

A two port 3 dB splitter for 13 cm and WLAN

Typical applications:

- connect two high gain antennas to an access point to cover two directions
- connect one omni and one high gain antenna to an access point to provide omni coverage and one link

Description:

The splitter consist of four quarterwave striplines connected at their ends and four terminals (input, ground, output1, output2) connected to the corners of the square formed by the striplines. The impedance of the terminal leads is 50 Ohm to connect them directly to RF-connectors such as SMA. The impedance of the striplines is 71 Ohm, translating the 50 Ohm impedance to 100 Ohm.

$$Z_{strip} = \sqrt{50 \Omega \cdot 100 \Omega} = 71 \Omega$$

Two striplines are connected to each of the terminals in parallel making the translated 100 Ohm match to 50 Ohm. Get the best board material you can get. FR4 is lossy but cheap. Teflon boards are less lossy but more expensive.

PCB properties:

To calculate dimensions, the dielectric constant (dc) of the material must be known. Sometimes, dielectric constant is called epsilon-relative, E_r or permittivity. For **FR4 dc is typical 4.2 (at 2.5 GHz)** but may vary between 4 to 5 depending of the amount of resin and glass content in the material. The dc of Telfon board is typically around 2.5, ceramic substrate boards may have dc up to 10.

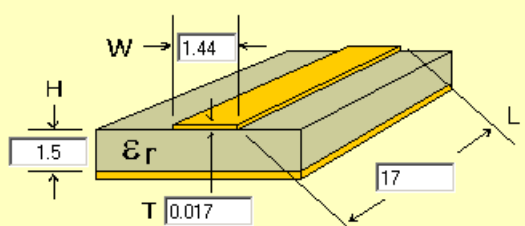
Stripline length:

The wireless LAN band streches from 2400 to 2485 MHz, center is abt. 2440 MHz. The corresponding wavelenght is 300/2440 meter, or 12.3 cm. A quater wavelenght is 12.3/4= 3.1 cm (in free space). Since we are talking about stripline on FR4 and not in free space, the stripline length has to be multiplied with the "shortening factor" of the PCB. The shortening factor (sf) can be calculated from the dielectric constant (dc). $sf = 1 / \sqrt{dc}$. **Stripline length is 3.1 cm * 1/sqrt(4.2) = 15 mm**

Stripline width:

Calculating the stripline width is a bit more work. Factors like desired impedance (100 Ohm in this case), copper layer thickness, board width and dielectric constant are involved. There are several formulas available, for instance [here](#). An easier way is to let software do the job, for instance Agilent`s AppCad (see screenshot below). AppCad is free and can be downloaded from Agilent`s website. **Stripline width is 1.5 mm**

Microstrip



Calculate Z0 [F4]

