DTG3F3
Teknik Antena
dan propagasi

Antena Mikrostrip

By : Dwi Andi Nurmantris

Where Are We?

1. **PENDAHULUAN**
   - Silabus, referensi, sasaran pengajaran
   - Aturan penilaian: Quis, Ujian, Tugas dll
   - Kontrak belajar : Aturan perkulihan
   - Sistem Komunikasi Radio Secara Umum
   - Review electromagnetic dan Latar belakang sejarah
   - Definisi dan Fungsi dasar antena
   - Cara Kerja Antena
   - Perkembangan Antena dan aplikasinya
2. **KONSEP DASAR ANTENA**
   - Teorema Resiprositas
   - Teorema daya dan intensitas radiasi
   - Diagram arah dan diagram fasa
   - Beamwidth Antena (lebar berkas)
   - Frekuensi Kerja Antena, Impedansi antena, tahanan pancar, VSWR, Return Loss, dan Bandwidth Antena
   - Direktivitas (pengarahan)
   - Gain dan effisiensi antena
   - Polarisasi Antena
   - Konsep Aperture Antena
   - Transmisi Friss
3. **SUSUNAN ANTENA&IMPEDANSI GANDENG ANTENA**
   - Pengenalan Antena dipole dan monopole
   - Pengenalan antena mikrostrip
   - Pendahuluan susunan Antena (array antenna)
   - Konsep dasar susunan dan prinsip perkalian diagram
   - Susunan n-elemen sumber isotropic linier: persamaan medan, array factor, gain susunan
   - Distribusi arus antena susunan linier uniform
   - Distribusi arus antena susunan linier tak-uniform
   - Susunan n-elemen sumber isotropic tak linier
   - Impedansi Sendiri dan Impedansi Gandeng Antena
   - Impedansi gandeng antar 2 antena
   - Impedansi susunan n-Element identik
4. **PENGENALAN SOFTWARE ANTENA DESIGN**
   - Pendahuluan Antenna design procedure
   - Klasifikasi Computational Electromagnetic (CEM)
   - Numerical Method: Time Domain Method dan Frequency Domain Method
   - Pengenalan CST Microwave Studio
5. **MACAM-MACAM ANTENA**
   - Antena Loop dan Helix (Perkembangan, Aplikasi, Karakteristik, dan Desain)
   - Antena Horn (Perkembangan, Aplikasi, Karakteristik, dan Desain)
   - Antena Reflektor (Perkembangan, Aplikasi, Karakteristik, dan Desain)
   - Antena Yagi Uda (Perkembangan, Aplikasi, Karakteristik, dan Desain)
6. **PENGUKURAN ANTENA**
   - Pendahuluan
   - Persyaratan umum pengukuran antenna
   - Teknik-teknik Pengukuran antenna
   - Pengukuran diagram arah dan diagram fasa
   - Pengukuran gain, direktifitas, effisiensi
   - Pengukuran impedansi, SWR, BW, dan distribusi arus
   - Pengukuran polarisasi antenna

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Sejarah Antena Mikrostrip

- **Invented by Bob Munson in 1972.**
- **Became popular starting in the 1970s.**

element array. The four-element ϕ-plane circumferential pattern of Fig. 10 and the four-element θ-plane elevation pattern of Fig. 11 verify that an 18° beam is achieved by the 16-element array section.

REFERENCES

[1] W. S. Gregorwich, "A mechanically despun antenna for the Skynet IDCSP/A communications satellite," in *Communication Satellites for the 70's*, Feldman and Kelly, Eds. Cambridge, Mass.: M.I.T. Press, 1971, pp. 241–254.

[2] T. S. Chu, "On the use of uniform circular arrays to obtain omnidirectional patterns," *IRE Trans. Antennas Propagat.* (Commun.), vol. AP-7, pp. 436–438, Oct. 1959.

[3] L. I. Parad and R. L. Moynihan, "Split-tee powder divider," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-13, pp. 91–95, Jan. 1965.

[4] E. J. Wilkinson, "An N-way hybrid power divider," *IRE Trans. Microwave Theory Tech.* (Corresp.), vol. MTT-8, pp. 116–118, Jan. 1960.

[5] R. C. Chapman and N. L. Exum, "Series diode SP4T switch for satellite applications," in *IEEE 1972 Nat. Telecommun. Conf. Rec.*, pp. 36E-1–36E-5, Dec. 1972.

[6] J. H. Lange and B. E. Rose, "A Y to Δ transformation of a three-way hybrid junction," *IEEE Trans. Microwave Theory Tech.* (Corresp.), vol. MTT-17, pp. 789–790, Oct. 1969.

[7] W. S. Gregorwich and C. W. Westerman, "A near-isotropic microwave antenna for communications satellites," in *Communication Satellite Technology*, Bargellini, Ed. Cambridge, Mass.: M.I.T. Press, 1973.

Conformal Microstrip Antennas and Microstrip Phased Arrays

ROBERT E. MUNSON

Abstract—A new class of antennas using microstrips to form the feed networks and radiators is presented in this communication. These antennas have four distinct advantages: 1) cost, 2) performance, 3) ease of installation, and 4) the low profile conformal design. The application of these antennas is limited to small bandwidths. Phased arrays using these techniques are also discussed.

I. INTRODUCTION

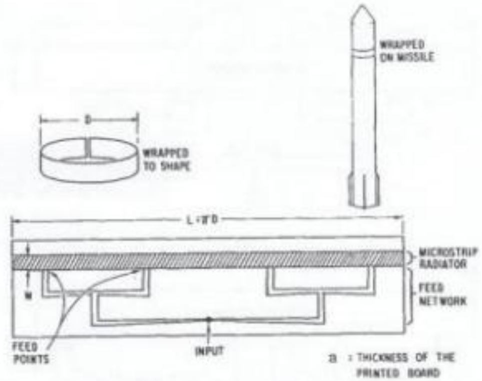


Fig. 1. Microstrip wraparound antenna.

This communication will discuss microstrip arrays of three general types: wraparound microstrip antennas that wrap around missiles, rockets, and satellites to provide omnidirectional coverage; flat thin microstrip antennas that provide a high gain fan beam or a pencil beam; a phased array that consists of flat (or curved) thin microstrip antennas with pin diodes added to the microstrip substrate to provide an electronic beam steering capability.

II. MICROSTRIP WRAPAROUND ANTENNAS

The wraparound antennas which provide omnidirectional coverage are similar in performance (coverage and bandwidth) to the stripline (two layer PC board) antennas discussed by Waterman and Henry [1], Campbell [2], and Johnson [3]. In general, stripline and microstrip antennas will produce bandwidths (VSWR $< 2:1$) of 30 MHz to 100 MHz in the L band and S band regions with a 1- to 2-dB variation in the roll plane. The microstrip wraparound antenna consists of two parts: 1) microstrip feed network and 2) microstrip radiator.

R. E. Munson, "Microstrip Phased Array Antennas," Proc. of Twenty-Second Symp. on USAF Antenna Research and Development Program, October 1972.
R. E. Munson, "Conformal Microstrip Antennas and Microstrip Phased Arrays," IEEE Trans. Antennas Propagat., vol. AP-22, no. 1 (January 1974): 74–78.

Sejarah Antena Mikrostrip

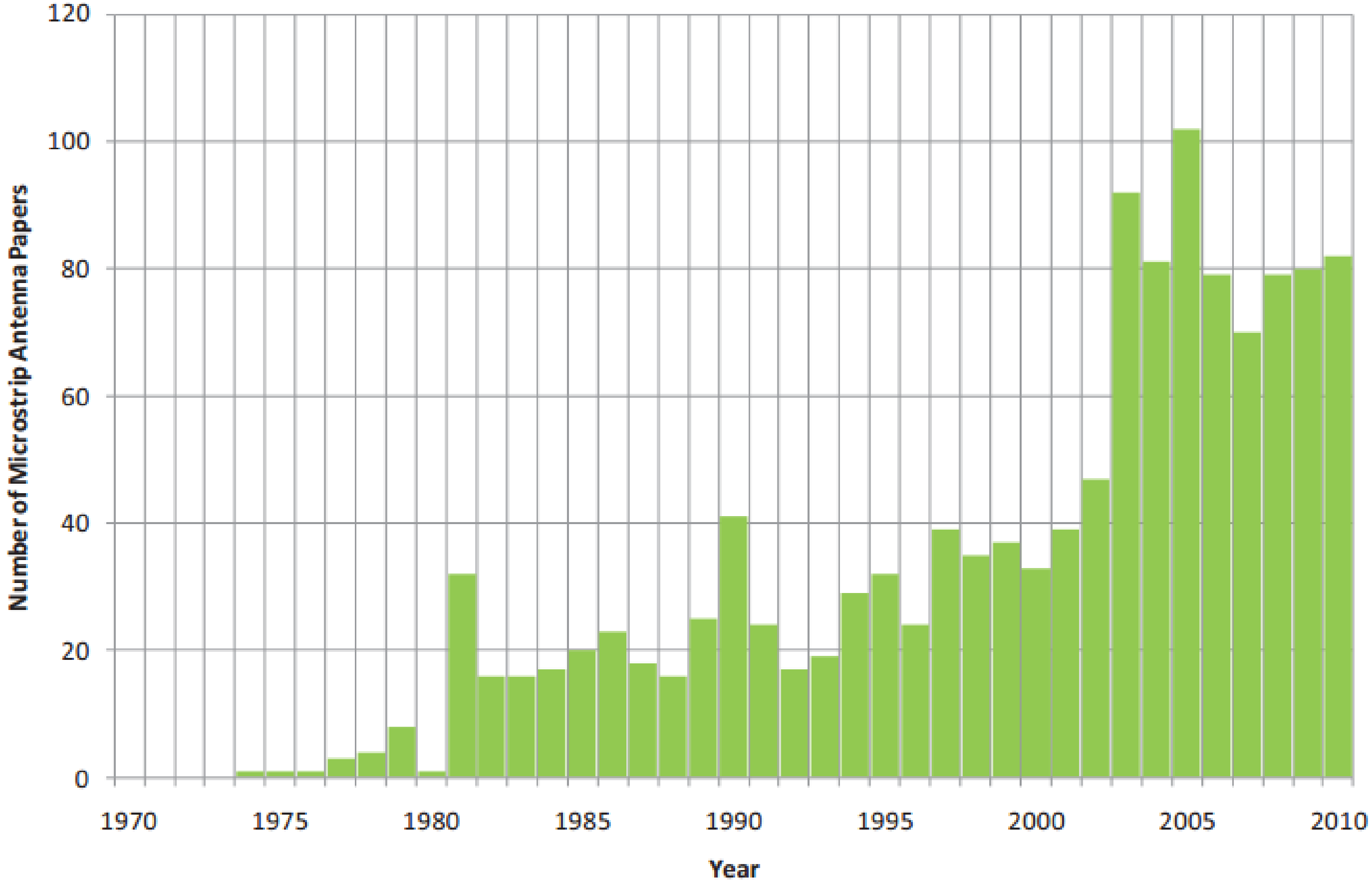


Figure 1. Number of microstrip antenna papers published in the IEEE Transactions on Antennas and Propagation.

Custodio Peixeiro "Microstrip Patch Antennas An Historical Perspective of the Development" IEEE Trans. Antennas Propagation 2011.

