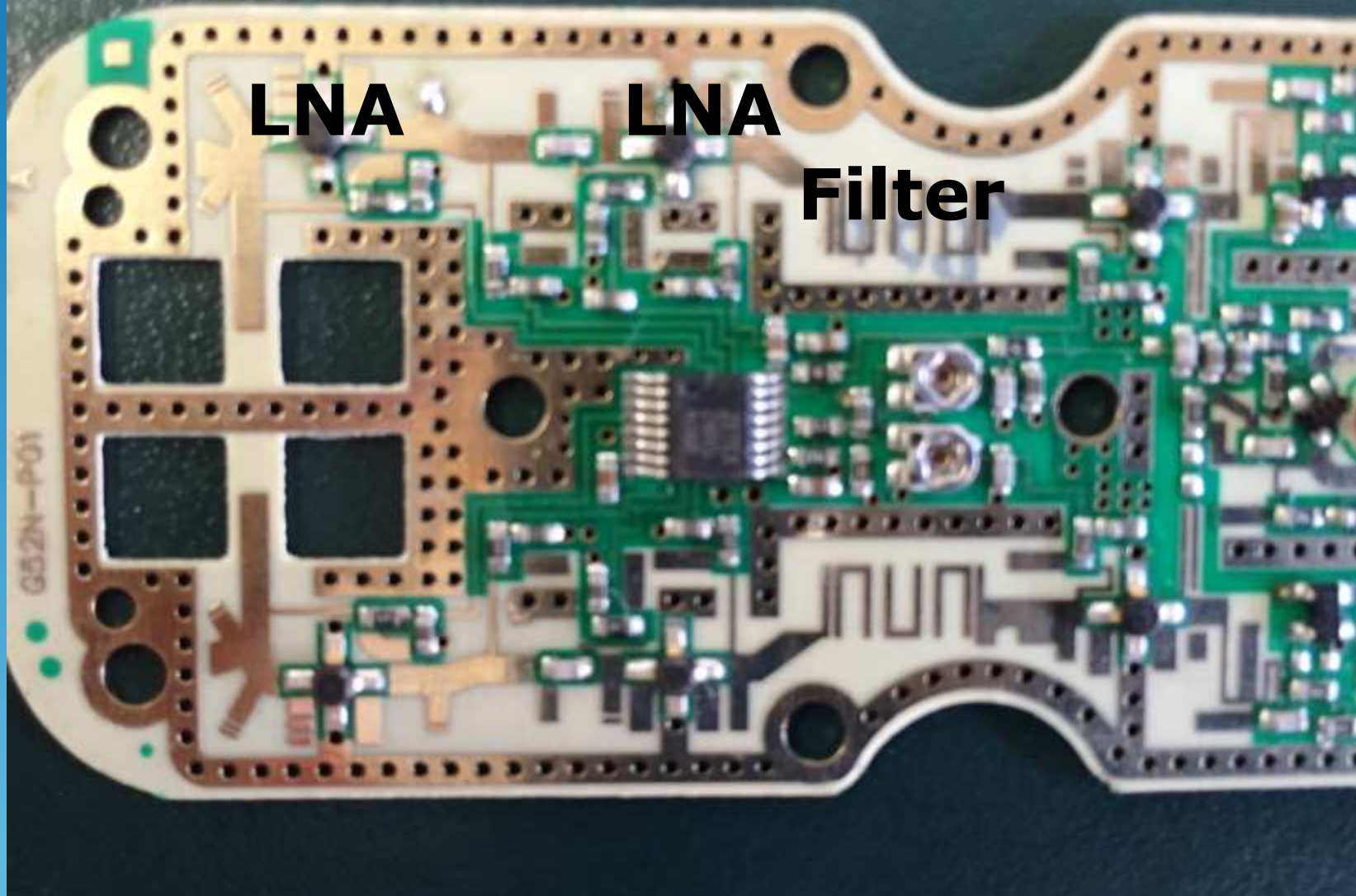
Can these be used for
Amateur 10 GHz?

Sometimes



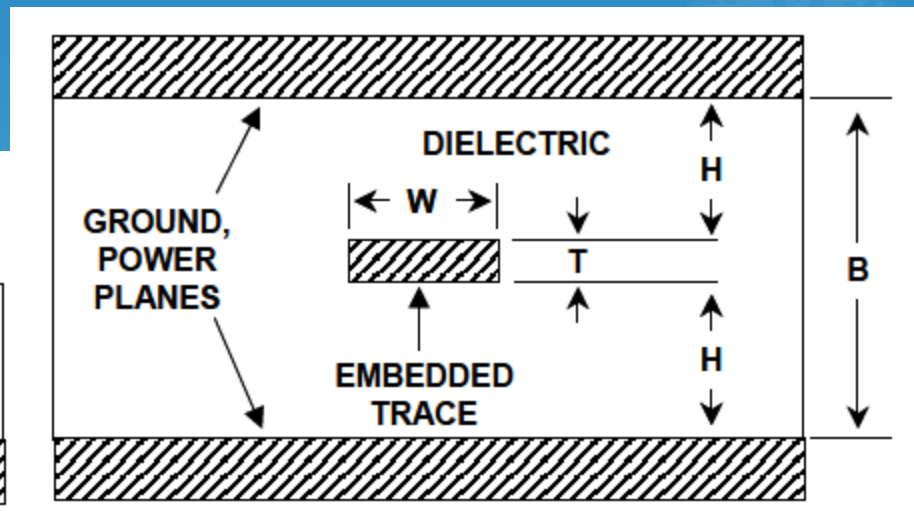
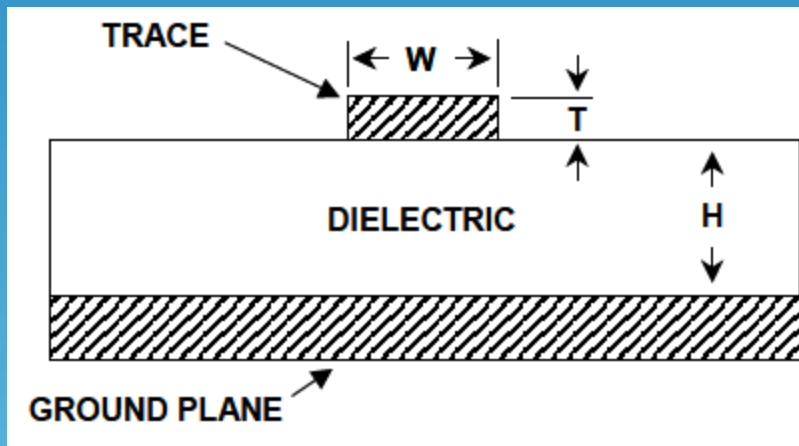
A Ku-Band LNB for Direc-TV:

