REFERENCE

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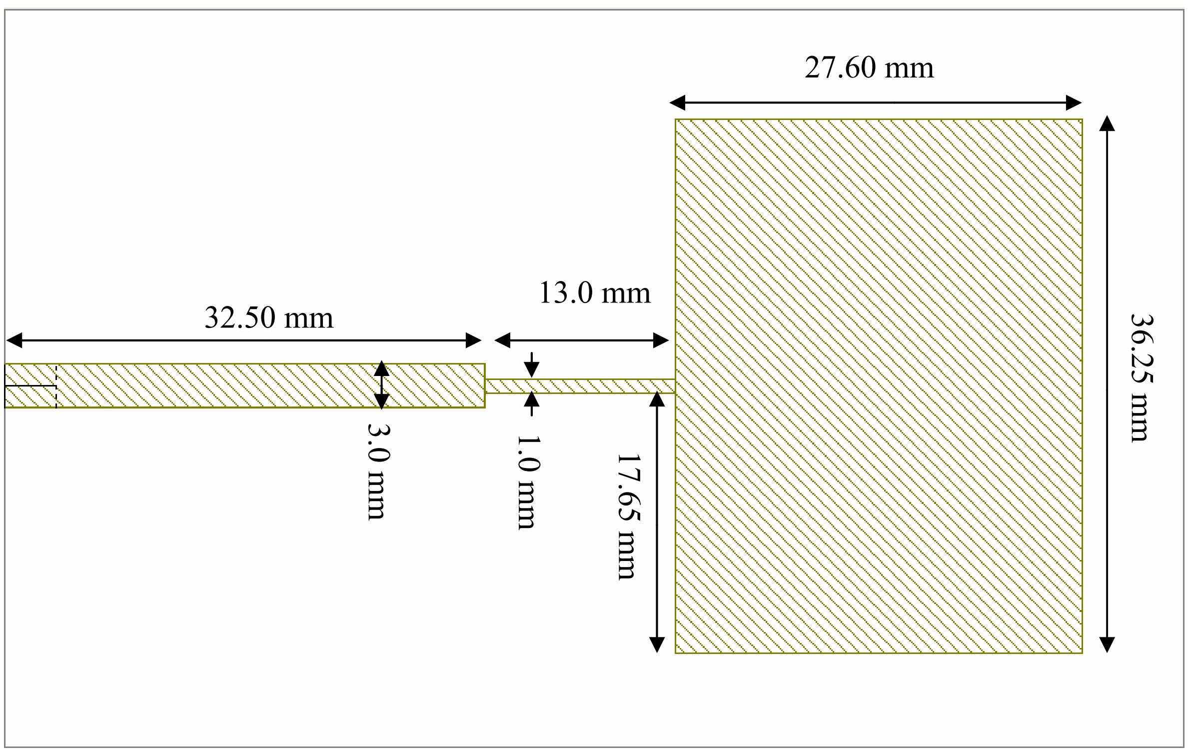
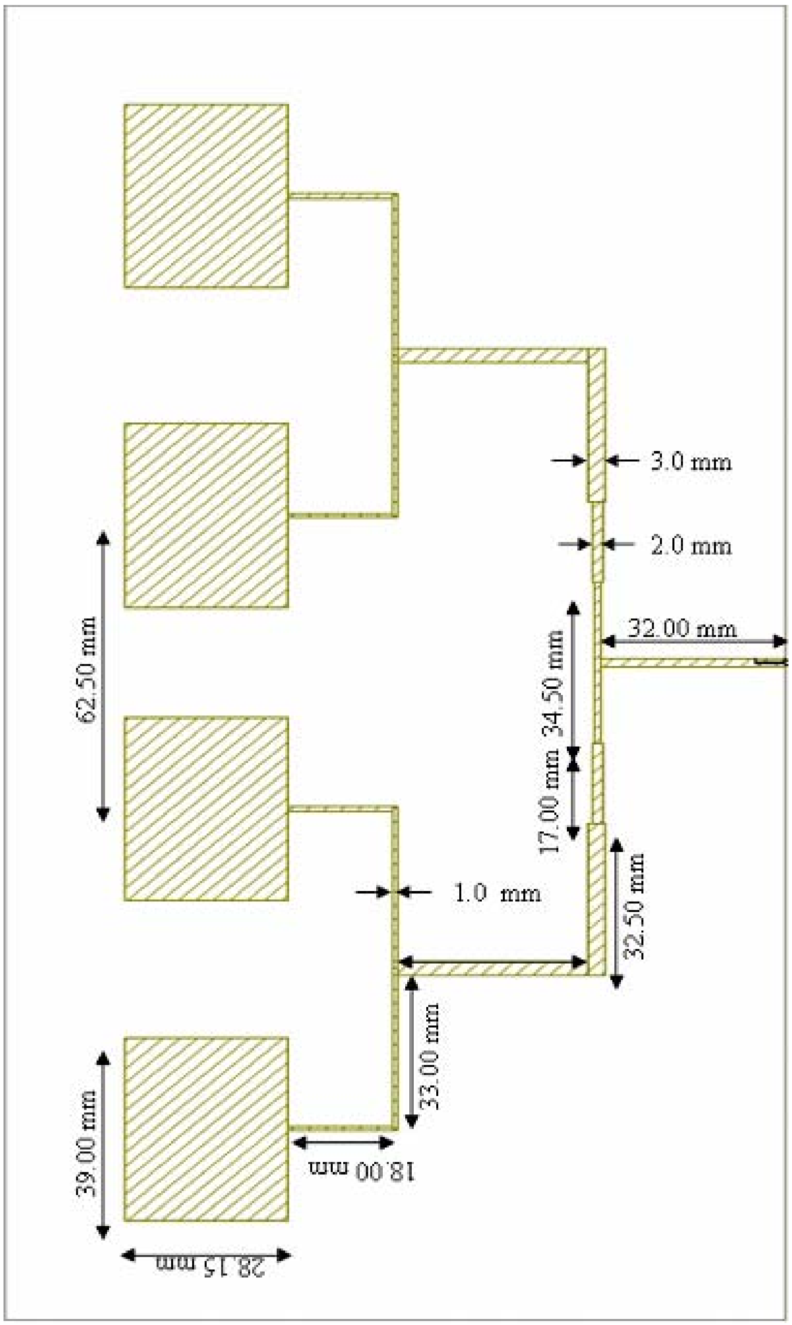
Appendix A



Optimized Dimensions Design Layout of Single Microstrip Patch Antenna

Appendix A(i)



Optimized Dimensions Design Layout of Microstrip Patch Array Antenna

Appendix B

FR4 Datasheet

Microponents

FOTOBOARD...the photosensitive copper laminate system

PRODUCT DESCRIPTION

FOTOBOARD is a high quality pre-sensitised laminate, ideal for producing small numbers of printed circuit boards (PCBs) for use by design engineers or for work in the classroom or laboratory. Its key benefits are that it enables the manufacturing process to be fast and consistent - for both single and double sided boards.