Sejarah Antena Mikrostrip

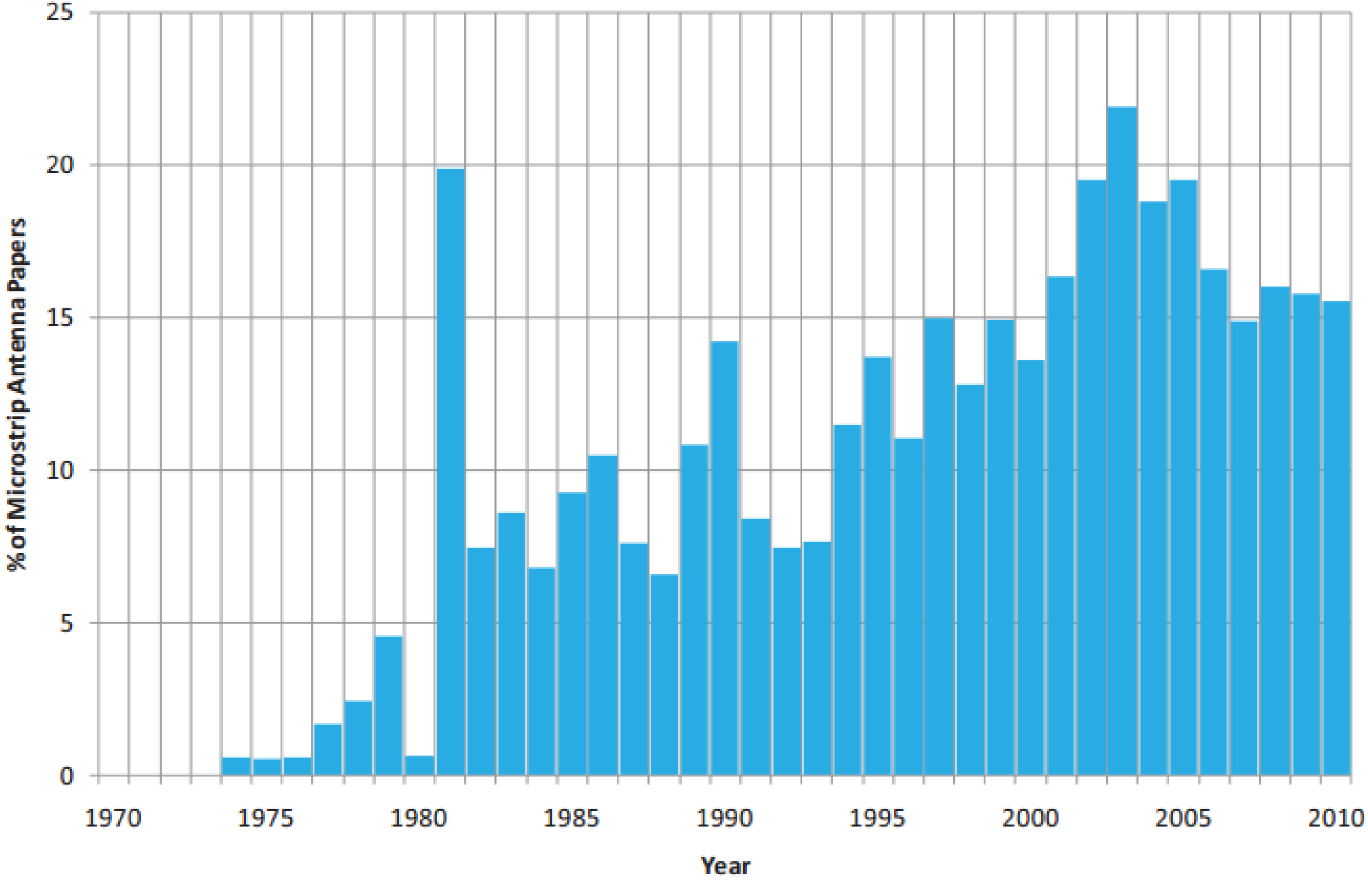
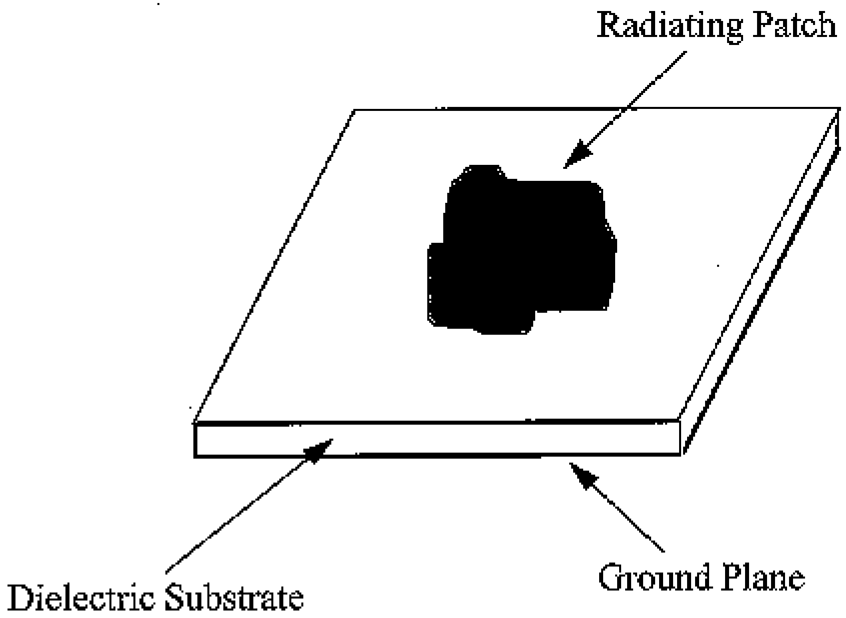


Figure 2. Percentage of microstrip antenna papers published in the IEEE Transactions on Antennas and Propagation.

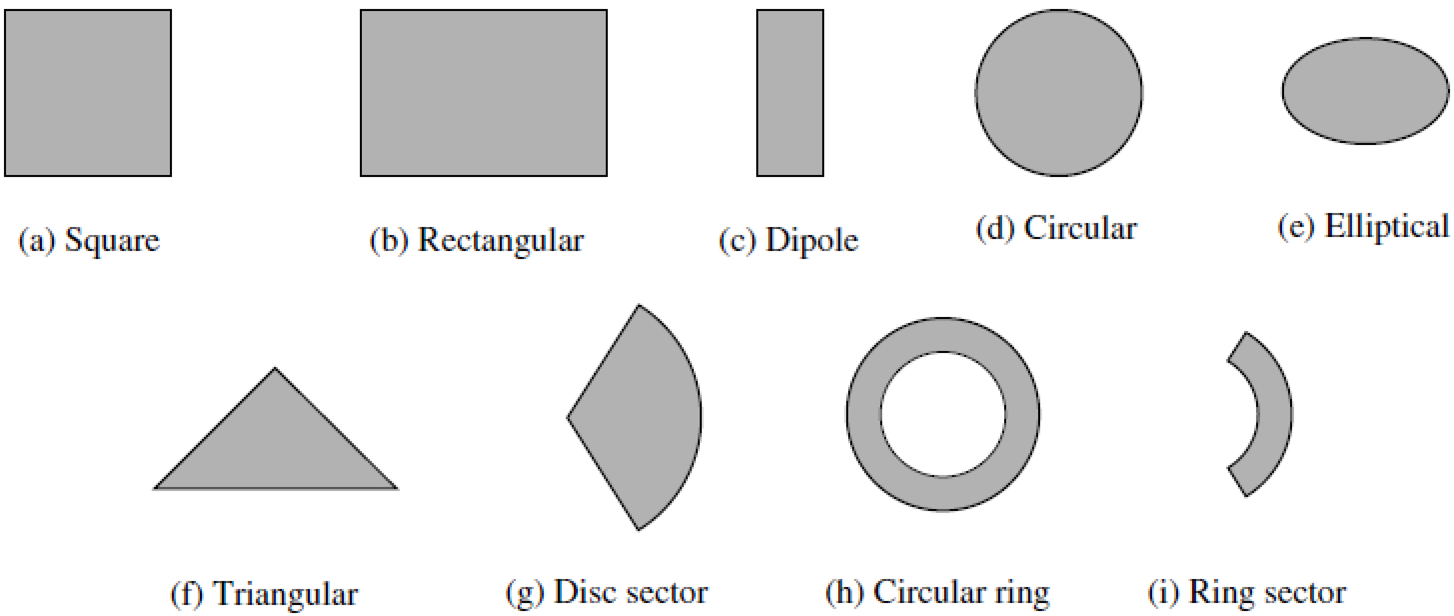
Custodio Peixeiro "Microstrip Patch Antennas An Historical Perspective of the Development" IEEE Trans. Antennas Propagation 2011.

Struktur Antena Mikrostrip

- Antena Mikrostrip tersusun dari Konduktor tipis (patch) yang terpisah dari groundplane oleh suatu bahan dielektrik (substrat)
- Biasanya digunakan untuk aplikasi frekuenci mikrowave



Bentuk-Bentuk patch pada mikrostrip



Kelebihan dan Kekurangan Antena Mikrostrip

Kelebihan

- Low profile: $h << l_0$
- Conformal
- Light weight
- Inexpensive
- Robust
- MMIC compatible
- Versatile

Kekurangan

- Small bandwidth
- Poor efficiency: losses due to surface waves in addition to conductor and dielectric losses
- Low power-handling capability
- Difficult to design - require full wave analysis

Aplikasi Antena Mikrostrip

- Radar
- Satellite communication
- Biomedicine
- Automotive industry
- Mobile Communication (base station and handset)
- WLANs
- RFID

Metoda Analisis

- ***Transmission-line model***
  - simplest
  - good physical insight
  - less accurate, valid only for rectangular patches
- ***Cavity model***
  - more complicated
  - good physical insight, more accurate, more versatile
- ***Integral Equation/Moment Method***
  - most complicated, less physical insight, very accurate & versatile
- ***Differential Equation Techniques (FDTD, FEM)***
  - complicated, computationally slow
  - most versatile and can take into consideration surrounding environment

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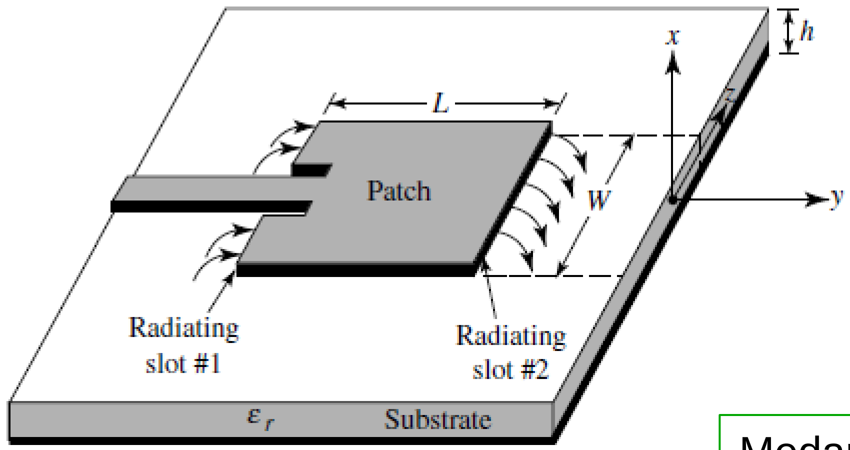
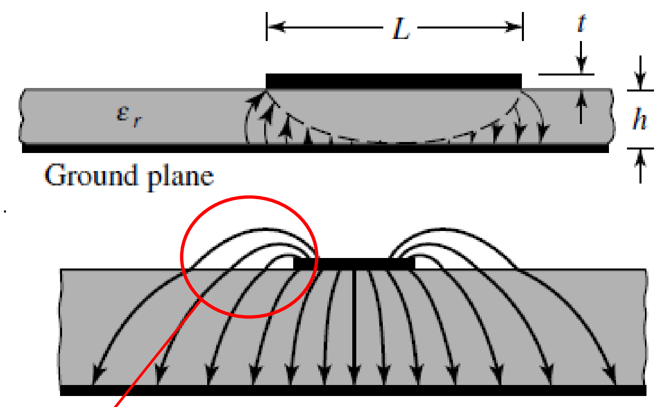
Prinsip Kerja

Rectangular Patch Antenna





(b) Electric field lines

$$t << \lambda_0 \rightarrow \lambda_0 = \textit{free space wavelength}$$

$$h << \lambda_0 \rightarrow 0{,}03\lambda_0 \le h \le 0{,}05\lambda_0$$

$$\lambda_0/3 \le l \le \lambda_0/2$$

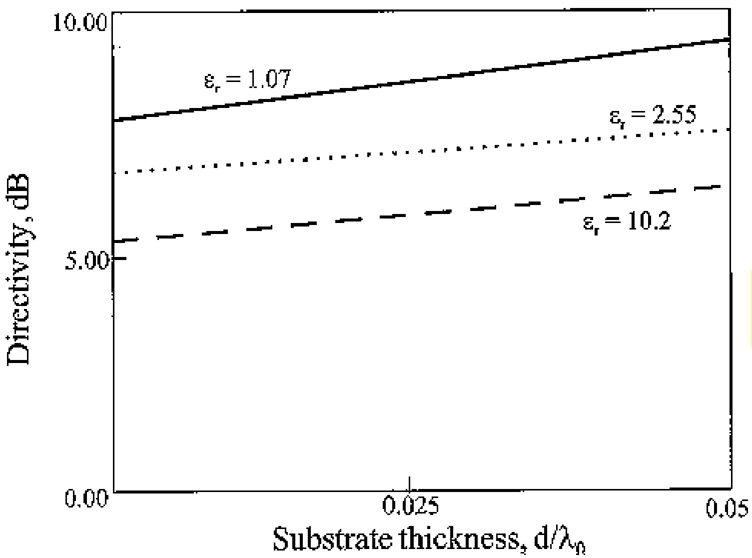
$$W < \lambda_0 \ (\textit{tapi tidak boleh terlalu sempit, nanti bisa jadi mikrostrip line, bukan radiator})$$

$$\textit{substrate} \rightarrow \textit{biasanya} \ \ 2{,}2 \le \varepsilon_r \le 12$$

Medan listrik tidak berhenti begitu saja pada tepi rongga mikrostrip, tetapi medan tersebut merambat hingga ketepi dan memanjang dan biasanya disebut *fringing field,* dimana medan listrik ini akan merambat sebagian besar didalam substrat dan sebagian kecil diudara. Peristiwa tersebut kita sebut ***fringing effect*** dan menyebabkan patch meradiasaikan gelombang elektromagnet

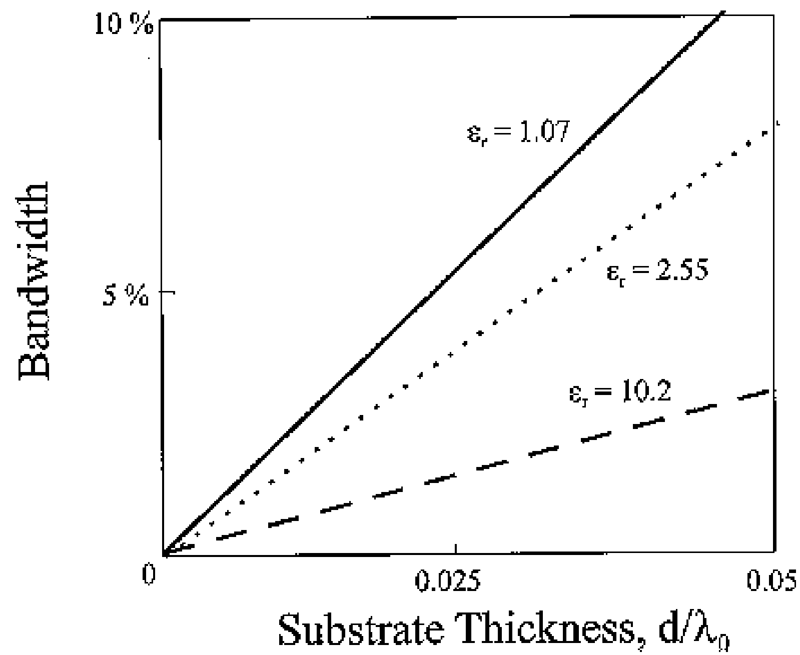
Karakteristik Antena Mikrostrip

Rectangular Patch : Directivity



$$D = \begin{cases} 6.6 = 8.2\,\text{dBi}, & W \ll \lambda_0 \\ 8W/\lambda_{0,} & W \gg \lambda_0 \end{cases}$$