Z0 = **70.48** Ω

Elect Length = **0.247** λ

Elect Length = **89.0** degrees

1.0 Wavelength = **68.787** mm

Vp = **0.551** fraction of c

ε_{eff} = **3.298**

W/H = **0.960**

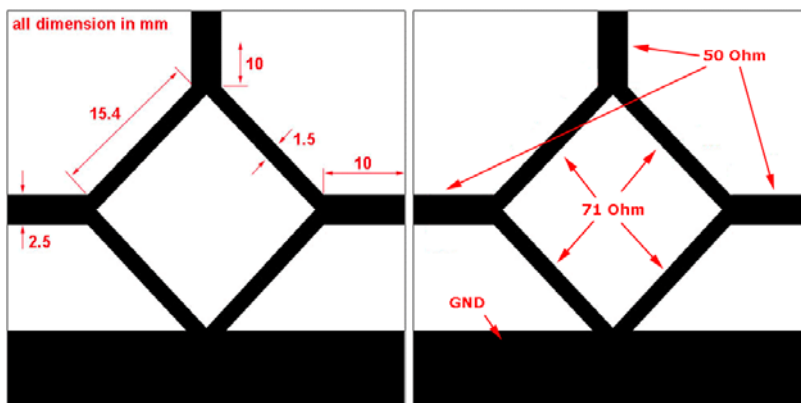
Dielectric: ε_r = **4.6**

FR-4

Frequency: **2.4** GHz

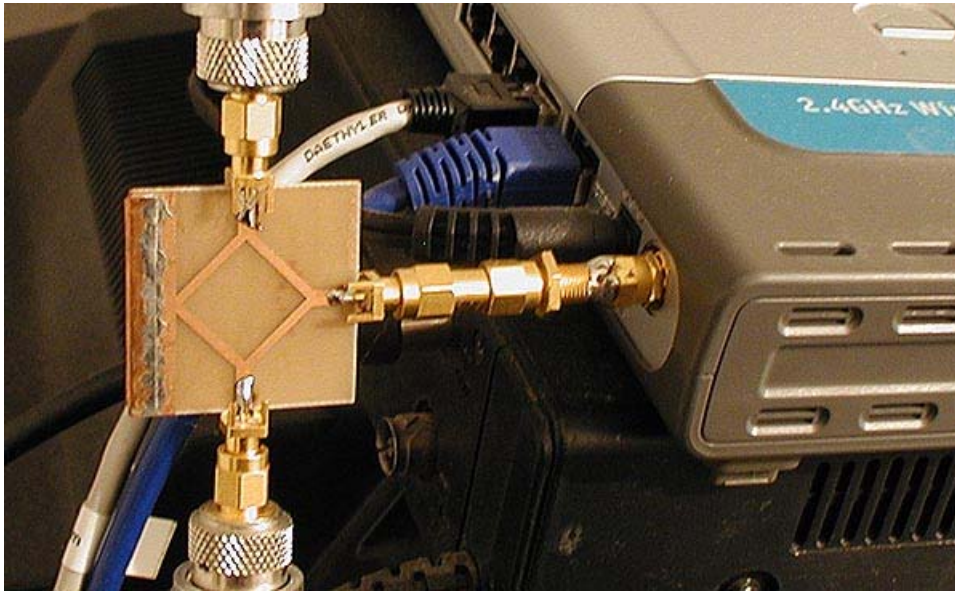
Length Units: **mm**

Depending on which formula is used the results may be different. Calculating from formulas yields 15/1.5 mm for length/thickness while in AppCad is 17/1.44 mm. The bandwidth of the splitter is broad enough so this minor errors have little to no performance decreasing effect.



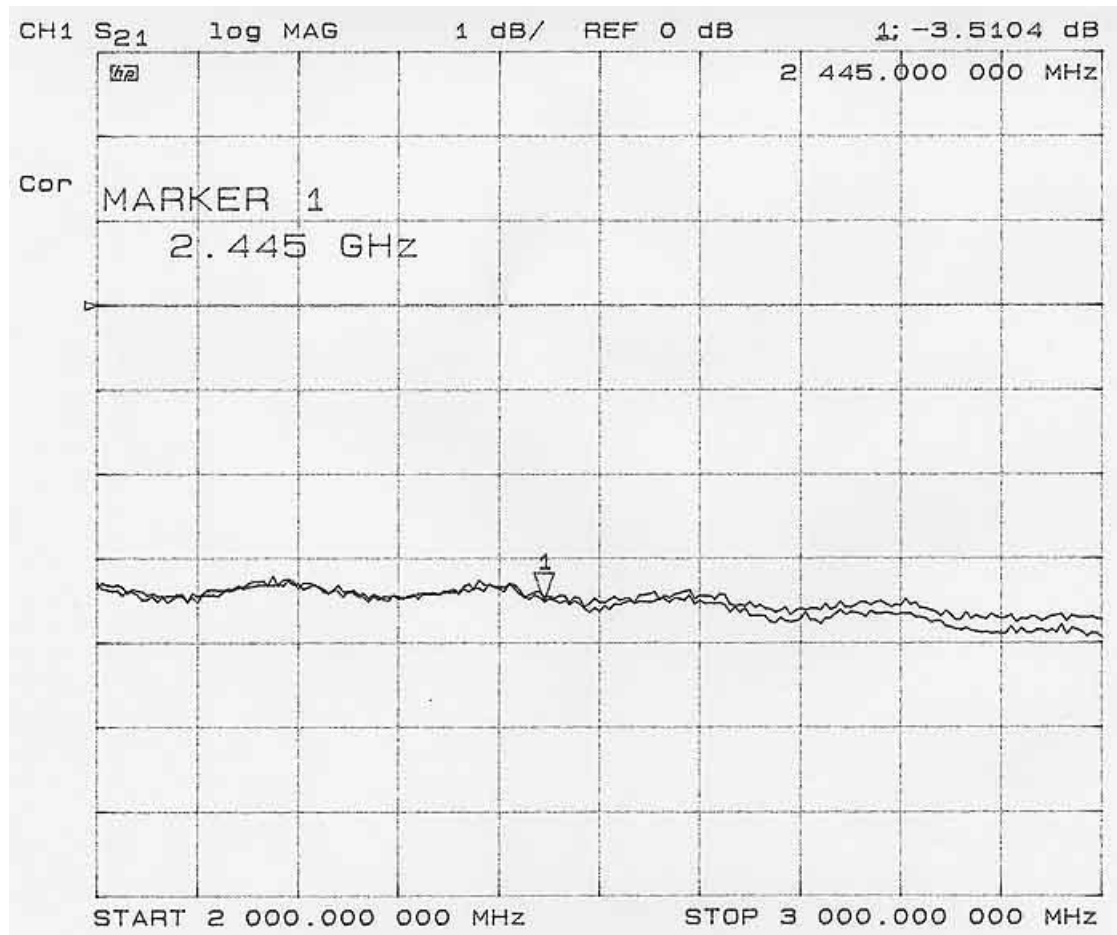
click on the pictures to see them in bigger size