All materials used in the manufacture of FOTOBOARD are high quality. This, together with our technical expertise and stringent manufacturing controls, ensures the high standard of every product which is delivered to our customer.

FOTOBOARD is coated with a positive working photo resist which is inherently capable of reducing defects caused by dust and dirt on the photowork and printing frame. The unexposed photo resist remains hard after exposure to form the image or circuit pattern and remains unaffected by the developing process.

The unexposed resist is a blue/green in colour and when exposed, tends to go a shade lighter - the change can be seen in daylight.

To ensure a uniform coating thickness, we have incorporated a roller coating system in our production line. This gives more stability, particularly in the final processes, and consistency from batch to batch.

The board's final coat is a low tack black film which affords mechanical and light protection.

FOTOBOARD SPECIFICATION

Two basic substrates are used in the manufacture of FOTOBOARD. FR4 and CEM/1 are both rigid composite laminates - standard thickness 1/16" (1.6mm) Ω/Ω, 1/0, 1/1, copper.

FR 4 is a material composed of class woven glass cloth and copper foil. It is flame retardant according to UL-94 grade V-O.

The laminate meets most commonly used specifications and is tested according to NEMA, LI-1: MIL-P-13949 and IEC249-2-5.

- Thickness tolerances to MIL-P-13949H Glass II and IEC 249-2-5 (TAB II)
- Copper surface aspect to MIL-P-13949H
- Copper foil to IEC 249-3 Type A electrodeposited copper foils
- Copper thickness to IEC 249-3A Class I (TABIII)

Up to a maximum thickness of 3.2mm can be supplied on request.

CEM/1 is a material composed of a paper-based core impregnated with epoxy resin, glass woven face sheets impregnated with epoxy resin and copper foil. Like FR 4, it is flame retardant according to UL-94 grade V-O and meets most commonly used specifications. It is tested according to NEMA, LI-1: IEC249-2-9.

- Thickness tolerances to IEC 249-2-9 (TAB I)
- Copper surface aspect to MIL-P-13949G
- Copper foil to IEC 249-3
- Copper thickness to IEC 249-3A Class I (TABII)

Up to a maximum thickness of 3.2mm can be supplied on request.

MICROPONENTS LIMITED P.O. BOX 162, 30 CURZON STREET, BIRMINGHAM B4 7XD ENGLAND
TEL: ++44 (0)121-380 0100 FAX: ++44 (0)121-359 3313 E-MAIL: sales @microponents.co.uk

Microponents

PROCESS SPECIFICATION

Preparation of Artwork

The finished printed circuit pattern can only be as good as the artwork used to produce it, so great care must be taken in its preparation. The pattern required to remain as copper must be opaque and can be formed by applying opaque tape on to clear polyester film or by using drafting pens. This can be used to produce a positive - or directly to produce the PCB if only one is required. If a number of boards are required, it may be better to have the pattern reversed twice onto a professional, high contrasting film.

Exposure

While the unprotected FOTOBOARD will operate in daylight it is advisable to carry out the exposure operation in subdued, or under yellow light conditions. Do not leave unprotected FOTOBOARD in direct daylight.

To use, remove the black protective film from the FOTOBOARD and place the positive artwork onto the board. The circuit should be the correct way round when placed on the surface of the board. Place into an ultra violet exposing unit and expose for approximately six minutes. (This exposure time will vary depending on the size and type of light unit used). When removed from the exposing unit, the board should show a visible colour change when viewed in daylight.

Developing

Mix FOTOBOARD Developer at the rate of 1:1 with water which should be at room temperature (20-23∞C/ 68 - 41.4∞F).

Place exposed boards into the developer solution for two minutes, then inspect the exposed part. The photo resist should have dissolved into the solution. If not, replace into the developer for a further one minute and then inspect again. When fully developed, rinse the board thoroughly in running water for two minutes. Allow to dry.

The final developing time will depend on the working temperature and the age of the developing solution. After use, the developing solution can be kept in an air-tight plastic container and re-used at a later date.

Etching

Etching can be carried out using ferric chloride - a closed spray system produces the best results. The working temperature should not exceed 38∞C (100∞F). Etching will take longer using a dish.

WARNING - all chemicals can be dangerous and should be used with great care. Wear gloves, eye protection and a plastic apron at all times. In the event of a spillage (of ferric chloride???), neutralise with sodium bicarbonate and wash down with water. Keep away from children and animals. See separate Health & Safety Data Sheet.

Stripping

To remove the photo resist, place the etched board into a dish or tray of FOTOBOARD stripper - again using a mixture of 1:1 stripper to water. Leave for three minutes, then rinse for two minutes.

The unexposed resist can be left on the board to act as a protecting film if required. If a solder joint is to be made, it can be done without removing the resist.

Precautions when using FOTOBOARD

As previously stated, FOTOBOARD is by its nature, sensitive to light. After the protective film has been removed, the FOTOBOARD should be exposed as soon as possible. Work should be carried out in subdued light and boards should never be left unprotected in daylight.

The shelf-life of FOTOBOARD is approximately six months if stored in the correct environment (15 - 20∞C 59 - 68∞F).

FOTOBOARD is a very easy material to use and much thought has been given to the use and safety of the process. However, basic safety rules must be observed at all times.

Repeated or prolonged contact with the process chemicals should be avoided. The ultra violet light should never be switched on with the lid open - both skin and eyes could be harmed.