Example of microstrip LNAs & Filter



Microstrip and Stripline

"MICROSTRIP"



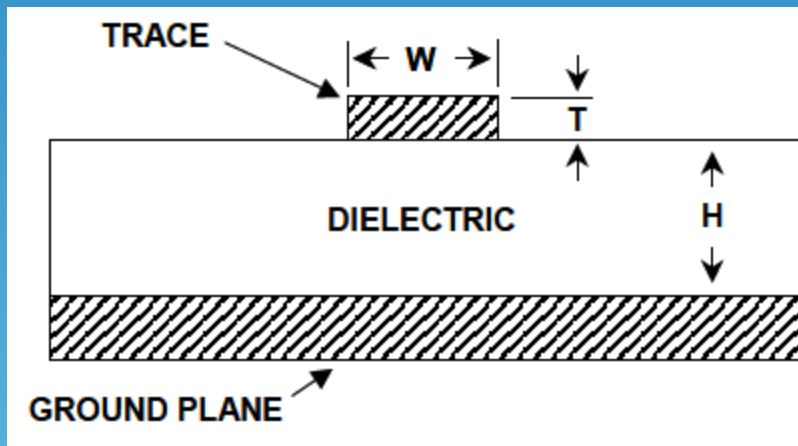
"STRIPLINE"

Microstrip and Stripline

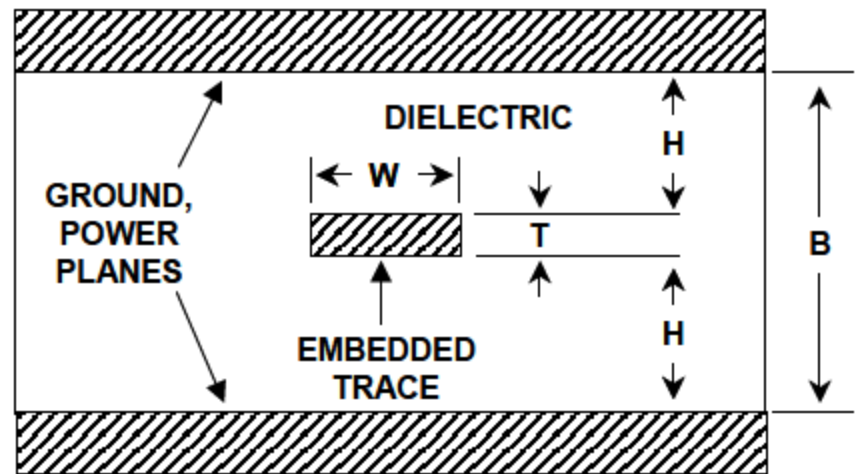
Impedance (Z_o) Calculation

$$Z_o(\Omega) = \frac{60}{\sqrt{\epsilon_r}} \ln \left[\frac{1.9(B)}{(0.8W + T)} \right]$$

"MICROSTRIP"



$$Z_o(\Omega) = \frac{87}{\sqrt{\epsilon_r + 1.41}} \ln \left[\frac{5.98H}{(0.8W + T)} \right]$$

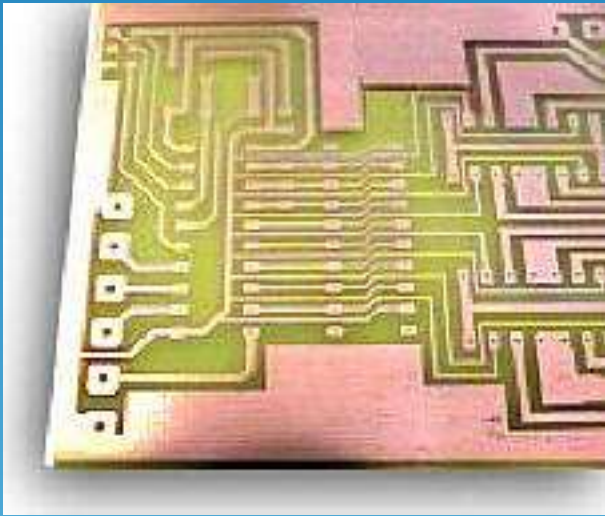


"STRIPLINE"

Microstrip

Typical Circuit Materials

Dielectric Constant (ϵ_r)



G-10 Fiberglass
(Epoxy)
 $\epsilon_r - 4.7$





RT-Duroid
(Teflon)
 $\epsilon_r - 2.2$


http://www.mantaro.com/resources/impedance_calculator.htm


resources/impedance_calculator.htm Impedance Calculators - M... help

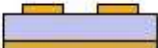
Calculator Group: PCB Microstrip Structures



Microstrip Zo


Width from Zo


Mitered Corner


Microstrip Zdiff

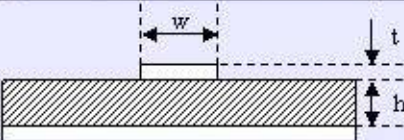

Zdiff from Zo


Embedded Zo

Microstrip Impedance Calculator

Note: valid for (w/h) from 0.1 to 3.0
Dimensional units: ☐ mm ☒ mils

| | |
|-------------------------------------|------|
| w (trace width) = | 111 |
| t (trace thickness) = | 1.37 |
| h (dielectric thickness) = | 62.5 |
| er (relative dielectric constant) = | 4.7 |



| | |
|-------------------------------------|---------|
| Zo (Single Ended Impedance, Ohms) = | 50.045 |
| Propagation Delay, Tpd (ps/inch) = | 144.23 |
| Inductance, L (nH/in) = | 7.218 |
| Capacitance, C (pF/in) = | 2.88198 |
| DC Resistance, Rdc (mOhm/in) = | 4.453 |

Note: 1oz = 1.4mils = 0.03556mm

$$Z_0 = \frac{87}{\sqrt{\epsilon_r + 1.41}} \ln \left(\frac{5.98h}{(0.8w + t)} \right) \quad T_{pd} = 3.333 \sqrt{0.475 \cdot \epsilon_r + 0.67} \left(\frac{ns}{meter} \right)$$

<http://www.eeweb.com/toolbox/microstrip-impedance>








EEWeb.com/toolbox/microstrip-impedance

Tools Help

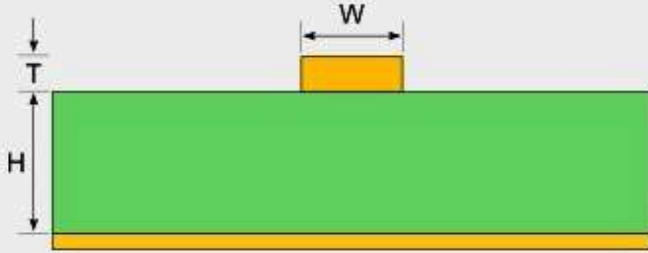
Join EEWeb's Community: Sign-Up or Login