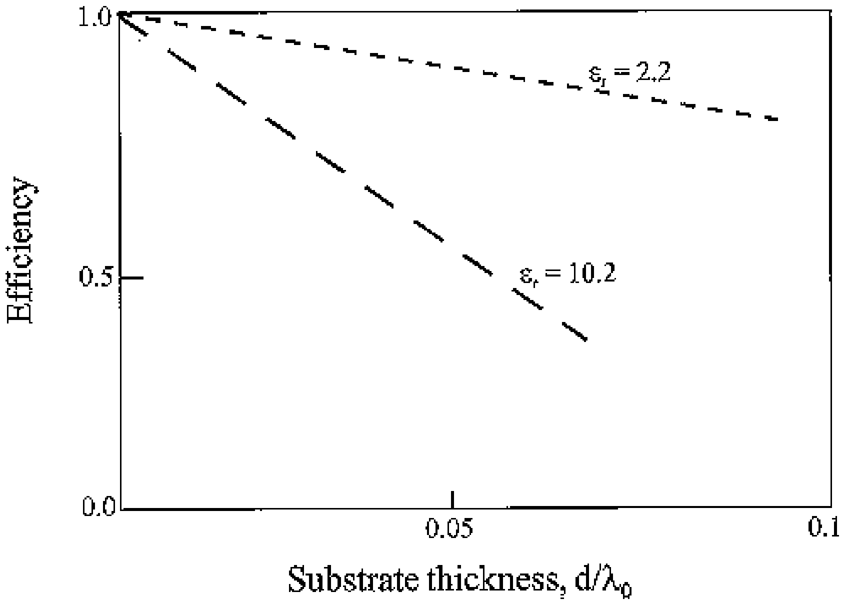
Rectangular Patch : Bandwidth



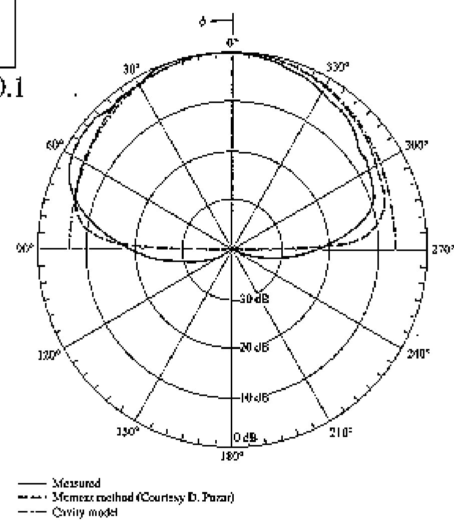
$$fraction\ BW = \frac{\Delta f}{f_0} \approx 3{,}77 \frac{\varepsilon_r - 1}{\varepsilon_r^{\,2}} \frac{Lh}{\lambda W}$$

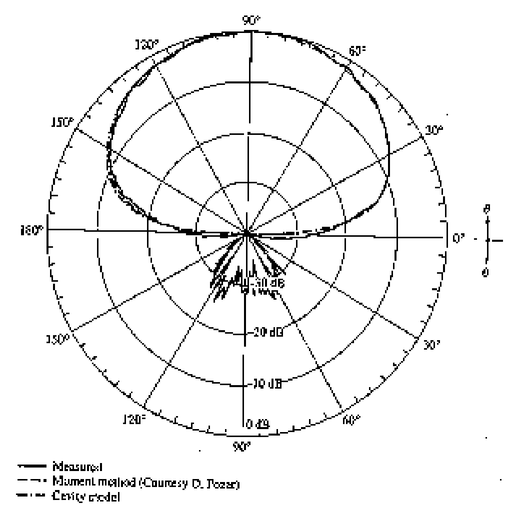
Karakteristik Antena Mikrostrip

Rectangular Patch : Efficiency



Rectangular Patch : Radiation Pattern





- **E-plane pattern**
- **H-plane pattern**

Surface Wave dan Efeknya

- One of the main disadvantages of printed antennas

➡ *excitation of surface waves*

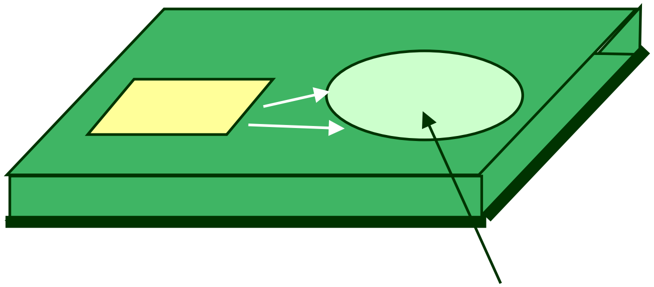
$$\eta_{sw} = \frac{P_{rad}}{P_{rad} + P_{sw}}$$

- Trends :

$\varepsilon_r \uparrow \Rightarrow \eta_{sw} \downarrow$

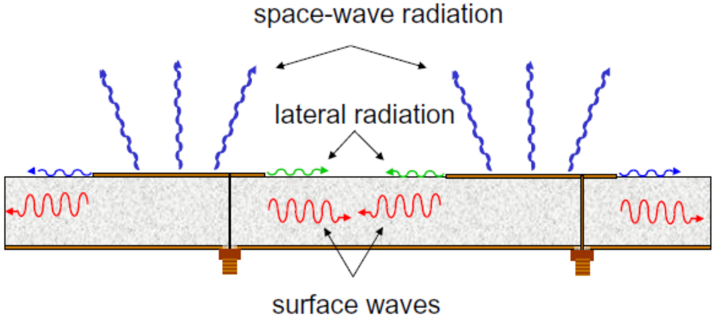
thickness $\uparrow \Rightarrow \eta_{sw} \downarrow$

Effect

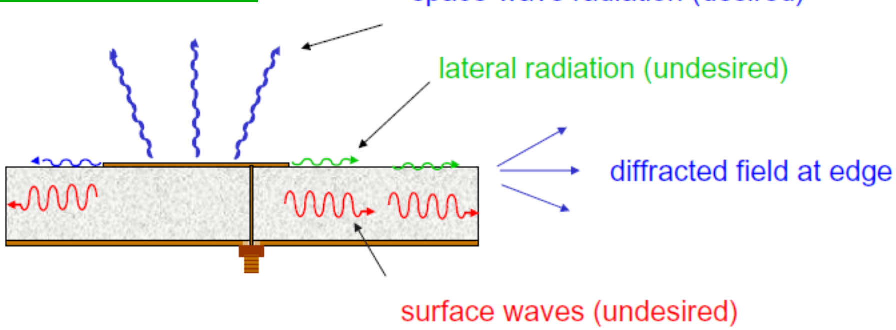


Interference

Active devices



Mutual coupling

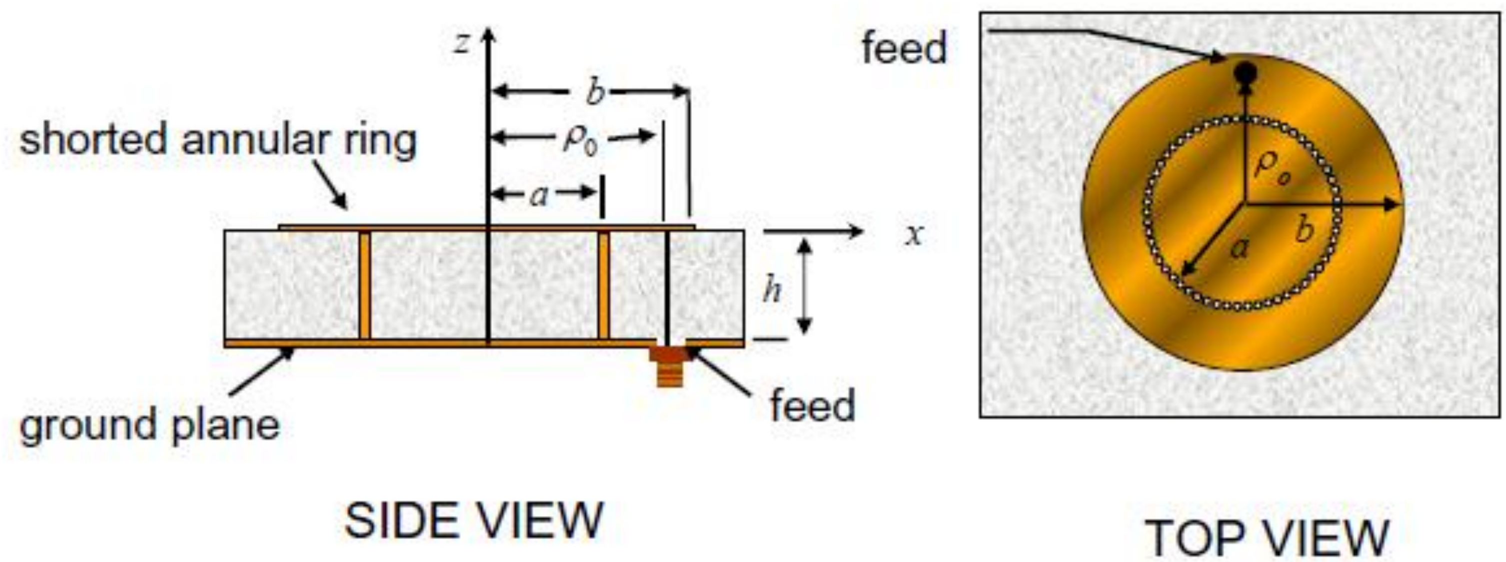


Diffraction at substrate edges (SLL, polarisation?)

Mengatasi Surface Wave

- **Surface-wave power is more important for thicker substrates or for higher substrate permittivities. (The surface-wave power can be minimized by using a foam substrate.)**
- **For a foam substrate, higher radiation efficiency is obtained by making the substrate thicker (minimizing the conductor and dielectric losses). The thicker the better!**
- **For a typical substrate such as $\varepsilon_r = 2.2$, the radiation efficiency is maximum for $h / \lambda_0 \approx 0.02$.**

Mengatasi Surface Wave



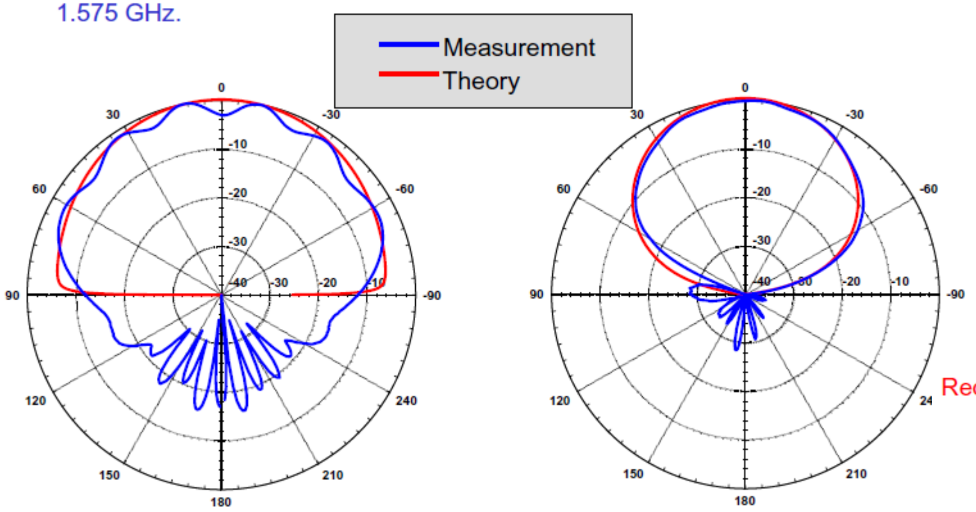
Reduced Surface Wave (RSW) Antenna

D. R. Jackson, J. T. Williams, A. K. Bhattacharyya, R. Smith, S. J. Buchheit, and S. A. Long, "*Microstrip Patch Designs that do Not Excite Surface Waves,*" IEEE Trans. Antennas Propagat., vol. 41, No 8, pp. 1026-1037, August 1993.

Mengatasi Surface Wave

RSW: E-plane Radiation Patterns

Measurements were taken on a 1 m diameter circular ground plane at 1.575 GHz.

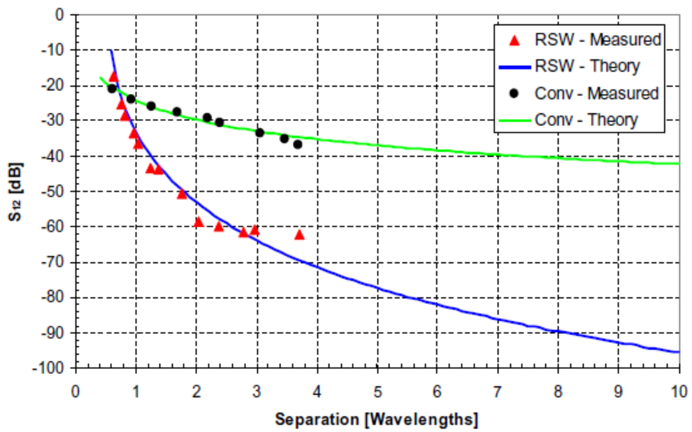


conventional

RSW

RSW: Mutual Coupling

Reducing surface-wave excitation and lateral radiation reduces mutual coupling.



"Mutual Coupling Between Reduced Surface-Wave Microstrip Antennas," M. A. Khayat, J. T. Williams, D. R. Jackson, and S. A. Long, IEEE Trans. Antennas and Propagation, Vol. 48, pp. 1581-1593, Oct. 2000.

