# Communications Systems based on Software Defined Radio (SDR)

Dr. Ing. Alejandro José Uriz
Ing. Juan Alberto Etcheverry

## Complementary elements of a communications system

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# Complementary elements of an SDR system

A communications system is made up of several subsystems. Although the SDR paradigm reduces the amount of hardware, it is still necessary.

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# Complementary elements of an SDR system

The complementary subsystems that an SDR device should have to become a prototype with a certain Technological Readiness Level (TRL) will be studied.

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For the reasons described above, if we at least want to obtain a TRL 4, 5 or 6, we must assemble a prototype that, in addition to the SDR, includes the most important subsystems of a communications system.

# TRL levels

**TRL 1** – Basic principles observed and reported.

**TRL 2** – Applied research: the concept of technology and/or its application is formulated.

**TRL 3** – Experimental proof of concept.

**TRL 4** – Laboratory validated technology.

**TRL 5** – Technology validated in a relevant environment.

**TRL 6** – Technology demonstrated in a relevant environment.

**TRL 7** – Demonstration of the system prototype in an operational environment.

**TRL 8** – Complete and qualified system.

**TRL 9** – Actual system tested in the operating environment (competitive manufacturing in the case

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# Link calculation

The first design step consists of a feasibility analysis. That is, determine in the event that our system acts as a receiver, the sensitivity that it must have (minimum signal to receive) or in the event that it acts as a transmitter, the minimum output power that it must have for the information to be received. at the other end.

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# Link calculation

To do this, use an equation that considers the gains and losses of each component of the system to determine the sensitivity of a receiver (knowing the transmitted power) or the power of the transmitter, based on the sensitivity of the receiver. Also the remaining components of the radio link could be unknowns or variables.

# Link calculation

If the radiated power of the emitter were available,
it would only be.

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# Link calculation

$$P_{RX} = P_{TX} + G_{RX} + G_{TX} - 20 \log (d) - 20 \log (f) + 147$$

$P_{RX}$: Received power expressed in dBm.

$G_{RX}$: Gain of the antenna used for reception expressed in dBi.

$G_{TX}$: Gain of the antenna used to transmit expressed in dBi.

$f$: Link operating frequency in Hz.

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# Link calculation

Effective Radiated Isotropic Power (ERIP) is the amount of power that a theoretical isotropic antenna (i.e. one that distributes power exactly equally in all directions) would emit to produce the observed power density in the direction of maximum antenna gain. This assumes an isotropic pattern where the radiated value is the same in all directions and is equal to the maximum radiated power value of the antenna.

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# Link calculation

Effective Isotropic Radiated Power takes into account transmission line and connector losses and includes antenna gain. The ERIP is usually expressed in decibels with respect to a reference power emitted by an equivalent signal power. It is typically described in $dBm$ or $dBW$. The ERIP allows different emitters to be compared regardless of their type, size or shape. Knowing the ERIP and the gain of the real antenna it is possible to calculate the real power and the values of the electromagnetic field.

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# Link calculation

The ERIP value is related to the antenna gain and the loss in cables and connectors:

$$PIRE|_{dBm} = P_T|_{dBm} - Lc|_{dB} + G_T|_{dB}$$

In the previous expression, the ERIP is expressed in $dBm$, $Lc$ is the loss of cables and connectors in $dB$, and the antenna gain $G_T$ is also expressed in $dB$.

The ERIP is used to estimate the area in which the antenna can provide service and to coordinate the location between transmitters so that coverage does not overlap.

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# Link calculation

In the case of satellite receivers, power curves are available, which show us with what power the satellite transmits to a certain region of the map. In turn, this curve usually has gradients with 1dB steps.

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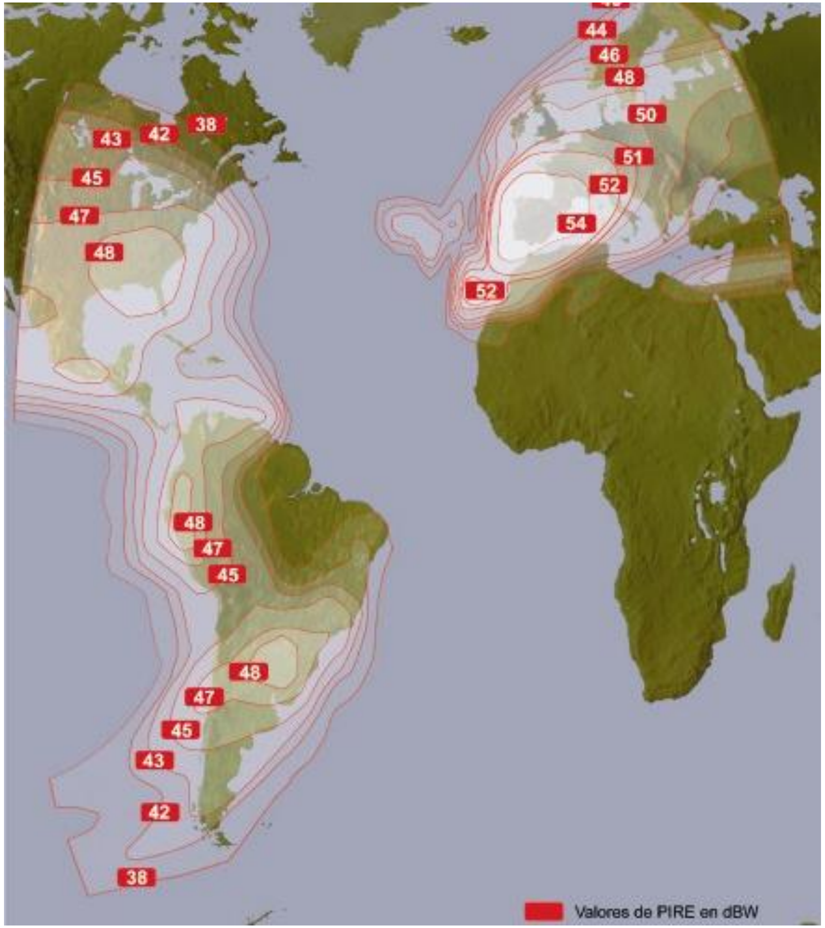
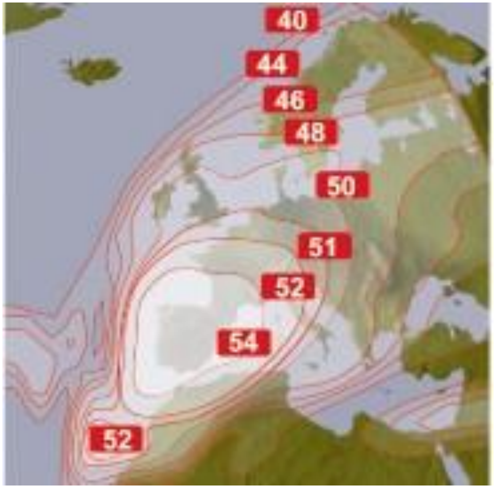
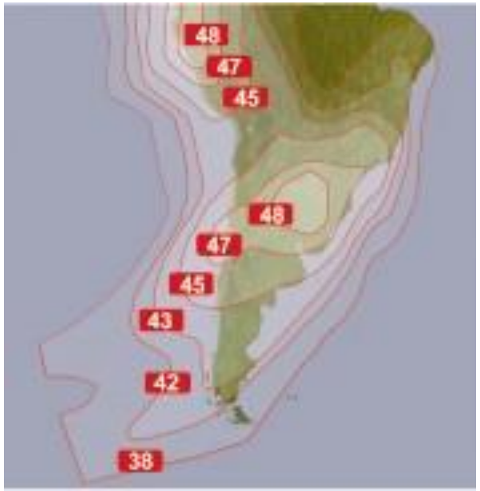
# SATELLITE FOOTPRINT OF HISPASAT 1C




Source: https://viasatelital.com/satelites/huella_hispasat_1c.htm

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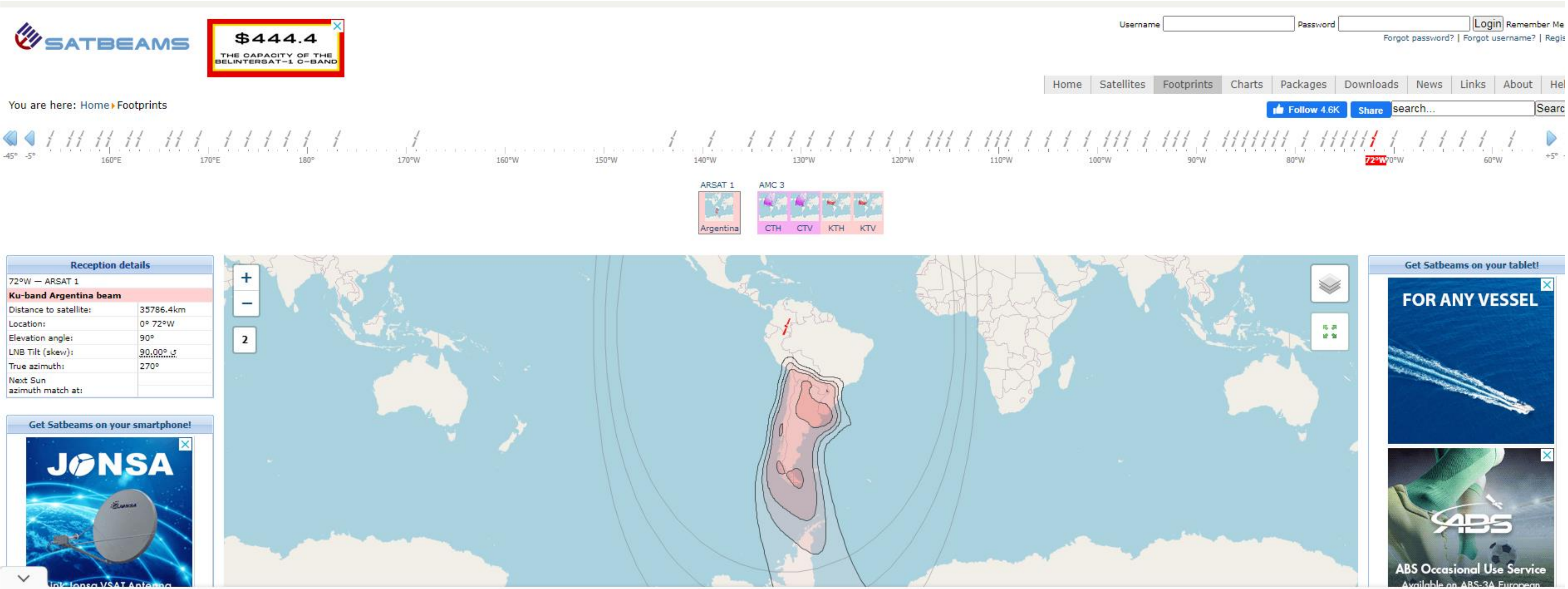
# Websites with usage information




Source: https://www.satbeams.com/footprints

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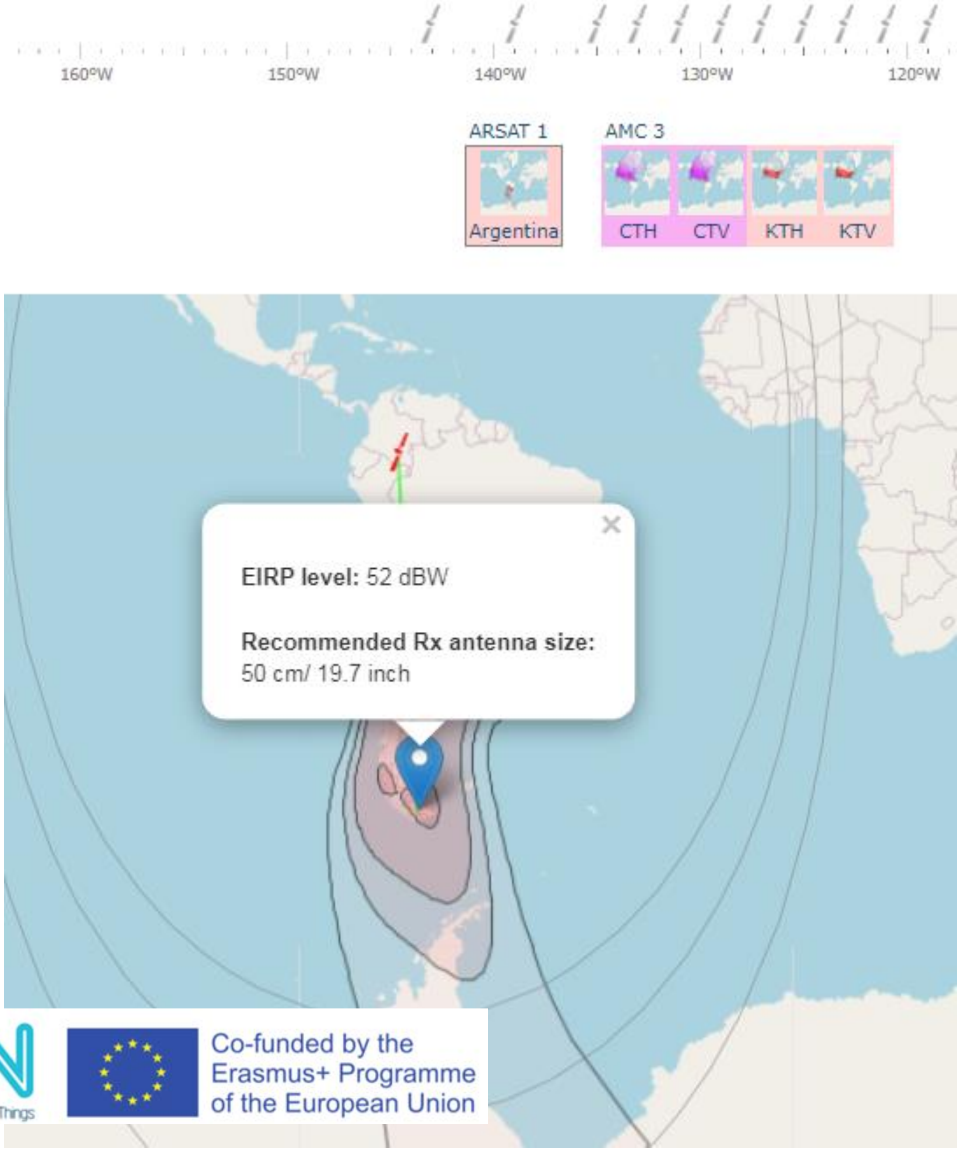


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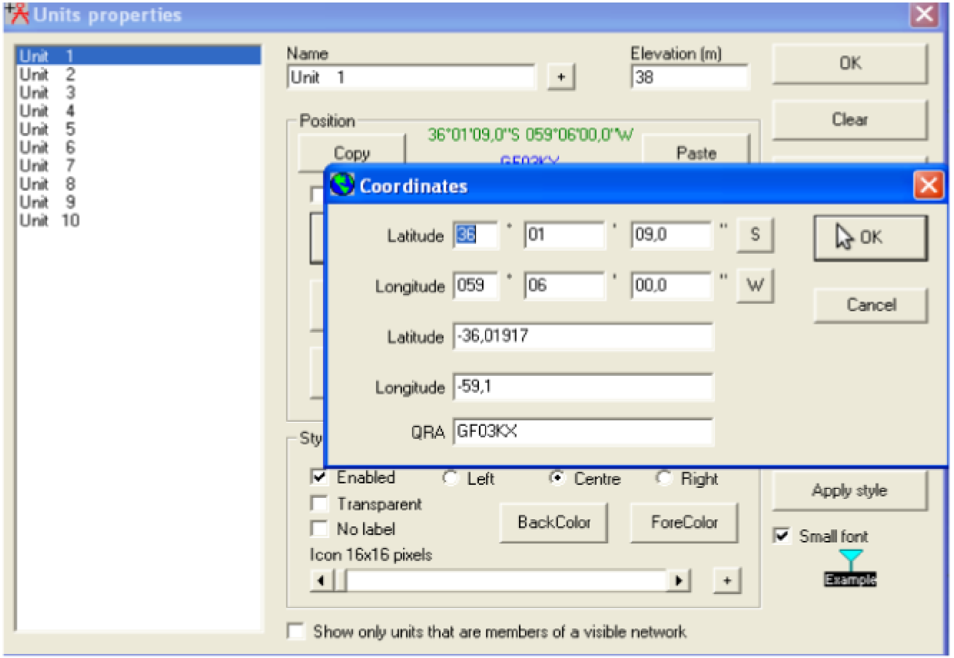
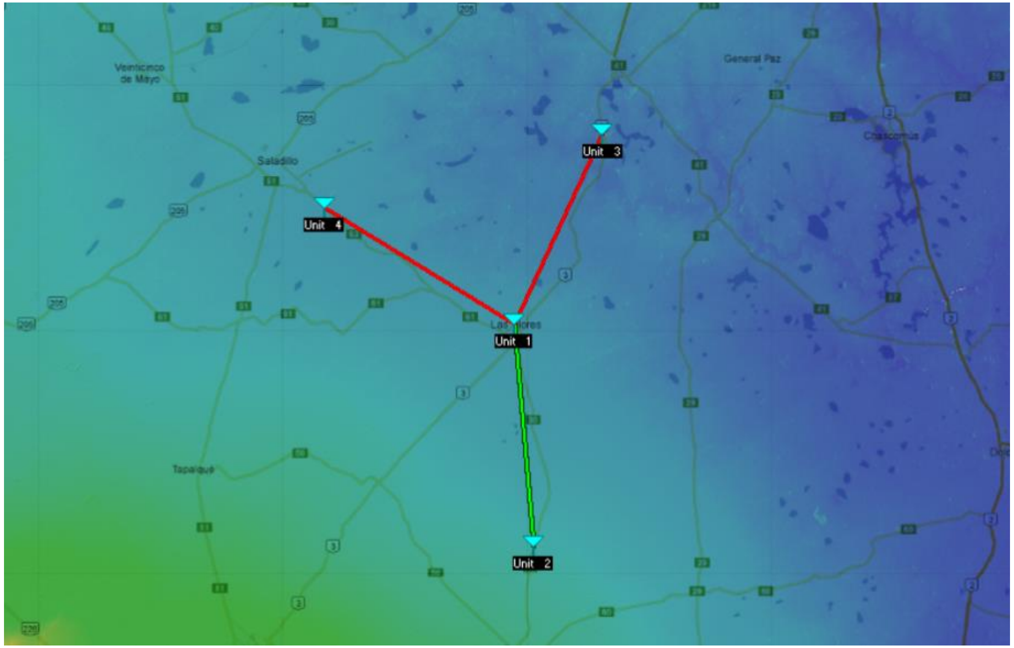
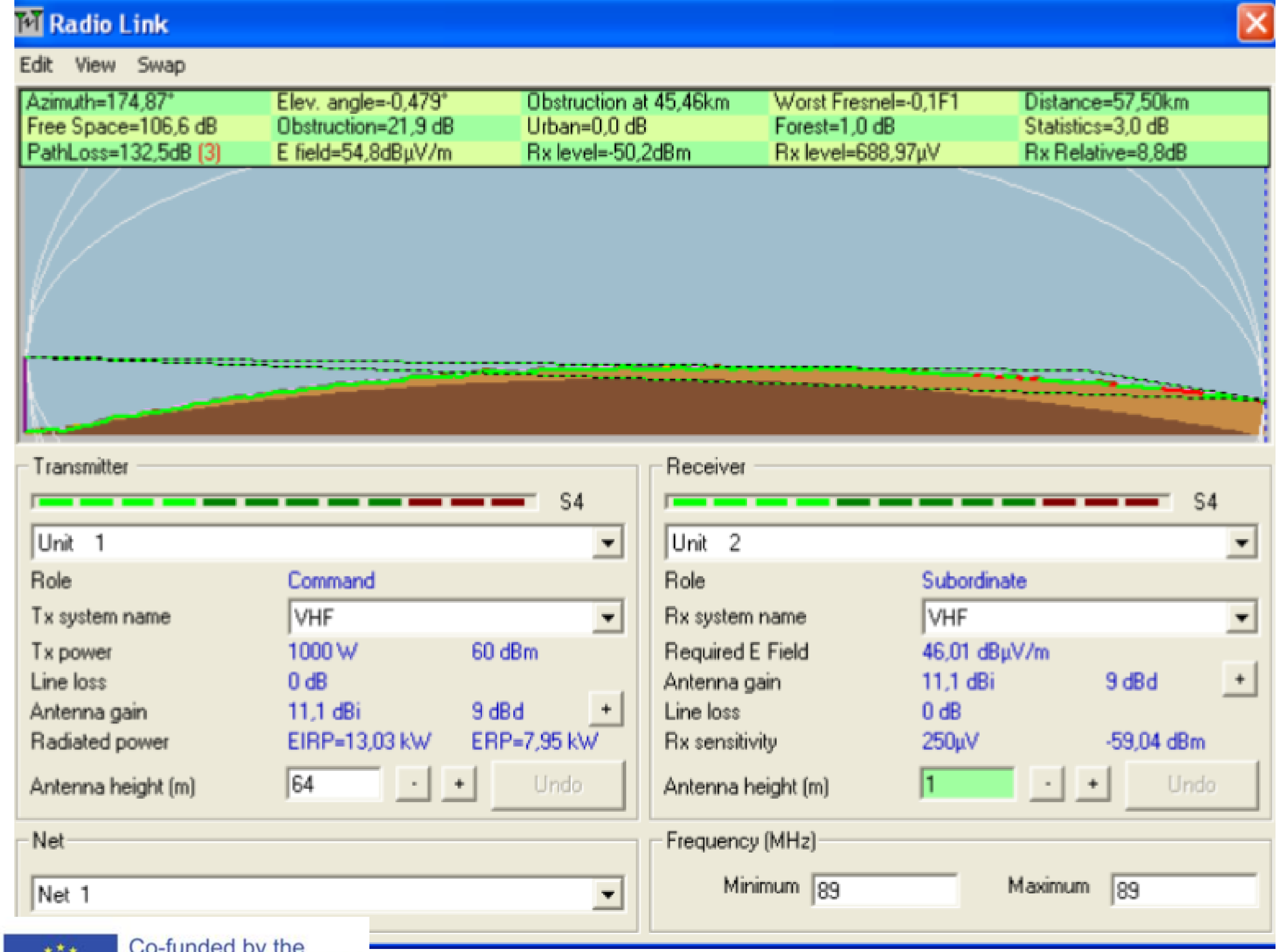
# RADIOMOBILE






Source: http://www.ve2dbe.com/english1.html

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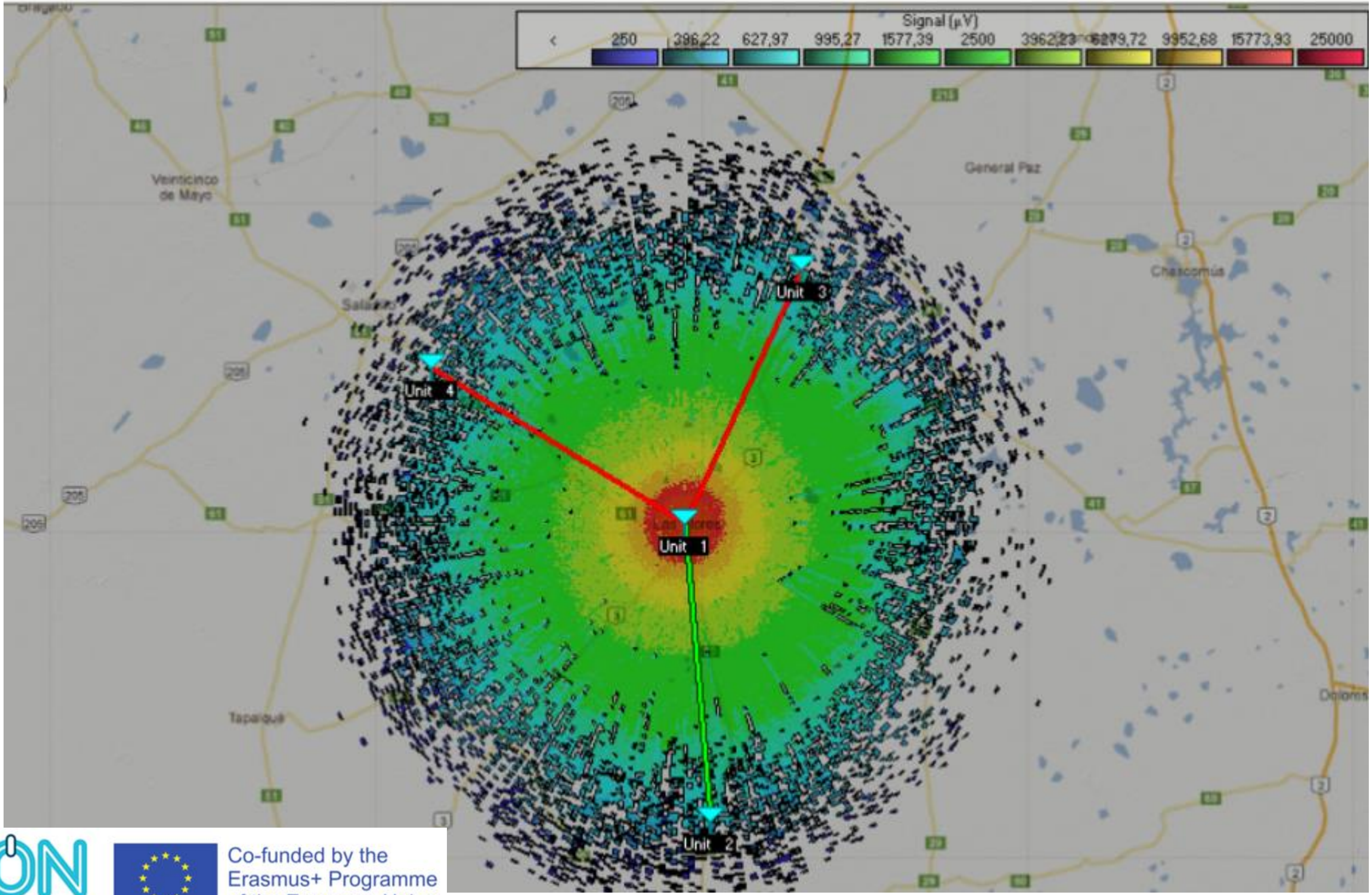
Source: http://www.ve2dbe.com/english1.html

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Source: http://www.ve2dbe.com/english1.html

# Link calculation

Then, once the sensitivity of the receiver and/or the maximum output power have been defined, as the case may be, it will be possible to begin to design the system.