EEWeb Microstrip Impedance Calculator

Choose Type

-  **Microstrip**
-  **Embedded Microstrip**
-  **Symmetric Stripline**
-  **Asymmetric Stripline**
-  **Wire Microstrip**
-  **Wire Stripline**
-  **Edge-Coupled Microstrip**

Microstrip Impedance Calculator



Inputs

| | | | | |
|----------------------|----|-------------------------------------|-----------------------------------|----------------------------------|
| Trace Thickness | T | <input type="text" value=".00137"/> | <input type="text" value="inch"/> | <input type="button" value="v"/> |
| Substrate Height | H | <input type="text" value=".0625"/> | <input type="text" value="inch"/> | <input type="button" value="v"/> |
| Trace Width | W | <input type="text" value=".112"/> | <input type="text" value="inch"/> | <input type="button" value="v"/> |
| Substrate Dielectric | Er | <input type="text" value="4.7"/> | | |

Output

Impedance (Z): 50.0 Ohms

Microstrip

Typical 50-Ohm line Width (inches)

| PCB Material (1oz. Cu) | | .0625" | | .03125" |
|------------------------|--|--------|--|---------|
| G10 Fiberglass | | .112" | | .056" |
| RT Duroid | | .155" | | .077" |
| | | | | |

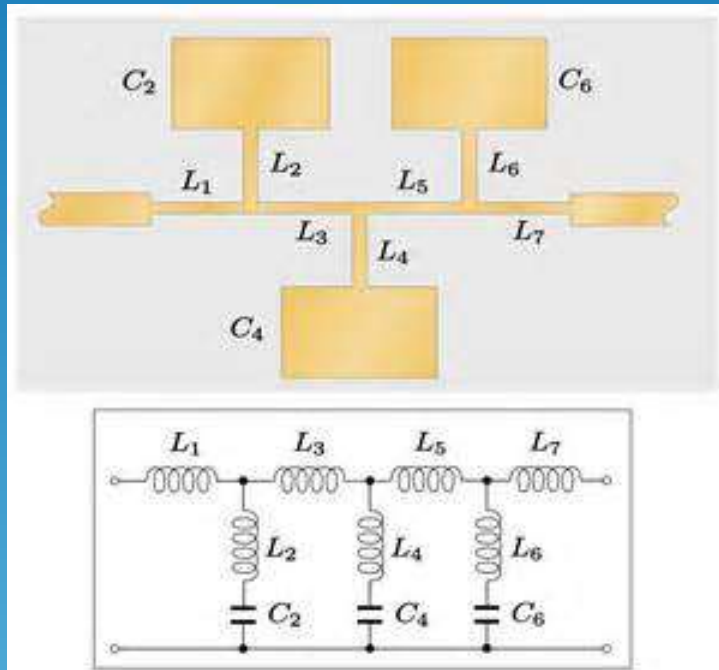
Dielectric Constant (Er)