All processes must be carried out in a well-ventilated area

If you have any queries about FOTOBOARD or any of the processes involved in its use - please contact our Technical Department on

Tel: 0121 380 0100 Fax 0121 359 3313,
E-mail sales@microponents.co.uk

GENERAL TECHNICAL CHARACTERISTICS

	CHARACTERISTICS	CONDITIONING	UNIT	FR4	METHODOLOGY	CEM/1	METHODOLOGY
Non Electrical Tests Base Material	Flexural Strength	Lengthwise/Crosswise A	N/mm²	570/460	MIL.P 13949	370/250	NEMA L1-1
	Punchability	A		1	DIN 53488	1	DIH 53488
	Hardness	A	M Scale	112		105	
	Shear Strength	A	N/mm²	138.5		105	
	Flammability	A; E-168/170	S	20(V-0)	UL94	10(V-0)	UL 94
	Temperature Index	A	°C	130	UL746	130	UL 746
	Water Absorption	E-1/105+ D- 24/23	%	0.1	MIL.P 13949	0.25	NEMA L1-1
	Pressure Vessel Thermal Stress	C-1/2 /15 psi + E-20s/260		5	MIL.P 13949		
Non Electrical Tests on Metal Clad Material	Thermal Stress	E-6/150+ E-10s/288	S	>40	MIL.P 13949	>40	MIL.P.13949
	Peel Strength	As received	N/mm	2.2	MIL.P 13949	2.10	MIL.P.13949
	Peel Strength	After thermal stress	N/mm	1.9	MIL.P 13949	1.8	NEMA L1-1
	Peel Strength	E-1/125 (FR3:E-1/105)	N/mm	1.7	MIL.P 13949	1.6	NEMA L1-1
	Peel Strength	After exposure to processing Sol.	N/mm	1.85	MIL.P 13949	1.7	MIL.P.13949
	Warp on Panels 304 x 304 mm	A	%	≤0.5	MIL.P 13949	≤1.0	MIL.P.13949
Electrical Tests	Electrolytic Corrosion	C-96/40/92		A/1.4	1EC.249	A/1.0	1EC.249
	Dielectric Breakdown	To lamination D48/50+D-1/2 /23	KV	70	MIL.P 13949	65	NEMA L1-1
	Electric Strength	D-48/50+D-1/2 /23	V/mil		MIL.P 13949		
	Permittivity	1 MHZ C-40/23/50		4.7	MIL.P 13949		
	Permittivity	1 MHZ D-24/23			1EC.249	4.2	NEMA L1-1
	Dissipation Factor	1 MHZ C-40/23/50		0.019	MIL.P 13949		
	Dissipation Factor	1 MHZ D-24/23				0.03	NEMA L1-1
	Surface Resistance	Moisture resistance	Ω	22×10^{12}	MIL.P 13949		
	Surface Resistance	E24/125 (FR3:E-4/105)	Ω	5×10^{11}	MIL.P 13949	7×10^{10}	MIL.P.13949
	Volume Resistivity	Moisture resistance	Ω cm	27×10^{12}	MIL.P 13949		
	Volume Resistivity	E24/125 (FR3:E-4/105)	Ω cm	3×10^{12}	MIL.P 13949	8×10^{9}	MIL.P.13949
	Volume Resistivity	C-96-35-90	Ω cm	3×10^{12}	MIL.P 13949	40×101^{12}	NEMA L1-1

Appendix C

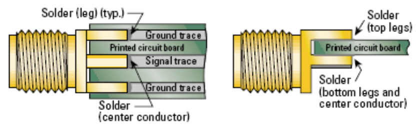
SMA Connector Datasheet

SMA Edge Mount P.C. Board Receptacles

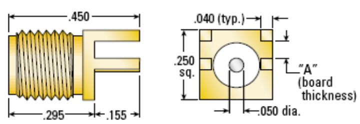
AEP SMA edge-mount P.C. board receptacles offer quick, convenient assembly with no board drilling required, and can replace more expensive right-angle types in many applications. Gold plating is standard, but other body finishes are available. Their compact size makes them ideal for applications requiring dense packaging.

SMA edge-mount types can be supplied quickly for any board thickness up to .062" maximum. Connectors for thicker boards can be supplied by special order.

How they work:



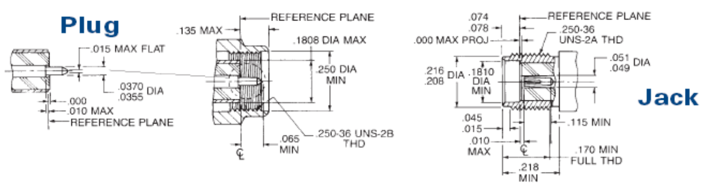
Ordering Information



"A"	AEP P/N
.032	9650-1113-014
.062	9650-1113-017

Also available in bulkhead jack and plug mating end configurations.

Interface Dimensions



Specifications (MIL-PRF-39012 as applicable)

Materials:
Body components: Stainless steel per ASTM-A-582, type 303.
Contacts: Beryllium copper per ASTM-B-196, Condition HT.
Insulators: Teflon TFE per ASTM-D-1710.
Gaskets: Silicone rubber per ZZ-R-765, Class 2B, grade 65-75.

Finish:
Center contacts: Gold plated per current revision of MIL-PRF-39012*
Other metal parts: Gold plated to meet current MIL-PRF-39012 corrosion requirements.*

Electrical:
Impedance: 50Ω.
Frequency range: DC–18 GHz.
Insulation Resistance: 5,000 megohms min.
Voltage Rating: 250VRMS @ sea level.
Dielectric Withstanding Voltage: Per MIL-STD-202, Method 301.
Contact Resistance: 3 milliohms maximum.
RF highpot: 335 VRMS @ 5 MHz.
RF leakage: -60 dB min @ 2–3 GHz.
Insertion loss: .44 dB max to 6 GHz.

Mechanical:
Force to engage/disengage: 2 pounds max.
Force to engage/disengage (female contacts): (After 5 insertions of .375" diameter pin, .040" min depth): Insertion force for .037 min diameter pin, 2 pounds max. Withdrawal force for .0355" max diameter pin, 1 ounce min.
Contact retention: 6 pounds min axial force.
Durability: 500 mating cycles.