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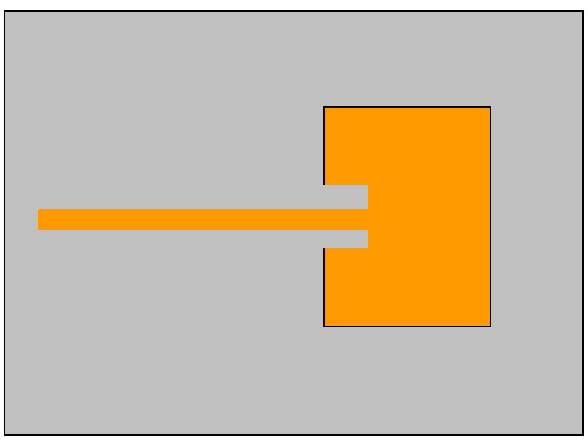
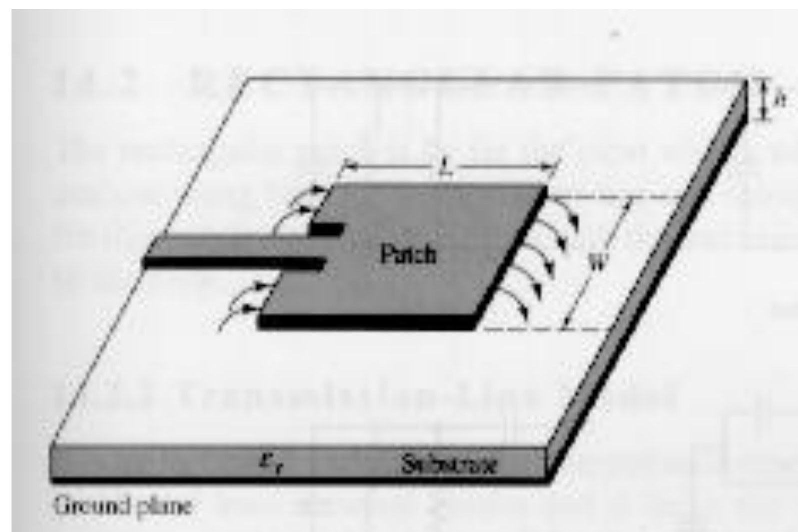
Microstrip line Feed

- **Advantage**
  - easy to fabricate
  - easy to match by controlling inset position
  - "easy" to model (approximately)
  - allows for planar feeding

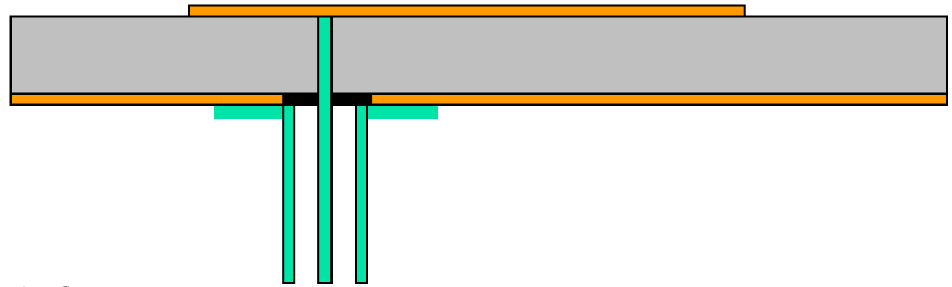
- **Disadvantage**
  - spurious feed-line radiation and surface-wave excitation
  - for deep notches, pattern may shown distortion.

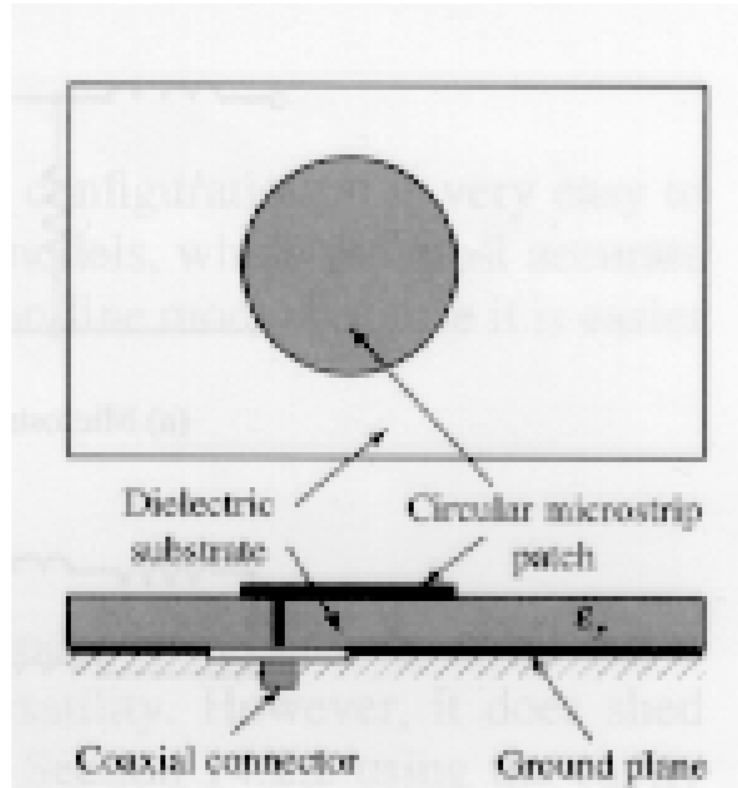




Probe Coaxial Feed

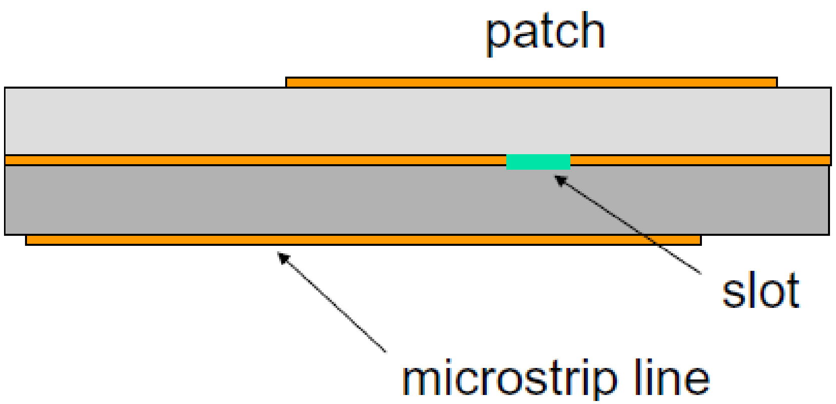
- **Advantage**
  - easy to fabricate
  - easy to match by controlling position
  - requires via hole
- **Disadvantage**
  - difficult to obtain input match for thicker substrates, due to probe inductance.
  - significant probe radiation for thicker substrates



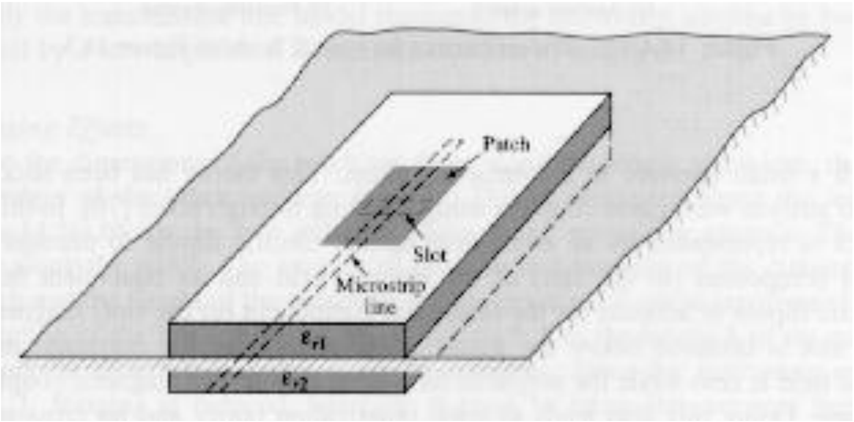


Aperture Coupled Patch Feed

- **Advantage**
  - can give broader bandwidth since probe inductance problem restriction is eliminated and a double-resonance can be created.
  - allows *independent optimisation* of feed substrate and antenna radiator
  - allows for planar feeding
  - feed radiation is isolated from patch radiation

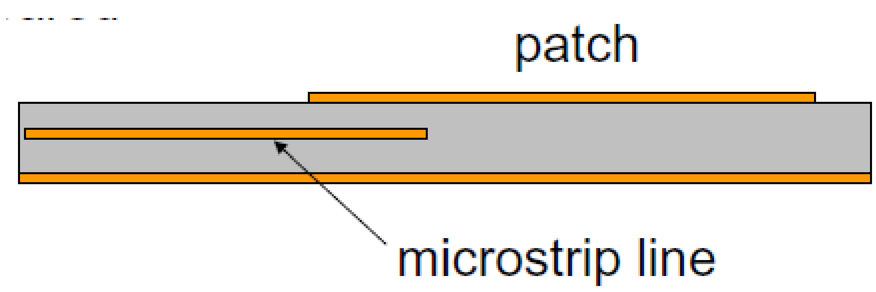


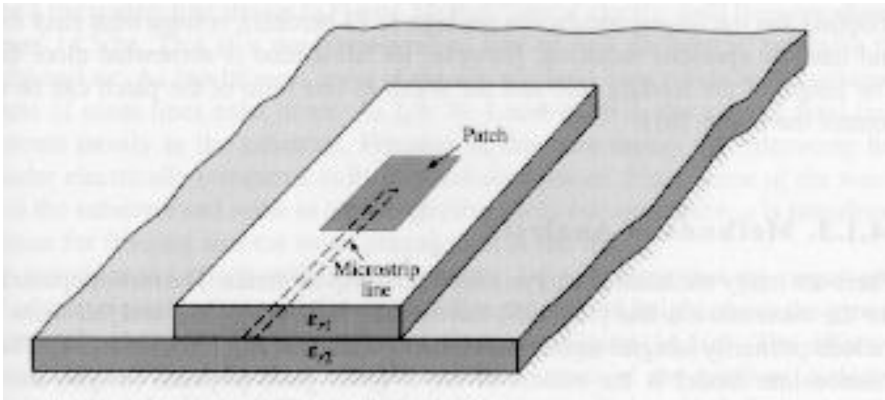
- **Disadvantage**
  - requires multilayer fabrication and more difficult to fabricate
  - alignment is important for input match
  - some spurious radiation due to slot



Proximity Coupled Patch Feed

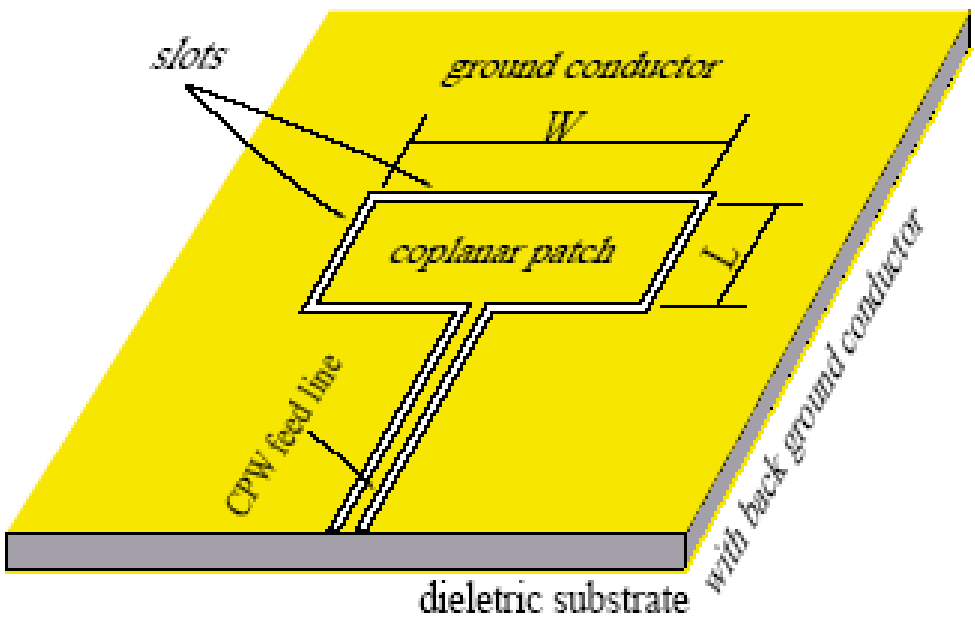
- **Advantage**
  - Can give broader bandwidth
  - low spurious radiation
  - more difficult to fabricate
- **Disadvantage**
  - requires multilayer fabrication
  - alignment is important for input match





Coplanar Patch Antenna

The coplanar waveguide, compared with the microstrip line, has advantages such as low radiation loss, less dispersion, uniplanar configuration



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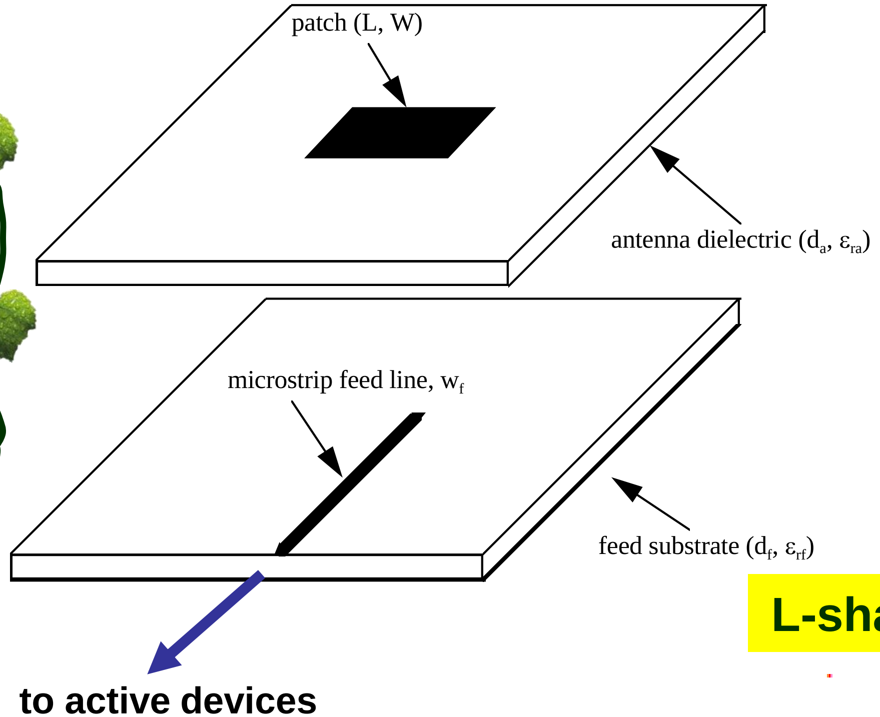
1) Pelebaran Bandwidth Mikrostrip