G-10 Fiberglass
(Epoxy)
Er – 4.7

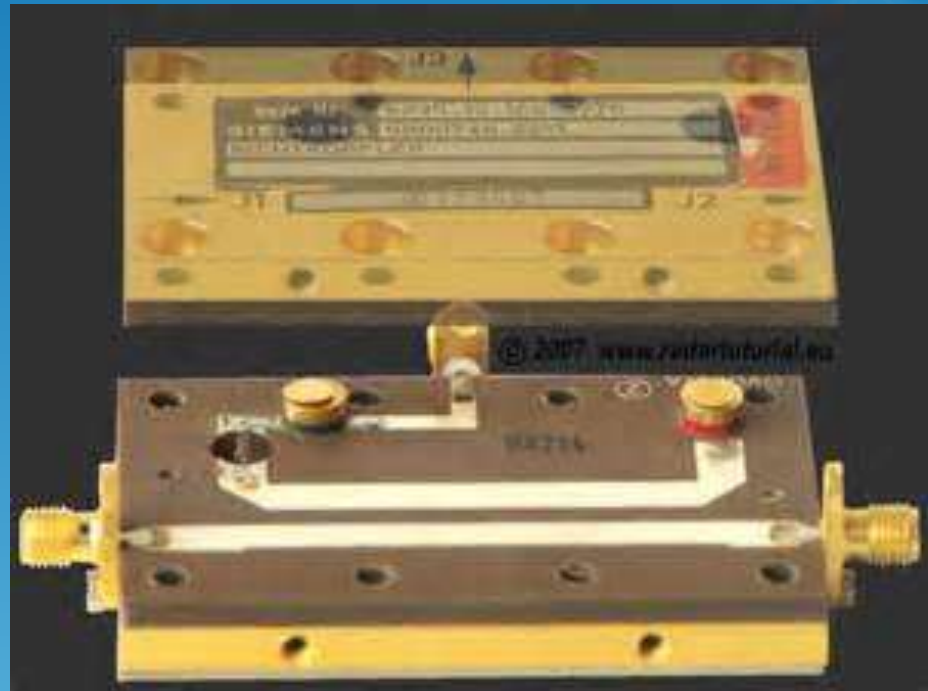
RT Duroid
(Teflon)
Er – 2.2

Microstrip Components

CAPACITORS



TRANSFORMER

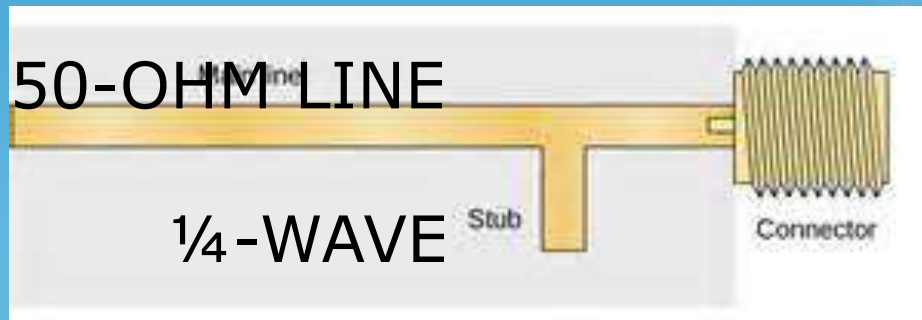


50-OHM LINE

$\frac{1}{4}$ -WAVE

Stub

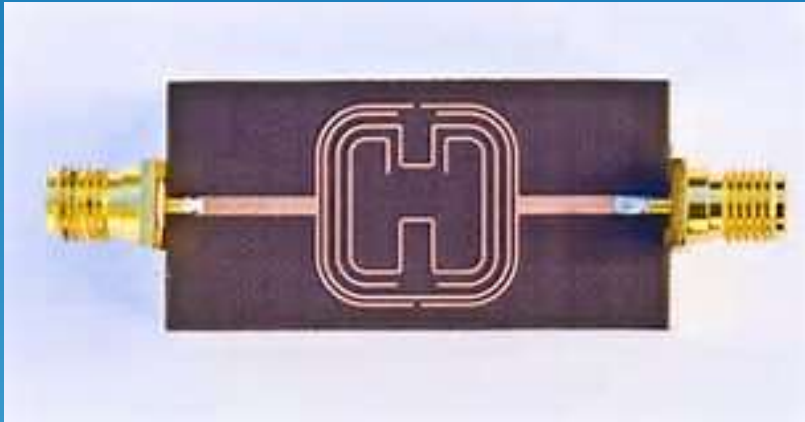
Connector



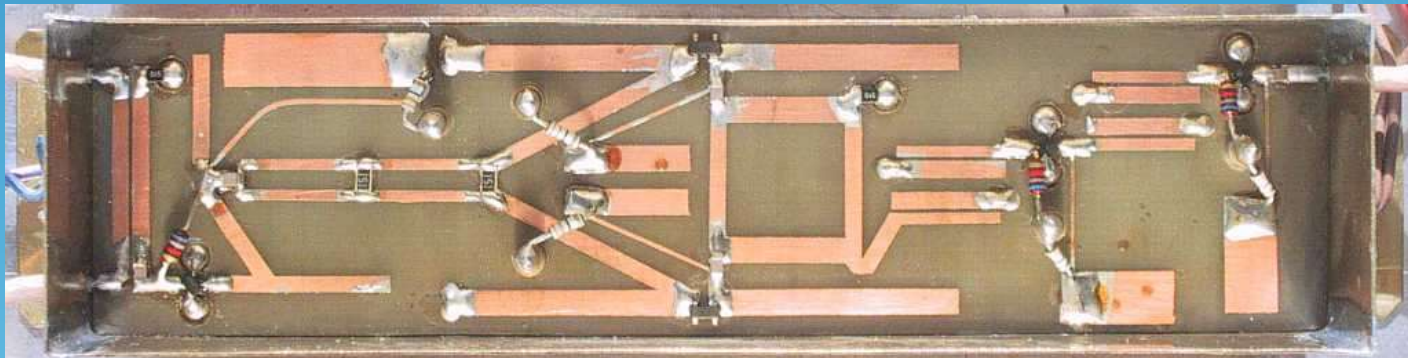
Microstrip Components



RESONATOR



FILTER



MIXER



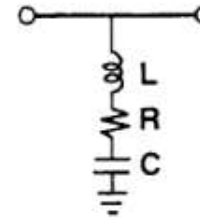
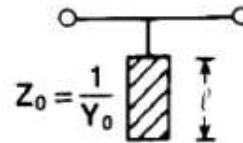
Microstrip Components

Stub Configuration

Equivalent LRC Network

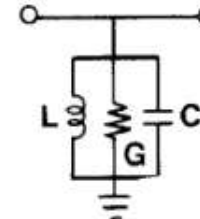
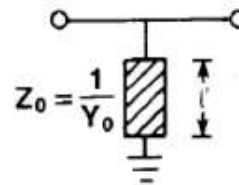
Element Values

$\lambda/4$ Open Circuited



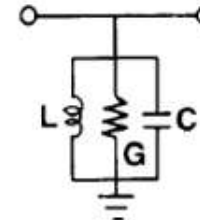
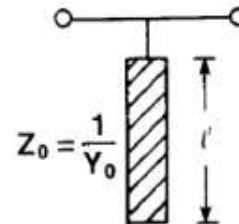
$$\begin{aligned}\omega_0 L &= \frac{\pi}{4} Z_0 \\ Z_0 &= \frac{4}{\pi} \sqrt{\frac{L}{C}} \\ R &= Z_0 \alpha l' \\ Q &= \frac{\omega_0 L}{R} = \frac{\pi}{4 \alpha l'} \\ \omega_0 &= \frac{1}{\sqrt{LC}}\end{aligned}$$

$\lambda/4$ Short Circuited



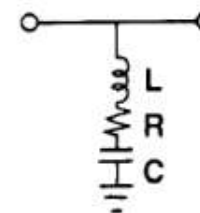
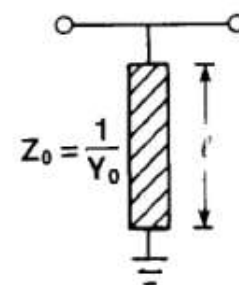
$$\begin{aligned}\omega_0 C &= \frac{\pi}{4} Y_0 \\ Z_0 &= \frac{4}{\pi} \sqrt{\frac{L}{C}} \\ G &= Y_0 \alpha l' \\ Q &= \frac{\omega_0 C}{G} = \frac{\pi}{4 \alpha l'}\end{aligned}$$

$\lambda/2$ Open Circuited



$$\begin{aligned}\omega_0 C &= \frac{\pi}{2} Y_0 \\ Z_0 &= \frac{2}{\pi} \sqrt{\frac{L}{C}} \\ G &= Y_0 \alpha l' \\ Q &= \frac{\pi}{2 \alpha l'}\end{aligned}$$