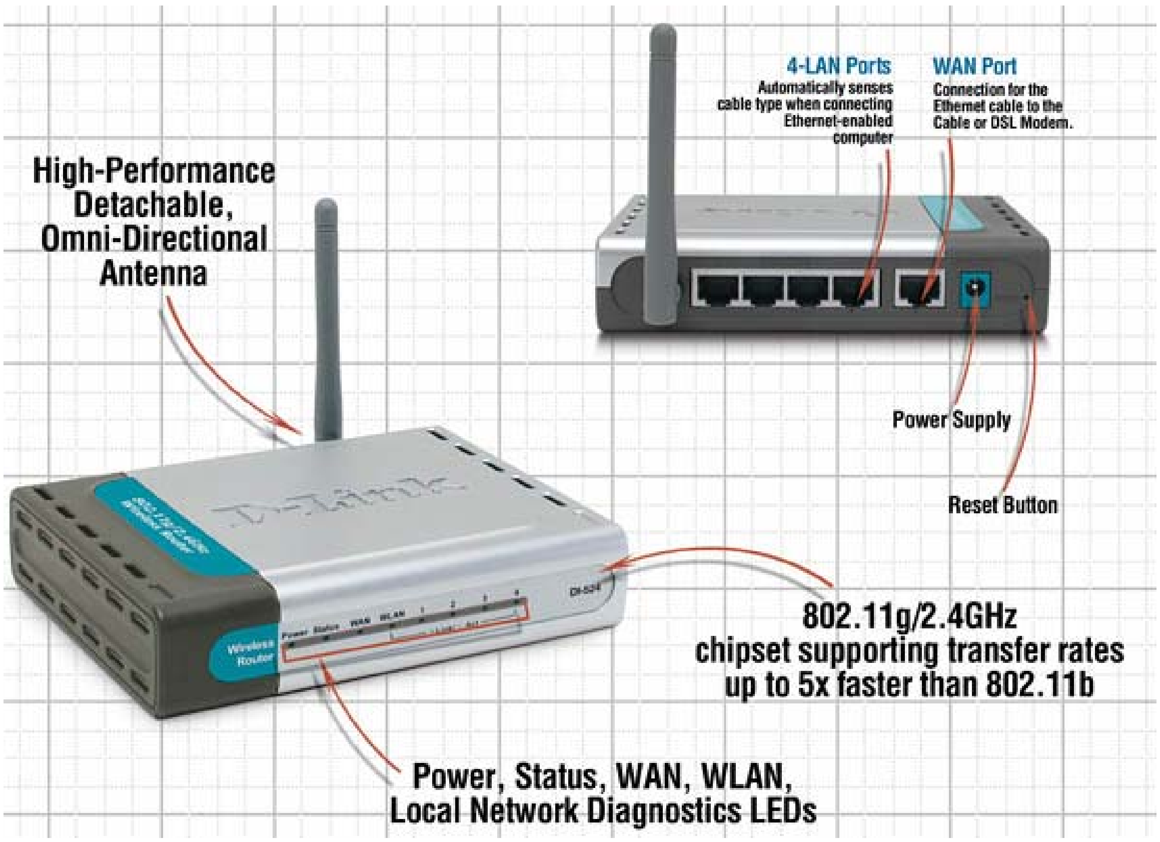
Environmental (MIL-STD-202):
Temperature range: -65° C to +165° C.
Corrosion: Method 101, condition B, 5% salt solution.
Vibration (Method 204): Condition B.
Mechanical shock (Method 213): Condition B.
Thermal shock (Method 107): Condition B.

*These specifications change periodically with updates to MIL-PRF-39012 requirements. Contact factory for latest specifications.

APPLIED ENGINEERING PRODUCTS
(203) 776-2813 • FAX (203) 776-8294 www.aepconnectors.com • aepsales@aepconnectors.com
P.O. Box 510 • New Haven, CT 06513

Appendix D

D- Link Wireless Router Specifications



Standards

- IEEE 802.11g
- IEEE 802.11b
- IEEE 802.3
- IEEE 802.3u

Wireless Signal Rates* with Automatic Fallback

- 54Mbps

• 48Mbps

• 36Mbps

• 24Mbps

• 18Mbps

• 12Mbps

• 11Mbps

• 9Mbps

• 6Mbps

• 5.5Mbps

• 2Mbps

• 1Mbps

Security

• 802.1X

• 64-, 128-bit WEP

• WPA — Wi-Fi Protected Access (WEP with TKIP, MIC, IV Expansion, Shared Key Authentication)

Modulation Technology

• Orthogonal Frequency Division Multiplexing (OFDM)

Receiver Sensitivity*

• 54Mbps OFDM, 10% PER,-68dBm)

• 48Mbps OFDM, 10% PER,-68dBm)

• 36Mbps OFDM, 10% PER,-75dBm)

• 24Mbps OFDM, 10% PER,-79dBm)

• 18Mbps OFDM, 10% PER,-82dBm)

• 12Mbps OFDM, 10% PER,-84dBm)

• 11Mbps CCK, 8% PER,-82dBm)

• 9Mbps OFDM, 10% PER,-87dBm)

• 6Mbps OFDM, 10% PER,-88dBm)

• 5.5Mbps CCK, 8% PER,-85dBm)

• 2Mbps QPSK, 8% PER,-86dBm)

• 1Mbps BPSK, 8% PER,-89dBm)

VPN Pass Through/Multi-Sessions

• PPTP

• L2TP

• IPSec

Device Management

• Web-Based – Internet Explorer v6 or later; Netscape Navigator v6 or later; or other Java-enabled browsers.

• DHCP Server and Client

Advanced Firewall Features

• NAT with VPN Pass-through (Network Address Translation)

• MAC Filtering

• IP Filtering

• URL Filtering

• Domain Blocking

• Scheduling

Wireless Signal Range*

• Indoors: Up to 328 ft (100 meters)

• Outdoors: Up to 1312 ft (400 meters)

Wireless Frequency Range

• 2.4GHz to 2.462GHz

Wireless Transmit Power

• 15dBm ± 2dBm

External Antenna Type

• Single detachable reverse SMA

Operating Temperature

• 32°F to 131°F (0°C to 55°C)

Humidity

• 95% maximum (non-condensing)

Safety & Emissions

• FCC

LEDs

• Power

• Status

• WAN

• WLAN (Wireless Connection)

• LAN (10/100)

Dimensions

• L = 5.6 inches (142mm)

• W = 4.3 inches (109mm)

• H = 1.2 inches (31mm)