- **For a single layer geometry**
  - use low dielectric constant material such as *hard foam* ($\varepsilon_r = 1$)
  - use *thick substrate* ($h > 0.05\lambda_0$)
- **Non-contact feed techniques**
  - Proxy-coupled patches
- **Achieve a dual resonance:**
  - with aperture coupled patches
  - with stacked patches
- **Use parasitic coupled patches (horizontally)**

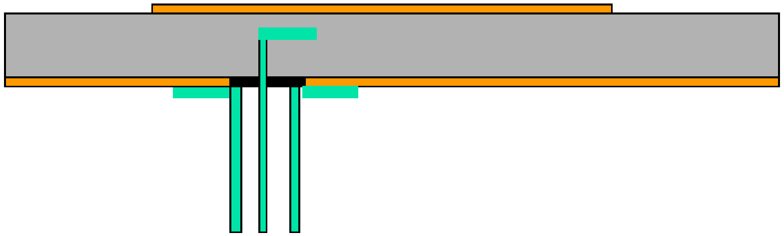
1) Pelebaran Bandwidth Mikrostrip

Proximity Coupled Patch



Disadvantage: **more difficult to construct (alignment of layers important), surface wave losses higher, therefore less gain**

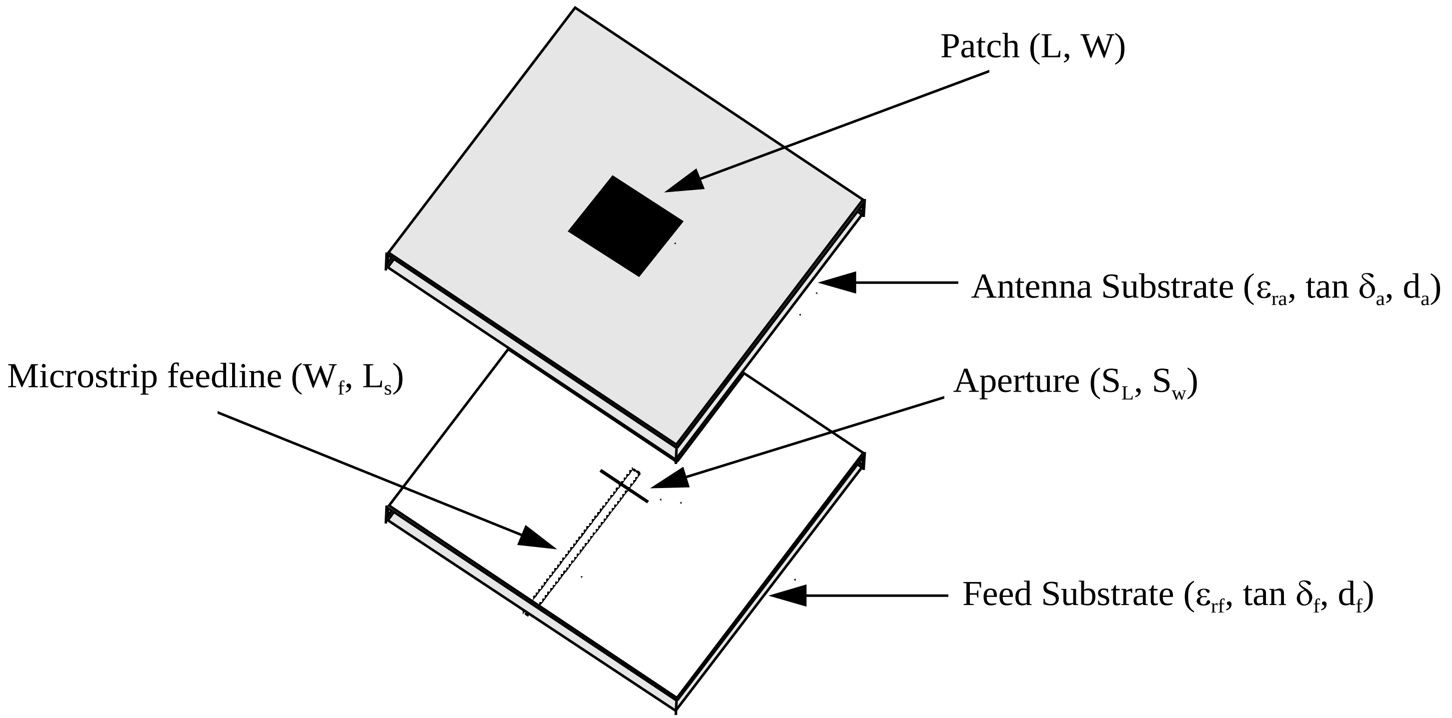
L-shaped Probe



BW_{10dB} = 10 %

1) Pelebaran Bandwidth Mikrostrip

Aperture Coupled Patch



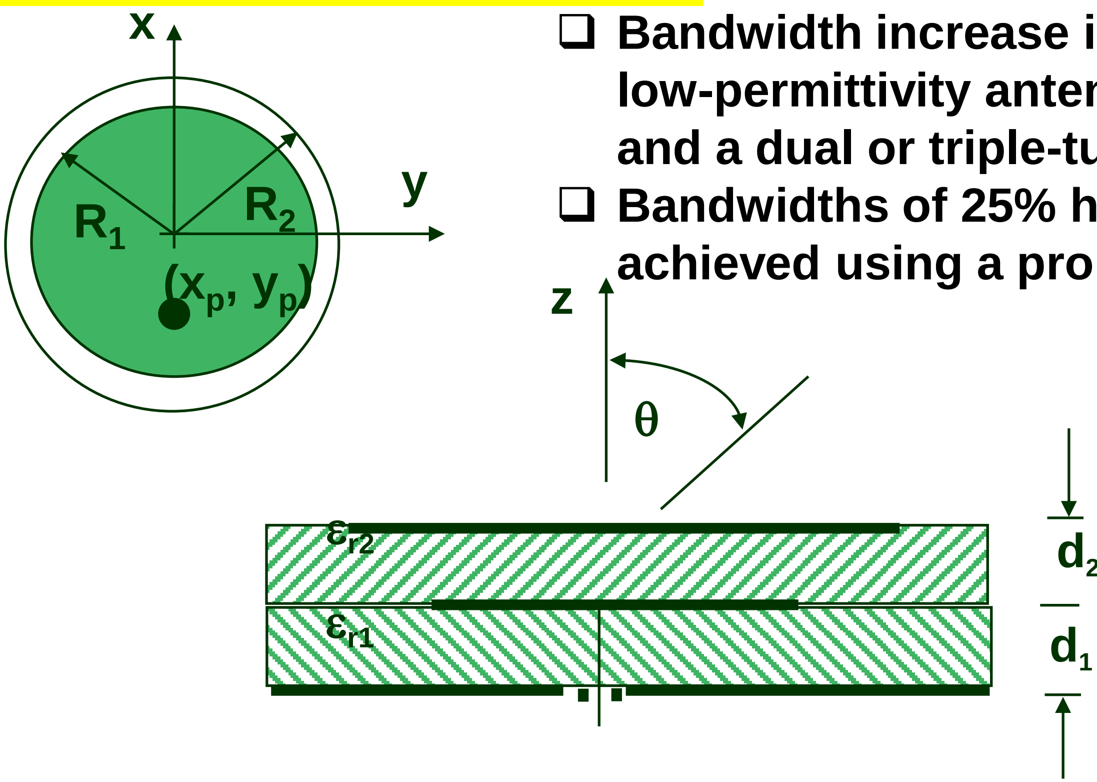
Advantages: **high bandwidth, polarisation purity**

Disadvantages: **F/B ratio, construction**

Analysis: **full-wave spectral-domain integral equation**

1) Pelebaran Bandwidth Mikrostrip

Probe-fed/ACP Stacked Patch



- Bandwidth increase is due to thick low-permittivity antenna substrates and a dual or triple-tuned resonance.
- Bandwidths of 25% have been achieved using a probe feed.

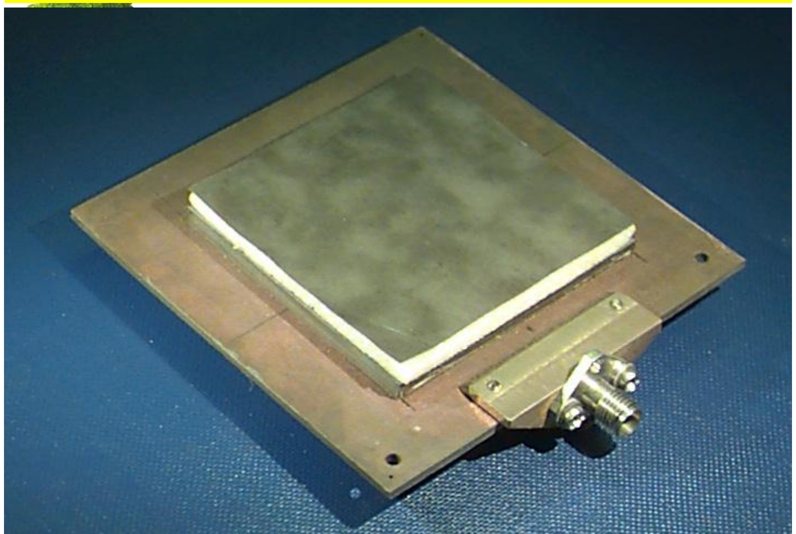
Advantages: robust, ease of construction, good isolation between feed network and antenna element

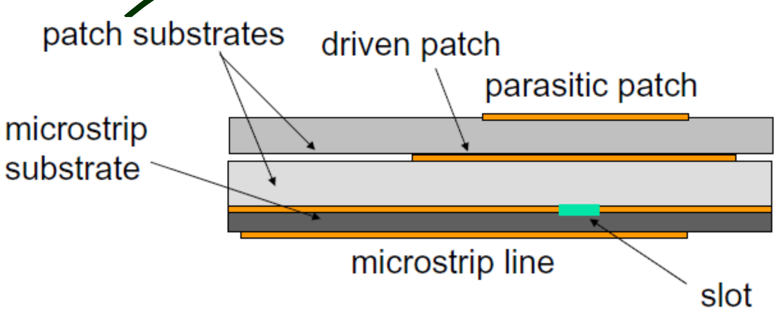
Disadvantages: cross-polarisation levels, difficult to design

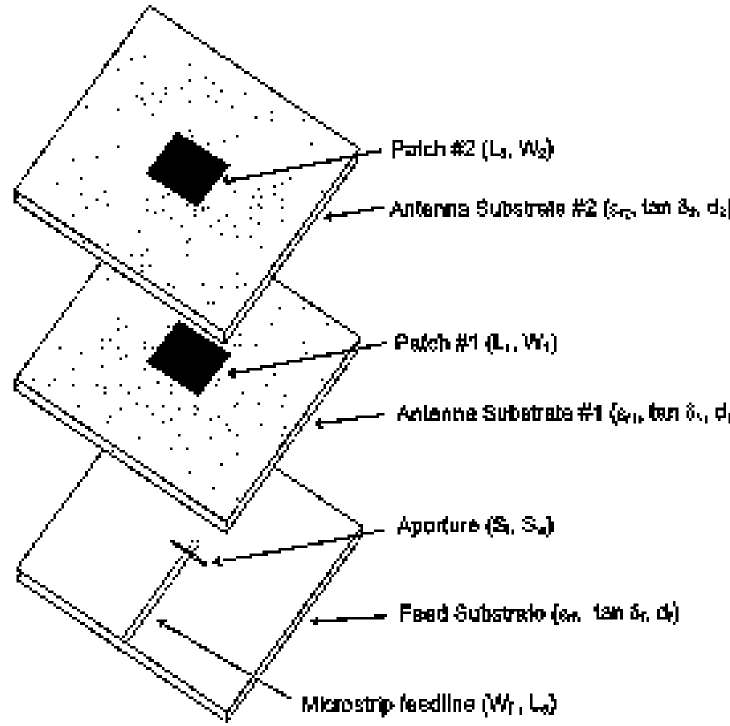
Analysis: full-wave spectral domain with attachment mode

1) Pelebaran Bandwidth Mikrostrip

Aperture Coupled stacked Patch







Bandwidths of 100% have been achieved using an ACP (Aperture Coupled Patch) feed.