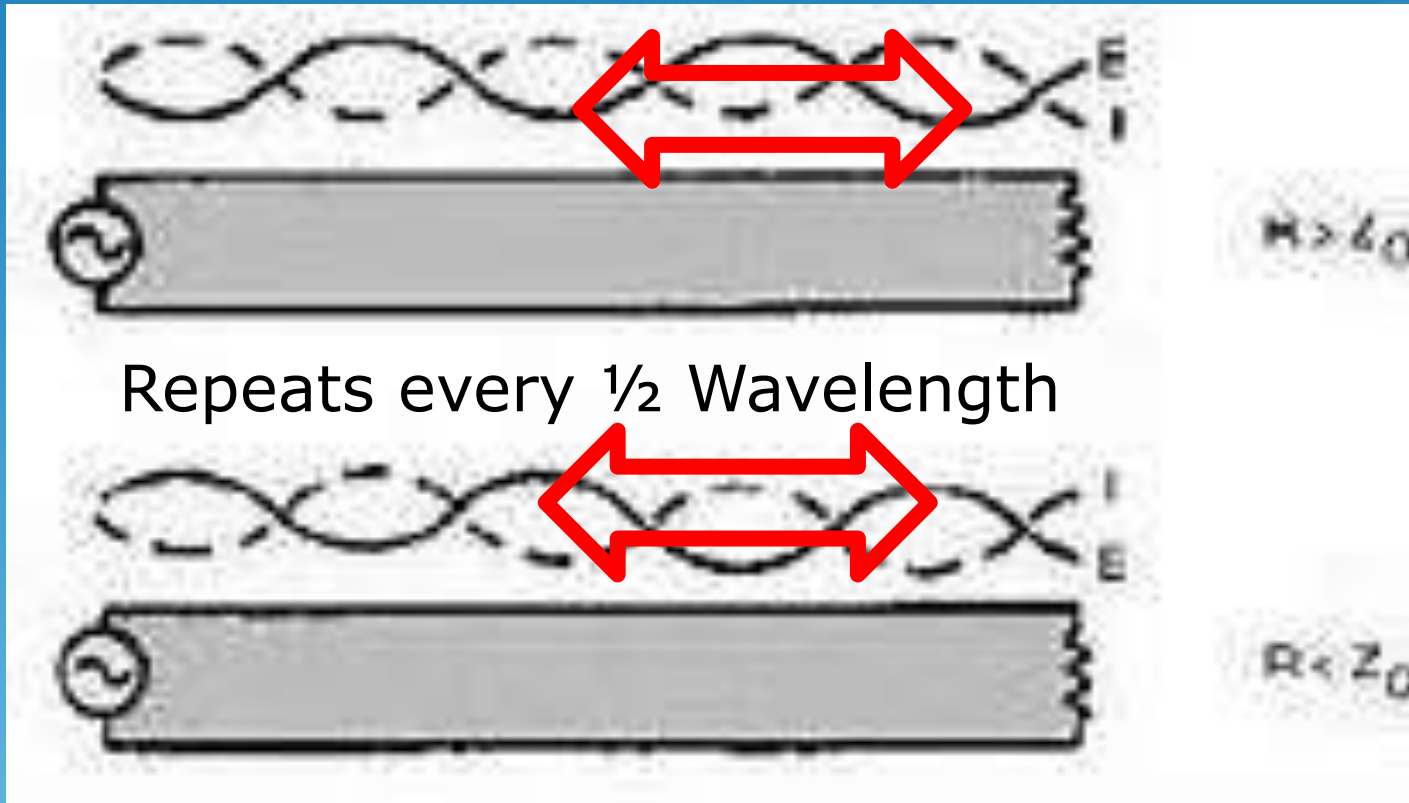
$\lambda/2$ Short Circuited



$$\begin{aligned}\omega_0 L &= \frac{\pi}{2} Z_0 \\ Z_0 &= \frac{2}{\pi} \sqrt{\frac{L}{C}} \\ R &= Z_0 \alpha l' \\ Q &= \frac{\pi}{2 \alpha l'}\end{aligned}$$

Transmission Line Review

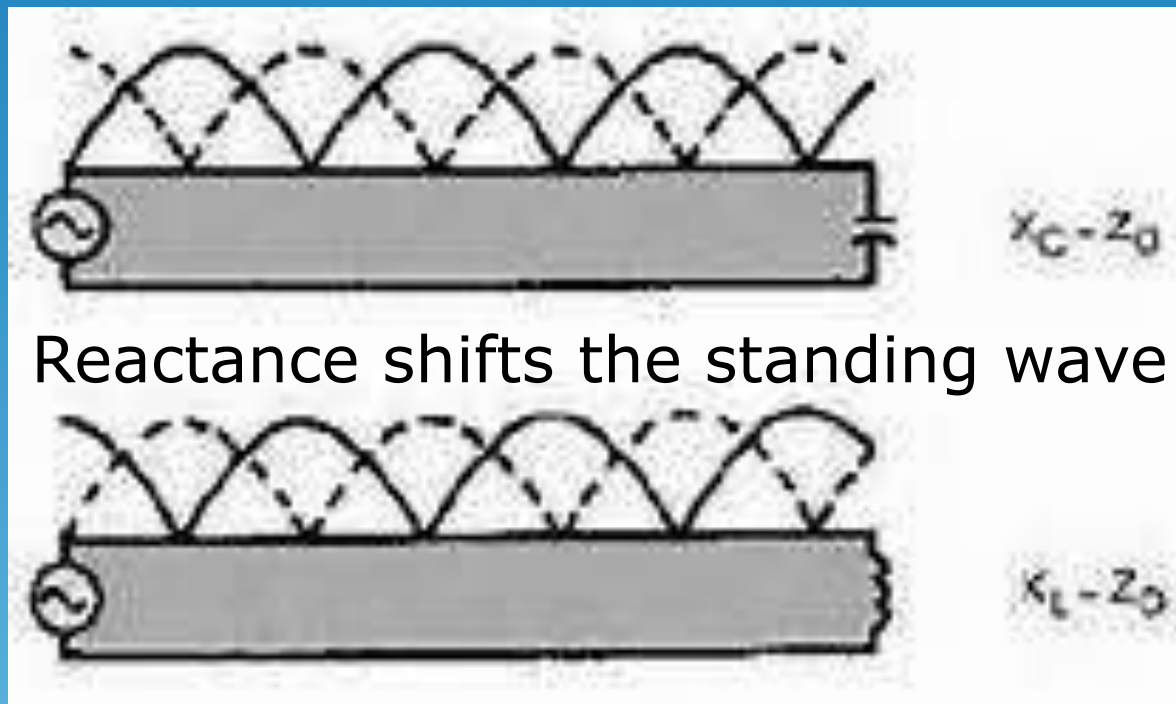
Unequal Load and Line Impedances
Cause a "Standing Wave" to develop