Weight

• 0.49lbs (22g)

DEVELOPMENT OF MICROSTRIP PATCH ARRAY ANTENNA FOR WIRELES LOCAL AREA NETWORK (WLAN)

Azizan Mat Hashim

School of Computer and Communication Engineering
University Malaysia Perlis
Malaysia

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Abstract: In this project, a 4x1 Rectangular Microstrip Patch Array Antenna at frequency 2.45 GHz for Wireless Local Area Network (WLAN) will be design, fabricate and test. The antenna will be design base on optimization and characteristics analysis. Some methods for optimize the Microstrip Patch Antenna are studied and implemented to produce this antenna. The objective of this project is to develop the antenna that has high gain, directivity, bandwidth and efficiency. Theoretically, the objective of this project can be achieve through the use of high quality substrate such as RT Duroid 5870 which is have low relative permittivity or dielectric constant and higher substrate that will improve the bandwidth. This is because in Rectangular Microstrip Patch Array Antenna, the bandwidth is determined by the dielectric constant and the height of substrate. Low of loss-tangent will increase the efficiency of the antenna. The patch array also has a better directivity than the single patch. Microwave Office (MWO) will be introduce as an effective tool for modeling electromagnetic structure. The antenna was fabricated based on simulation and measured using Wave and Antenna Training System (WATS2002). The expected result from this project is the antenna will has a high gain, better directivity, larger bandwidth and more efficiency.

1. INTRODUCTION

Microstrips array antenna have received lots of attention since the last decade because of their advantages such as low cost, lightweight and ease of fabrication and integration. Microstrips are also able to operate in a wide range of frequencies. Antennas play an important role in today's wireless communication. Without the use of an antenna, signals are not able to be transmitted out or received. The raise of using microstrip for antennas has been due to the several advantages of microstrips. Microstrip patch antenna meets the requirements for portable equipment because of its lightweight. But the main disadvantage with the low profile microstrip patch antennas is their bandwidth. The bandwidth is limited and narrow. In order to overcome bandwidth limitation, a number of antenna elements or a feed matching network may be employed in order to satisfy the bandwidth requirement for a particular application.

Many applications require radiation characteristics that may not be achievable by a single element. The arrangement of the array may be such that the radiation from the element adds up to give a radiation maximum in particular direction or directions, minimum in others, otherwise as desired [1]. From that, the arrays have better directivity, and higher gain. Base on that advantage the array antenna has been developed.

2. ANTENNA DESIGN

The first step in design is to specify the dimension of a single microstrip patch antenna. The patch is in the shape of a rectangular which is etched on FR4 substrate of thickness h = 1.6 mm and dielectric constant $\varepsilon_r = 4.7$. The antenna was designed to resonate at 2.45 GHz. To obtain an initial value of width, w and length, *L* equation (1) and (2) is used,

$$w = \frac{c\left[(\varepsilon_r + 1)/2\right]^{-\frac{1}{2}}}{2fo} \qquad (1)$$

$$L = \frac{c}{2f_o\sqrt{\varepsilon_r}} \qquad (2)$$

To find effective relative permittivity, ε_{eff} equation (3) is used,

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(\frac{1}{\sqrt{1 + 12h/w}}\right) \qquad (3)$$

With the value of ε_{eff} obtain, the fringe factor can be calculate, given by equation (4)

$$\Delta L = 0.412h\frac{(\varepsilon_{eff} + 0.300)(w/h + 0.264)}{(\varepsilon_{eff} - 0.258)(w/h + 0.800)} \qquad (4)$$

By using equation (5), the L value can be obtained and improved.

$$L = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} - 2\Delta L \qquad (5)$$

The dimensions of the single microstrip patch and microstrip array antenna are illustrated in Figure 1 and Figure 2.

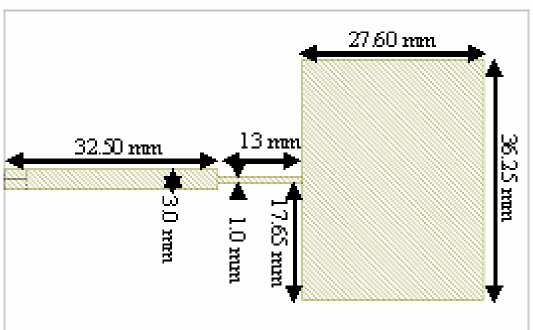

Figure 1: Dimension of the Single Patch Antenna

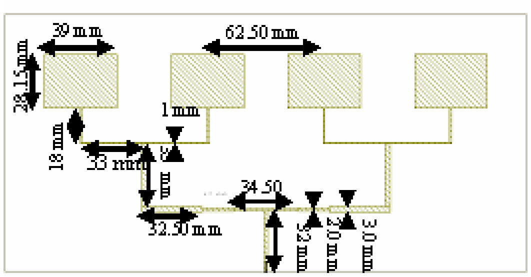

Figure 2: Dimension of the Array Patch Antenna

After all the parameters obtained, it can be simulate by using MWO.

3. SIMULATION RESULTS

In the MWO, Microwave Office enables the user to use either schematic based simulation (Figure 3) or layout based simulation (Figure 4). However in this project, the layout based simulation is used to design the single patch and array antenna.

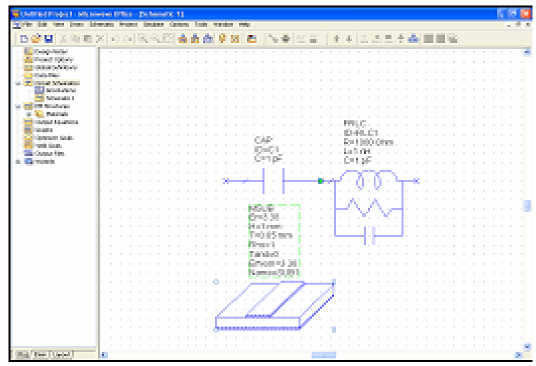
Figure 3: The Circuit Schematic Based Environment

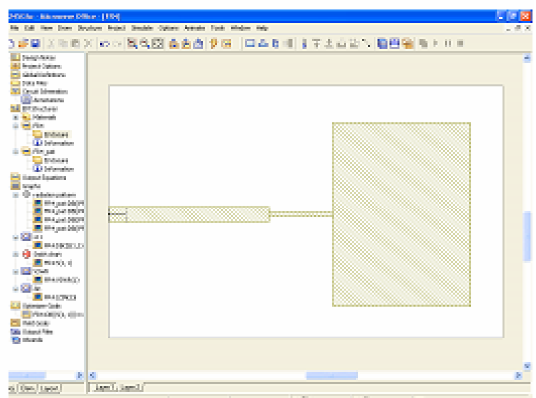
Figure 4: The Layout Schematic Based Environment

Figure 5 below show the return loss (S_{11}) for single patch antenna.