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# Link calculation

But, we should also take into account what happens in adjacent bands to which we are going to work. Verifying in the first place that our emissions do not affect security channels, secondly that they do not affect other emissions and thirdly that other emissions do not affect our reception or even damage the receiver.

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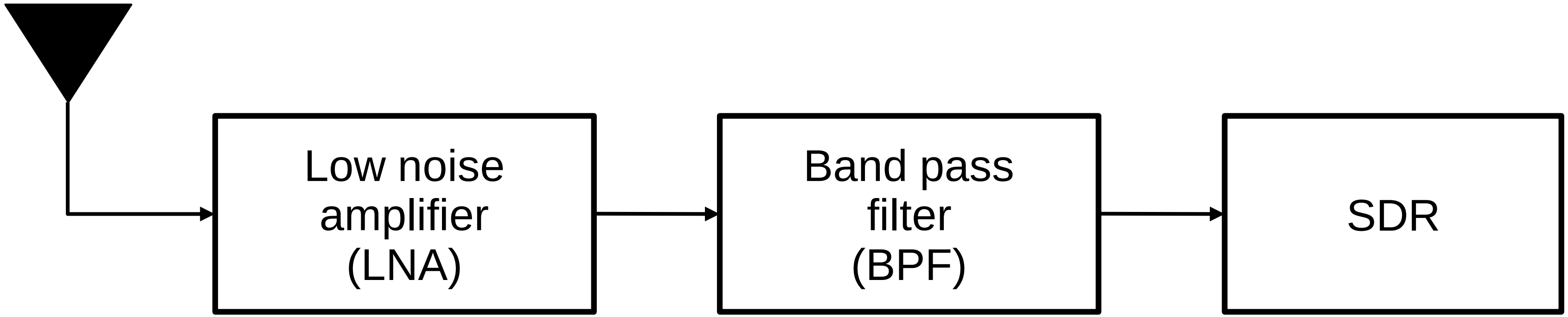
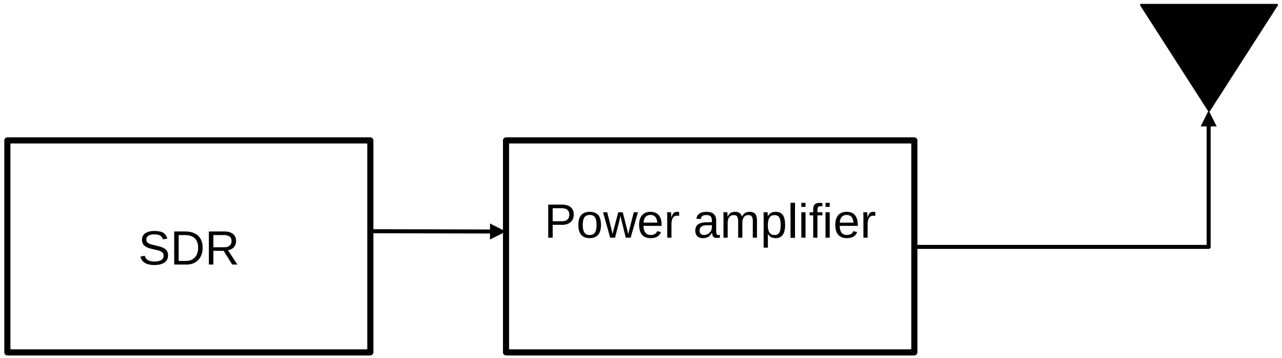
# Simplified schematic of a receiver



# Simplified schematic of a transmitter

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First of all we will study the antenna of the system. As is well known, an antenna could operate in one or more bands and its gain usually depends on the model used. Its polarization is also important.

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# Antennas: most important parameters

The parameters that are generally used to select an antenna is:

- Impedance / SWR.
- Operating frequency.
- Bandwidth.
- Gain.
- Radiation lobes.
- SWR

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806/896 MHz

## OMNI PARA CELULAR-TRUNKING

# OMNI CELULAR

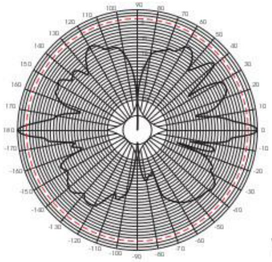
### *CARACTERISTICAS ELECTRICAS*

| | |
|---|---|
| Potencia | 500W |
| Impedancia | 50 Ohms |
| Ancho de banda | >90 MHz |
| Ganancia | 11 dB |
| R.O.E | <1.3:1 |
| Polarización | Vertical |
| Ancho de Haz (V) | 6° |
| Protección | DC Ground |
| Conector | 7/16 DIN Hembra |

Lóbulo inferior ampliado provee Fill In para instalaciones muy elevadas

### *CARACTERISTICAS MECANICAS*

| | |
|---|---|
| Longitud | 4002 mm. |
| Peso sin Embalaje | 12 Kg. |
| Boom de sujeción | Ø70 mm Aluminio Iridizado |
| Material irradiante | Aluminio Iridizado |
| Radomo | Fibra de vidrio c/filtro uv |
| Soporte | Acero Galvanizado |
| Area Expuesta | 0,14 mts2 |
| Resistencia al viento | >220 Km/h |



Vertical

Código 09-910

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806/869 MHz

## ANTENA TRIPOLE PARA TRUNKING

# TRIPOLE

### *CARACTERISTICAS ELECTRICAS*

| | |
|---|---|
| Potencia | 500W |
| Impedancia | 50 Ohms |
| Ancho de Banda | >70 Mhz |
| Ganancia | 16 dB 18,1 dBi |
| Relación Frente - Espalda | >25 dB |
| R.O.E | <1.3:1 |
| Polarización | +/- 45° |
| Ancho de Haz -V- | 8° |
| Ancho de Haz -H- | 65° |
| Protección | DC Ground |
| Conector | 3 x 7/16 DIN Hembra |
| Tilt Eléctrico | 0° |

### *CARACTERISTICAS MECANICAS*

| | |
|---|---|
| Longitud | 2364 x 470 x 130 mm. |
| Peso sin Embalaje | 19,4 kg. |
| Material Irradiante | Aluminio |
| Radomo | Fibra de vidrio con filtro uv |
| Soporte | Acero Galvanizado |
| Área Frontal | 1,1 mts2 |
| Área Lateral | 0,283 mts2 |
| Resistencia al Viento | >200 km/h |
| Tijera para downtilt | Opcional |

Diagrama Vertical

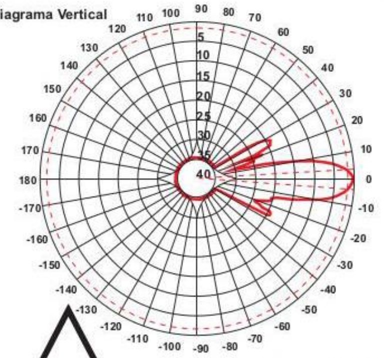
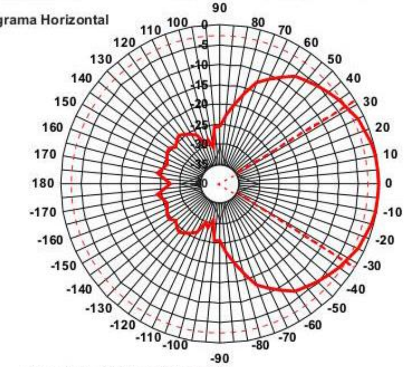


Diagrama Horizontal



**Tel:** (54-011) **4726-8111** **Fax:** (54-011) **4726-8980**

**ANTEN ANTENAS**

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**HF-BLU - VHF - FM - UHF - CELULAR - TRUNKING**

# 2.4 GHz – 2.5 GHz Dipole 2dBi Antenna for Reverse Polarity SMA

## ORDERING INFORMATION

| Order Number | Description |
|---|---|
| **001-0001** | 2.4 GHz Dipole Antenna for Reverse Polarity SMA Connector. |
| **080-0001** | U.FL to Reverse Polarity SMA Cable, 105mm |

**Table 1 Orderable Part Numbers**

## SPECIFICATIONS

| Specification | Value |
|---|---|
| Peak Gain | +2 dBi |
| Impedance | 50 ohms, Nominal |
| Type | Dipole |
| Polarization | Linear Vertical |
| VSWR | ≤2.5 : 1, Maximum |
| Frequency | 2400-2500MHz |
| Weight | 13g |
| Size | 105×10 mm |
| Antenna Color | Black |
| Operating Temp | -20℃ to +65℃ |
| UL Rating | UL 94HB |

**Table 2 Specifications**

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## PHYSICAL DIMENSIONS (MM)

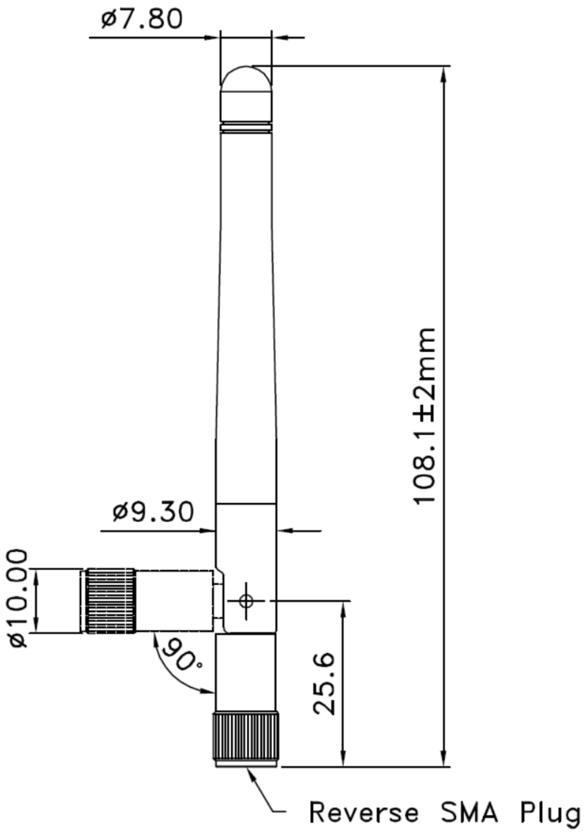



**Figure 1 Physical Dimensions**

## TYPICAL ANTENNA REFLECTION PERFORMANCE

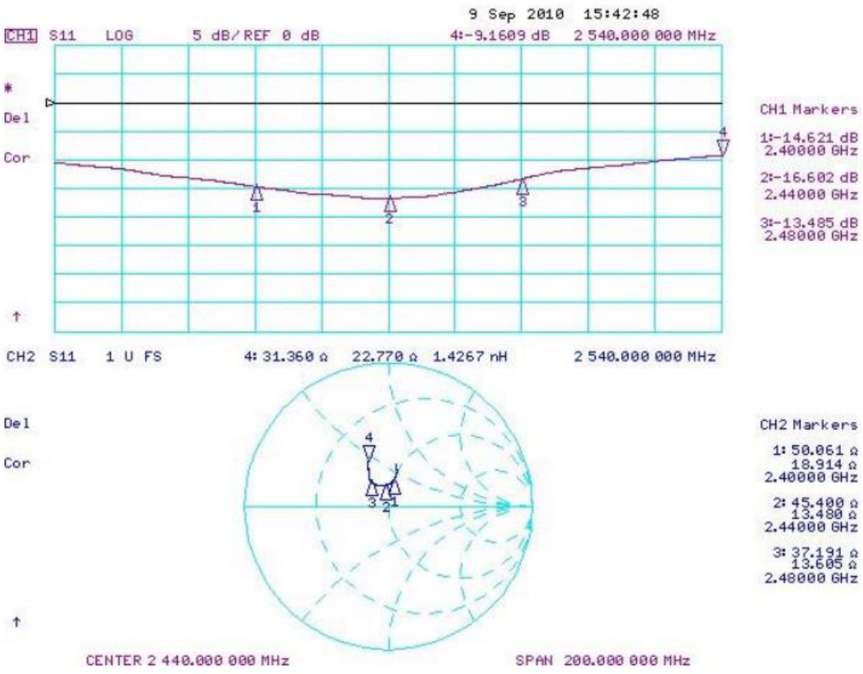



**Figure 2 Reflection Parameters for Extended Configuration (S11)**

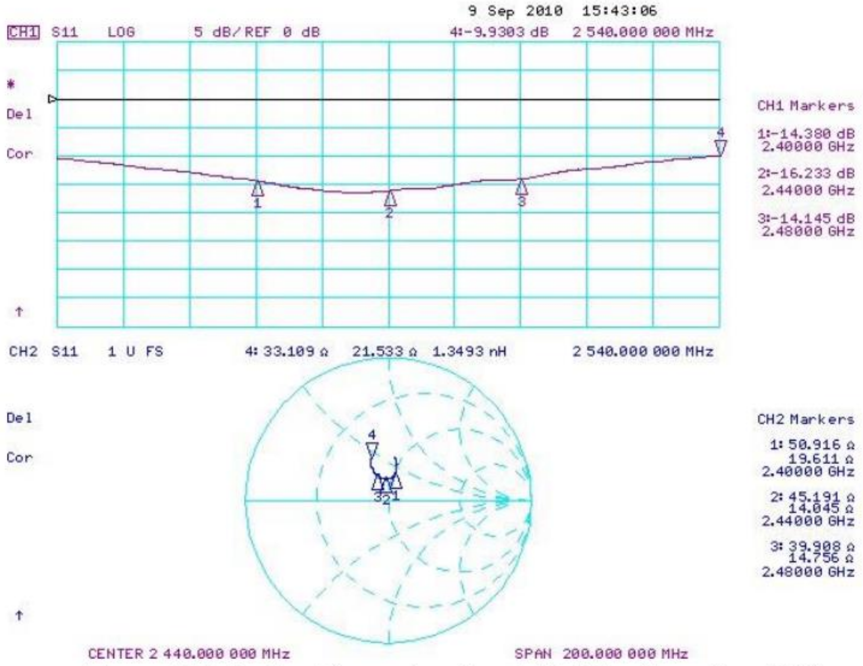



**Figure 3 Reflection Parameters for Folded Configuration (S11)**



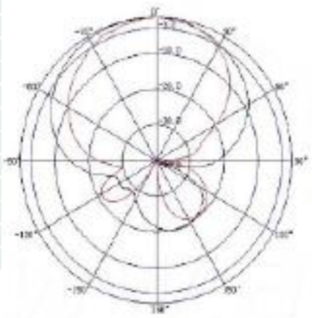
WIFI-antennas.co.uk

Tech

## 11dBi GSM Log-Periodic Penta-Band Antenna

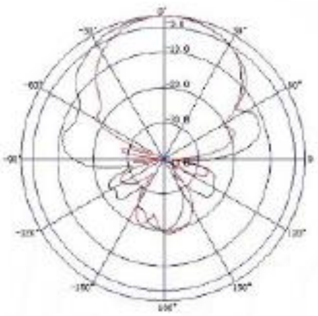
| Specification | |
|---|---|
| Frequency Range | 806-960 / 1710-2700 MHz |
| Gain (dBi) | 11 dBi |
| Front-Back Ratio | 12dB / 12dB |
| VSWR | <1.5 |
| Impedance | 50 Ohm |
| Polarization | Vertical |
| Beamwidth | H : 50° ±10° E : 40° |
| Power Handling | 50W |
| Connector | N-Type Female |
| Mounting Kit | L-Bracket & U-Bolts |
| Rated Wind Velocity | 126Km/h |
| Weight | 0.65Kg |
| Dimensions | 410 x 210 x 65 mm |
| Temperature | -40 to +70°C |
| Radome | White ABS |

**H/E 800MHz**

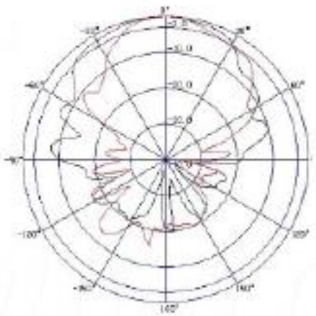


**H/E 960MHz**

**H/E 1710MHz**



**H/E 2500MHz**



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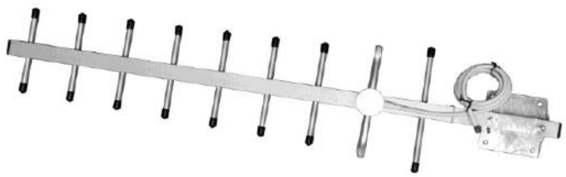
LPRS

**YAGI-868/914A**



# 868/914MHz YAGI Antenna Data Sheet

9 Element 824-960MHz Directional 13dBi Antenna

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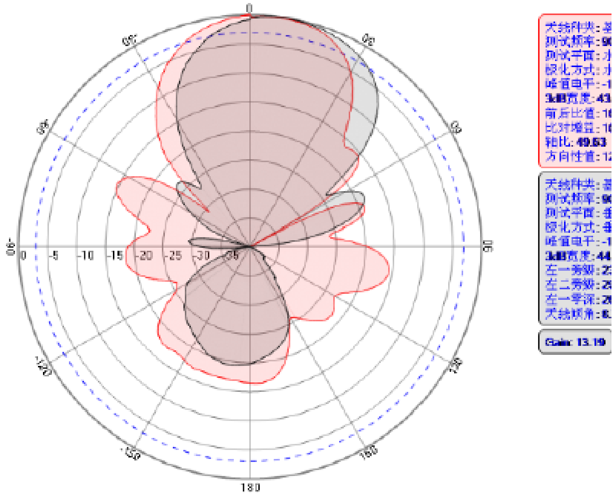
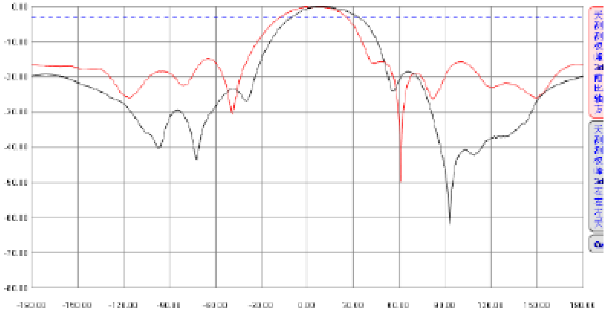
# 868/914MHz YAGI Antenna Data Sheet

9 Element 824-960MHz Directional 13dBi Antenna

| Electrical Specifications | |
|---|---|
| *Frequency Range* | **824-960MHz** |
| *Nominal Impedance* | **50 ohm** |
| *Gain* | **13dBi @ 900MHz** |
| *VSWR* | **1.5:1** |
| *F/B Ratio* | **>15dB** |
| *Maximum Input Power* | **100w** |
| *Polarization* | **Vertical** |
| *Connector* | **SMA male** |




| Mechanical Specifications | |
|---|---|
| *Support Boom Material* | **Steel Bracket** |
| *Element Material* | **Aluminium** |
| *Number of elements* | **9** |
| *Antenna dimensions* | **790x190x55mm** |
| *Cable Length* | **1000mm** |
| *Antenna weight* | **414g** |
| *Ambient temperature* | **-40 C -+ 60 C** |



| **Order Code:** | **YAGI-869/914A** |
|---|---|

*Note: Longer cable lengths available.*

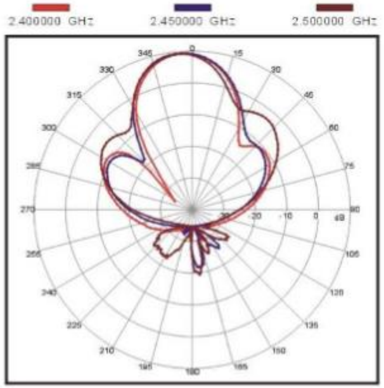
## 16dBi 2.4GHz Directional Panel Antenna...