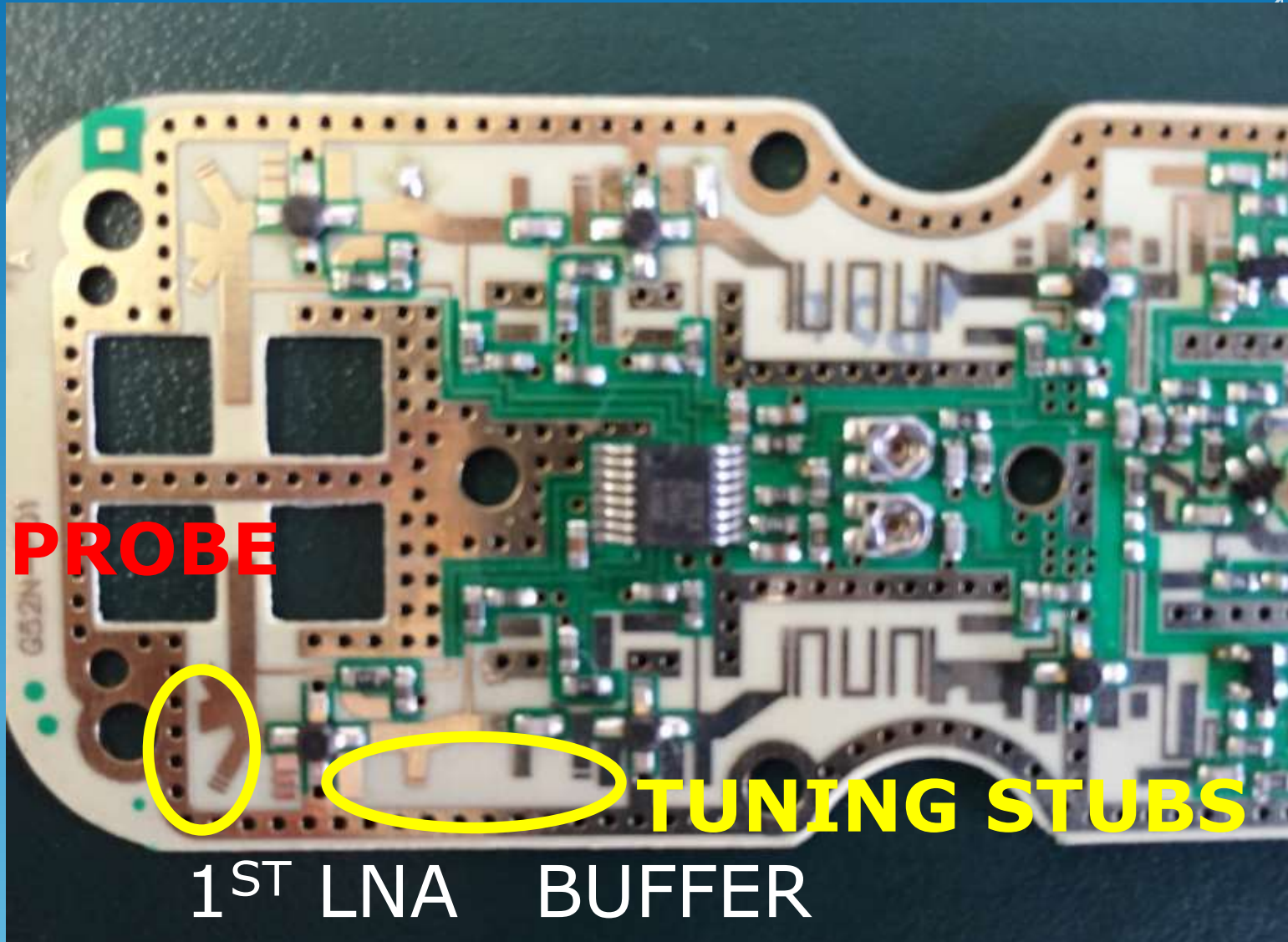
Transmission Line Review

Effects of Inductance and Capacitance

Z_0 Means "Characteristic Impedance"



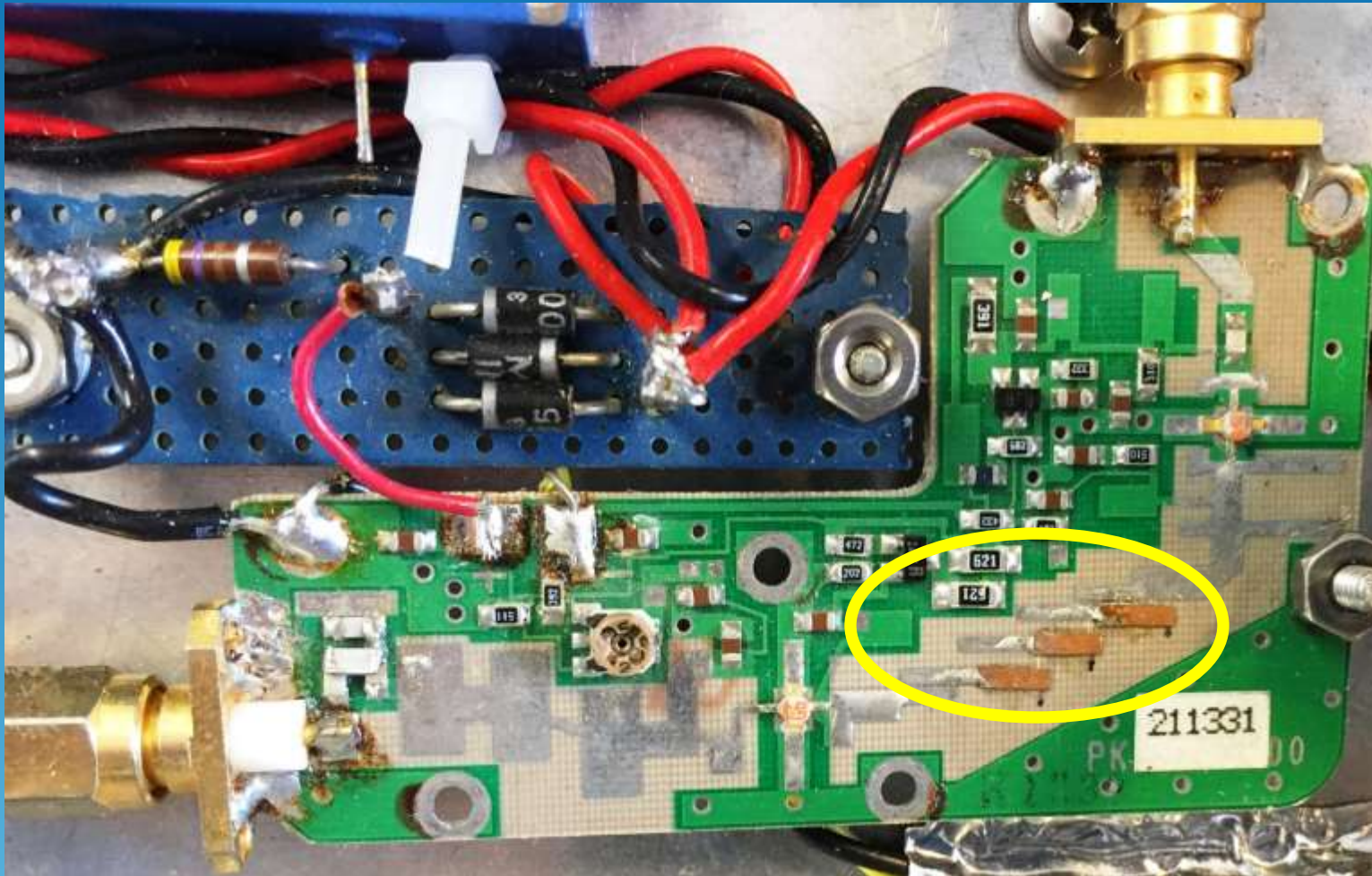
Application of the Theory



Application of the Theory

- Put Dielectric (Kapton) Tape over the filter to broadband it
- Jumper the filter with semi-rigid coax
- Take an output at the input side of the filter via a 1 or 2 pF coupling cap
 - 2 stages of LNA should be enough
- Tune both sides and use the best performer as online unit