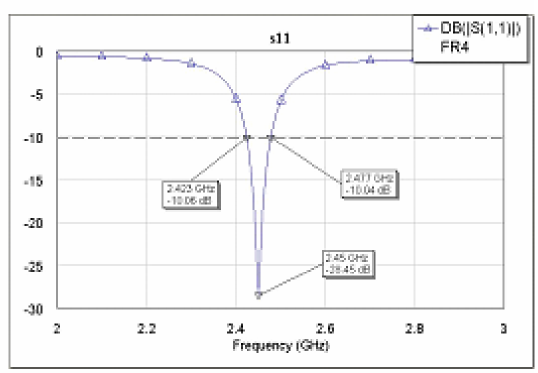

Figure 5: Optimize Single Patch Antenna S_{11} Respons

For the microstrip patch array antenna, the result is illustrated below.

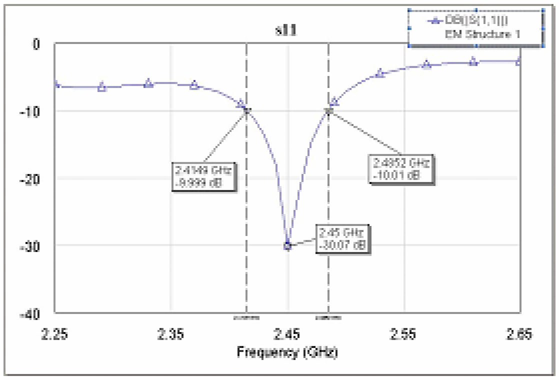

Figure 5: Optimize Array Patch Antenna S_{11} Response

The matching state of the antenna can be determined refer to the slope of S_{11} below or equal to -10 dB. As a summary, the greater the numbers of S_{11} will resulting the more matching to the antenna and more widely to the bandwidth.

For the simulated radiation pattern, the result is presented below.

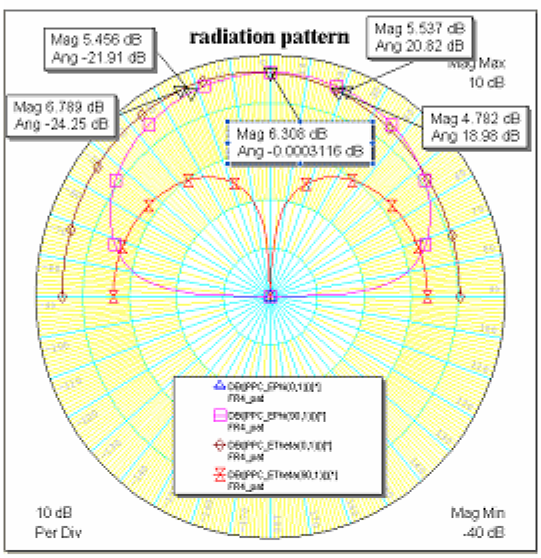

Figure 6: Single Patch Optimized Radiation Pattern

For the single patch antenna, the simulated *HPBW* is 43.2° for H plane while the E plane produced a *HPBW* of 42.73°. The *HPBW* for E plane is narrow caused by the thin substrate. In addition to that, the width of the antenna patch is larger, thus generating a larger beam width for the H plane. The simulated gain of the antenna is 6.308 dB.

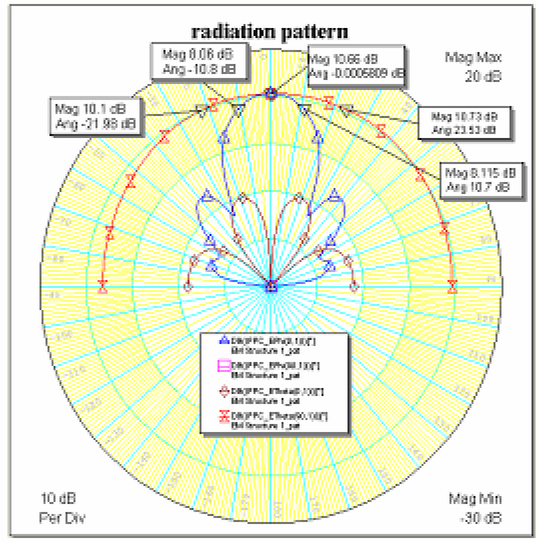

Figure 7: Array Patch Optimized Radiation Pattern

From the result obtained above, the *HPBW* for E plane is 45.51°. The H plane *HPBW* given by the simulated result is narrower than E plane which is 21.5°. The array antenna simulated gain from the radiation pattern approximately 10.66 dB.

4. MEASUREMENT RESULTS

This experiment started after the simulation successfully achieved and the antennas are fabricated. The parameters that will measure are return loss and radiation pattern. As an addition, the antenna also will be go through the Signal Transmission Performance test using Network Stumbler software. The first measurement that was performed is return loss. It is to ensure that the antenna exactly operate at 2.45 GHz. Figure below shows the result and measurement process for fabricated single and array microstrip patch antenna.

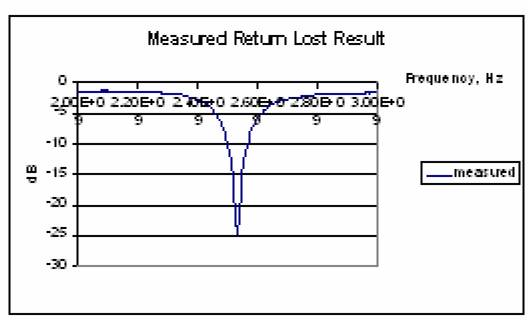

Figure 8: Single Patch Antenna Measured S_{11}

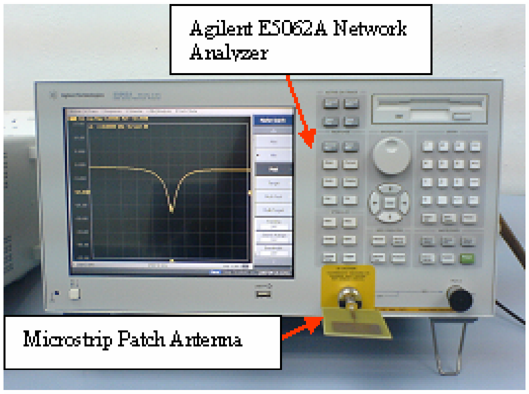

Figure 9: S_{11} Measurement Process Using Agilent E5062A Network Analyzer

From the Figure 8, it found that the S_{11} frequency is 2.52 GHz at -24.70dB. The bandwidth of the measured antenna is about 65 MHz.