N Type Female

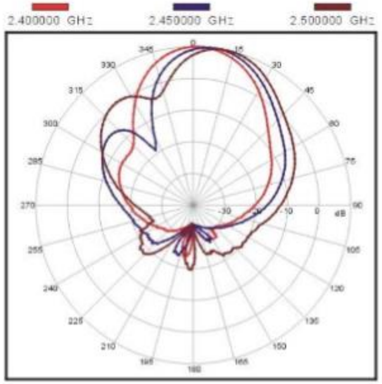
lead-free compliant

Pole Not Included

## Radiation Pattern...




H-PLANE




E-PLANE

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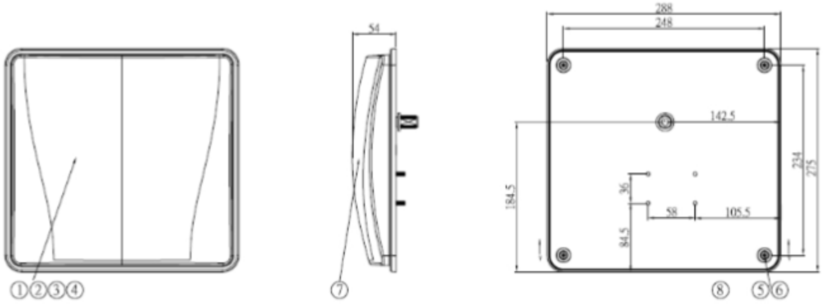
16dBi 2.4GHz Directional Panel Antenna Datasheet... Part No. 16-5-DB-SMA

## Antenna Dimensions...




| Technical Specification... | |
|---|---|
| Model no. | 16-5DB-SMA |
| Frequency | 2.4 - 2.5GHz |
| Gain | 16 dBi |
| Gain Tolerance | + / - 0.5dBi |
| VSWR | <= 1.8 :1 |
| Impedance | 50 Ω |
| Power Handling | 50W |
| Horizontal | 35° |
| Vertical | 35° |
| Connector | N TYPE Female |
| Operation Temperature | -40℃ ~ +80℃ |
| Humidity | 100% @ 25℃ |
| Wind Load | 180 Km/h |
| Lightning Protection | DC Ground |
| Radome Colour | Grey-White |
| Radome Colour | ABS, UV Resistant, Zinc Casting |
| Weight | 1.2 Kg |
| Dimensions | Length 283mm Width 270 Depth 81mm |
| Mounting | Pole mount |

Suitable for 2.4GHz Systems including:

WiFi Bluetooth Wireless CCTV

Always check connector type prior to ordering

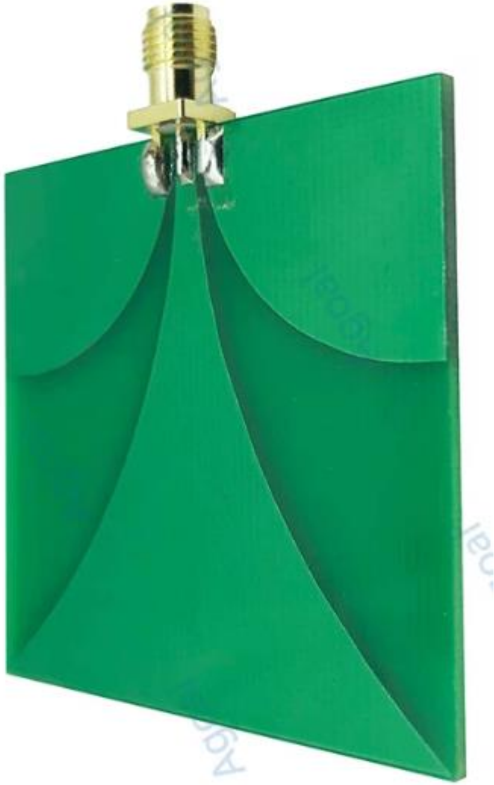

## Antena Eagle 2.30M Malla Banda C

**Características:**

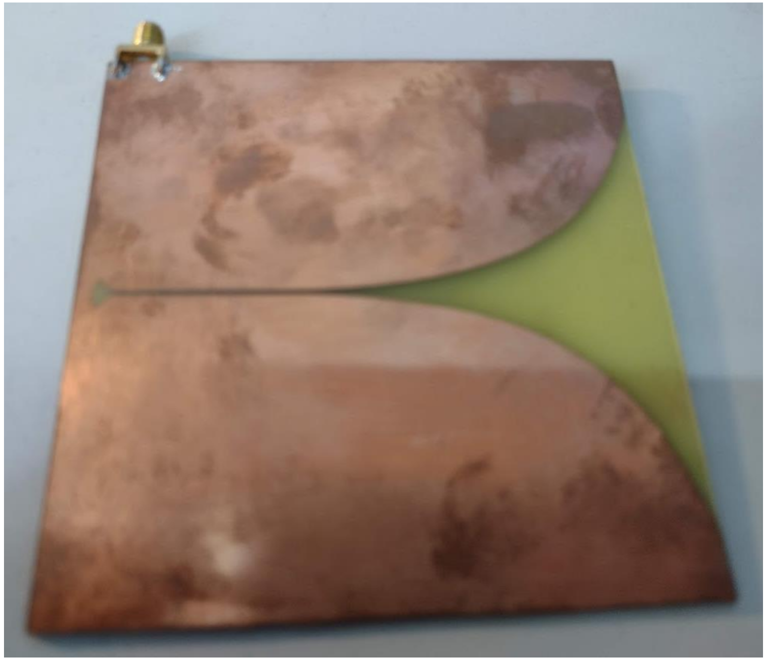
| | |
|---|---|
| MODEL | M-230-A / M-230-P |
| DISH DIAMETER | 7.5' (2.30 Mts) |
| F/D | .350 |
| FOCAL LENGTH | 31.5" (80 cm) |
| GAIN @ 4 Ghz | 38.98 dBi |
| GAIN @ 12 GHZ | 47.36 dBi |
| SECTIONS | 4, T-6 ALUMINUM RIBS |
| DISH MATERIAL | ALUMINUM .034" FLATENED PREFORMED MICRO MESH ATTACHED, C / Ku |
| MOUNT MATERIAL | STEEL, 24" RING DIAMETER |
| POLE SIZE | 3.5" O.D. |
| FINISH | GRAY ELECTROSTATIC POWDER COATING |
| BOX DIMENTIONS | MOUNT: 25" x 25" x 9" - DISH: 51" x 51" x 7" |
| WEIGTH | 86 Lbs |
| 45' H.C. CONTAINER | 190 Pz |
| 53' TRUCK LOAD | 220 Pz |

# Broadband antennas

1,35 GHz - 9,5 GHz



2,8 GHz - 10,5GHz



Log Vivaldi Antenna 1 GHz – 6 GHz

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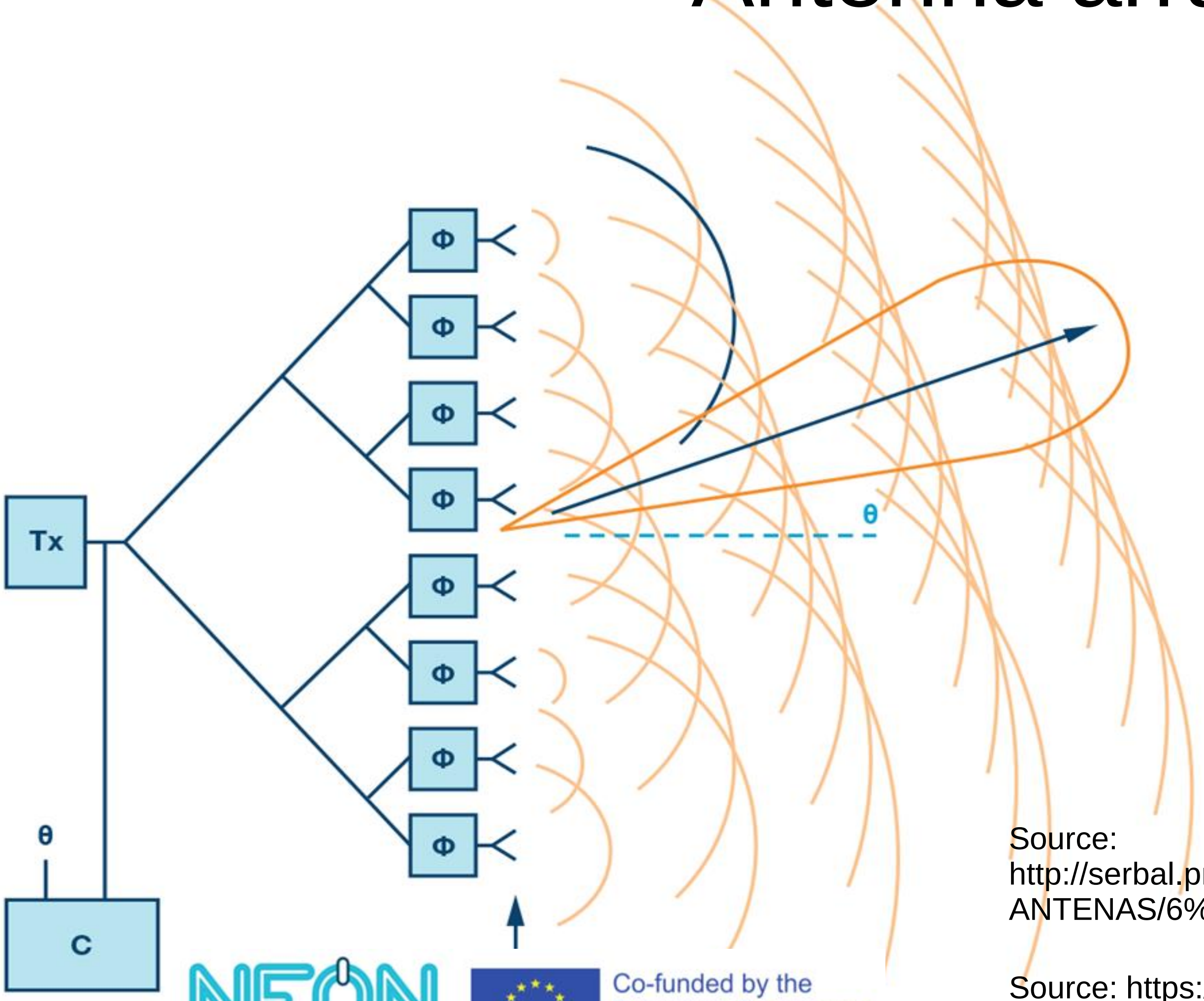
# Antenna arrays

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Source: https://www.analog.com/en/analog-dialogue/articles/phased-array-beamforming-ics-simplify-antenna-design.html

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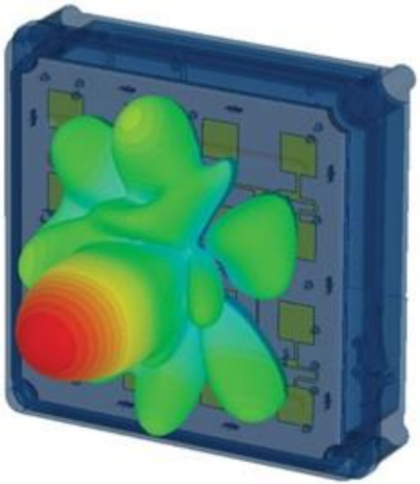
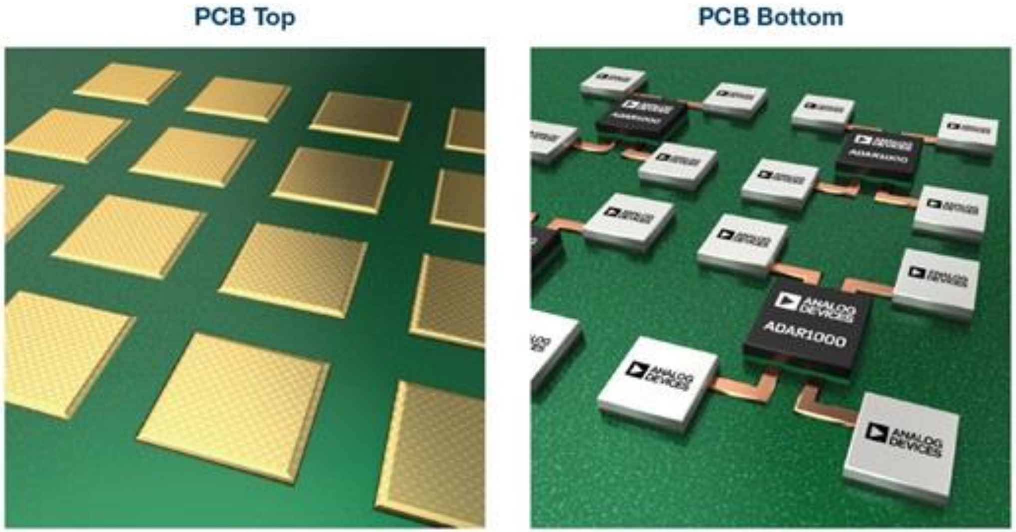
# Antenna arrangements



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Source: http://serbal.pntic.mec.es/srug0007/archivos/radiocomunicaciones/2%20ANTENAS/6%20Agrupaci%F3n%20de%20Antenas..pdf.pdf

Source: https://www.analog.com/en/analog-dialogue/articles/phased-array-beamforming-ics-simplify-antenna-design.html

In the event that our system operates as a receiver, a low noise amplifier (LNA) is usually placed very close to the antenna. This is done in order to amplify the signal and that it is not significantly damaged by cables, connectors and other components.

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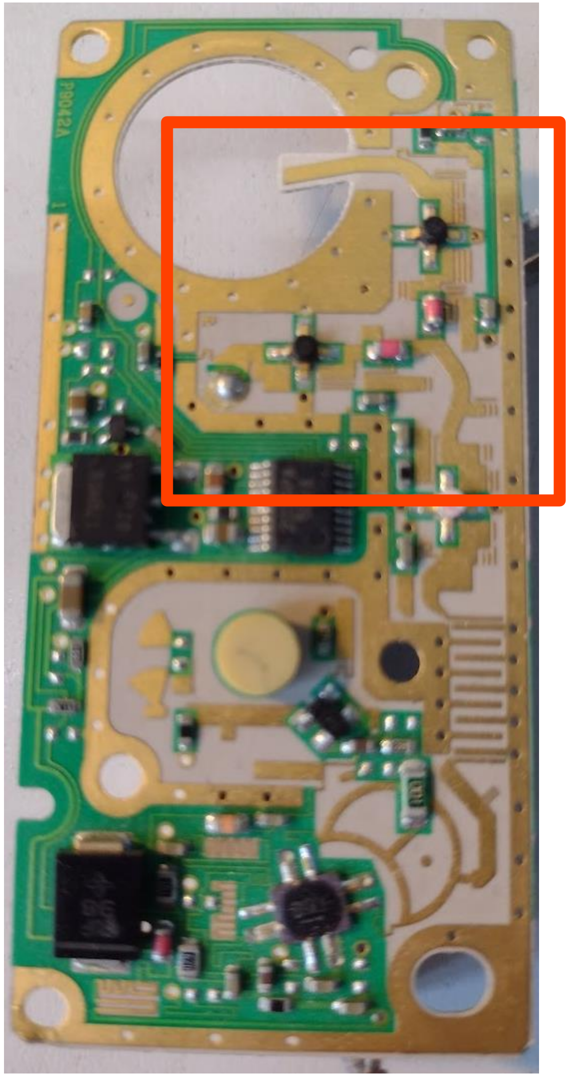
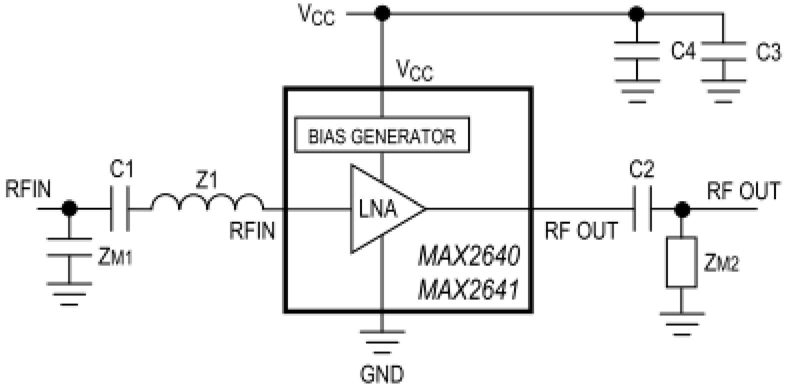
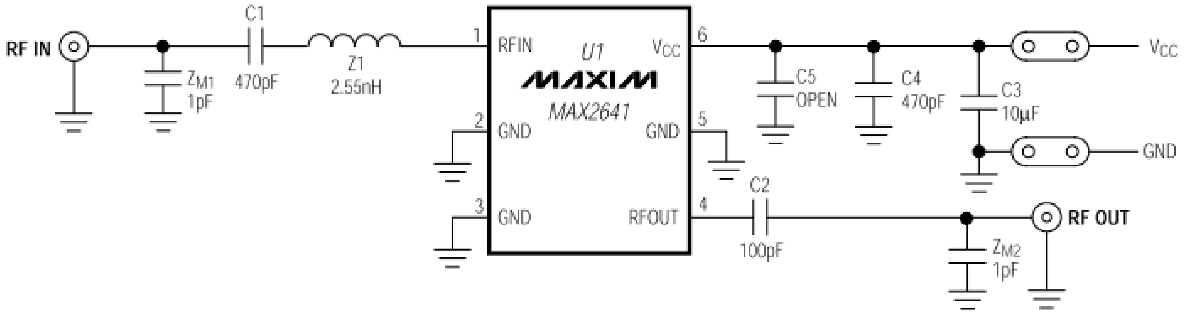
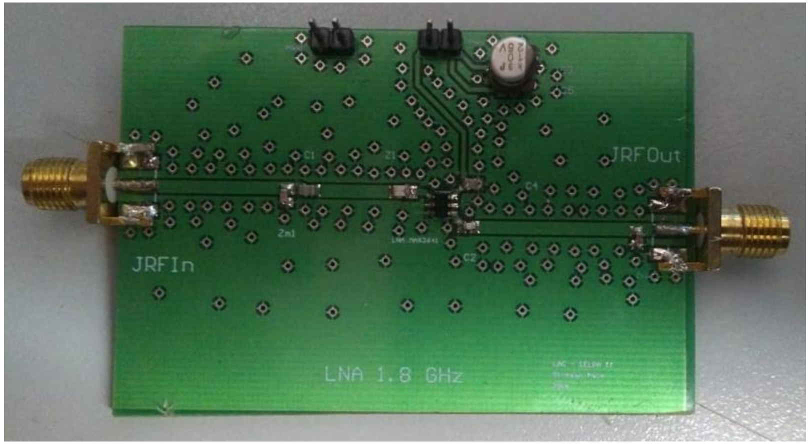


# Examples LNA: Commercial, Assembled and extracted from a DirecTV antenna.




# Examples of a LNA implementation.

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So, if possible, it is convenient to work in bands where there are commercial components that provide reliability to the design.

But in case this possibility is not feasible, they can be designed and implemented.

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# Input Stage: Filters

Like any receiving system, the predetection filter is very important. This filter is a bandpass, which is usually centered on the carrier frequency and must cover at least the bandwidth of the signal to be received.

It must be taken into account that for superheterodyne schemes, this filter must pass all the channels that it is desired to receive.

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# Input Stage: Filters

The filter must be considered to reject the surrounding or other emissions that can affect the performance of the system or even damage it. Likewise, the level of attenuation in the pass band, its ripple level and other factors that condition the choice of each solution must be considered.

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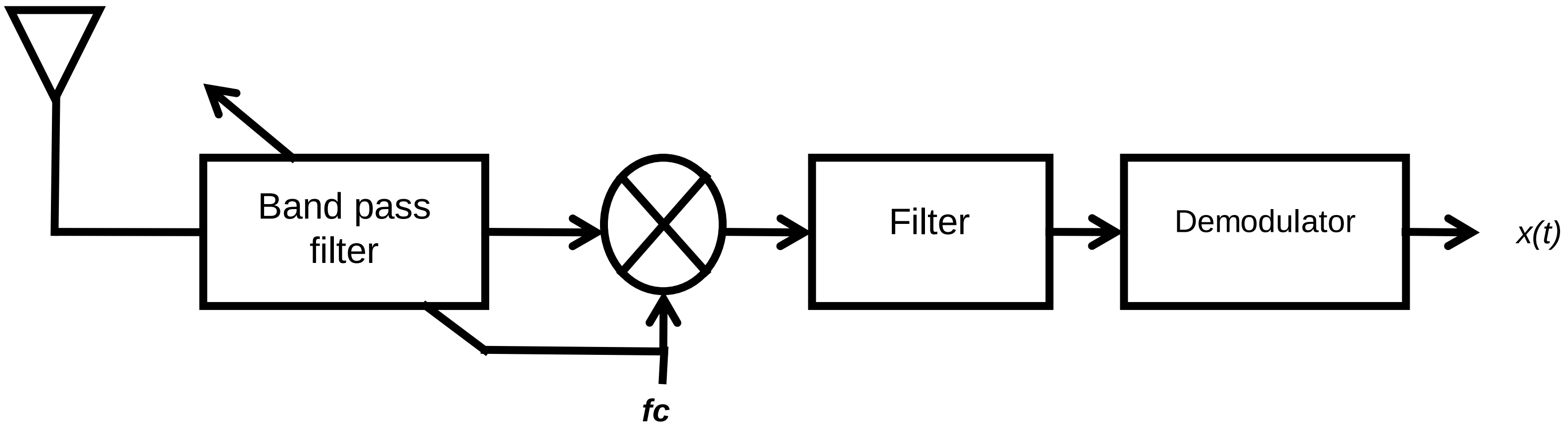
Band pass
filter
Filter
Demodulator
x(t)
fc

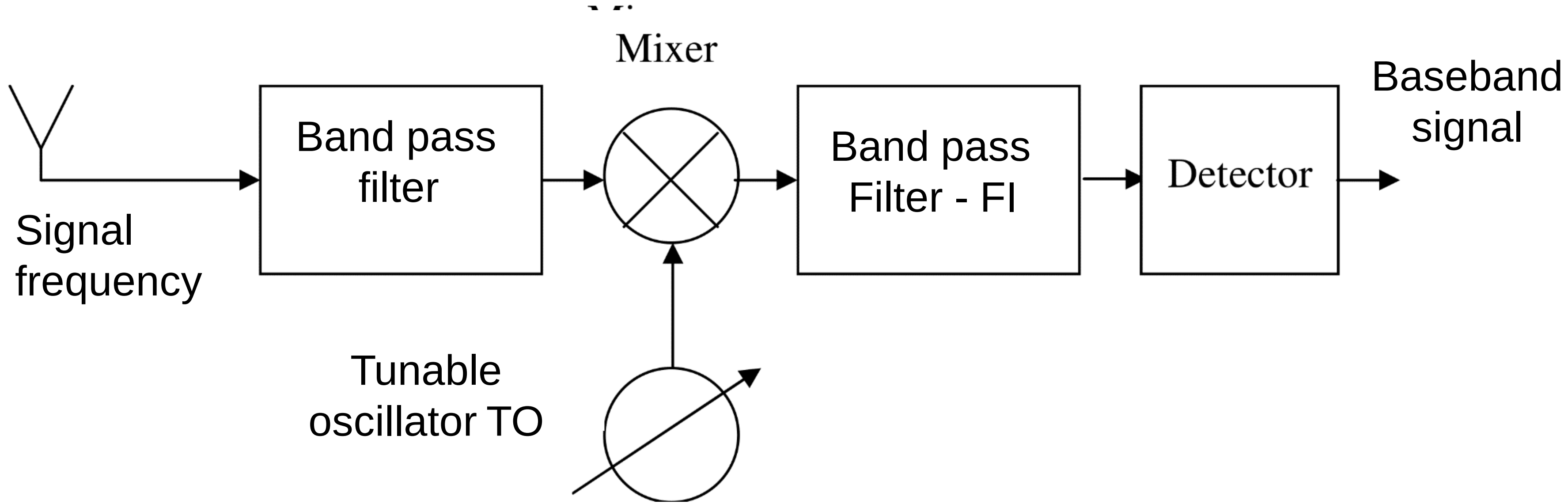


Figure 1. Superheterodyne receiver schematic

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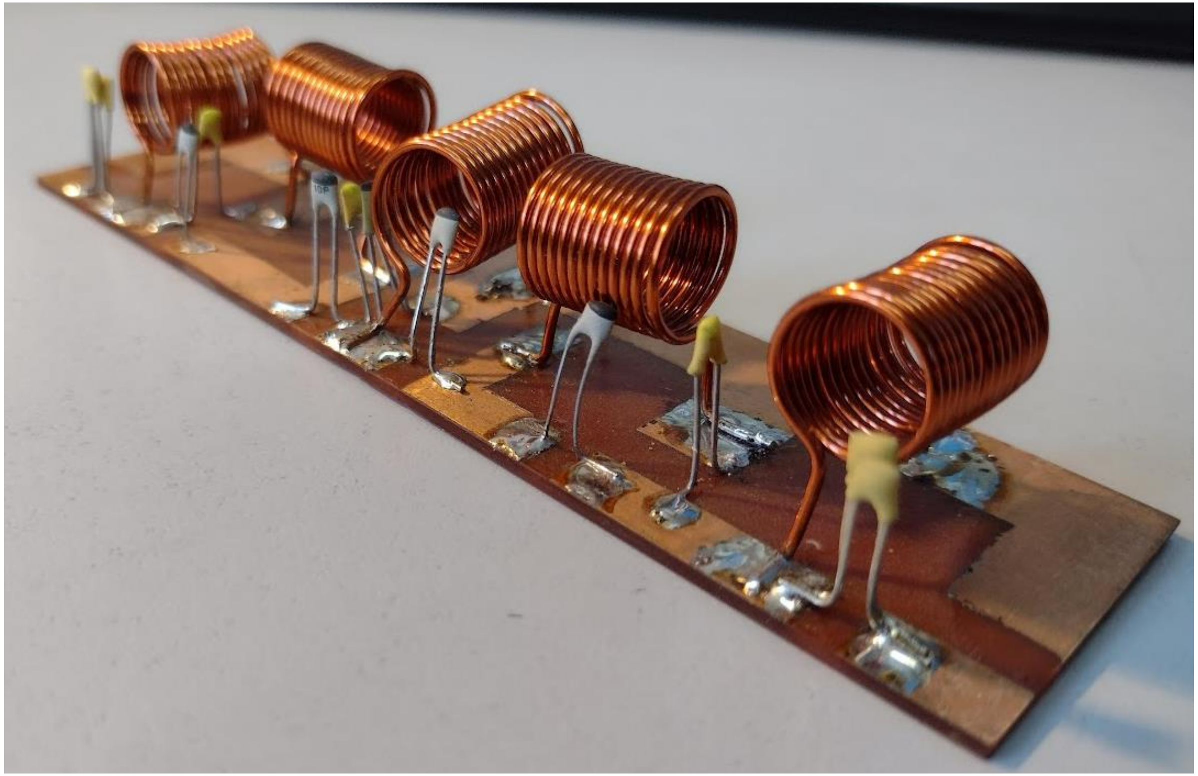

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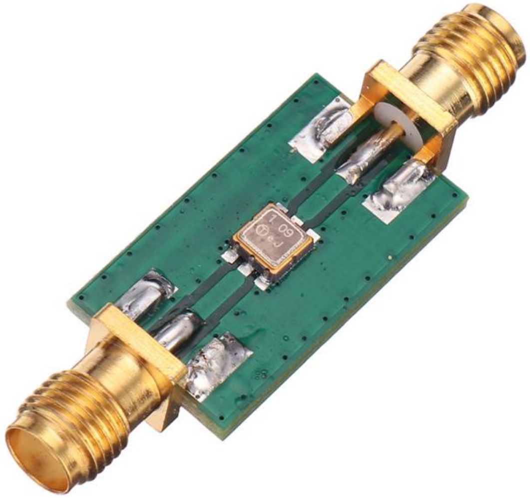
# There is a wide variety of commercial filters if you want to operate in traditional bands.