Application of the Theory:



2.556 GHz **X4 MULT.**
10.224 GHz FILTER

Application of the Theory:



AF6NA MOD.
TO LNB
(Added Copper
to Frequency
Det. Network)

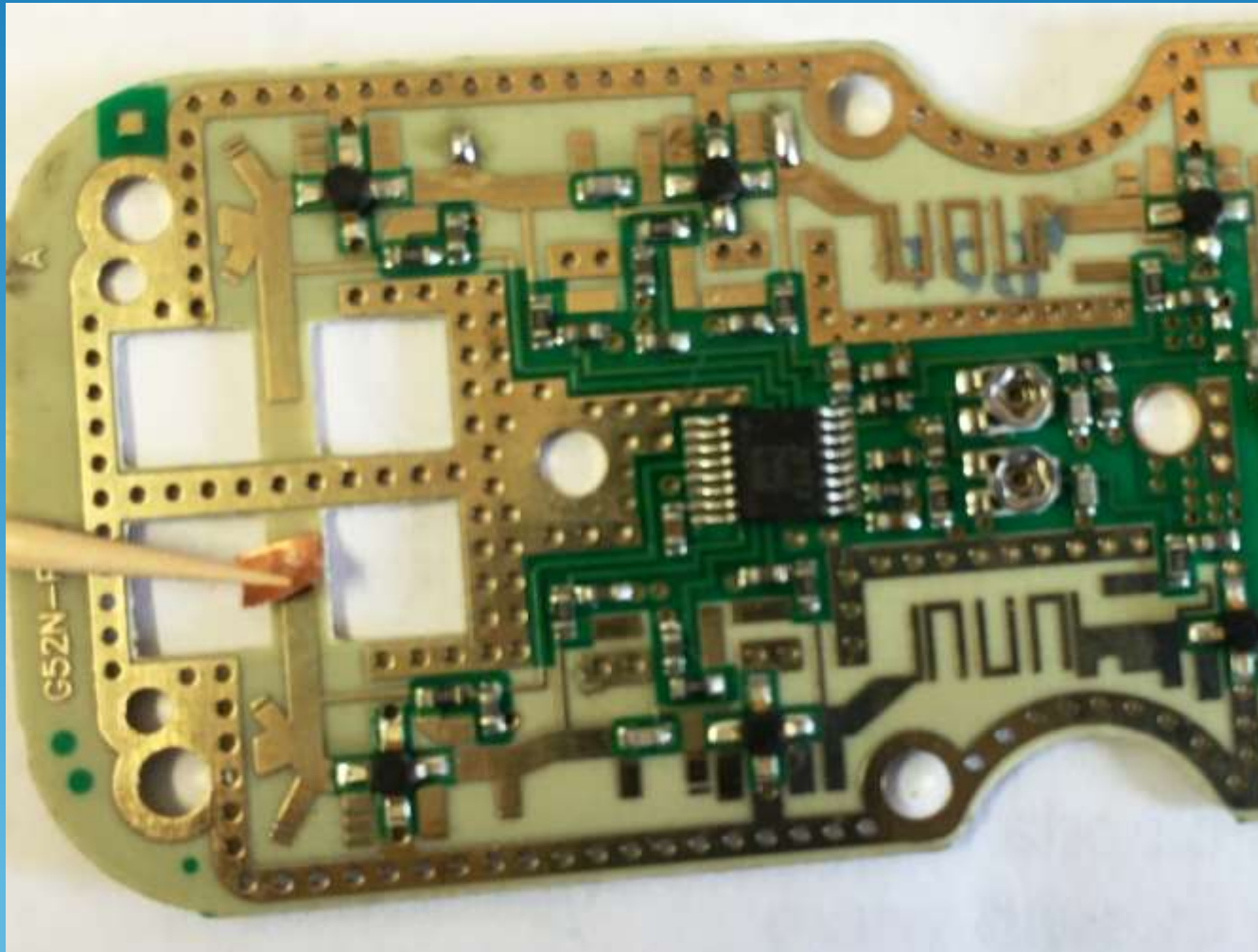
D.R.O.
FREQ. PULL
10.750 TO 10.400
GHz

Application of the Theory

- Adding Capacitance is the most common practice in tuning microstrip lines.
- Experimentation is the most common approach.
- An appropriate measurement system is a necessary tool to observe changes.
- Noise Floor
- Gain
- Frequency