The Figure 9 below shows the measured S_{11} response for microstrip patch array antenna that has been designed. From the figure found that the S_{11} response drop at 2.52 GHz within -20.15 dB.

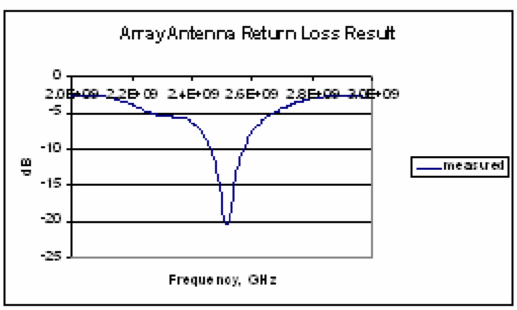

Figure 9: Measured S_{11} Response for Array

In this section will present the measurement results of radiation patterns plotted on a polar format. It was done using WATS 2002 equipment. The testing using Log Periodic Antenna (LPA) as a transmitter antenna. Figure 10 show the measurement process. After that the result will be normalized and plot using Microsoft Excel. The radiation pattern will be measured both for the E plane and H plane. The results for single patch and array antenna are illustrated in Figure 11 and 12 respectively.

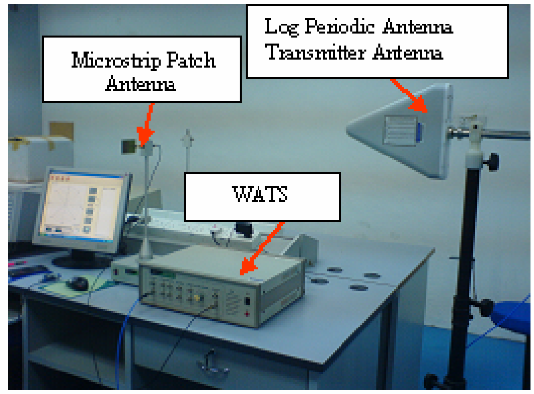

Figure 10: Radiation Pattern Measurement Process

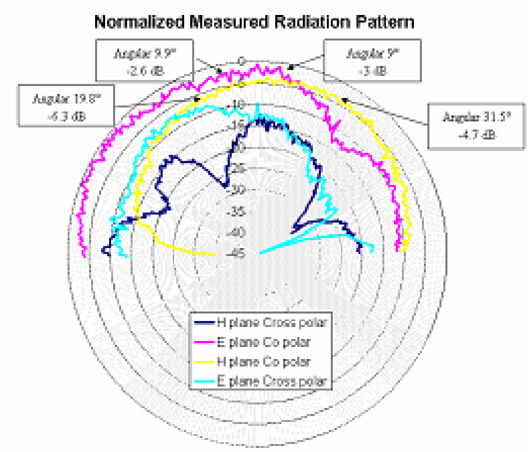

Figure 10: Measured Radiation Pattern for Single Microstrip Patch Antenna

From the figure, the *HPBW* for the E plane is only 19.9° only. For the H plane the *HPBW* is 51.3°. The measured result has a larger *HPBW* than simulated result for the H plane. However the E plane *HPBW* is narrower than simulated. The maximum cross polarization for H plane is -32.4 dbm and -27.8 dbm for co polarization. The 0° isolation between both polarization patterns is 10 db which satisfies the minimum threshold of 10 db.

For the E plane, maximum co polarization is -24.2 dbm. The cross polarization for this antenna is large, which is -31.1 dbm. The 0° isolation between both polarization patterns is 9 db for E plane.

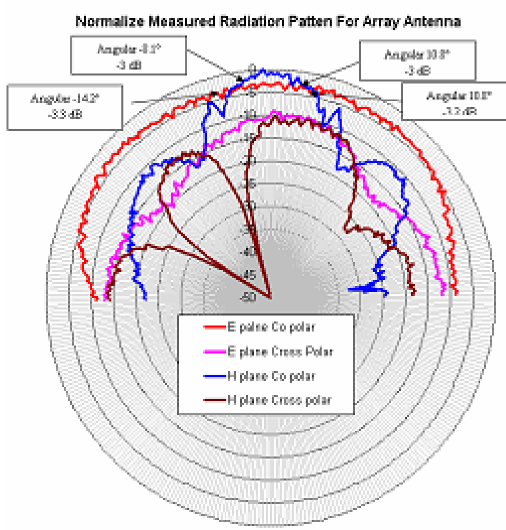

Figure 11: Measured Radiation Pattern for Microstrip Patch Array Antenna

The measured *HPBW* for h plane is 18.9° and the maximum co polarization is -7.8 dbm. The maximum cross polarization is -18.2 dbm. The maximum cross polarization is -18.2 dBm. The measured radiation pattern produced 11.1 dB for maximum 0° isolation for the H plane

On the other hand, the E plane produced a maximum co polarization of -10.4 dbm while the maximum cross polarization value is -17 dbm. This produces a nominal isolation of 7.8 db. The *HPBW* of this measurement on this plane is 25°.

After performed S_{11} response and radiation pattern measurement, the antenna will be test for it application which is use in WLAN. The objective of this test is to determine the ability of this antenna to transmit data over a network. The antenna will be swap to wireless router as a transmission element. Network Stumbler software will test on Signal to Noise Power Ratio (SNR). The Figures provide shows the testing set up and results.