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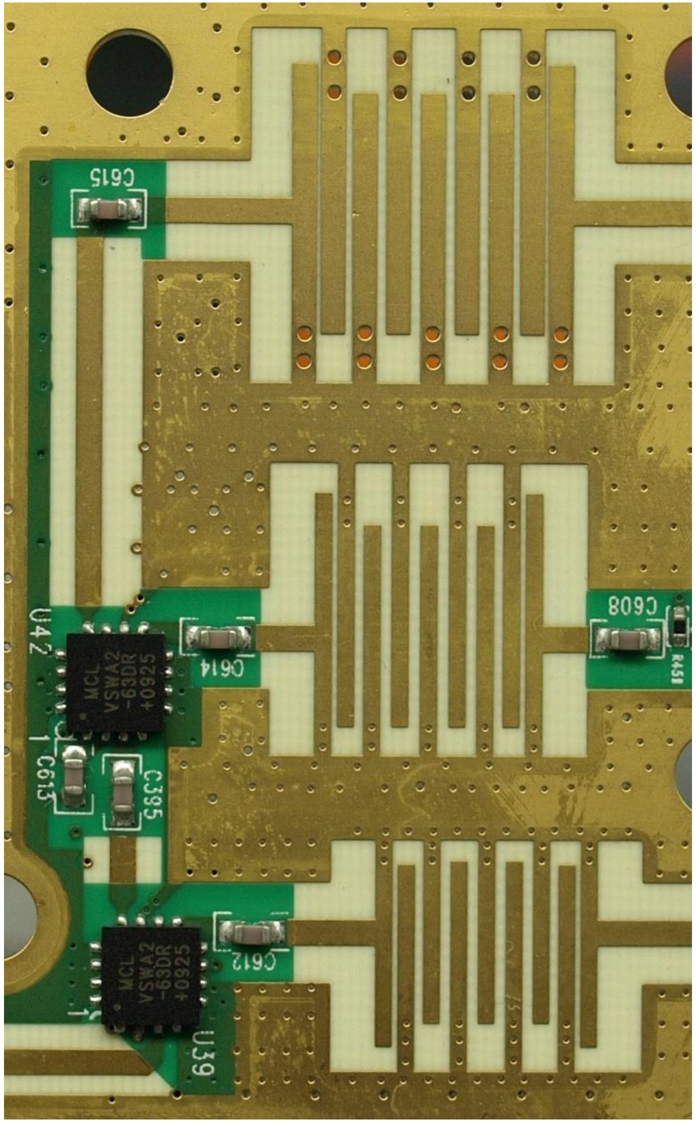


https://commons.wikimedia.org/wiki/File:Interdigital_Filter.jpg

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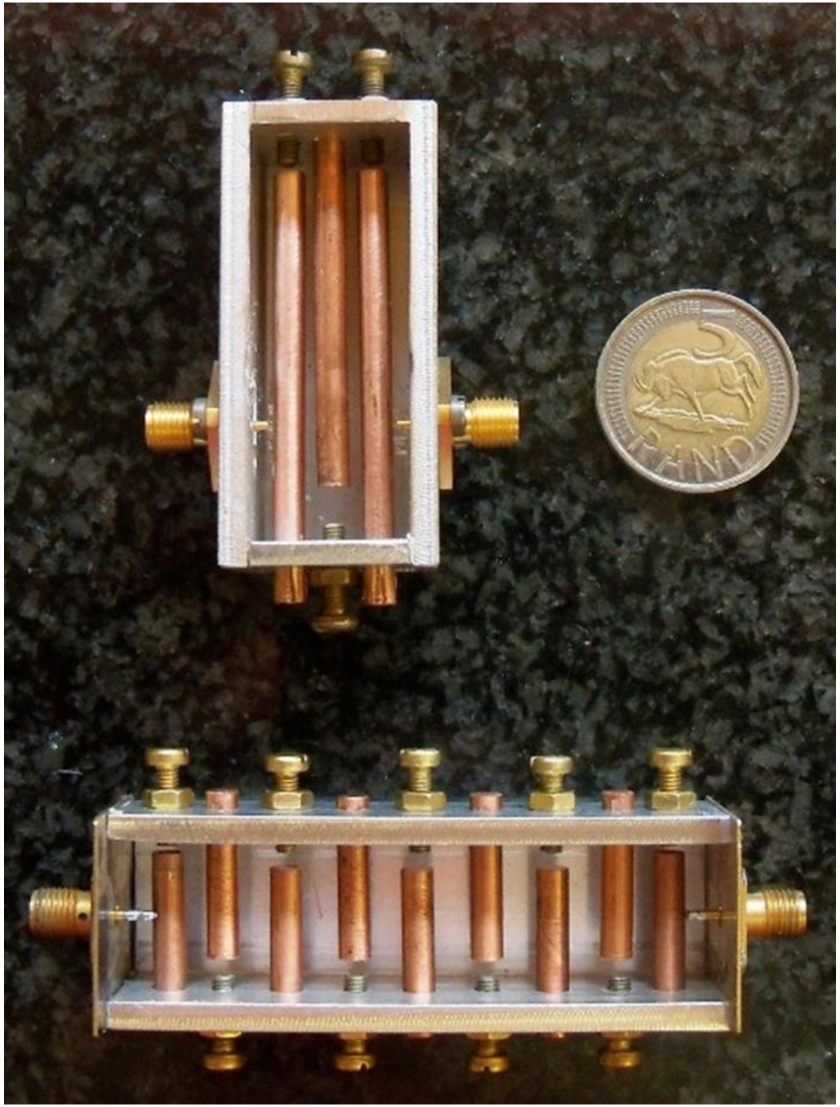


Source: https://www.changpuak.ch/electronics/interdigital_bandpass_filter_designer.php

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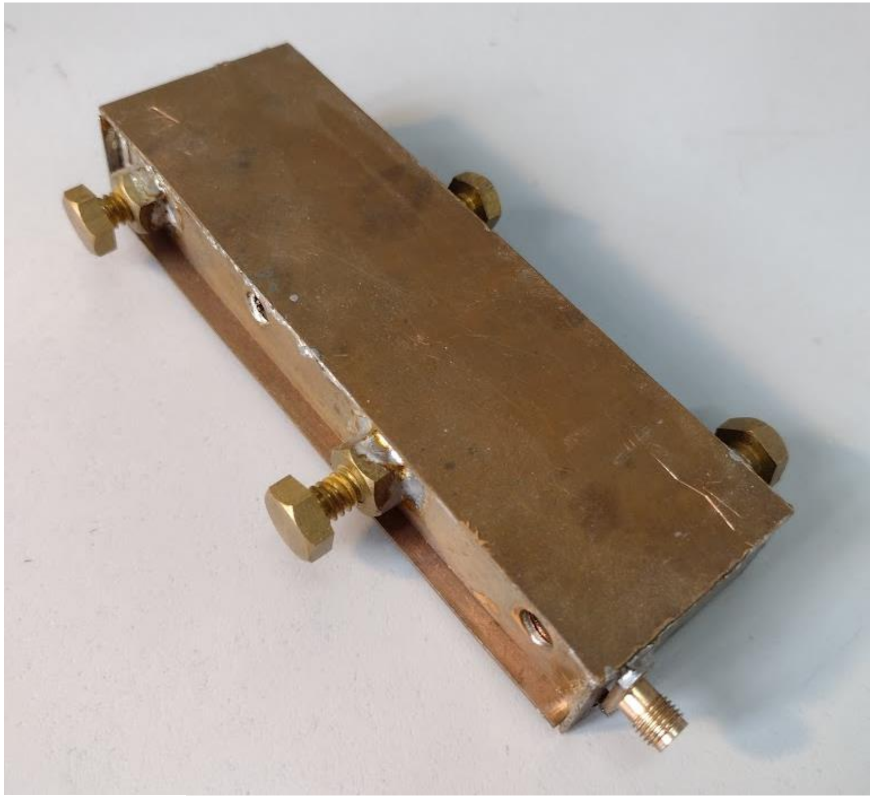

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# Filters with discrete components. It depends on the commercial L and C values

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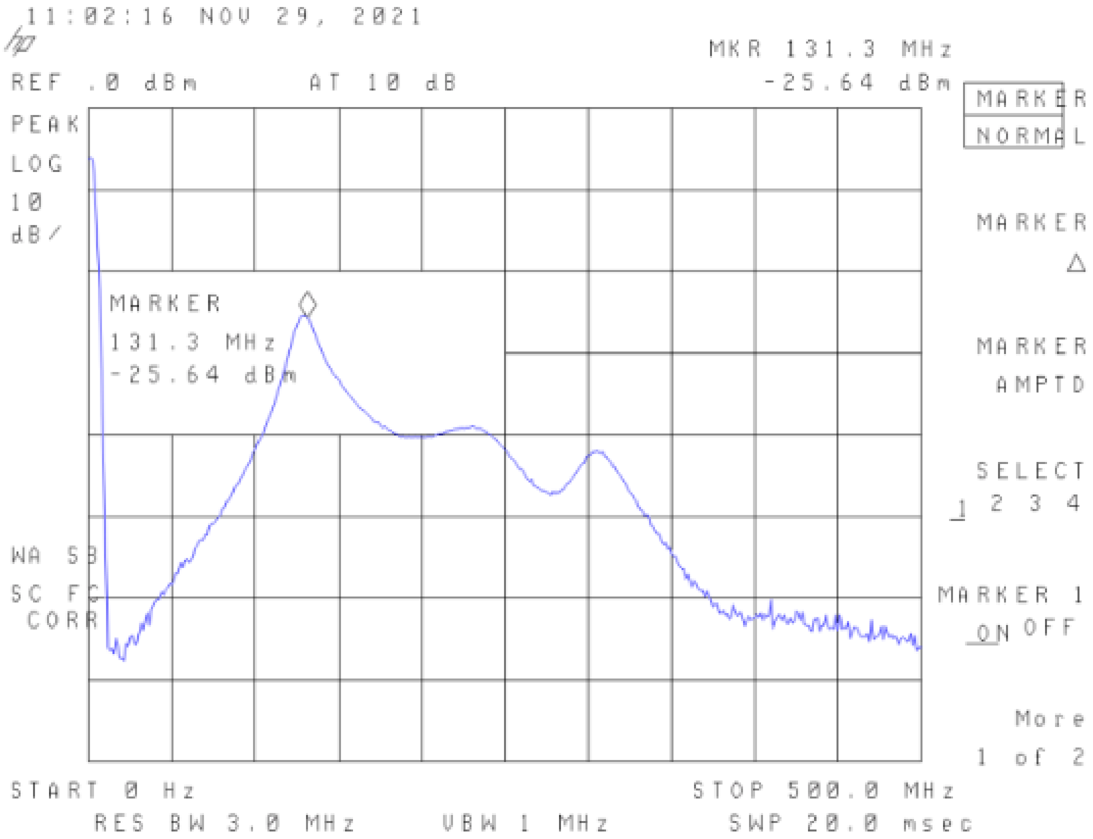



Figura 27: Captura de la respuesta del filtro de 131MHz en el analizador de espectros

# Filters implemented using transmission lines

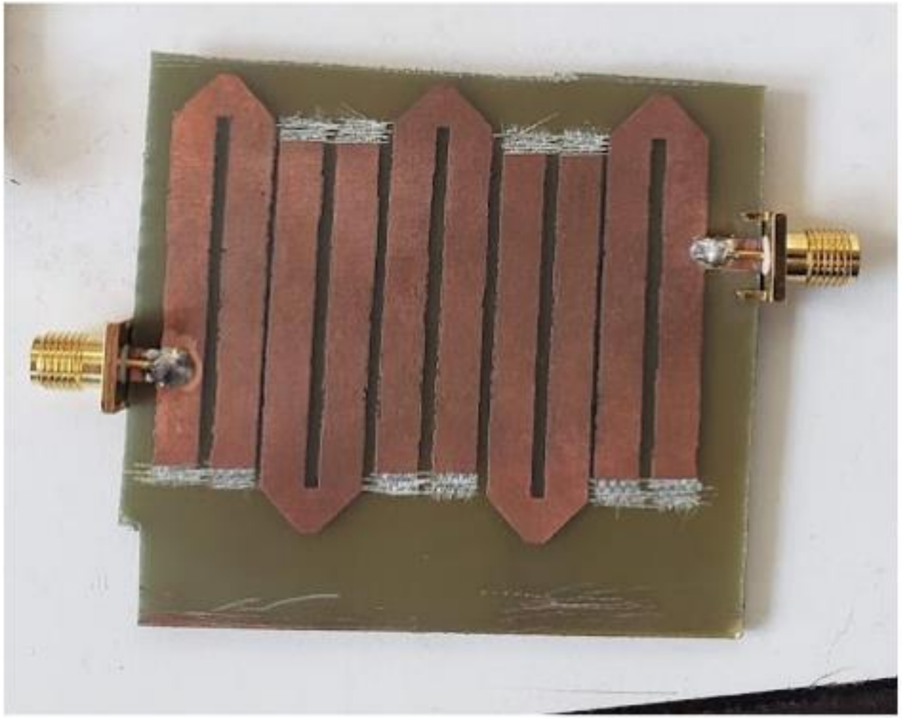
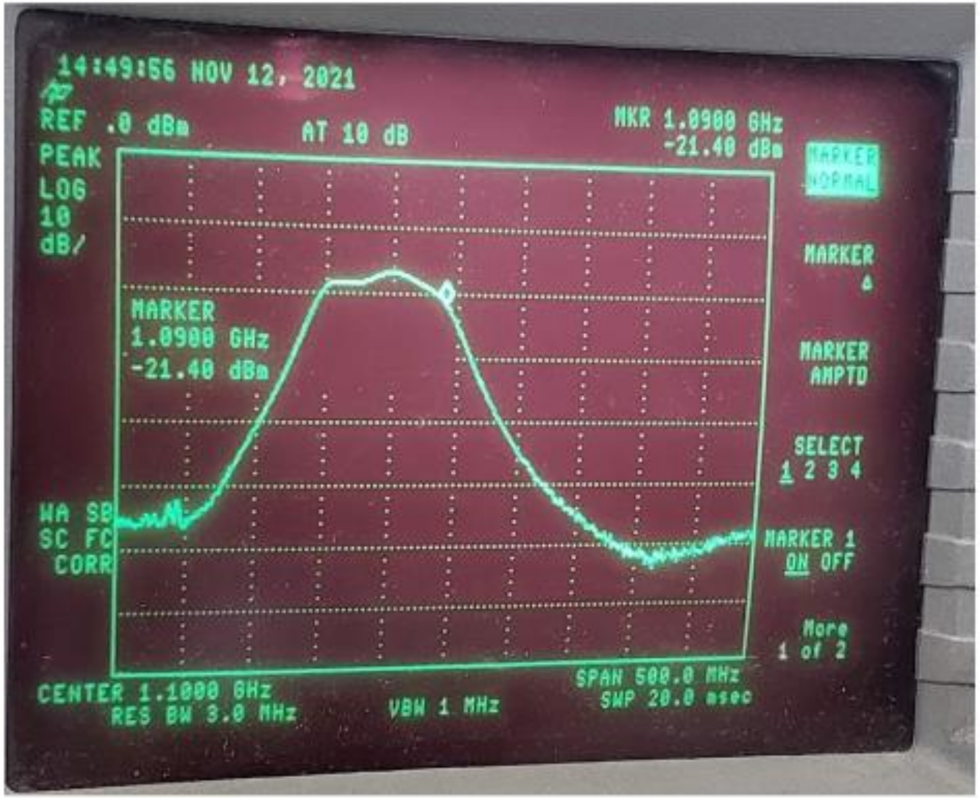


Figura 29: Foto del filtro calibrado

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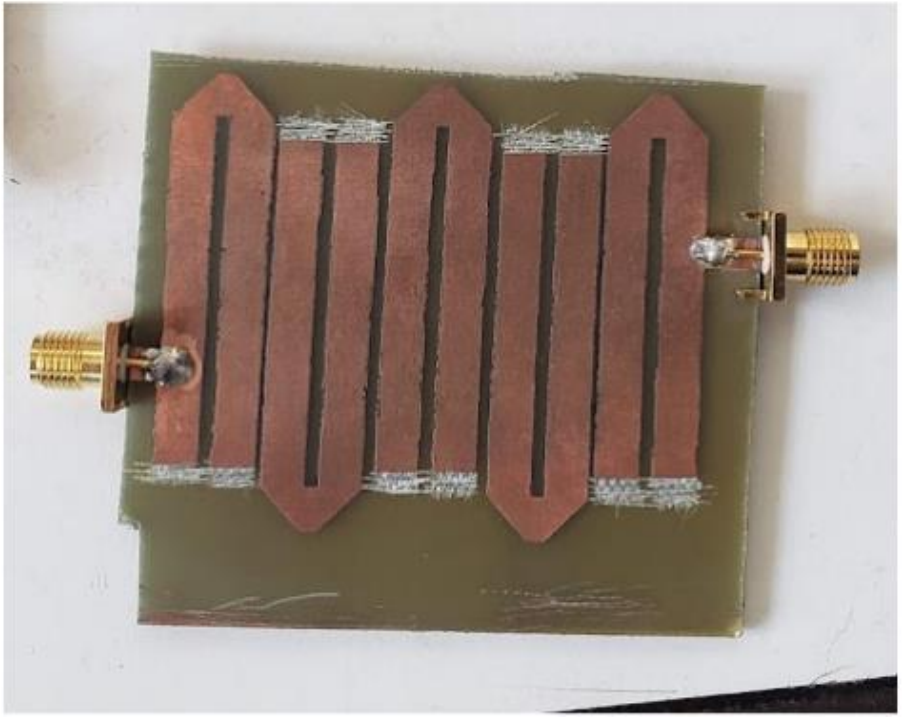
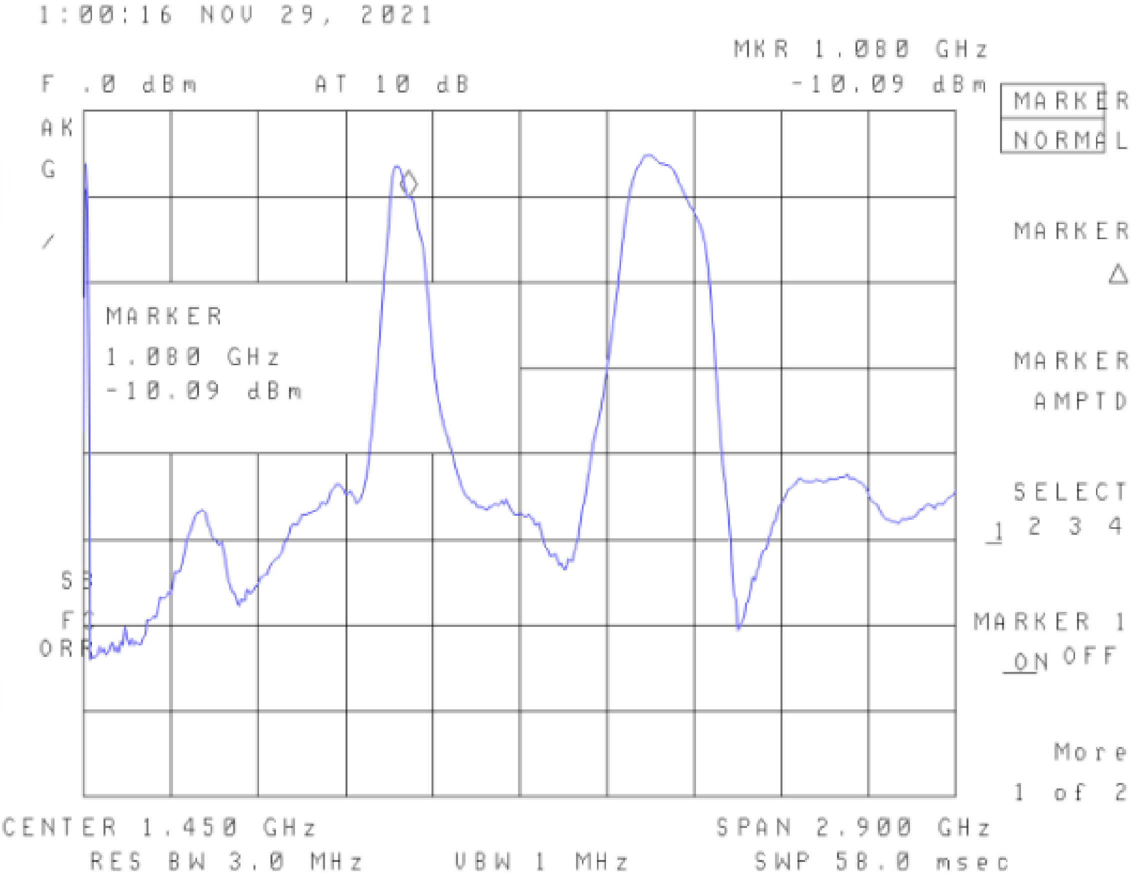
# Filters implemented with transmission lines: It is easier to obtain desired L and C values, but they present resonances at twice the center frequency.



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# Combiners - Splitters

In some systems that operate in more than one operating band, it is often necessary to use two antennas, two LNAs and two BPFs. But in the input of the SDR we find that we must combine both signals. For this, a combiner circuit must be incorporated.

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# Types of Combiners / Splitters

Combiners / Splitters through lines: Less bandwidth, greater isolation.

Resistive Combiners / Dividers: More bandwidth, less isolation between stages.

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# Combiners / Splitters: Most common topologies.

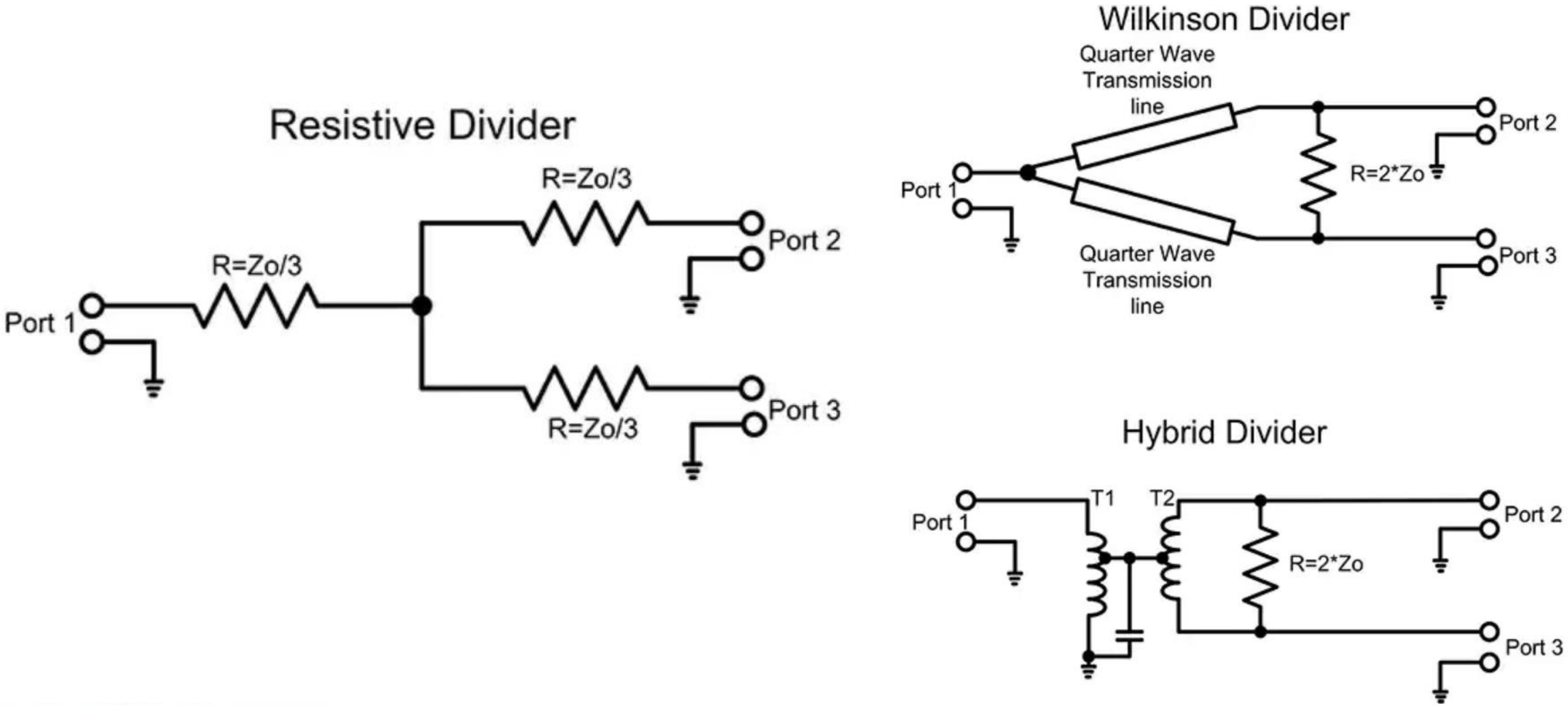


*Figura 3: Esquemas simplificados de las tres topologías comunes de divisores de potencia: resistiva, Wilkinson e híbrida. (Fuente de la imagen: Digi-Key Electronics)*

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# Combiners / Splitters: Most common topologies.