Advantages: bandwidth, polarisation purity, better F/B

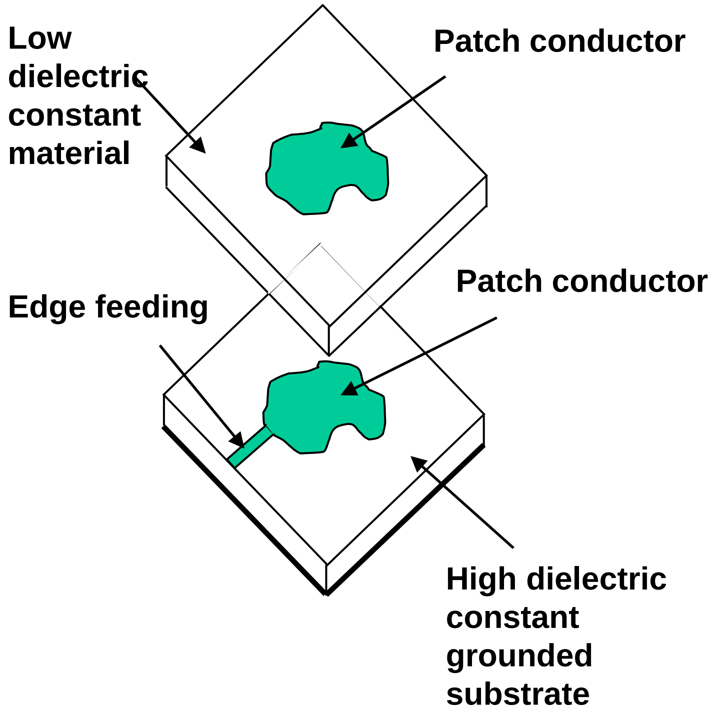
Disadvantages: construction

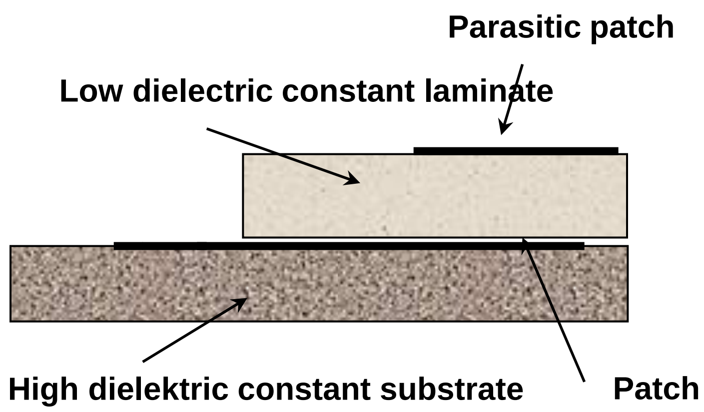
Analysis: full-wave spectral-domain integral equation

1) Pelebaran Bandwidth Mikrostrip

Hi-Lo Stacked Patch

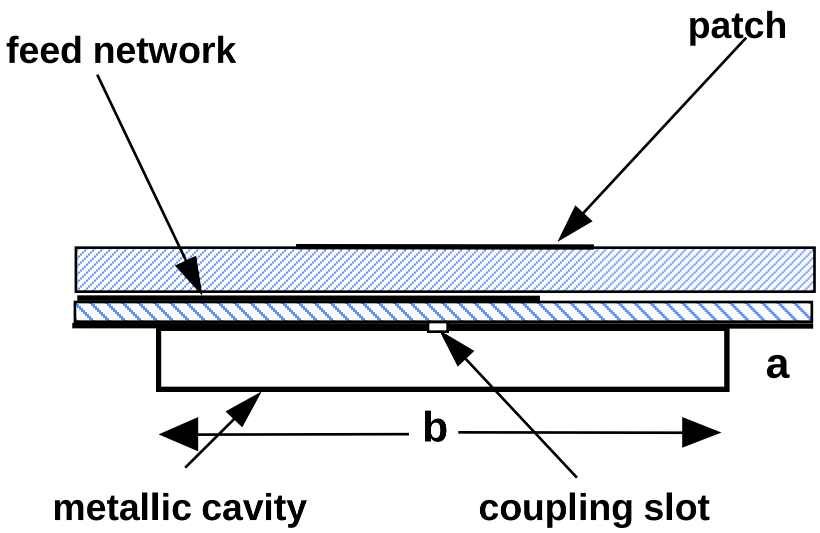
- Combination of high and low dielectric constant substrates
- Arbitrary shaped edge-fed patch on high ε_r (e.g. ε_r >10) substrate
- Parasitic patch stacked on low ε_r (ε_r =1.07) substrate





1) Pelebaran Bandwidth Mikrostrip

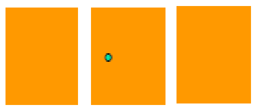
Cavity-Backed Aperture Coupled Patch



- **Advantages:** high bandwidth, polarisation purity, no backward slot radiation
- **Disadvantages:** construction
- **Analysis:** full-wave spectral domain integral equation

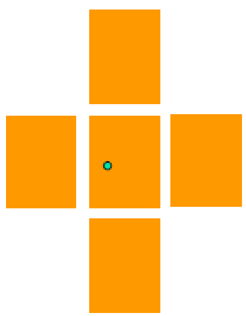
1) Pelebaran Bandwidth Mikrostrip

Parasitic Gap Coupled Patch

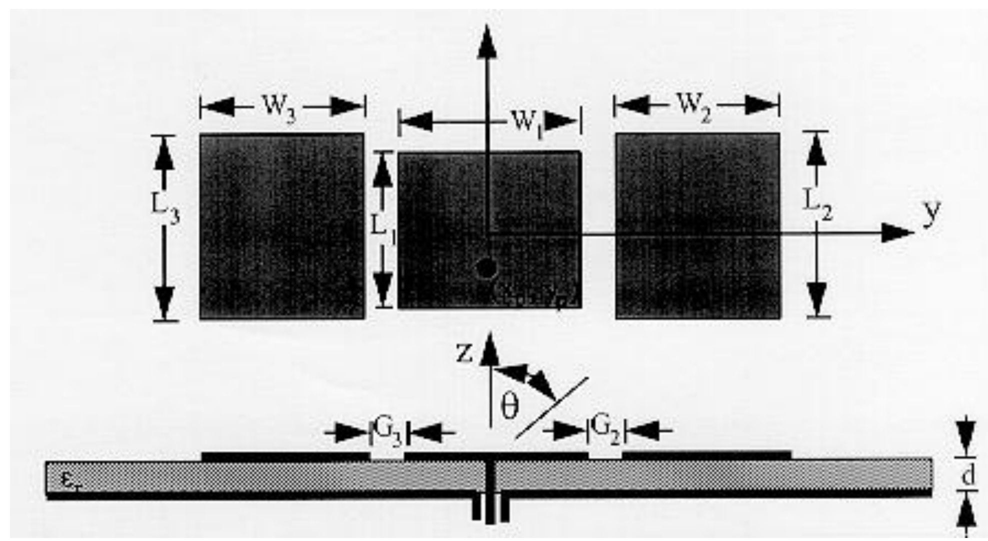


Radiating Edges Gap Coupled Microstrip Antennas (REGCOMA).

Non-Radiating Edges Gap Coupled Microstrip Antennas (NEGCOMA)

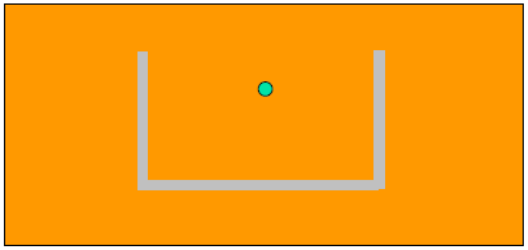


Four-Edges Gap Coupled Microstrip Antennas (FEGCOMA)



1) Pelebaran Bandwidth Mikrostrip

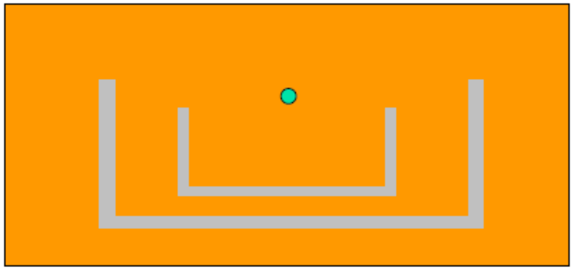
U-shaped slot Patch



The introduction of a U-shaped slot can give a significant bandwidth (10%-40%).

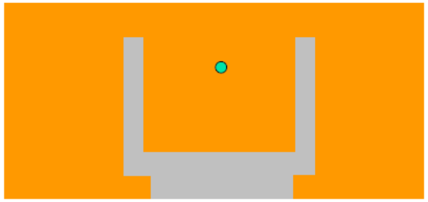
(This is partly due to a double resonance effect.)

"Single Layer Single Patch Wideband Microstrip Antenna," T. Huynh and K. F. Lee, Electronics Letters, Vol. 31, No. 16, pp. 1310-1312, 1986.



A 44% bandwidth was achieved.

"Double U-Slot Rectangular Patch Antenna," Y. X. Guo, K. M. Luk, and Y. L. Chow, Electronics Letters, Vol. 34, No. 19, pp. 1805-1806, 1998.



A modification of the U-slot patch.

A bandwidth of 34% was achieved (40% using a capacitive "washer" to compensate for the probe inductance).

"A Novel E-shaped Broadband Microstrip Patch Antenna," B. L. Ooi and Q. Shen, Microwave and Optical Technology Letters, Vol. 27, No. 5, pp. 348-352, 2000.

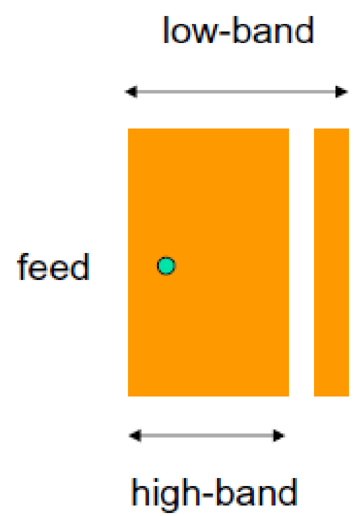
2) Multi Band Antenna

General Principle:

Introduce multiple resonance paths into the antenna. (The same technique can be used to increase bandwidth via multiple resonances, if the resonances are closely spaced)

A multi-band antenna is often more desirable than a broad-band antenna, if multiple narrow-band channels are to be covered.

Dual-Band E patch



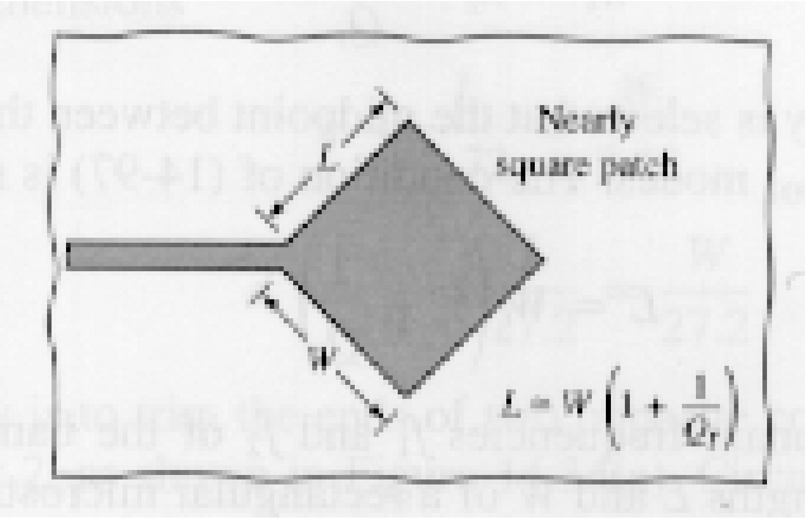
Dual-Band Patch with Parasitic Strip

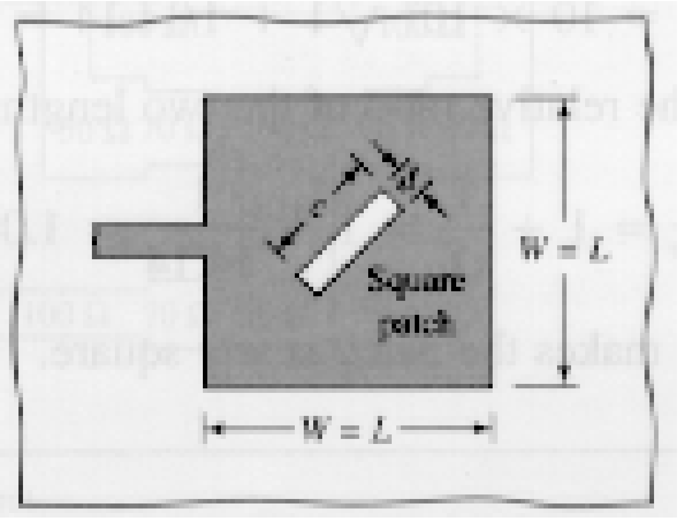
3) Circular Polarization Microstrip

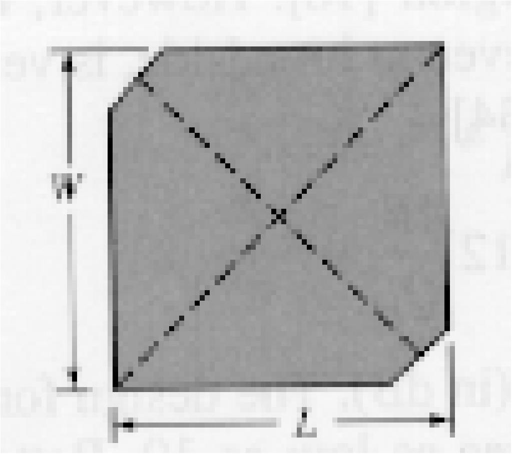
- **CP can be achieved using various feed arrangements and/or slight modifications to the elements**
- **CP is obtained when 2 orthogonal but otherwise identical modes are excited with a 90^o phase difference between them.**
- **Techniques include**
  - ***single feed***
    - simplest, narrowest bandwidth CP (less than impedance BW)
  - ***dual feed***
    - requires additional phasing in feed network, broader bandwidth
  - ***synchronous subarray***
    - most complicated geometry, best performance