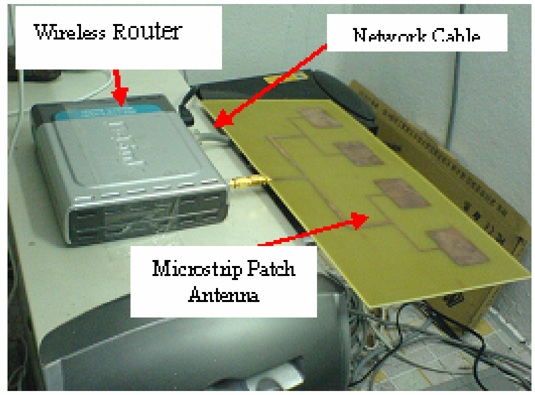

Figure 11: Wireless Router Setup

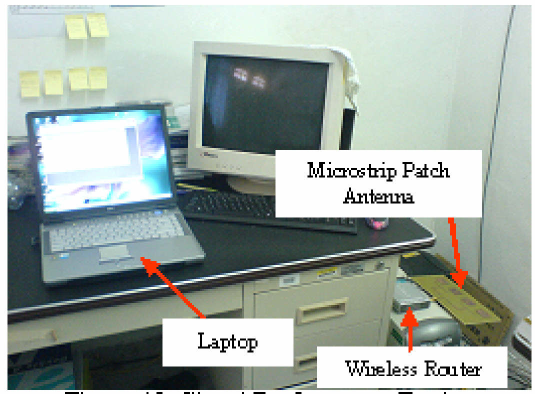

Figure 12: Signal Performance Testing Configuration

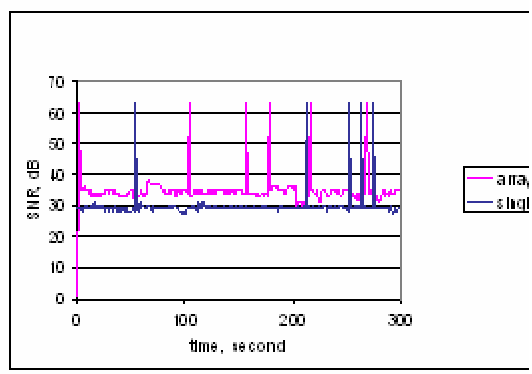

Figure 13: SNR between Single Patch and Array Antenna

From the result obtained in Figure 13, the average Signal to Noise Power Ratio for microstrip patch array antenna is 35 dB. On other hand, the average SNR for single microstrip patch antenna is 28 dB.

5. DISCUSSION

The results for measurement that has obtained at the previous section will be compared with the simulation results. The discussion for the results is present in this section base on the simulation result. The difference between those results for return loss, radiation pattern and network performance are discussed briefly.

S_{11} simulation response is plotted against the measured response and illustrated in the Figure 14.

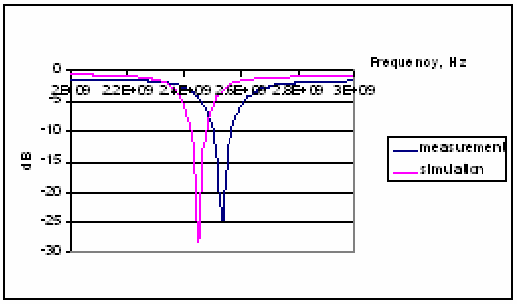

Figure 14: Single Patch Antenna S_{11} Response Simulation versus Measurement

From the figure above, found that the shifting frequency between simulation and measurement result is 3.27%.with a difference of 3.79dB. For the bandwidth (*BW*), the measured result is wider than simulated which about 20.37%. This is caused by the position of the feed line, which is etched on the same layer as the patch, and suffers from serious spurious radiation.

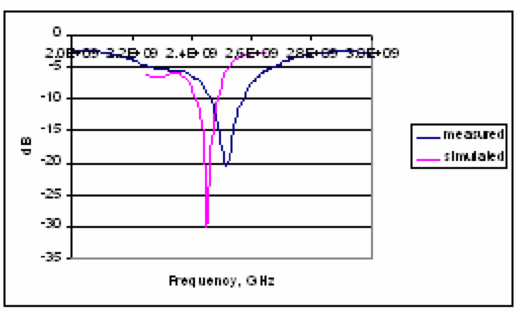

Figure 15: Array Antenna S_{11} Response Simulation versus Measurement

The shift frequency for array antenna is about 2.86 % with a difference of -9.92 dB. The difference between simulated and measured result for bandwidth is approximately 49.66 %. The measured bandwidth obtained is 0.11 GHZ

For the both single patch and array antenna result, various factors such as incorrect design procedures, inaccuracy of the MWO design software, poor fabrication or incorrect measurement process and environment could affect the results. In this project, the accuracy of return loss measurements also depends on two circumstances which are environment of measurement and the characteristics of the equipments used.

The dielectric constant value might not be exactly at 4.7 at 2.45 GHz, but with the measured response close to the simulated response, the value 4.7 used should be fairly accurate. Poor fabrication process might lead to inaccuracy of measurements, as a high level of accuracy is needed for microstrip circuitries. The fabrication need the high level of accuracy maintained when fabricating the microstrip antennas.

The MWO might be the problem because the accuracy of the software depends on the cell size that defined by user. The smaller of the cell size giving more accurate and smooth result. However, when the size of cell gets smaller, it wills takes long period of simulation process. It is because the software needs to perform the more calculation.

From the Figure 13 previously, it shows the array antenna has higher SNR if compare with the single patch antenna. The microstrip array antenna has an average about 35 dB SNR rather than single patch antenna which is only 28 dB. The higher the signal to noise power ratio, the better the performance and the higher the information capacity. [17]

From here, it can be summarize that the performance microstrip patch array antenna is better than single microstrip patch antenna. The array antenna is more directives and has a higher gain which made it more efficient than single patch.

6. CONCLUSIONS

This thesis detailed the various aspects associated with the design simulation of Microstrip Patch Array Antenna. One of the goals was the introduction of MWO as an effective CAD tool for electromagnetic analysis. A comprehensive and graphic description of each step taken in creating the simulation of the antenna was presented. It was observed that the measured resonant frequency still closer to the simulation value which is 2.45 GHz. However, it was difficult to pin point specific factors responsible for the mismatch that mentioned in the previous chapter. As a conclusion although the designed antenna has a shift in frequency, it still can be used as an access point since it still in the range of WLAN acceptable frequency.

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