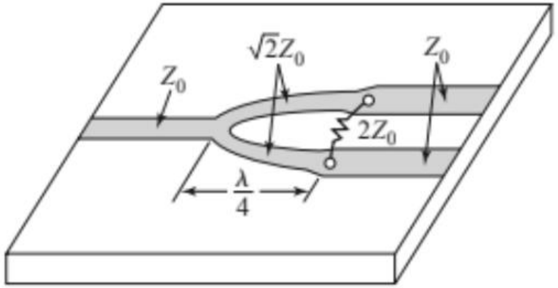
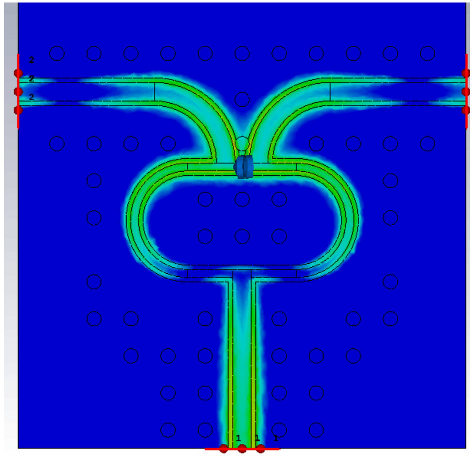
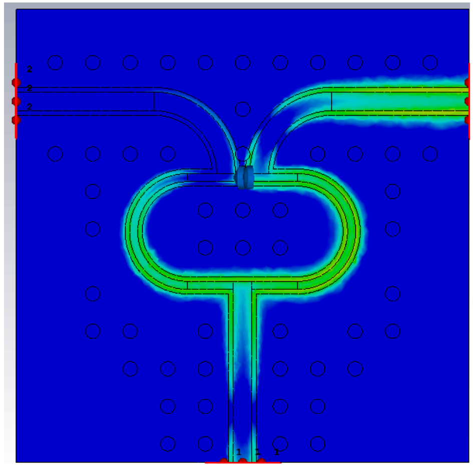
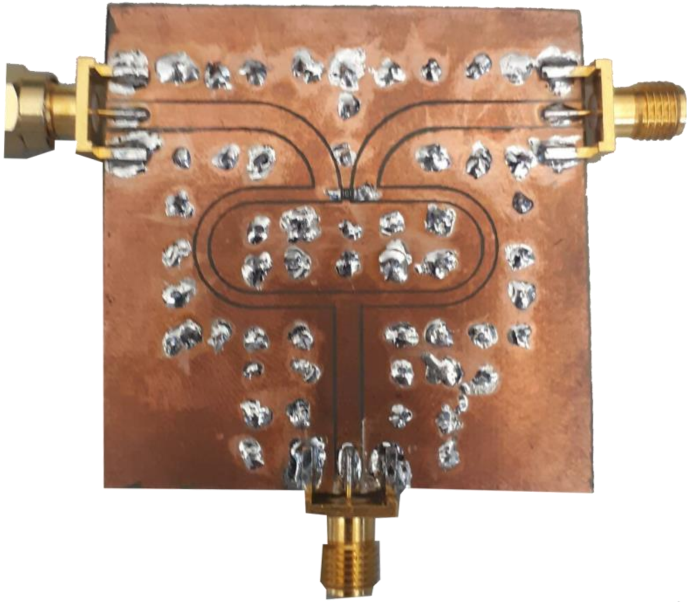



Figura 3.11: Splitter de Wilkinson, Diseño







- Economic.
- Simple.
- Low insertion losses.
- Good isolation between output ports.

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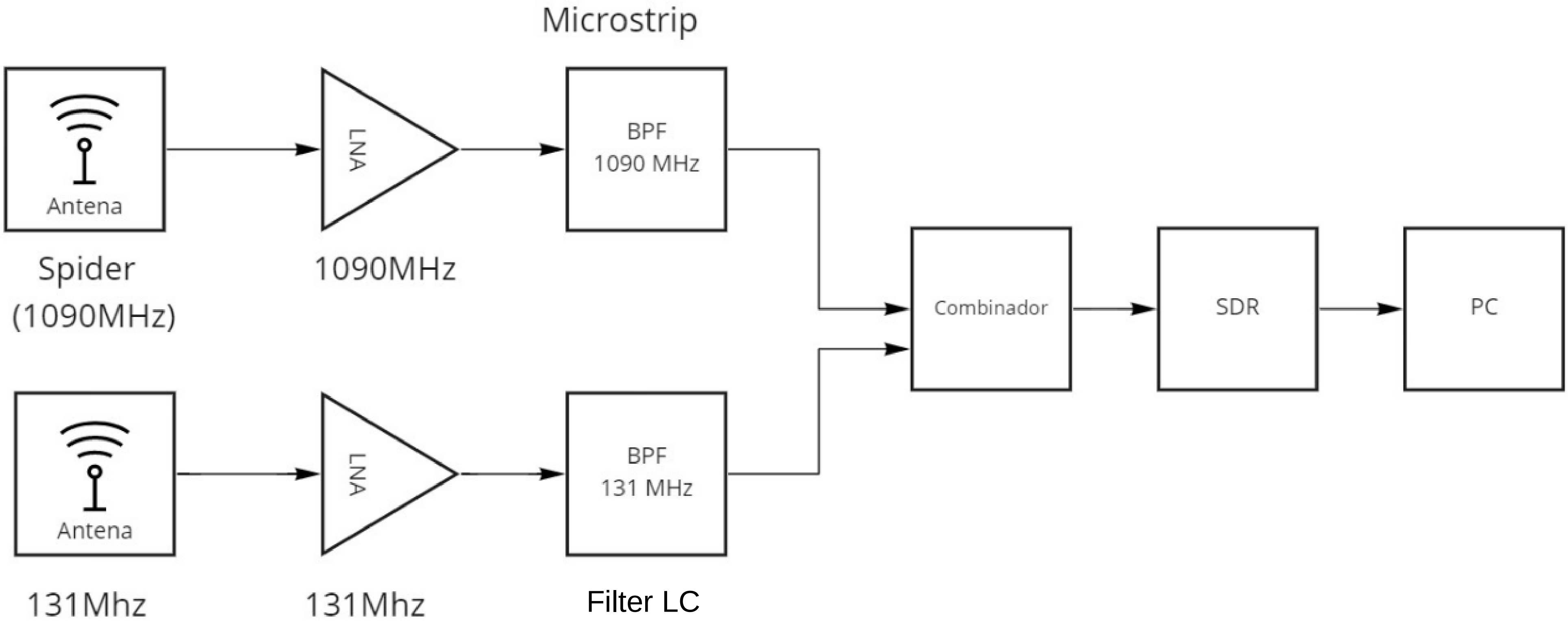
# Combiners / Splitters.

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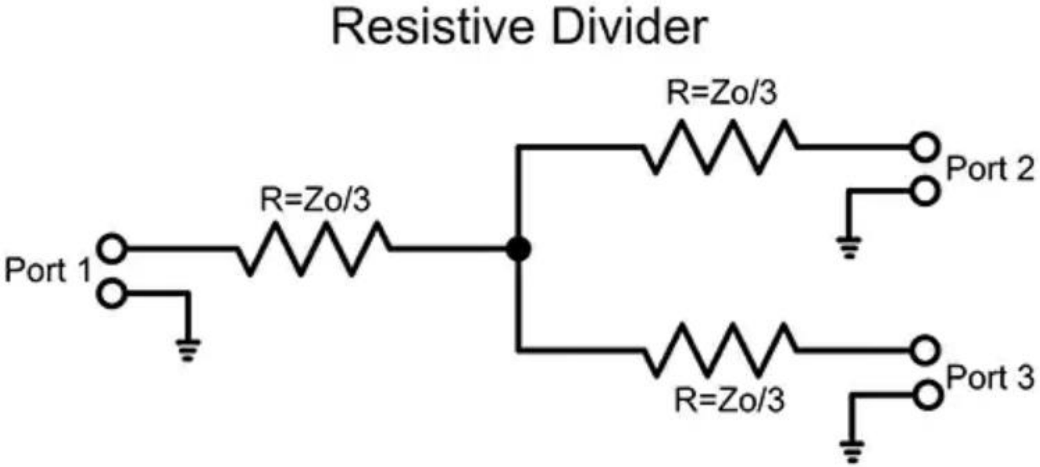
# Resistive combiners: Higher bandwidth, lower isolation.




Source: Digi-Key Electronics

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# RF Switches

In other cases, instead of adding two signals and inputting them to the SDR, you want to do time-domain multiplexing or choose one of them. For this, RF keys can be used.

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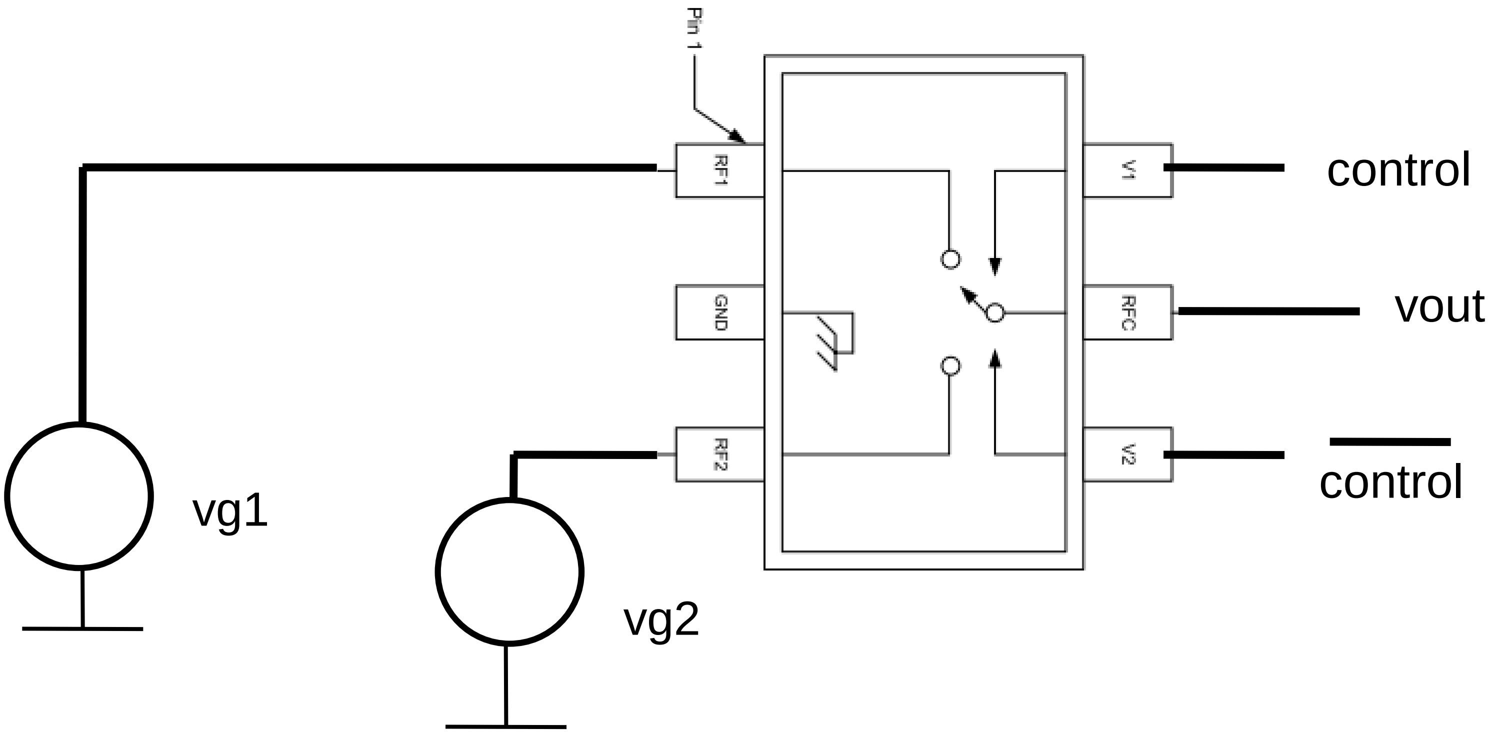


If control = 1 then vout = vg1
If control = 0 then vout = vg2

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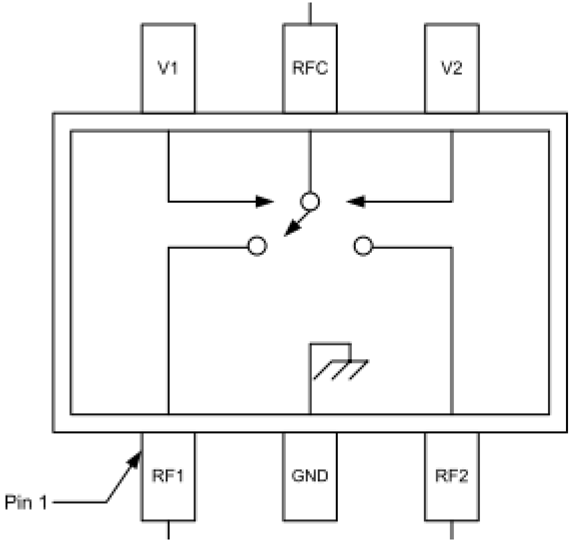
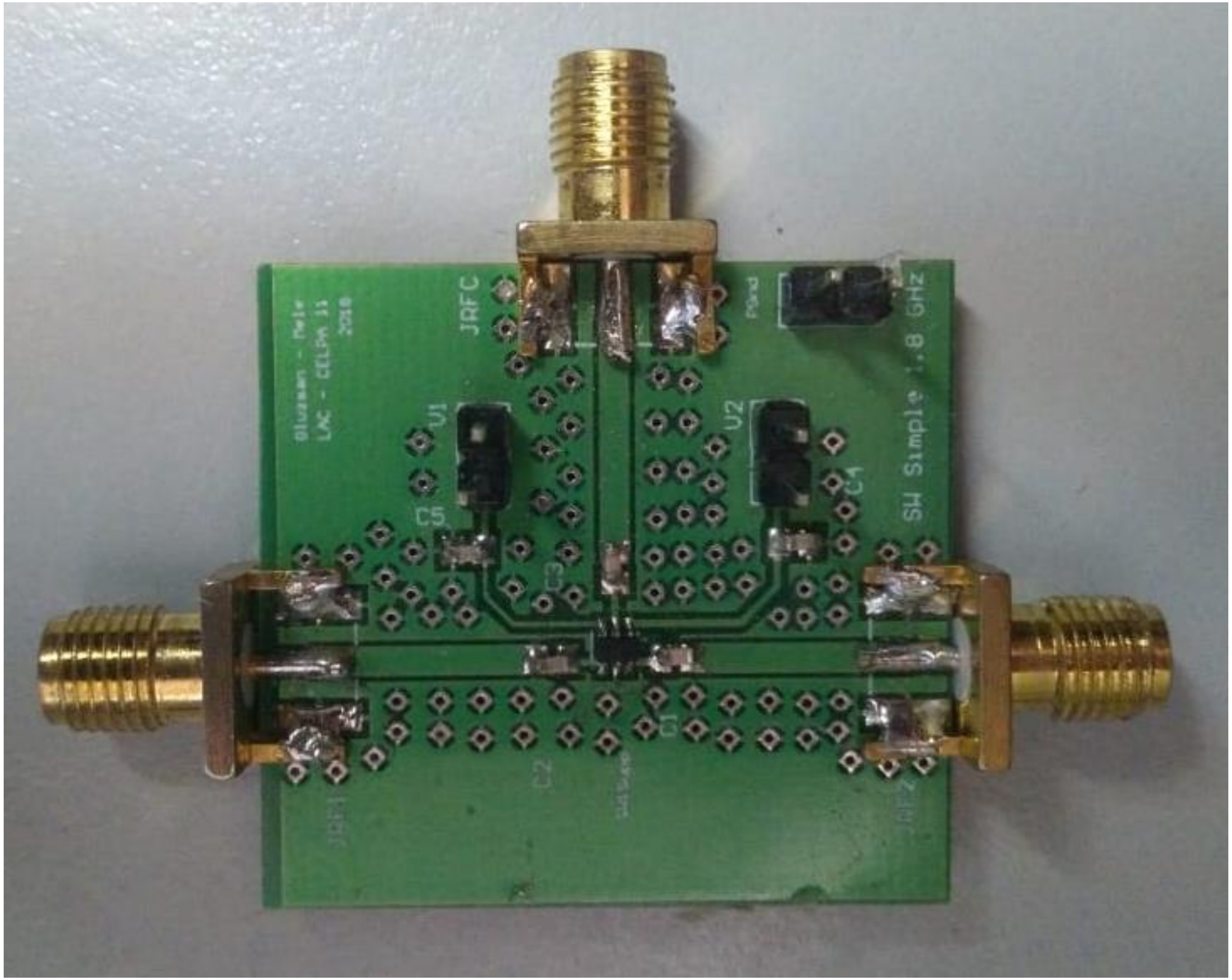



MASWSS0136

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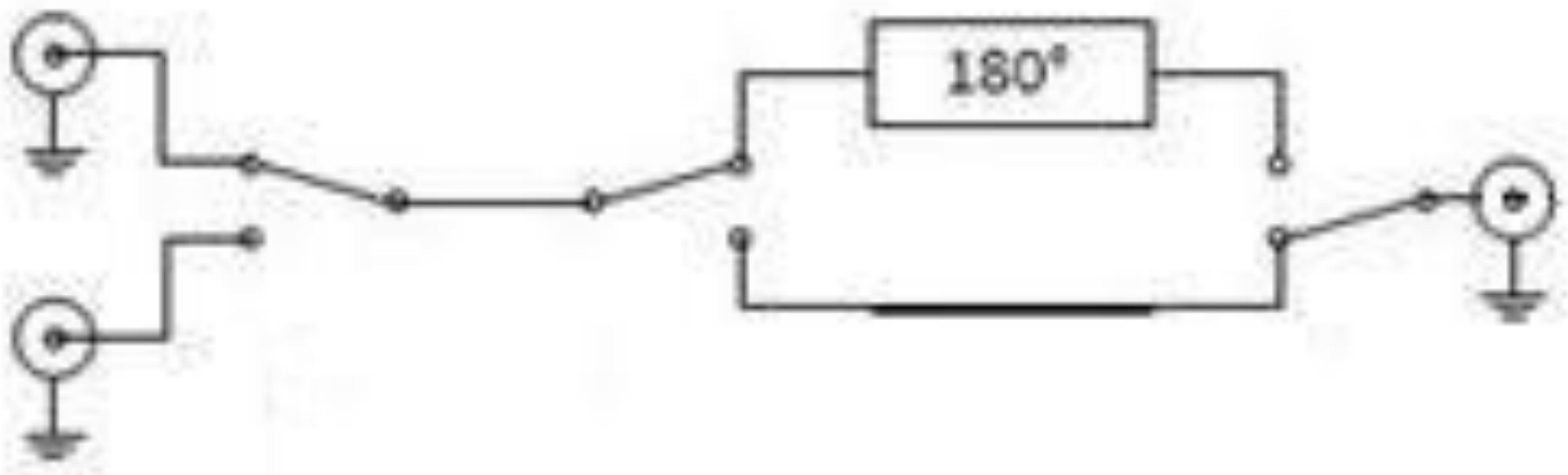


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Although the SDR has a large operating frequency range, it is sometimes necessary to operate with signals below the lower limit or above the upper limit. It may even be necessary to shift a signal in frequency for better processing. For this, it is usually necessary to use mixers that operate as down-converter or up-converter.

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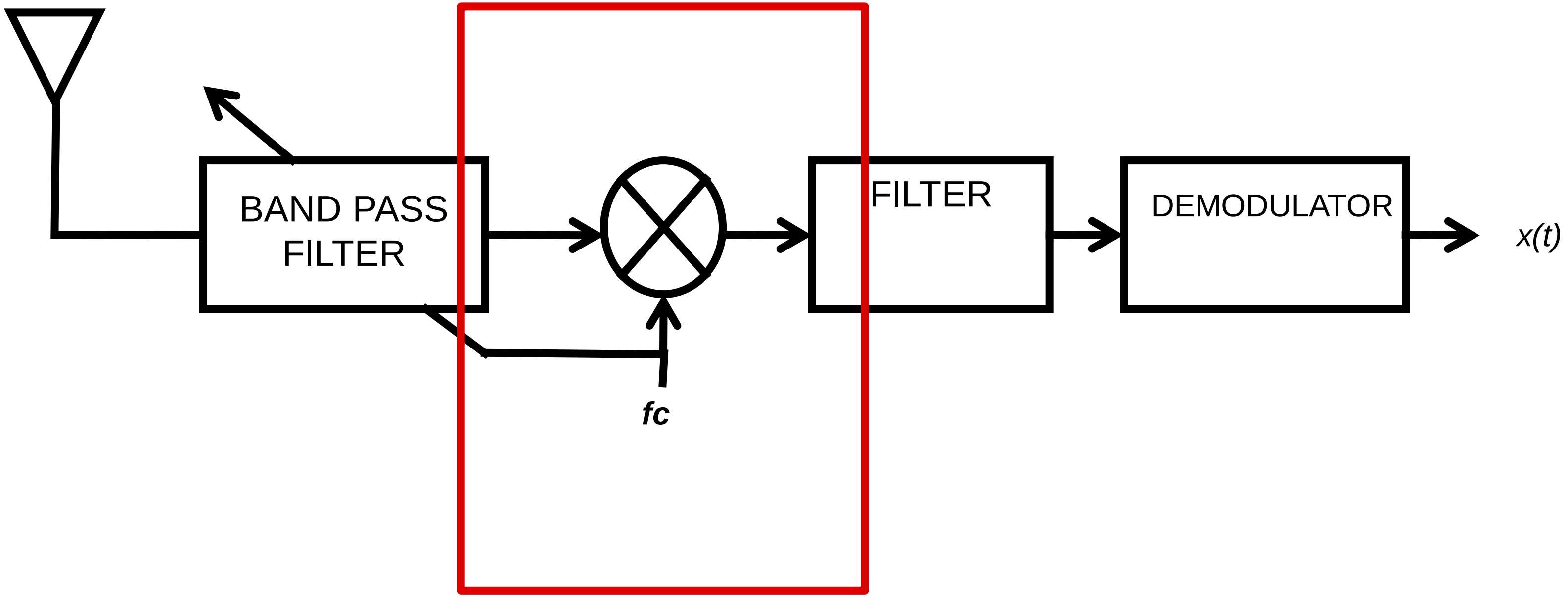


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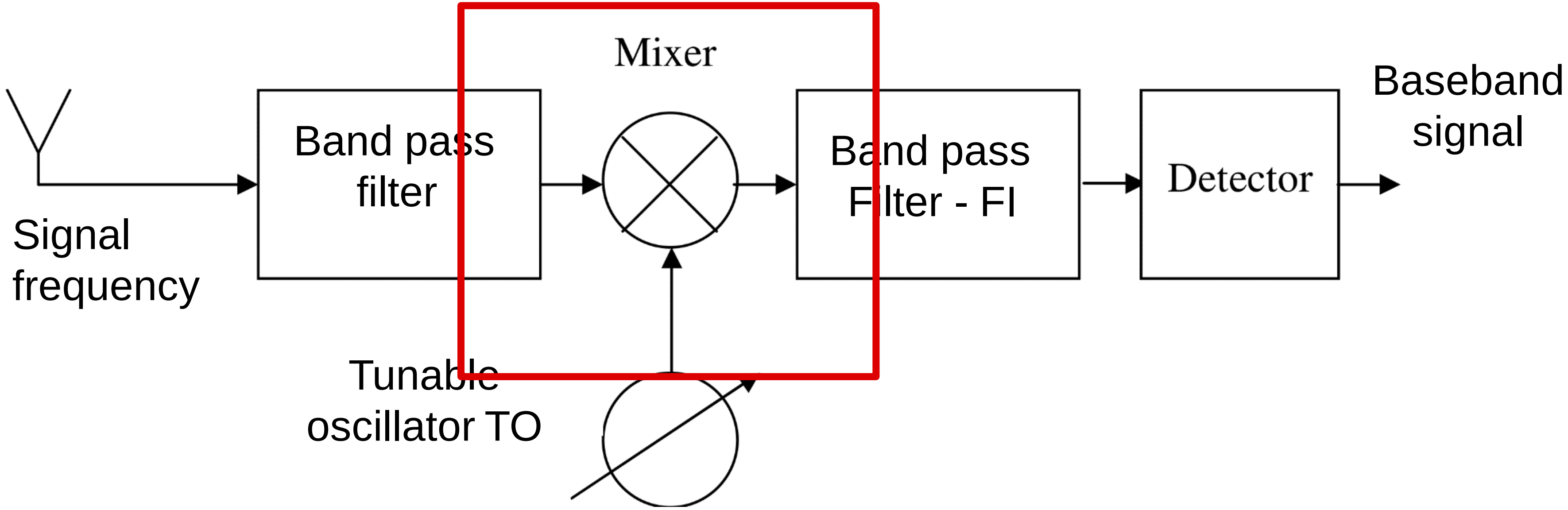