The [Eagle](#) board file is available for download [here](#).

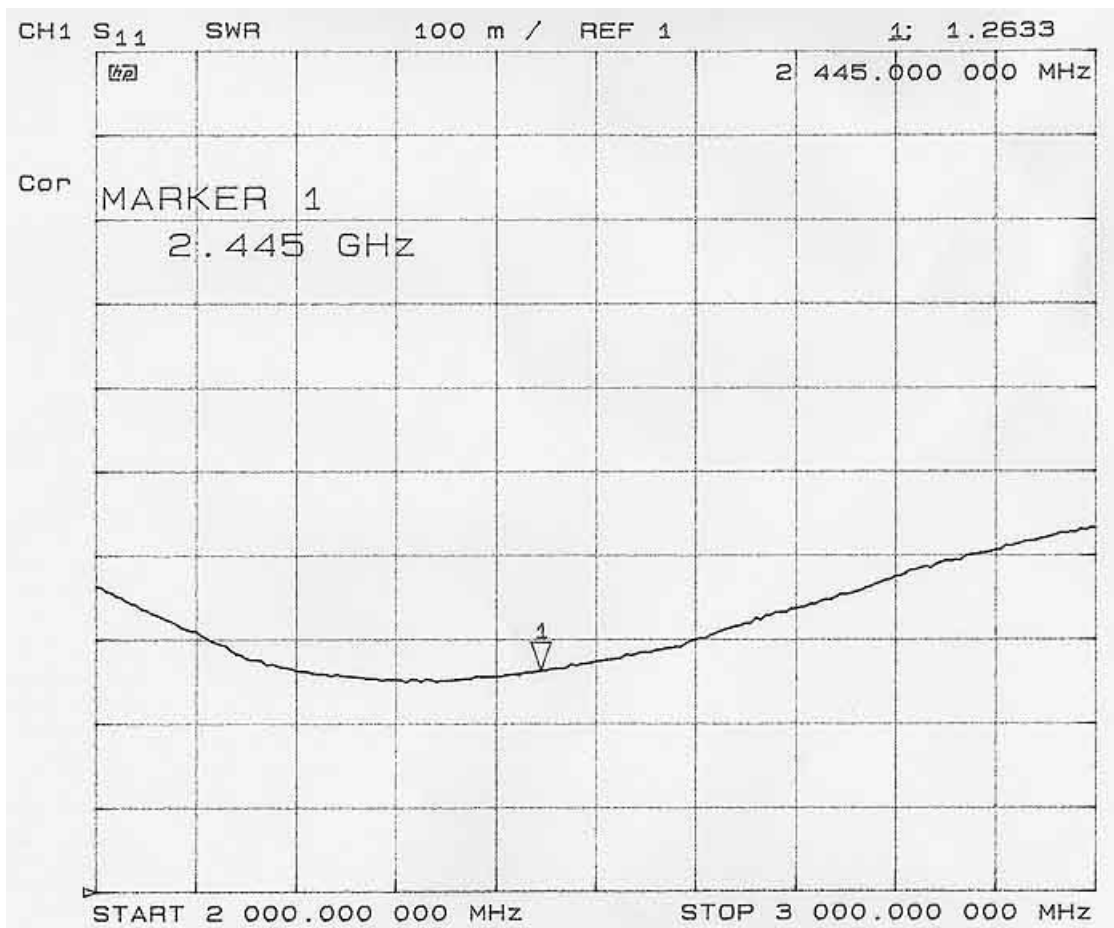


splitter in use to distribute signals from a Dlink DI614+ AP