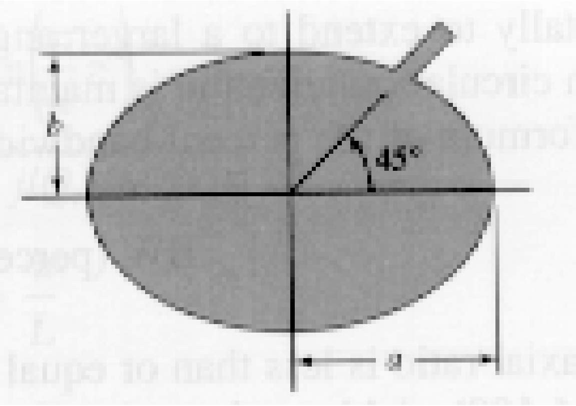
3) Circular Polarization Microstrip

Single Feed Arrangements for CP



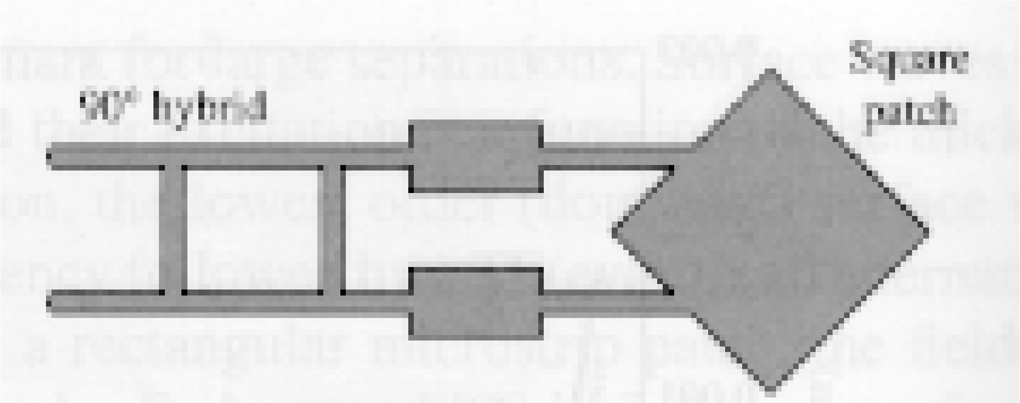


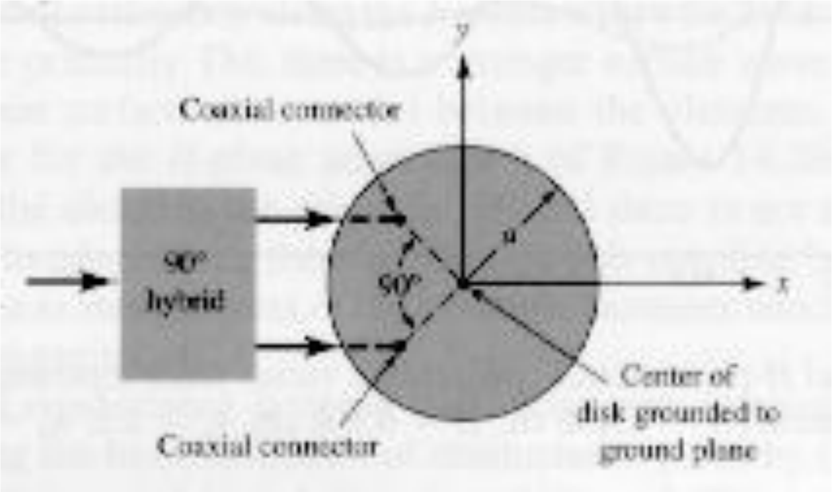




3) Circular Polarization Microstrip

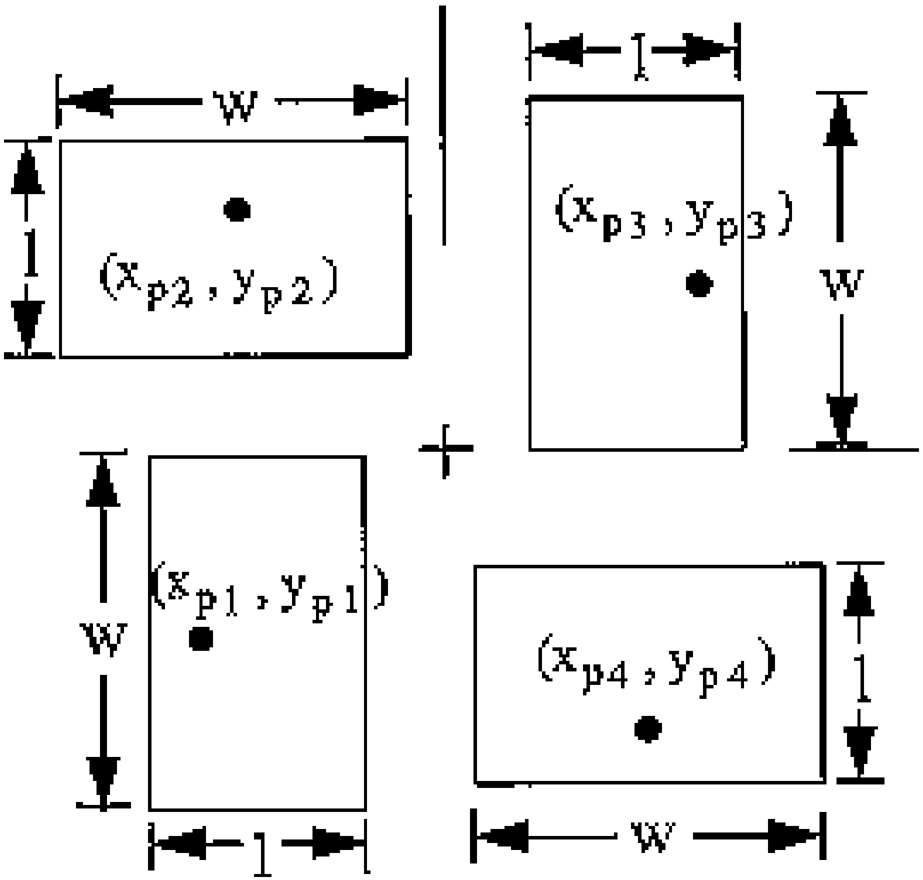
Dual Feed Arrangements for CP





3) Circular Polarization Microstrip

Synchronous Subarray Technique for CP

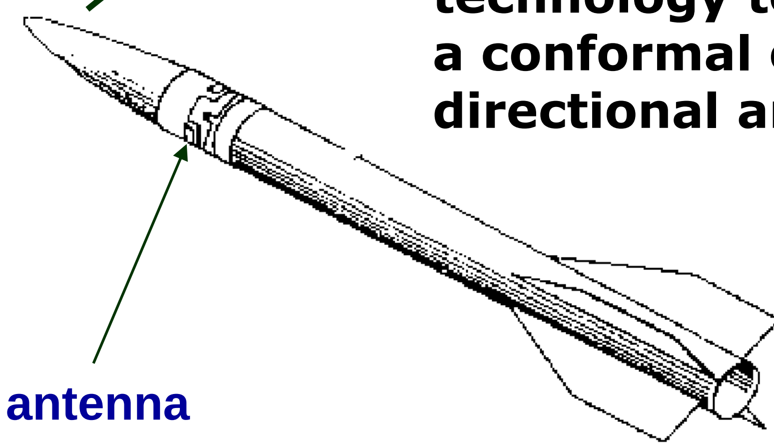


1) 0º
2) -90º
3) -180º
4) -270º

4) Omnidirectional Radiation Microstrip

- **Resonant frequency set by the size of the patch (length).**
- **Bandwidth - thickness of material, ε_r and here the feed-network!**
- **Number of elements in array set by the radius of cylinder.**

Use the advantages of printed-antenna technology to produce a conformal omni-directional antenna.

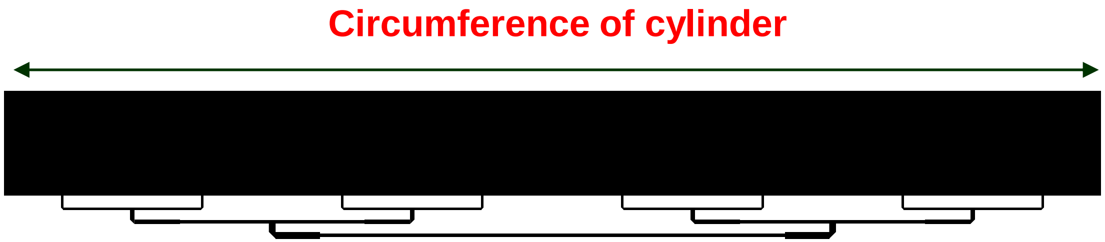


Telemetri Antenna

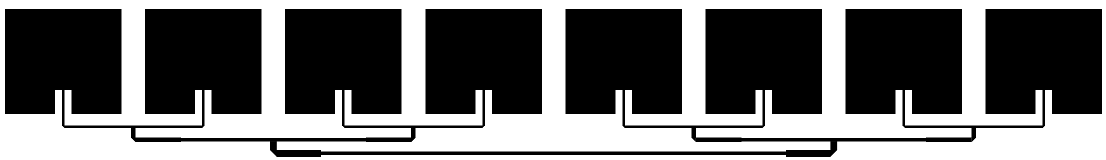
4) Omnidirectional Radiation Microstrip

Teknik yang digunakan

“Wrap-around”



Alternative



Use of discrete elements allows for input impedance to be nominally independent of number of feed points.

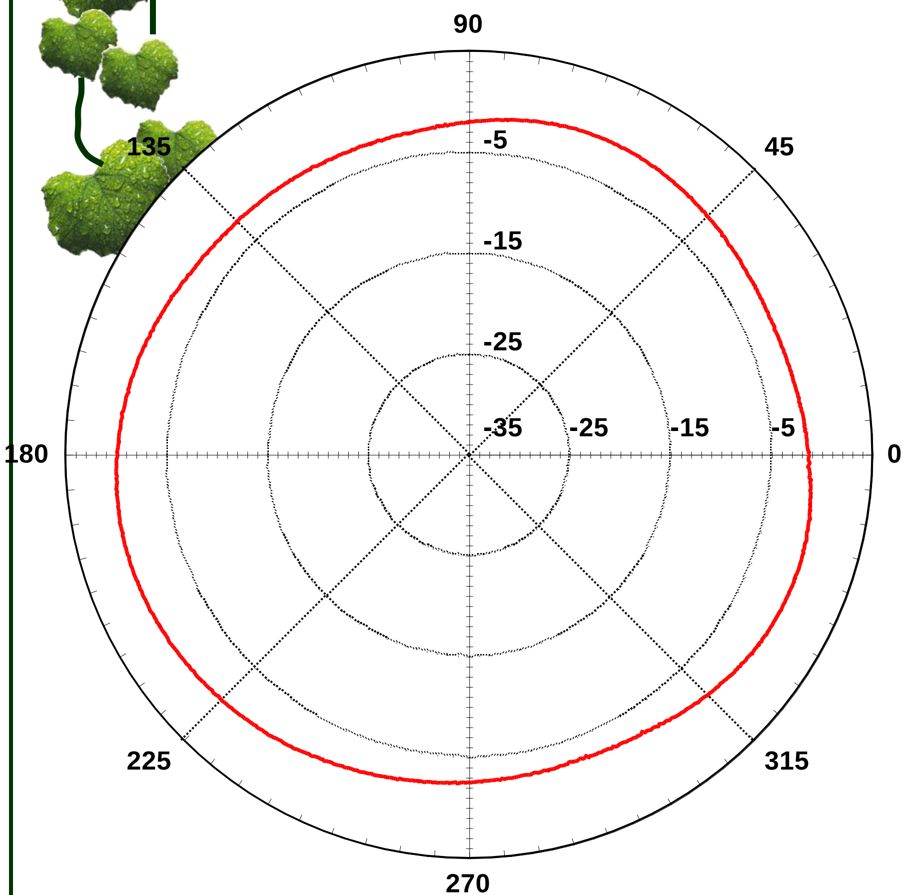
Patch width can be adjusted to control input impedance of each patch.

Use of inset patches allows another degree of freedom in controlling input impedance.

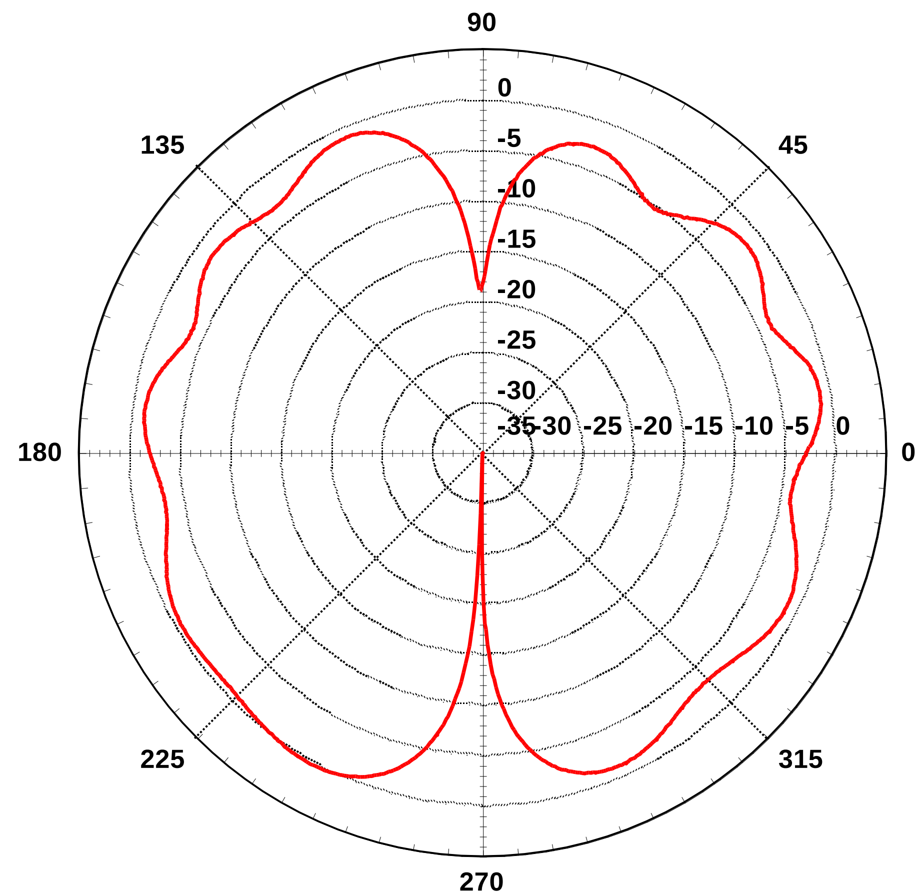
Capable of producing an omnidirectional radiation pattern in the azimuth plane.