Figure 1. Superheterodyne receiver schematic

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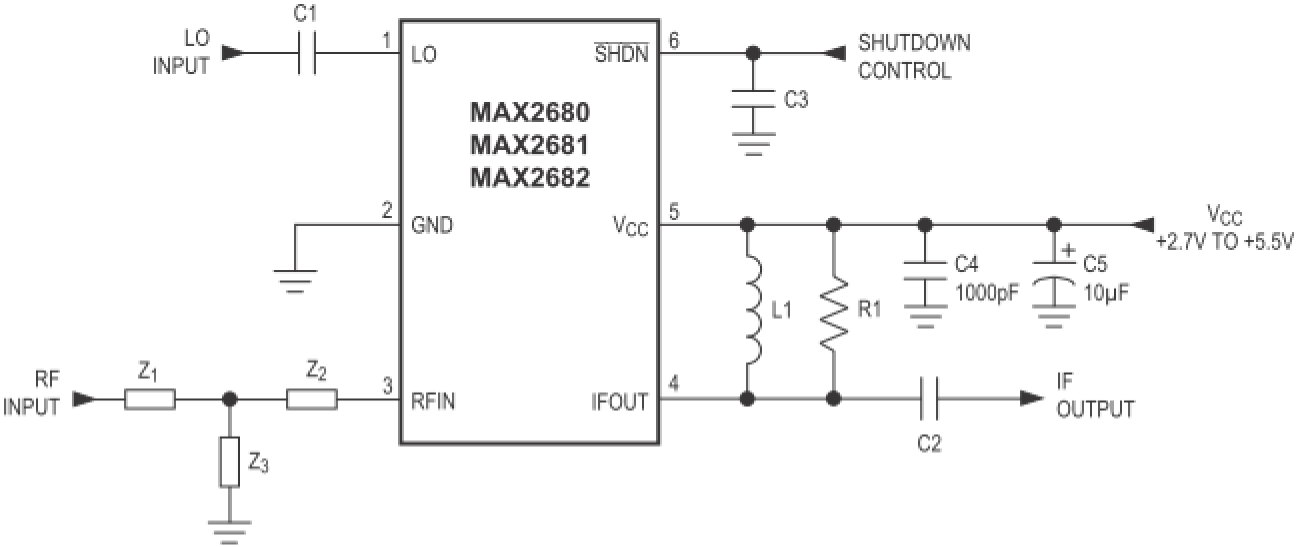
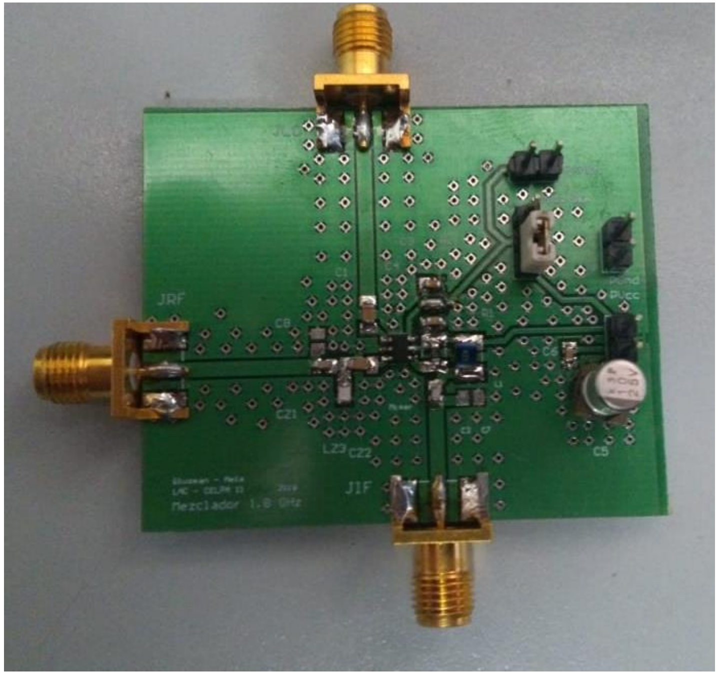
# Mixers

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# Output amplifiers

In cases the calculation of the link requires a certain power to be transmitted and this cannot be generated by the SDR system, an output amplifier must be included.

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# Circulators - Isolators

In cases where a system is operated to transmit and receive in the same band, the antenna is shared and the difference in the powers to be transmitted and received are significant, it is necessary to include an isolator to avoid damaging the input of the SDR during transmission.

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# Circulators - Isolators

Four-port passive transmission line type.

They have two inputs and two outputs.

It is built with sections with specific lengths,
so that:

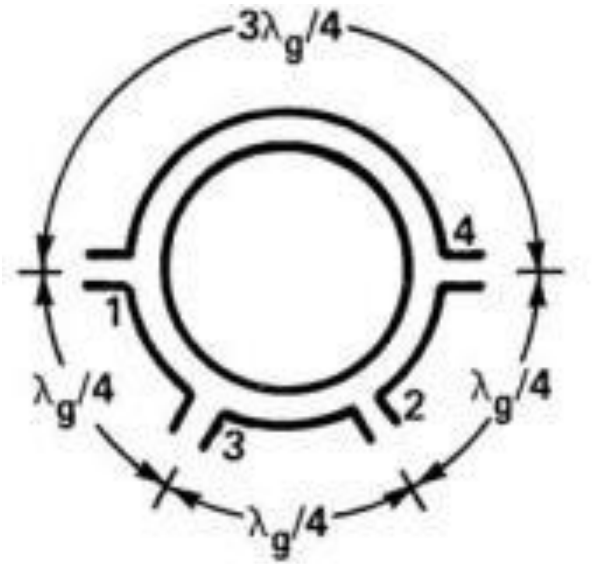
- An exit adds to the signs.

- A subtraction to the signals.

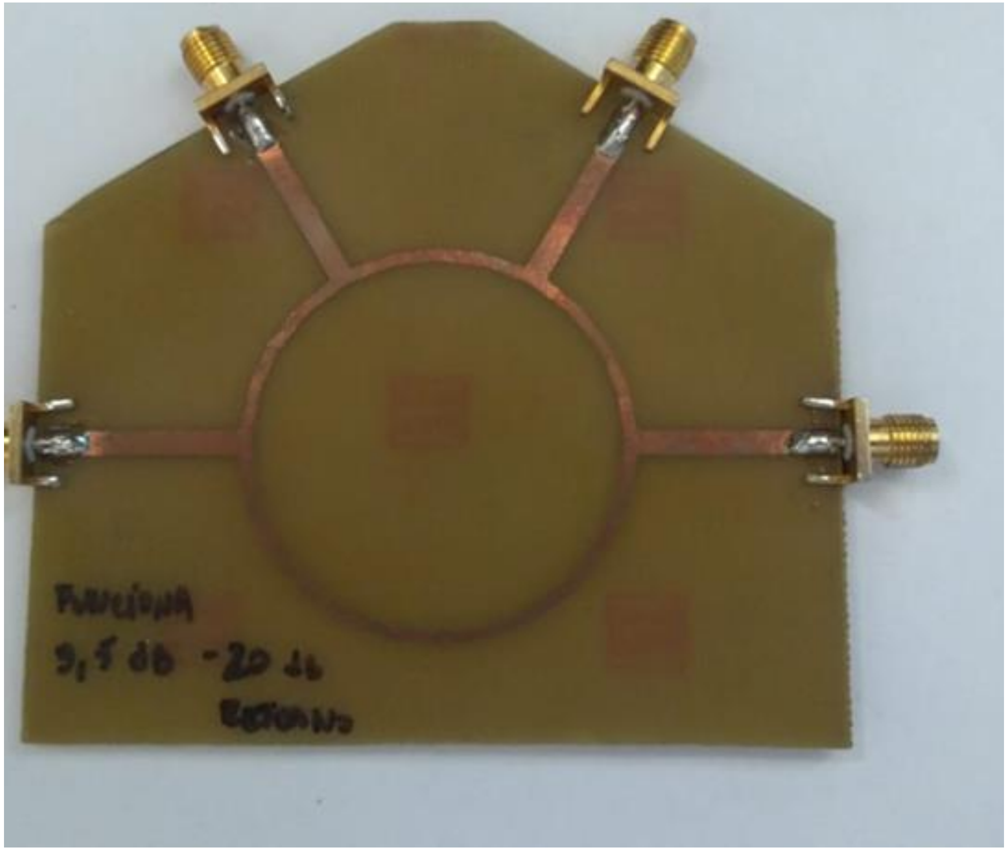
Use of Microstrip/Stripline technology in RF.

Parameters:

Impedance (Z0=50 Ohms)
Frequency (1.8GHz)
Dielectric (FR4)



# Circulators – Isolators

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# Circulators - Isolators



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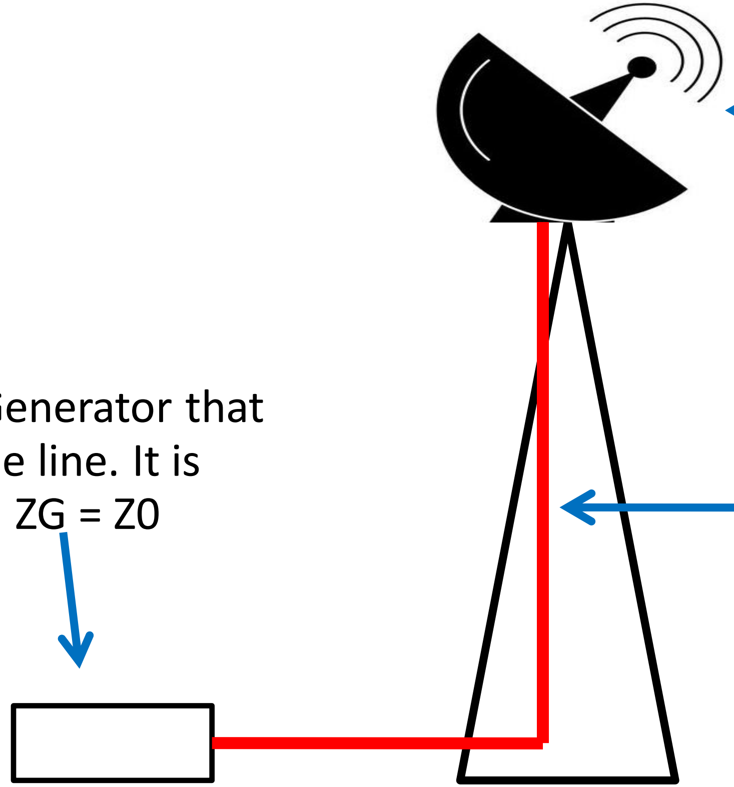
# Transmission Lines – Adapted Line

Load: Antenna. There is adaptation if ZL = Z0

Source: Generator that excites the line. It is assumed: ZG = Z0



Transmission line: Cable that connects the antenna and the generator. It has characteristic impedance Z0

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# Transmission Lines – Adapted Line

Transmission line: Cable that connects the antenna and the generator. It has characteristic impedance Z0

Load: There is adaptation if ZL = Z0

Source: Generator that excites the line. It is assumed: ZG = Z0

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# Transmission Lines – Adapters

When the transmission line is connected to a load of value $Z_0$, the reflection coefficient is zero. In this case, there is no reflected wave. This is the ideal condition in the design of transmission and reception systems. The presence of reflected wave indicates loss of power as a result of that reflection, which does not access the load, as well as power applied to the output of the generating device that have to be absorbed without causing destruction of the same. When the load is, for some forced reason, other than $Z_0$, it proceeds to its adaptation. Adapting the load implies connecting a network, in theory without losses, which modifies the impedance levels so that $Z_L$ is seen by the generator as a charge $Z_0$. There are many ways to perform the adaptation. Some are discussed here of them.

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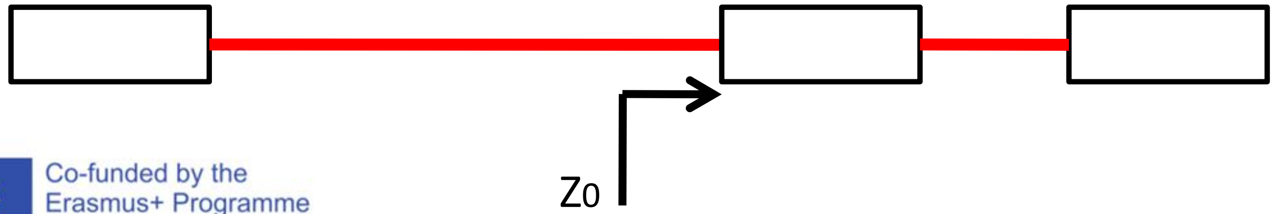
# Transmission Lines – Adapter Network

Transmission line: Cable that connects the antenna and the generator. It has characteristic impedance $Z_0$

Load not adapted (with $Z_L \neq Z_0$ )

Source: Generator that excites the line. It is assumed: $Z_G = Z_0$

Adapter Network



# Impedance matching

Impedance matching between stages is critical to avoid wasting power on reflections. In some cases even the system might not work because of it. Likewise, it must be taken into account that the impedance of each of the stages varies with frequency (it is not a $Z_0$= 50 Ohms constant.).

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# Impedance matching

There are different impedance matching techniques. When choosing the optimal one, we must know the type of load to adapt (which is usually real and imaginary) and the adaptation bandwidth. The latter is due to the fact that the adaptations are usually implemented at a frequency and then, as we move away from it, a mismatch appears that may or may not be acceptable depending on the application.

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# Transmission Lines – λ/4 Adapters.

In general, this adapter is used to adapt a resistive load $R_L$ other than $Z_0$, to that value.

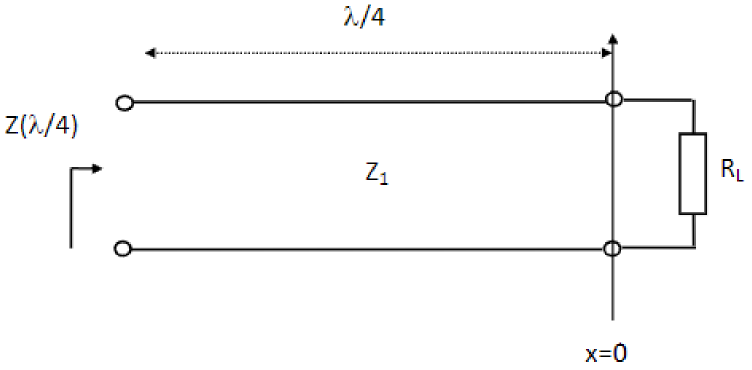


Figure 4.22 Quarter-wavelength adaptation

Then:

$$Z(\lambda/4) = \frac{Z_1^2}{R_L} = Z_0$$

$$Z_1 = \sqrt{Z_0 . R_L}$$

# Transmission Lines – λ/4 Adapters.

Steps:

$R_L$ and $Z_0$ dice:

1- Calculation $Z_1 = \sqrt{Z_0 . R_L}$

For example, a load of $R_L$=200Ω can be matched to 50Ω if the impedance characteristic of the quarter-wave stretch is $Z_1$=100Ω. Remember that this adapter is preferably used if the load is resistive pure. To see this adaptation effect in the abacus, one must normalize with respect to $Z_1$.

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# Transmission Lines – λ/4 Adapters.

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# Transmission Lines – Simple Stub Adapters

The adaptation called by simple stub uses what is called "taco", that is, a transmission line that is short-circuited (DC) or open circuit (AC), connected in parallel. As seen, these lines. They offer an impedance at input terminals that is pure reactive. The use combination of these lines with sections of line without losses allows to design lossless matching networks. The simplest adaptation scheme is the one seen in the figure

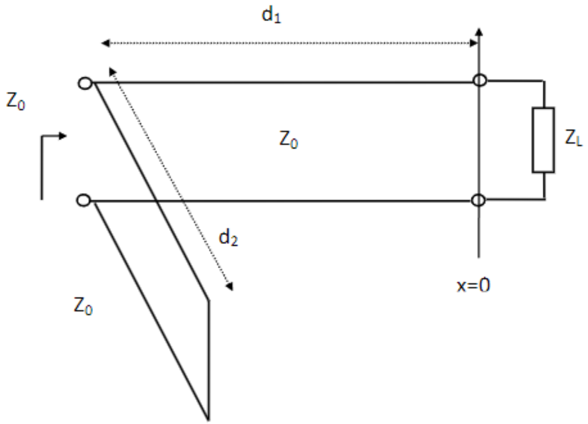
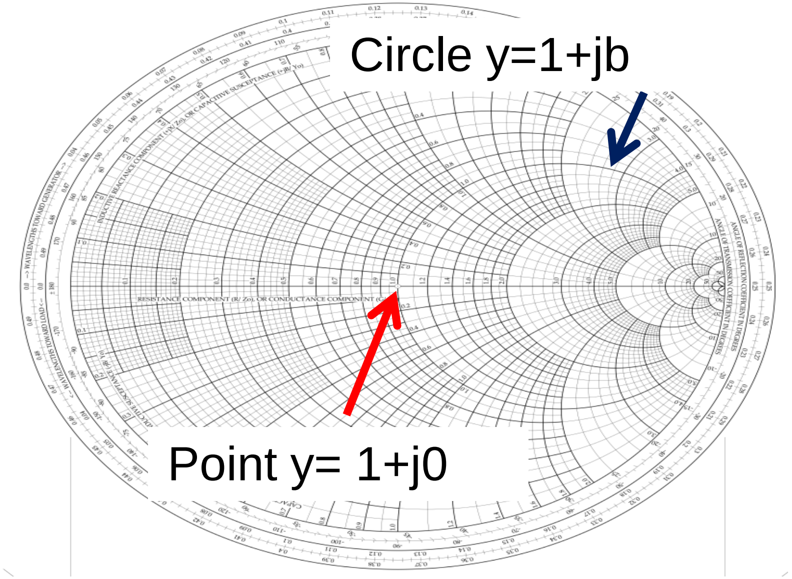
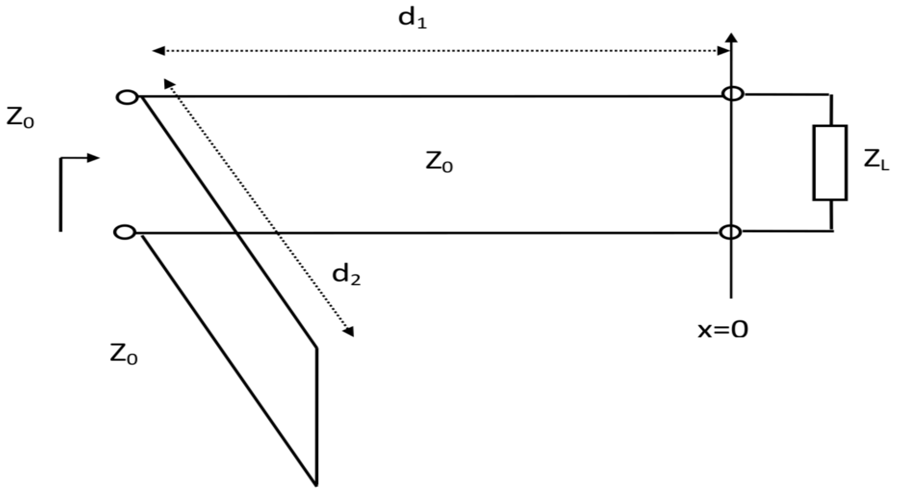



Figure 4.19 Simple stub adaptation



# Transmission Lines – Simple Stub Adapters




The section of transmission line without losses $d_1$ modifies the admittance $Y_L$ of so that at that distance, said impedance becomes $Y_0$ ± jB. The calculation of the adaptation is made by normalizing the impedance $Y_L$ to $Z_0$. Then proceed to calculate the corresponding normalized admittance $y_L$ (Taking the point diametrically opposite $Z_L$, the normalized impedance). The value of normalized admittance is modified by moving to constant ROE along line 1, to become 1±jb. The “stub”, or CC transmission line or CA, cancels the imaginary part ±jb, because being in parallel implies simply a sum of a suceptance of opposite sign. (This is the reason to work on admittance).

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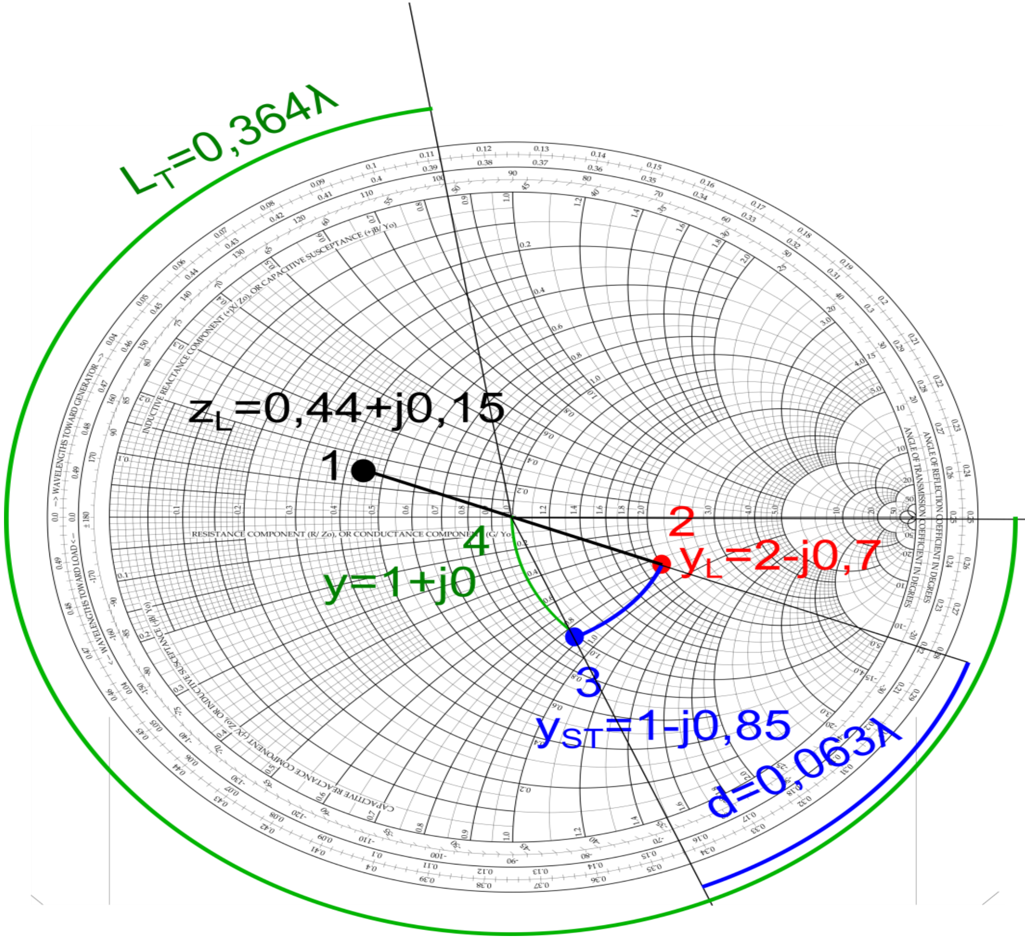
# Transmission Lines – Simple Stub Adapters

**Example:**

Adapt a load $Z_L$= (22 + j7.5) Ω, to an impedance generator $Z_0$=50 Ω, through impedance transmission lines $Z_0$=50 Ω. If the impedance is normalized, the value $z_L$ = 0.44 +j0.15 is obtained. The corresponding normalized admittance is: $y_L$=2-j0.7. the stretch of line transmission 1 is used to modify the normalized admittance, in a movement at constant SWR. The admittance becomes 1-j0.85 if produces a normalized displacement of $d_1$=0.063λ. On that site you can connect a stub or transmission line in parallel to cancel that suceptance. If that plug were one in short circuit, its length d2 would be: $d_2$= 0.364λ.