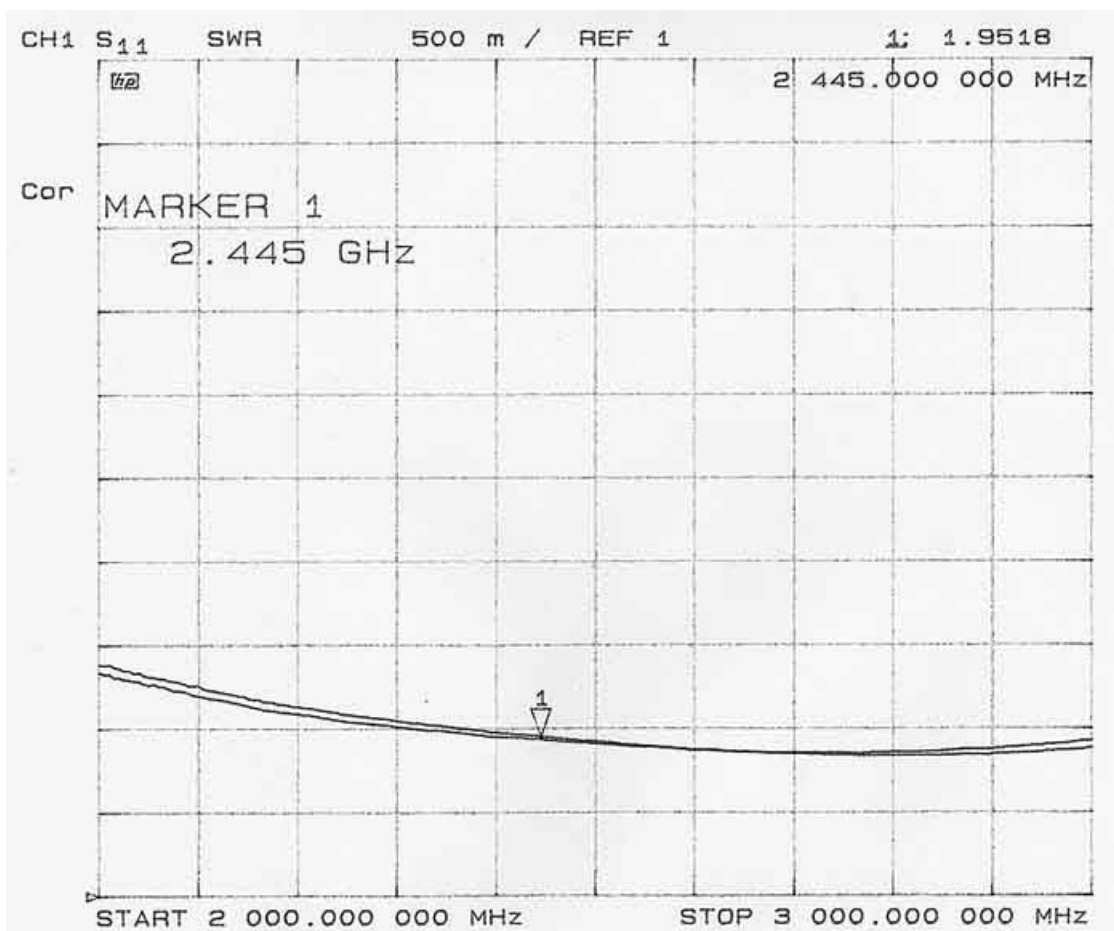
Thru loss (S_{21}) and SWR (S_{11}) measurements were done with Network Analyser HP8753A. Of course, all ports were calibrated.