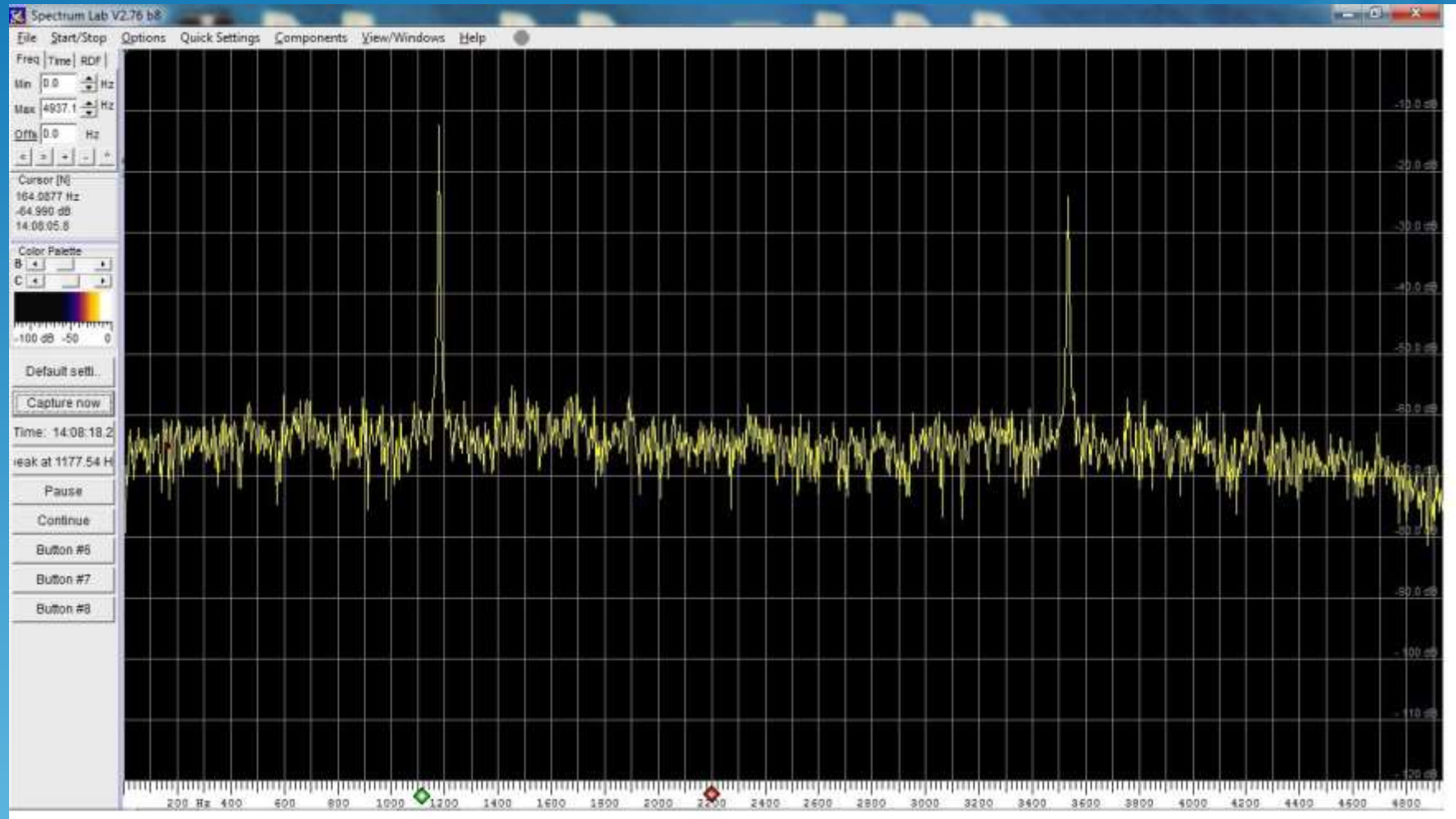


Move the copper 'snowflake'
around near the microstrip trace –
Avoid touching DC power traces!



Spectrum Lab Screen

Position the snowflake - Watch the noise



All AGC should be "OFF"

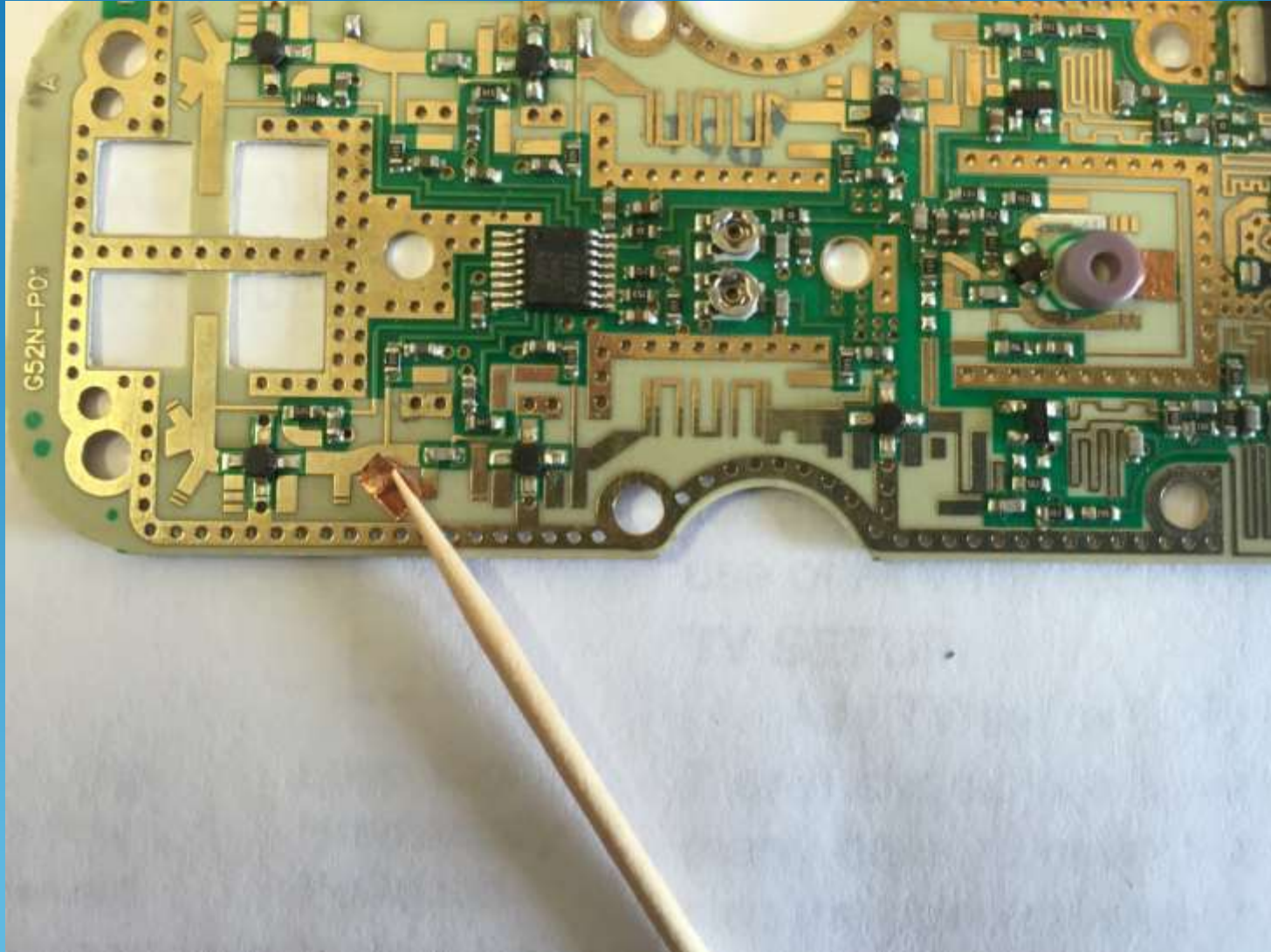
Alternative Monitoring Systems

Position the snowflake -

- **Use an audio voltmeter at the audio output – measure the noise***
- **Power meter output to Voltmeter with an audible tone output – listen to the noise***
- **Use a spectrum analyzer and tune for best carrier to noise***
- **An audio meter with “SINAD” function***

*** All AGC should be “OFF”**

Once the input side is optimized –
Try the output side – watch noise & gain



Glue the snowflakes down once
you find the “optimal” position

QUESTION:

What kind of glue is best?

Solder the snowflake in place