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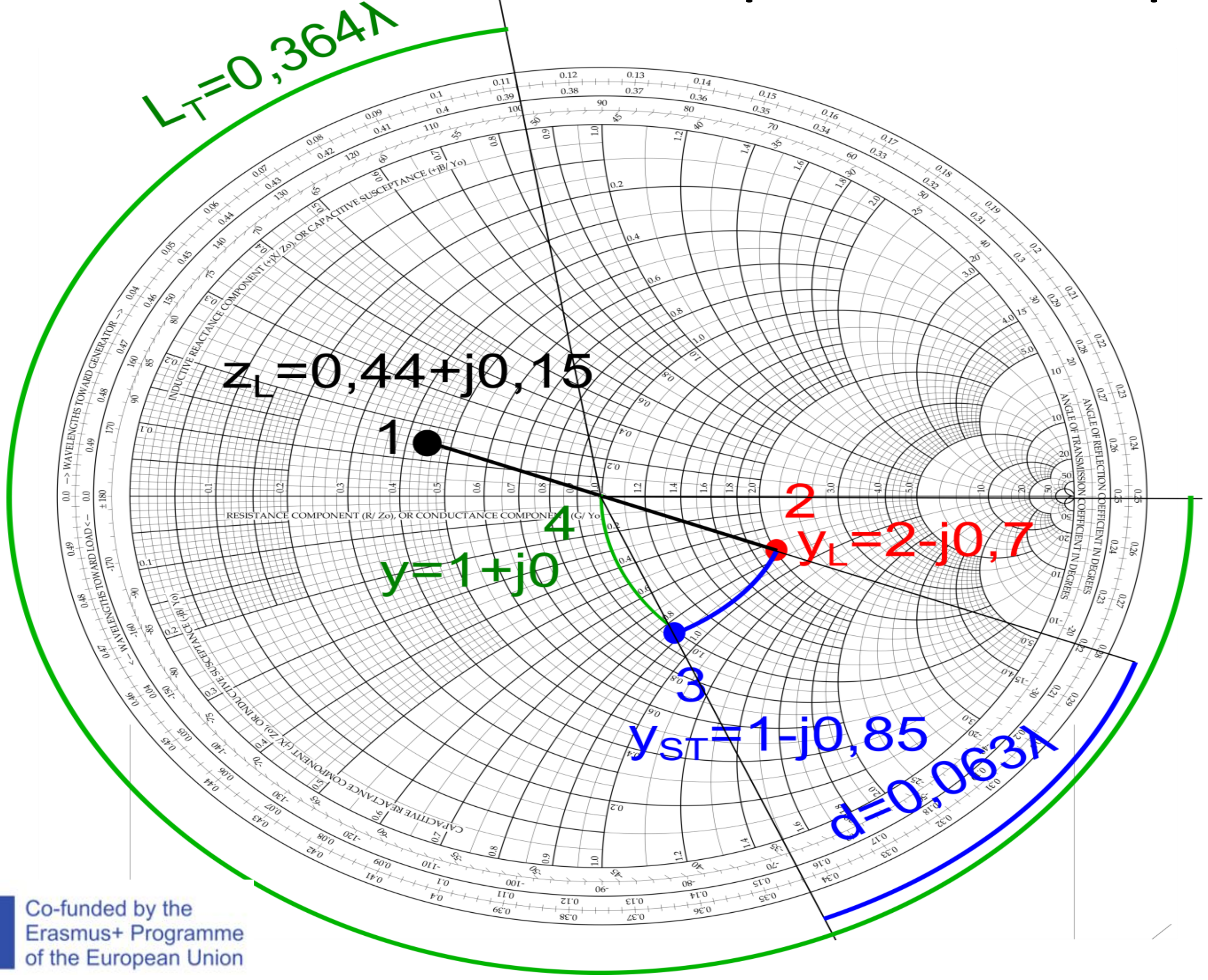
# Transmission Lines – Simple Stub Adapters



# Transmission Lines – Simple Stub Adapters

**Steps:**

**1 –** Normalize the impedance ZL  zL=ZL/Z0.

**2** – Due to the stub will be connected in parallel, I look for the diametrically opposite point of the abacus $\mathbf{y_L}$.

**3** - Since the stub is only going to add (or substract) an imaginary part -jB, and the objective is to reach the point 1+j0. We must move on the transmission line to point 1+jB. which is into the unit circle. **So, I move towards the generator a distance $\mathbf{d_1}$ until I reach the unit circle.**

**4** - Once at point 1+jB, the stub will and an admitance -jB in parallel and arrive at point 1+j0. **The system is adapted.**

**5** - Depending on whether the stub is CC or CA, its length is obtained in fractions of λ.

**6** - Depending on the frequency and phase speed of the line, the physical length of the stub is obtained in meters.

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# Transmission Lines – Simple Stub Adapters

**Advantages:**

- It is simple to calculate.
- You can adapt loads that are not real pure.
- The characteristic impedance of the tach a is the same as that of the transmission line. In other words, the plug can be assembled with the same cable or material that makes up the line.

**Disadvantages:**

- The distance $d_1$ is beyond the resolution of the exercise, and in some cases it is not accessible.
- The adaptation depends on the frequency. The adaptation is designed and implemented at a frequency, if we vary the frequency a mismatch appears.

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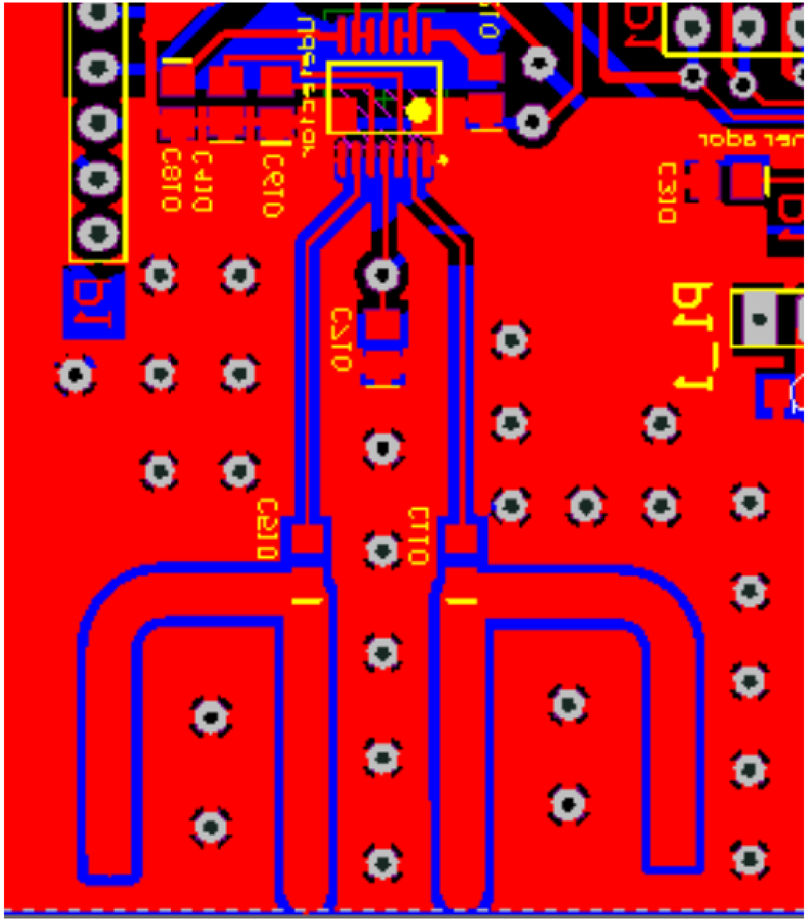
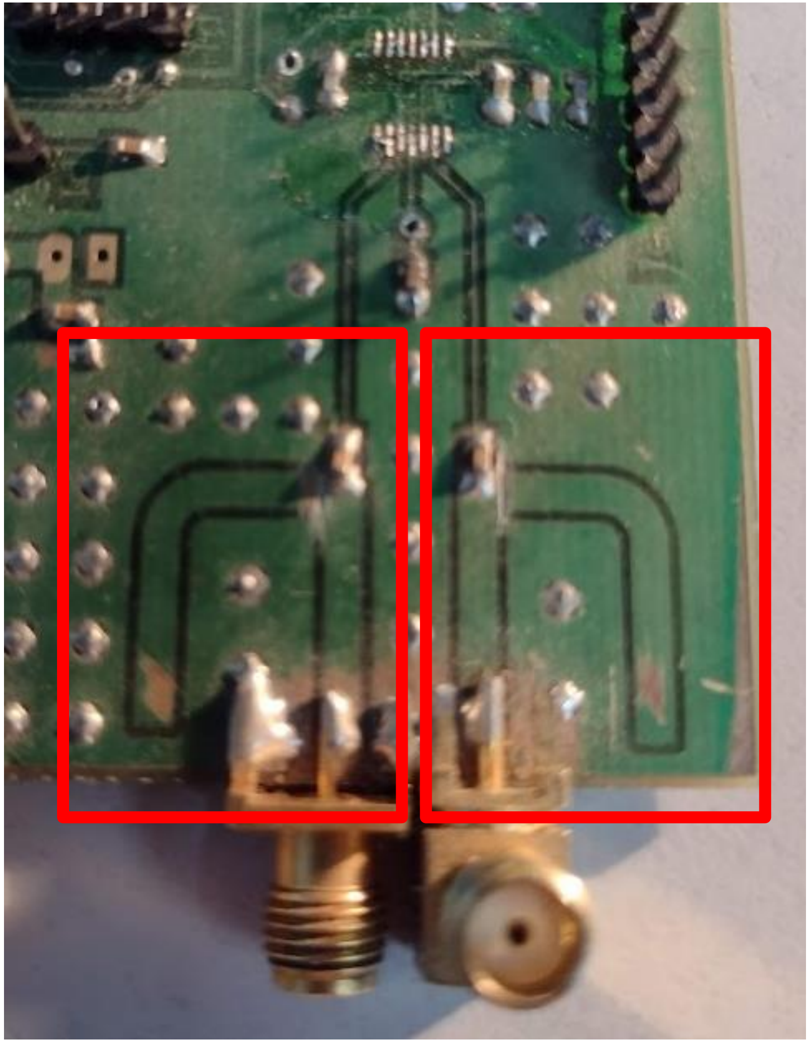
# Transmission Lines – Simple Stub Adapters





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# Resistive adaptations

Resistive attenuation networks are widely used in RF.

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# π-type attenuators

## Pi Attenuator Calculator

A Pi Attenuator uses a single series resistor, and two shunts to ground (input and output) to attenuate a signal. This calculator lets the user enter in the desired att
and it will calculate the needed shunt resistors (R1) and series resistor (R2).

**Pi** Bridged-Tee Reflection Tee

**ATTENUATION (DB)**

10

**IMPEDANCE**

50 Ω

**$R_1$**

96.2475 Ω

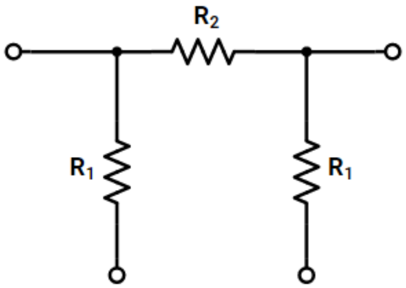
**$R_2$**

71.15125 Ω

**FORMULAS**

$$R_1 = Z_0 \left( \frac{10^{\frac{A_{dB}}{20}} + 1}{10^{\frac{A_{dB}}{20}} - 1} \right)$$

$$R_2 = \frac{Z_0}{2} \left( 10^{\frac{A_{dB}}{20}} - \frac{1}{10^{\frac{A_{dB}}{20}}} \right)$$






https://www.electronics-notes.com/articles/radio/rf-attenuators/pi-t-resistive-attenuator-pad-circuit-design-formula.php

# T-Type attenuators

## Tee Attenuator Calculator

This Tee Attenuator Calculator will calculate the values of R1 and R2. Please enter in the needed attenuation and the impedance of the line to be matched.

Pi Bridged-Tee Reflection **Tee**

**ATTENUATION (DB)**

10

**IMPEDANCE**

50 Ω

**$R_1$**

25.9747 Ω

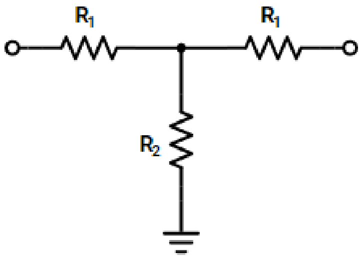
**$R_2$**

35.13642 Ω

**FORMULAS**

$$R_1 = Z_0\left(\frac{10^{\frac{A_{dB}}{20}}-1}{10^{\frac{A_{dB}}{20}}+1}\right)$$

$$R_2 = 2Z_0\left(\frac{10^{\frac{A_{dB}}{20}}}{10^{\frac{A_{dB}}{10}}-1}\right)$$

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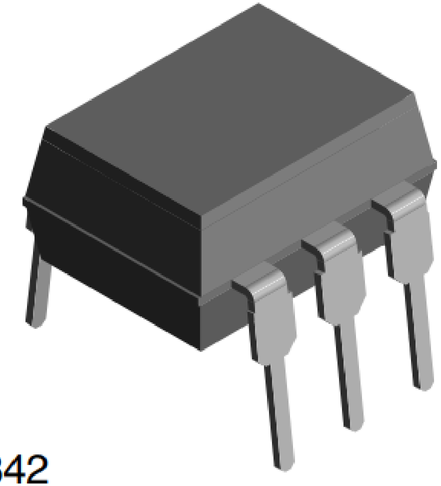
https://www.electronics-notes.com/articles/radio/rf-attenuators/pi-t-resistive-attenuator-pad-circuit-design-formula.php

# Optocouplers



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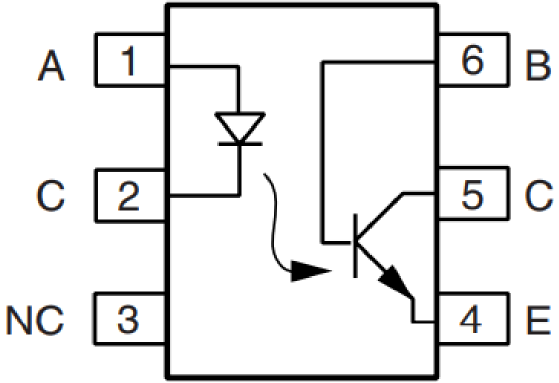


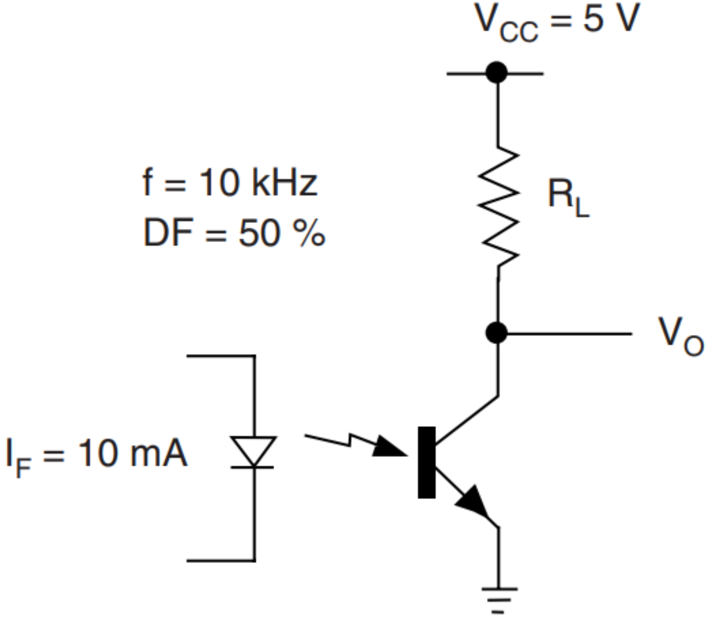


n25_14

Fig. 14 - Switching Schematic

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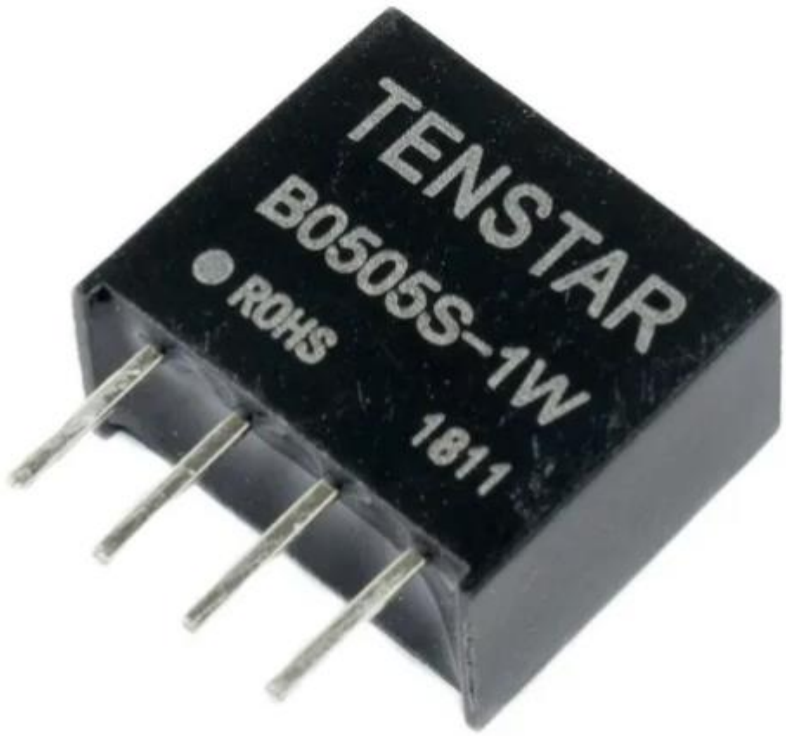
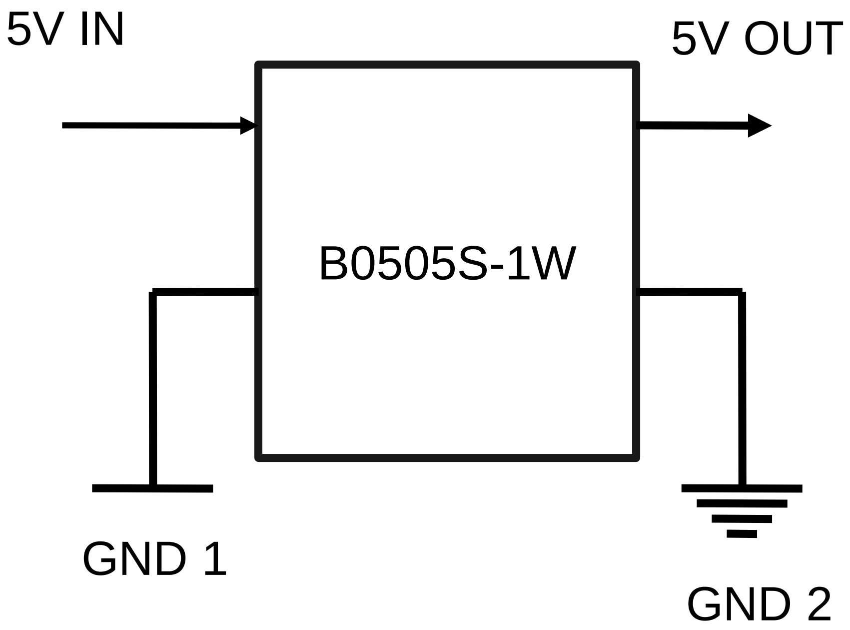
# Isolated sources

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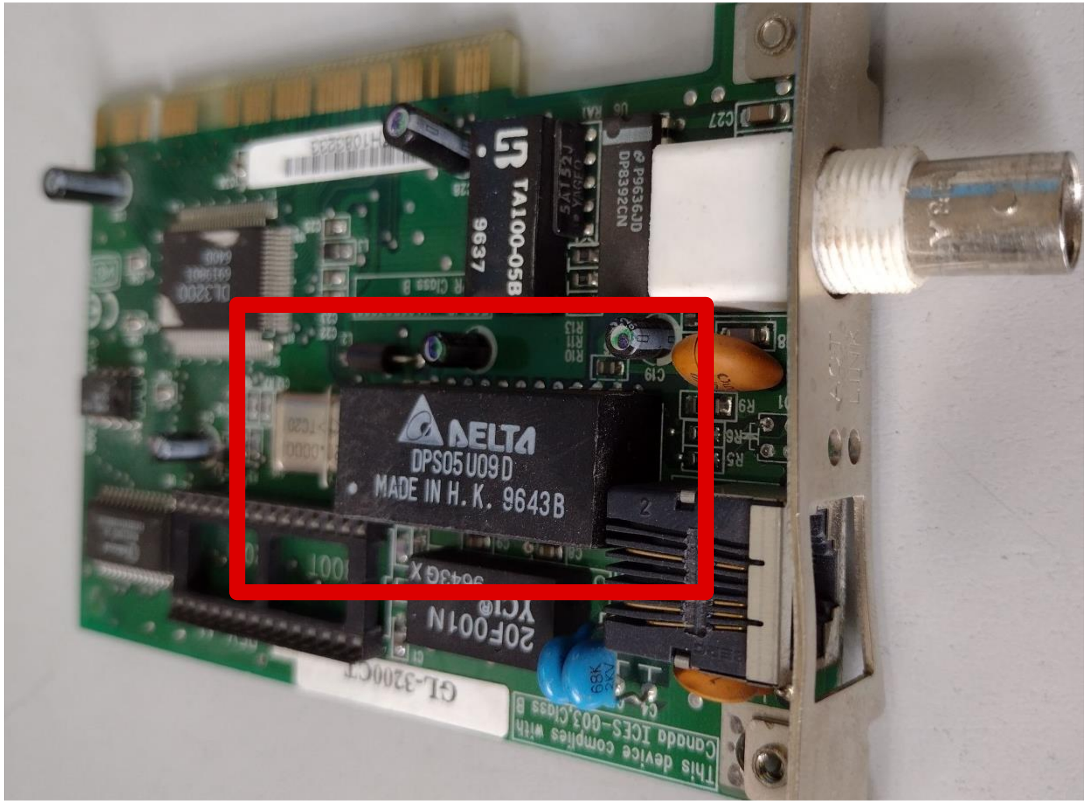
# Isolated sources

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*ELECTRICAL CHARACTERISTICS @25°C*

| Model | Input Voltage Nominal / Range (VDC) | | Output Voltage (VDC) | Output Current (mA) | Regulated Output | Enable Function | Efficiency (%) TYPE | Isolation |
|---|---|---|---|---|---|---|---|---|
| ~~DPS0501D~~ | ~~5~~ | ~~4.75-5.25~~ | ~~9~~ | ~~120~~ | ~~N~~ | ~~N~~ | ~~70~~ | ~~500VDC~~ |
| ~~DPS0502D~~ | ~~5~~ | ~~4.75-5.25~~ | ~~9~~ | ~~200~~ | ~~N~~ | ~~N~~ | ~~70~~ | ~~500VDC~~ |
| DPS05U09D | 5 | 4.75-5.25 | 9 | 200 | N | N | 75 | 500VAC |
| ~~DCS05U09MD~~ | ~~5~~ | ~~4.75-5.25~~ | ~~9~~ | ~~200~~ | ~~N~~ | ~~N~~ | ~~75~~ | ~~500VAC~~ |

# Limiters with diodes

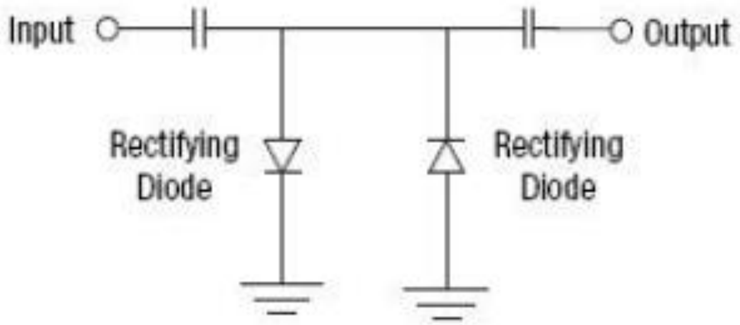
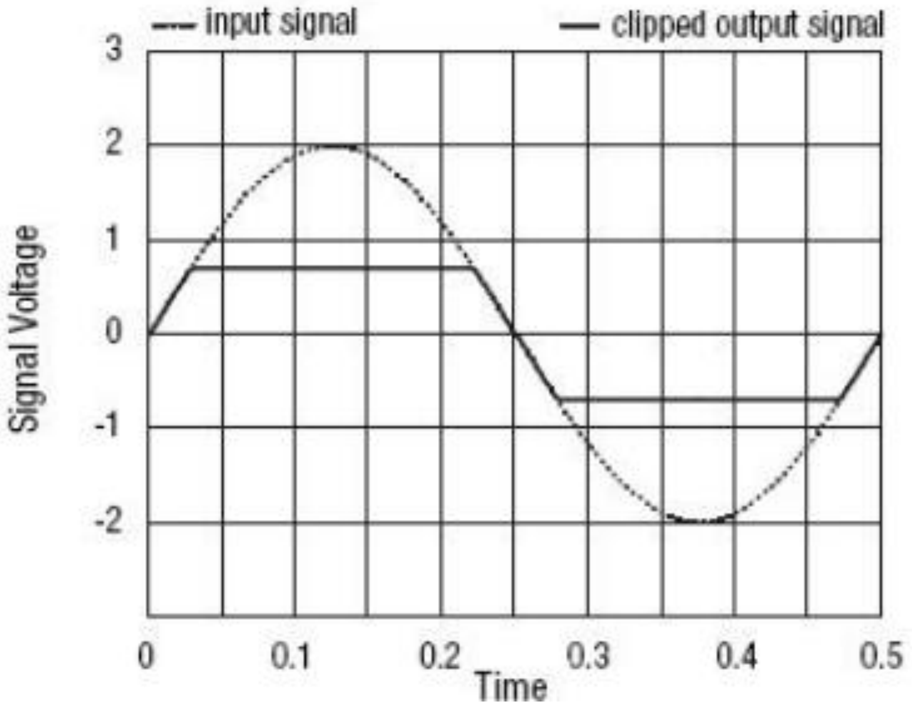