Thru loss from input port to the output ports, both channels are pretty equal. Thru loss is abt 3.5 dB at WLAN band center.

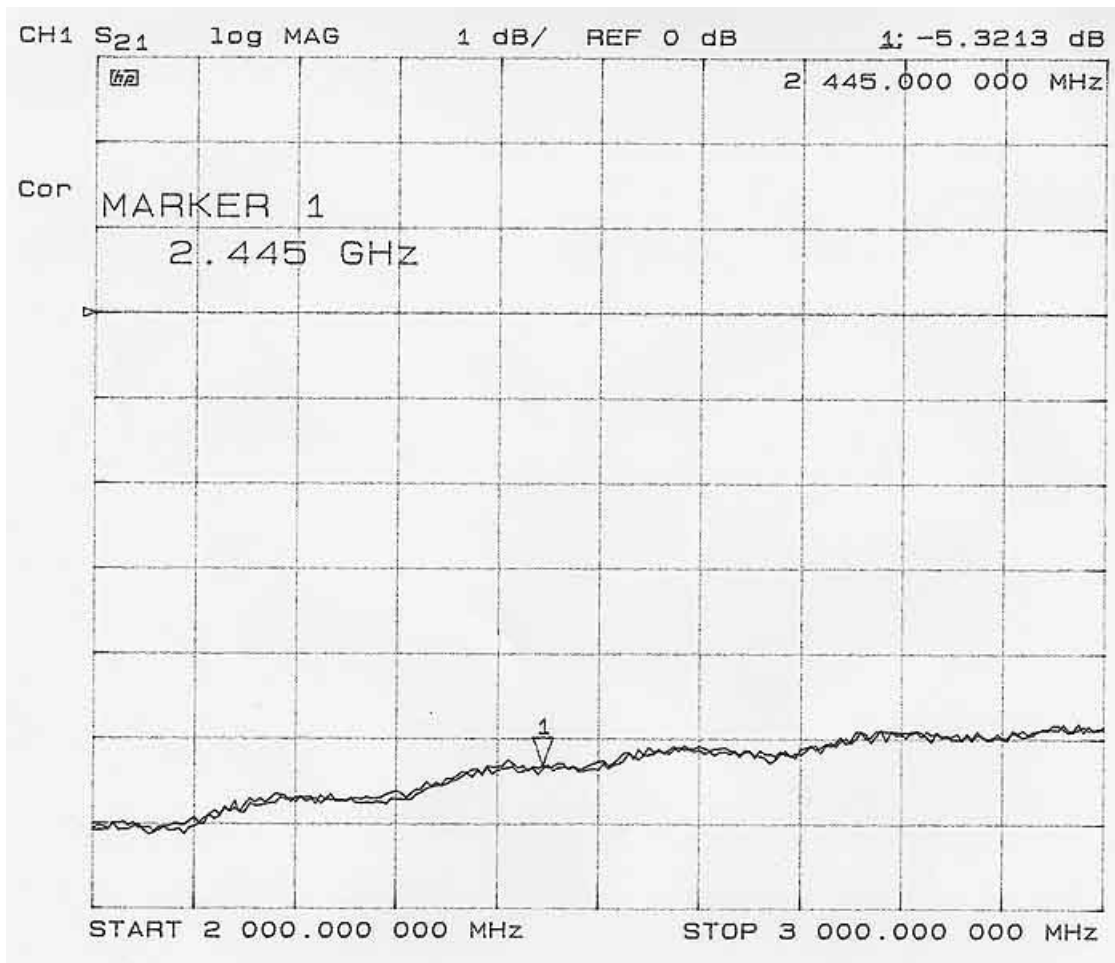


Input SWR into common port. Best matching point is about 100 MHz below midband WLAN but 1:1.26 at 2445 MHz still is good. Striplines are a bit too long. It should be noted that vertical scaling is 0.1 per division.



SWR measured into the output ports. Matching is 1:1.9 which indicates that something can be made better.

Vertical scaling is 0.5 per division here.



Isolation of the two output ports. Isolation is poor as expected but in most applications that does not matter.

last changed, Tue, Feb 10. 2004 by [df2ck](http://df2ck.de/)