**Figure 4. Clipper Circuit and Large Signal Input/Output Waveforms**

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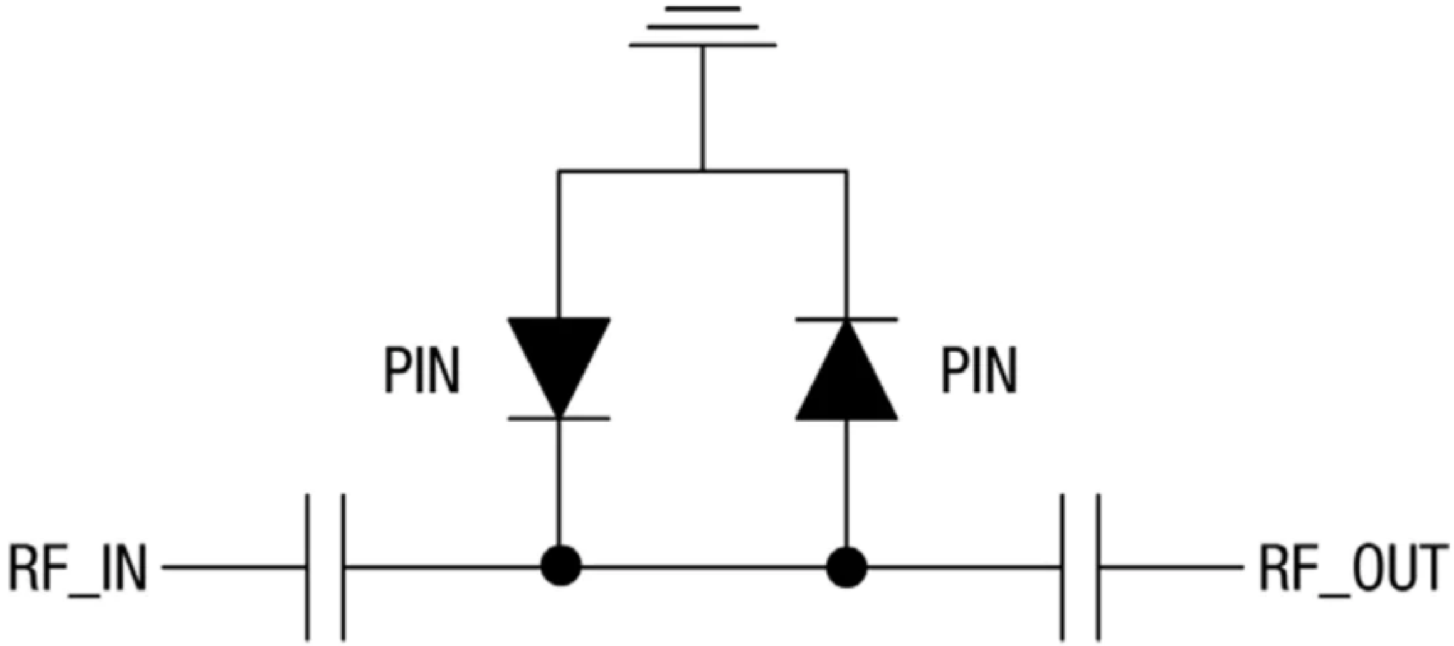
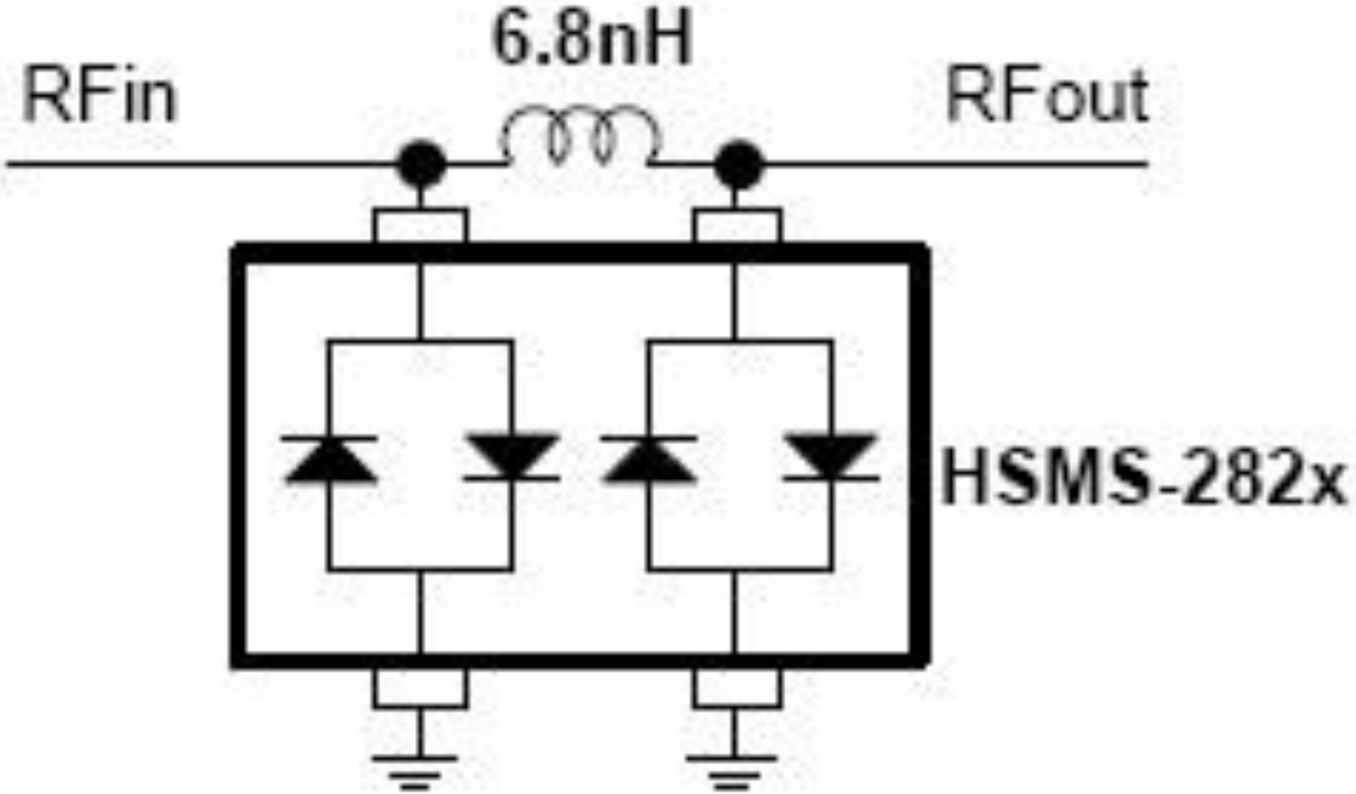
# Limiters with diodes



# Limiters with diodes



# Gas dischargers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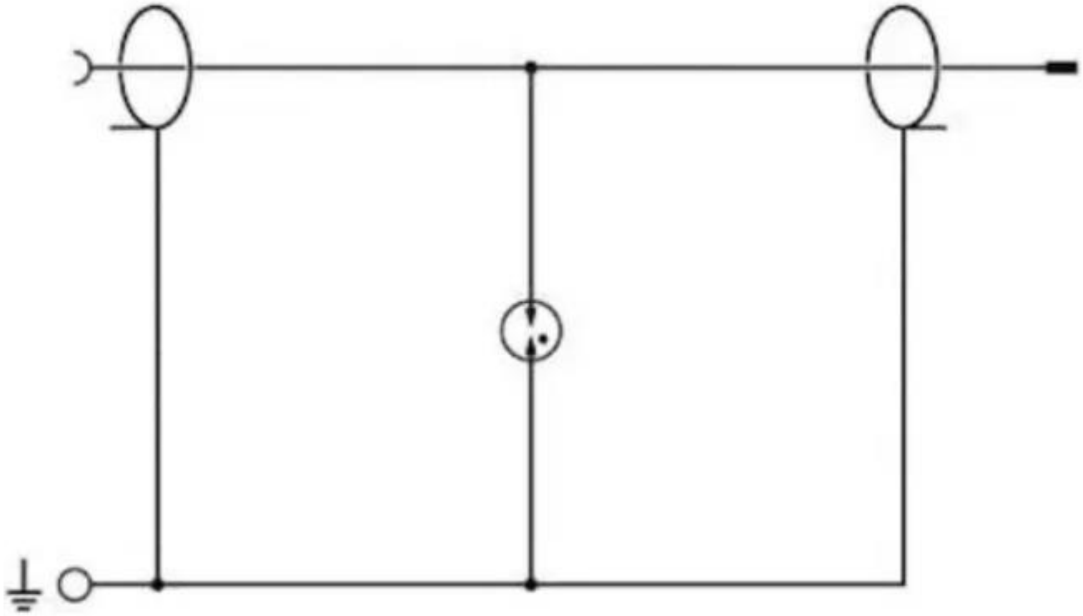
# Gas dischargers



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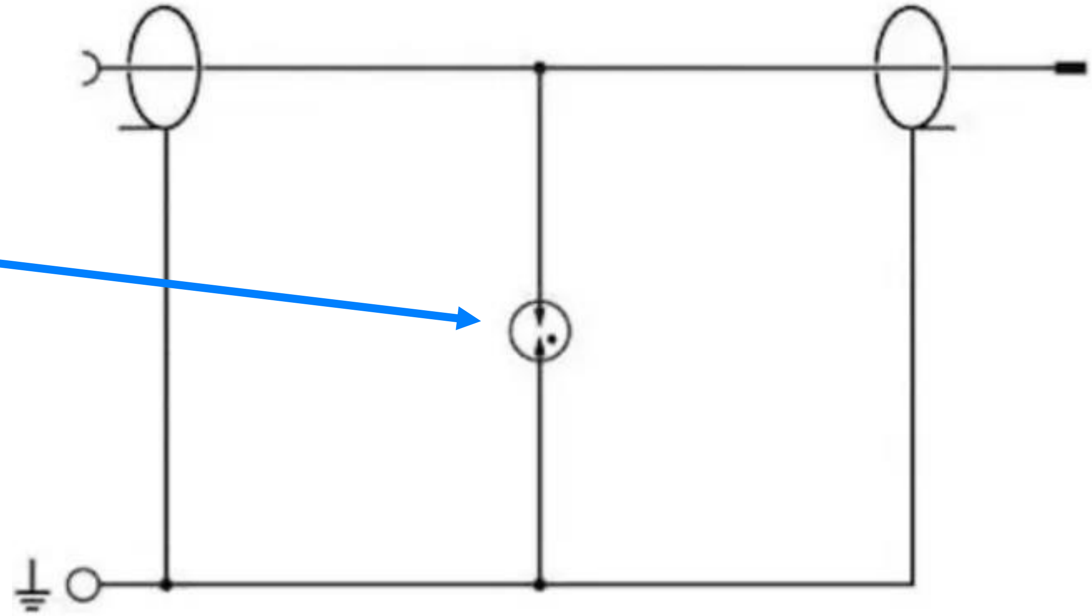
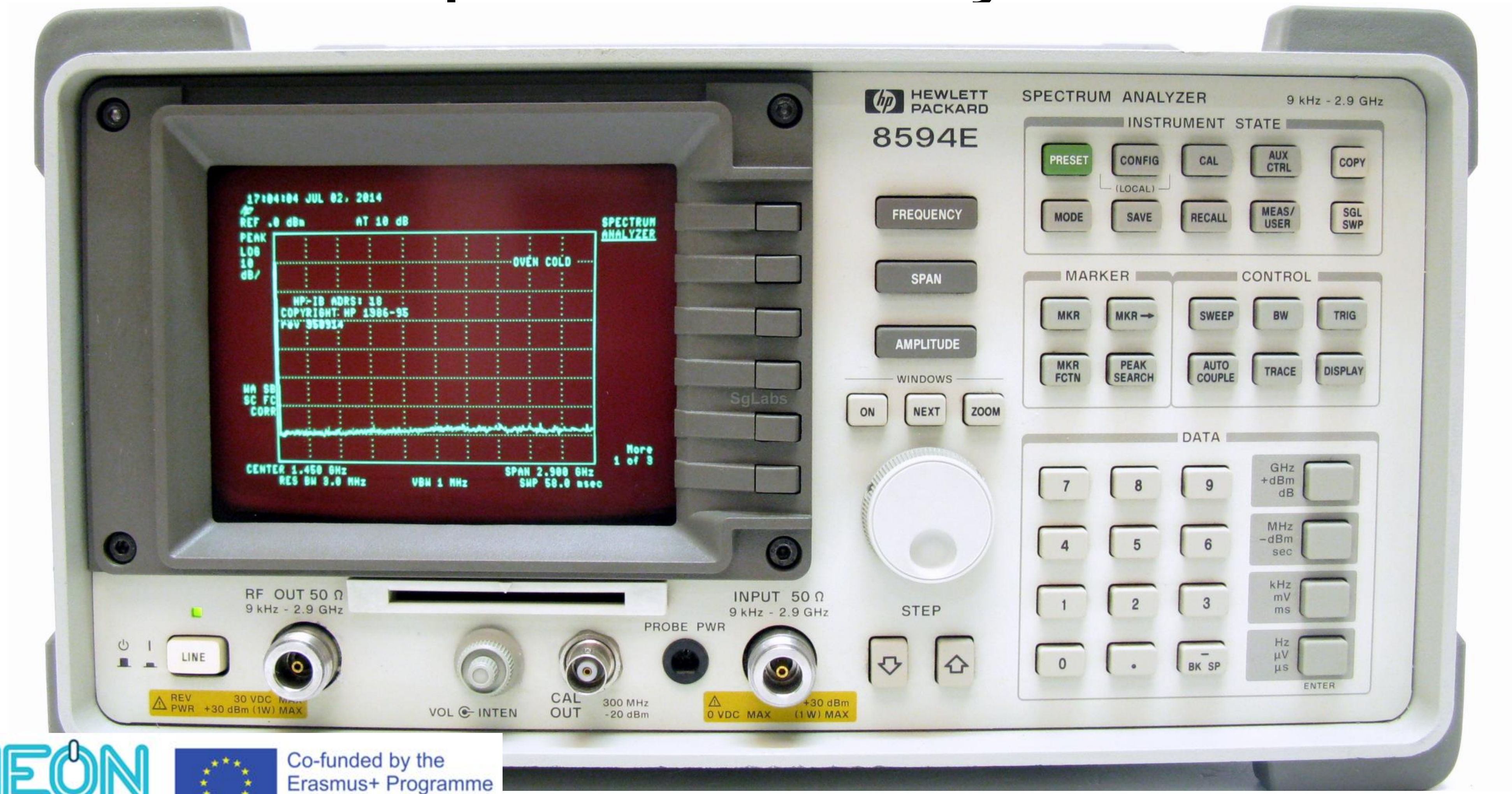
# Gas dischargers



# Spectrum analyzer

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# Spectrum Analyzer: Precautions

## Do not exceed the maximum input level!

Use dimmers






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# Spectrum Analyzer: Precautions

**Do not input signals with DC components!**

Measure with another instrument and verify that the system has decoupling capacitors at the measurement point.

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# Vector Network Analyzer


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# Vector Network Analyzer


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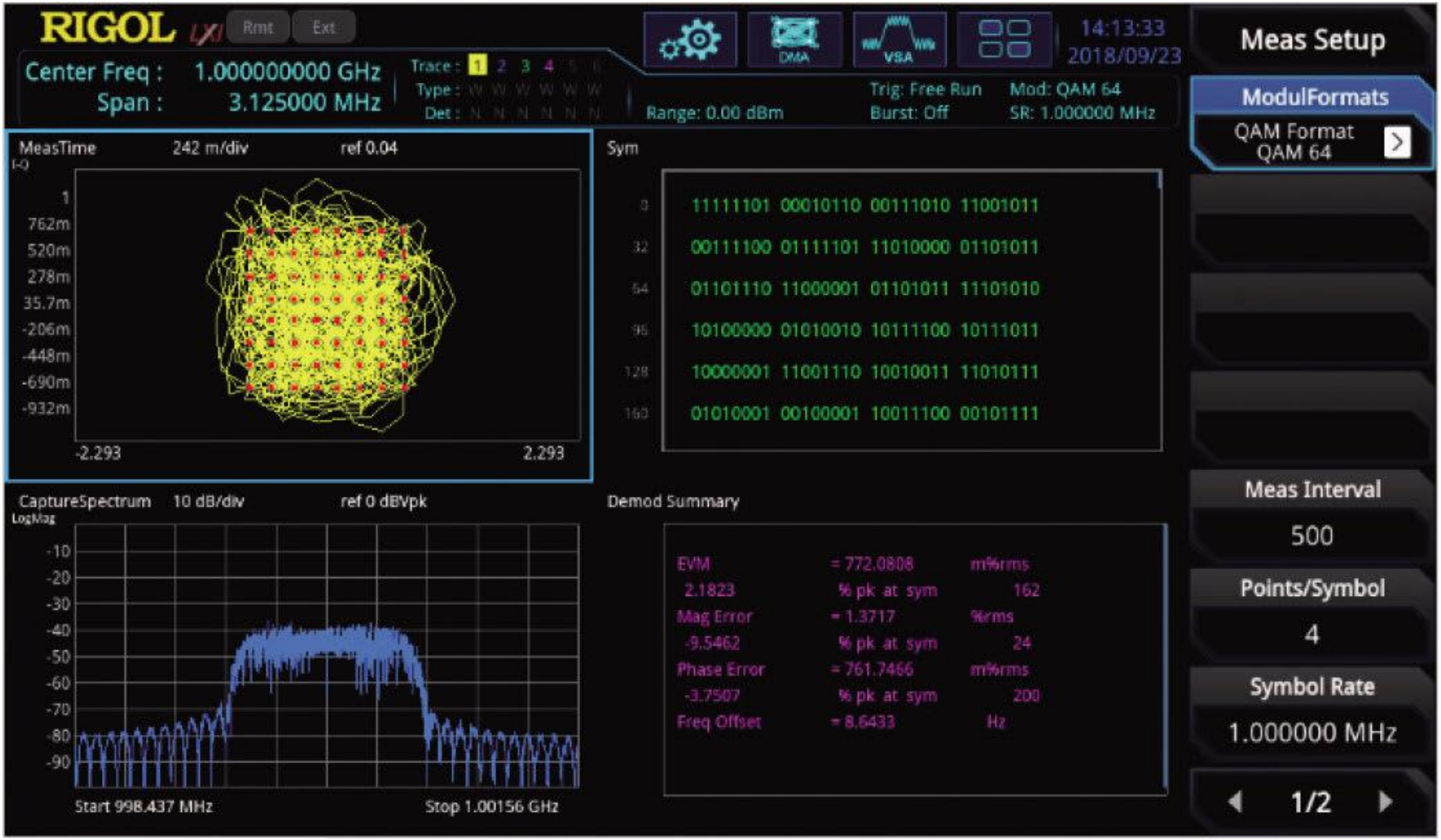
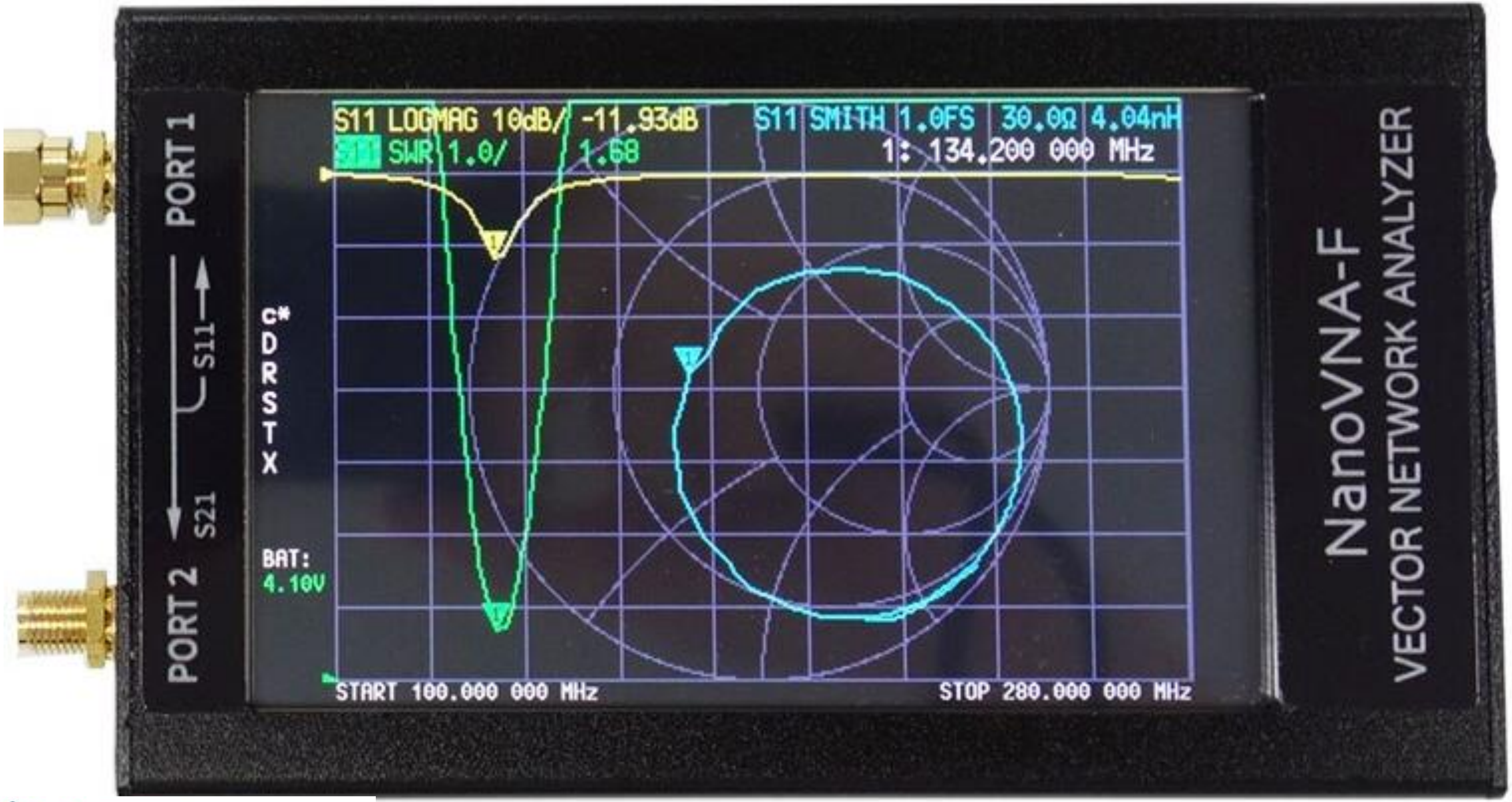

RIGOL
Rmt
Ext
Center Freq : 1.000000000 GHz
Span : 3.125000 MHz
Trace : 1 2 3 4 5 6
Type :
Det :
DMA
VSA
14:13:33
2018/09/23
Range: 0.00 dBm
Trig: Free Run
Burst: Off
Mod: QAM 64
SR: 1.000000 MHz
Meas Setup
ModulFormats
QAM Format
QAM 64
MeasTime
242 m/div
ref 0.04
1
762m
520m
278m
35.7m
-206m
-448m
-690m
-932m
-2.293
2.293
Sym
0 11111101 00010110 00111010 11001011
32 00111100 01111101 11010000 01101011
64 01101110 11000001 01101011 11101010
96 10100000 01010010 10111100 10111011
128 10000001 11001110 10010011 11010111
160 01010001 00100001 10011100 00101111
CaptureSpectrum
10 dB/div
ref 0 dBVpk
LogMag
-10
-20
-30
-40
-50
-60
-70
-80
-90
Start 998.437 MHz
Stop 1.00156 GHz
Demod Summary
EVM = 772.0808 m%rms
2.1823 % pk at sym 162
Mag Error = 1.3717 %rms
-9.5462 % pk at sym 24
Phase Error = 761.7466 m%rms
-3.7507 % pk at sym 200
Freq Offset = 8.6433 Hz
Meas Interval
500
Points/Symbol
4
Symbol Rate
1.000000 MHz
1/2

# nanoVNA

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