4) Omnidirectional Radiation Microstrip

Pola Radiasi



Axial-plane

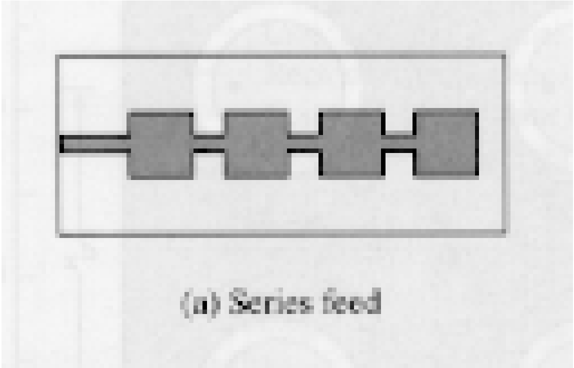


Azimuth-plane

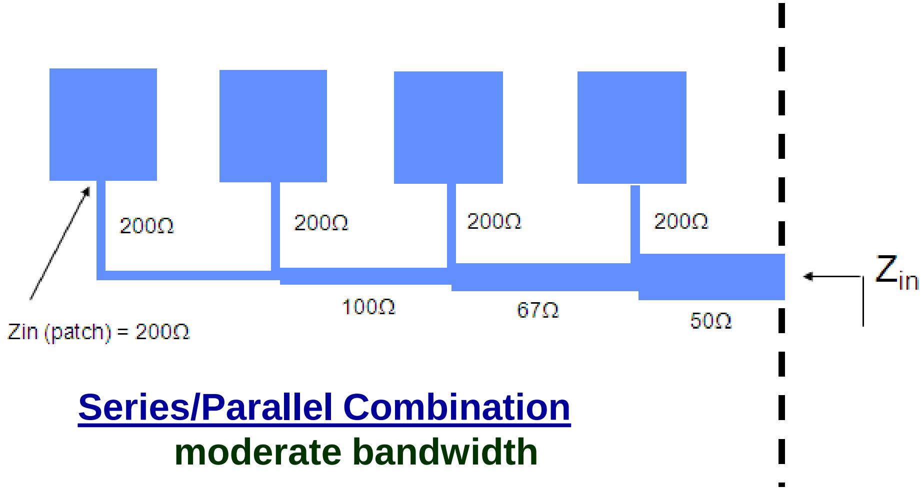
5) Array Microstrip

Types of feed of arrays:

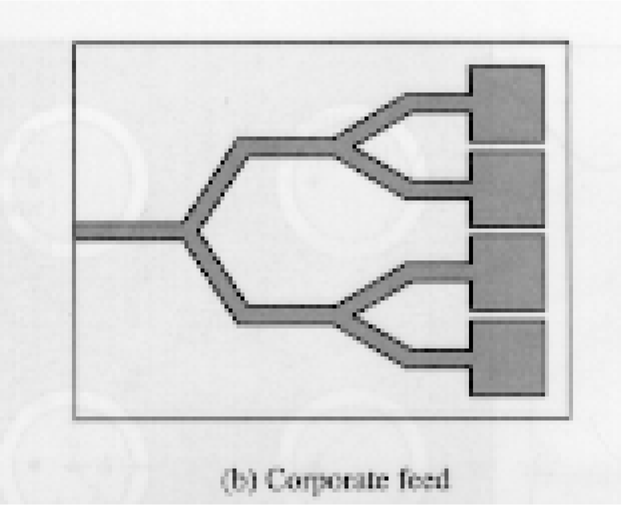
(1) Series Fed
(2) Parallel Fed (or Corporate feed)
(3) Combination



Series Fed
advantage: minimum antenna real estate
disadvantage: narrow bandwidth (~1/10 of the impedance bandwidth of the patch!)

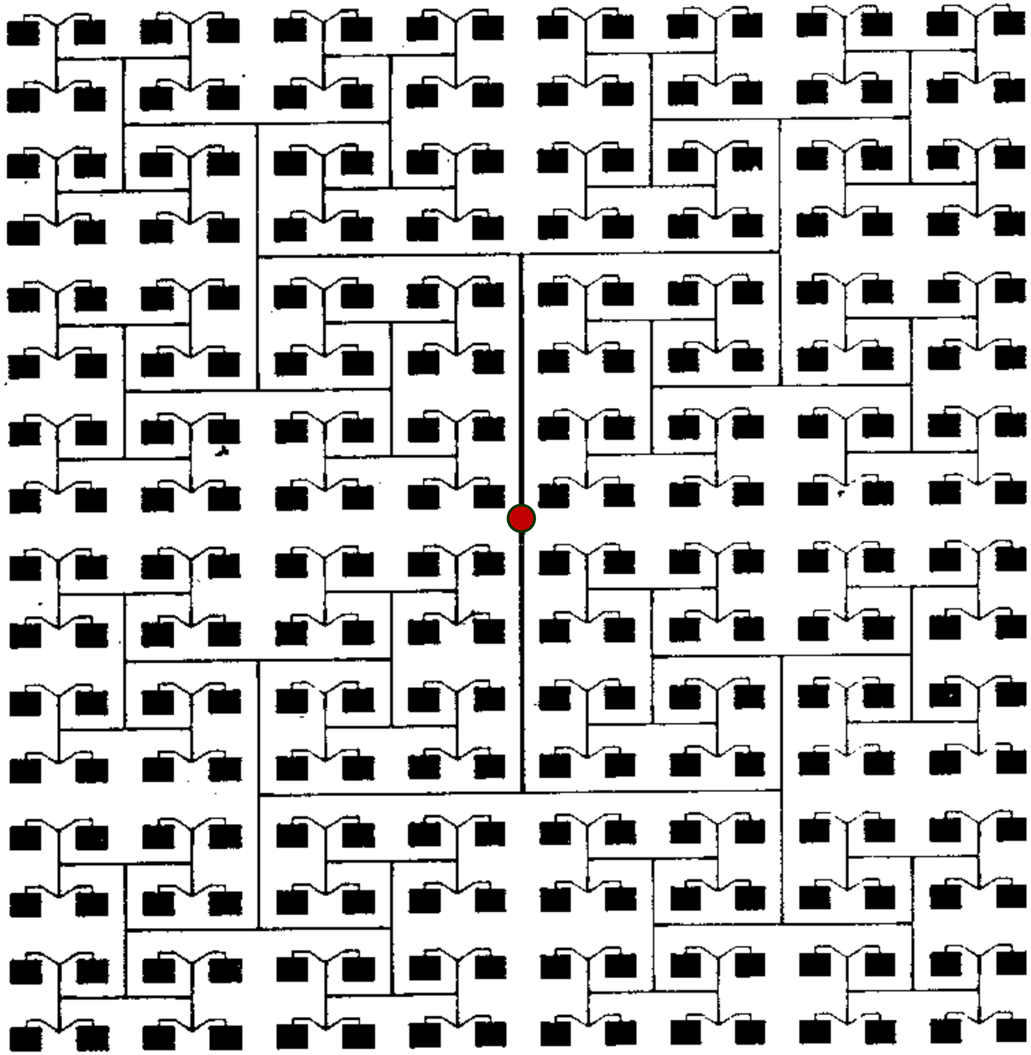


Series/Parallel Combination
moderate bandwidth



Parallel Fed
advantage: good bandwidth & phase control
disadvantage: feed loss

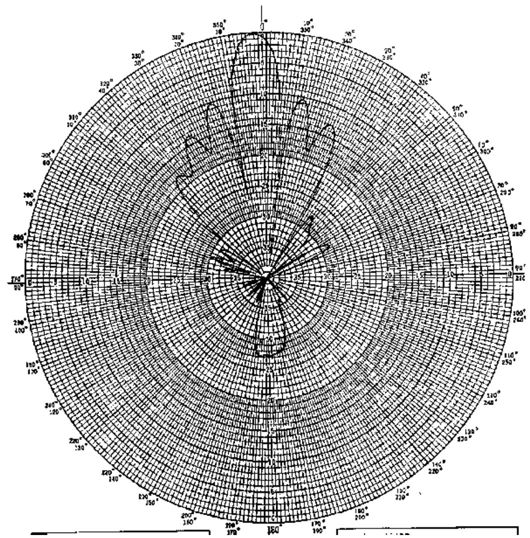
Contoh Patch Array



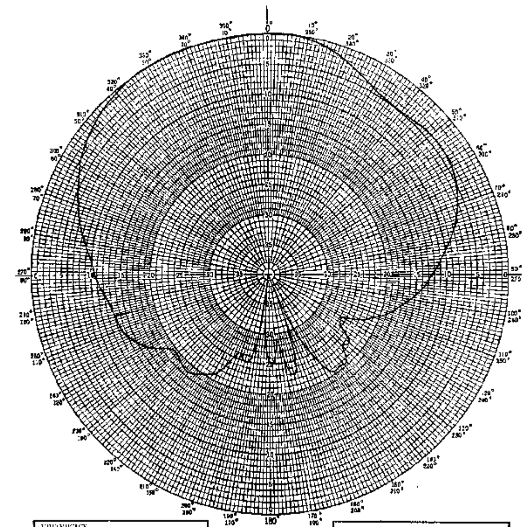
16 x 16 Planar Patch Array

Contoh Pola Radiasi Array Patch Antenna

8 element H-plane linear array

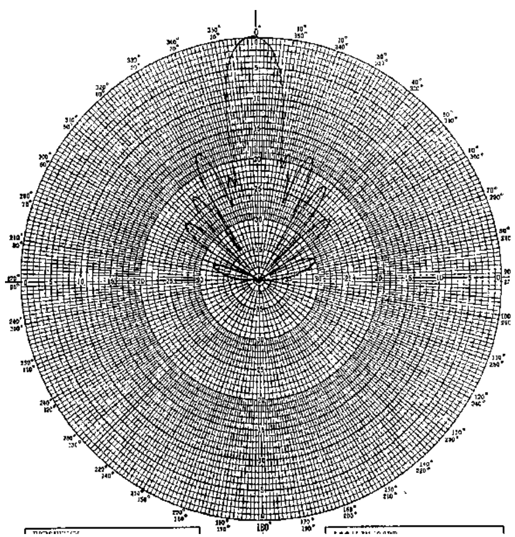


H-plane

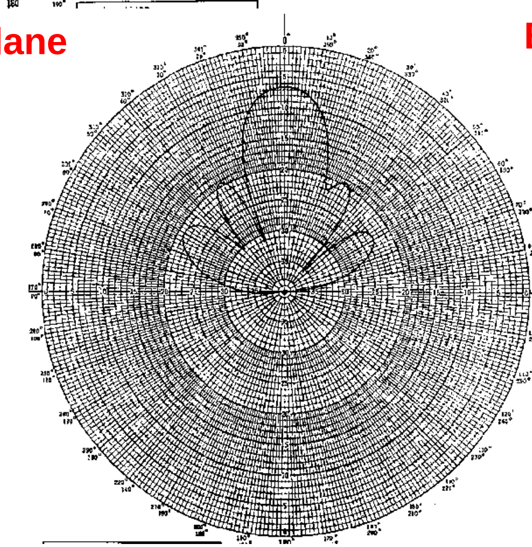


E-plane

4 x 8 element planar array



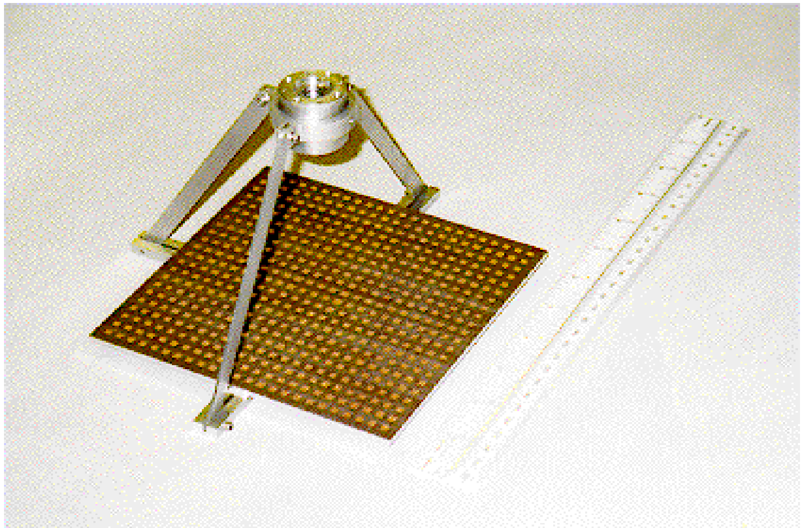
H-plane



E-plane

Advance Microstrip Array

Reflectarray



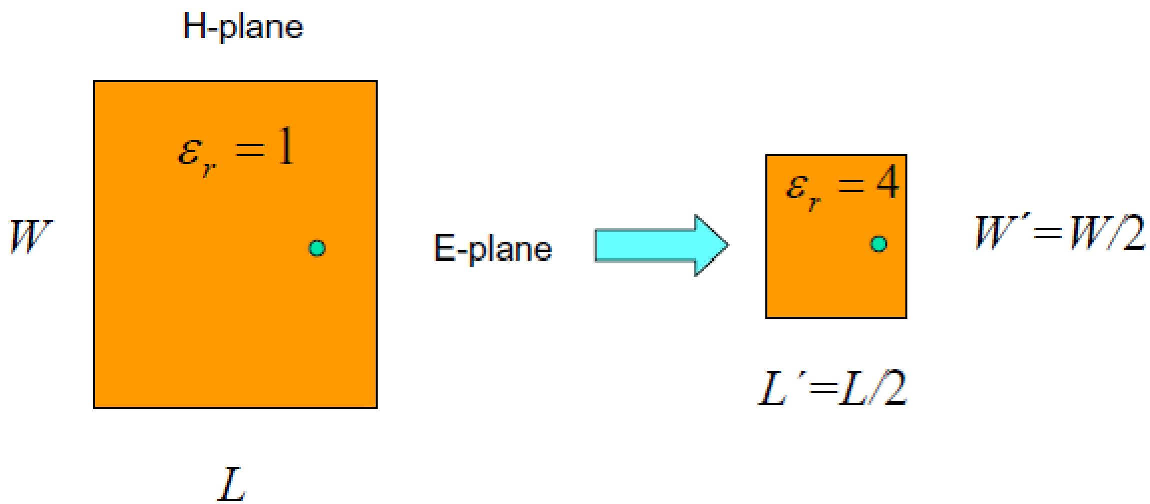
Lens-coupled printed antennas

Miniaturization patch Antenna

- **Note:** miniaturization usually comes at a price of reduced bandwidth.
- **General rule:** maximum obtainable bandwidth is proportional to the volume of the patch (based on the Chu limit)
- **Technique :**
  - High Permittivity
  - Quarter-Wave Patch
  - PIFA
  - Capacitive Loading
  - Slots
  - Meandering

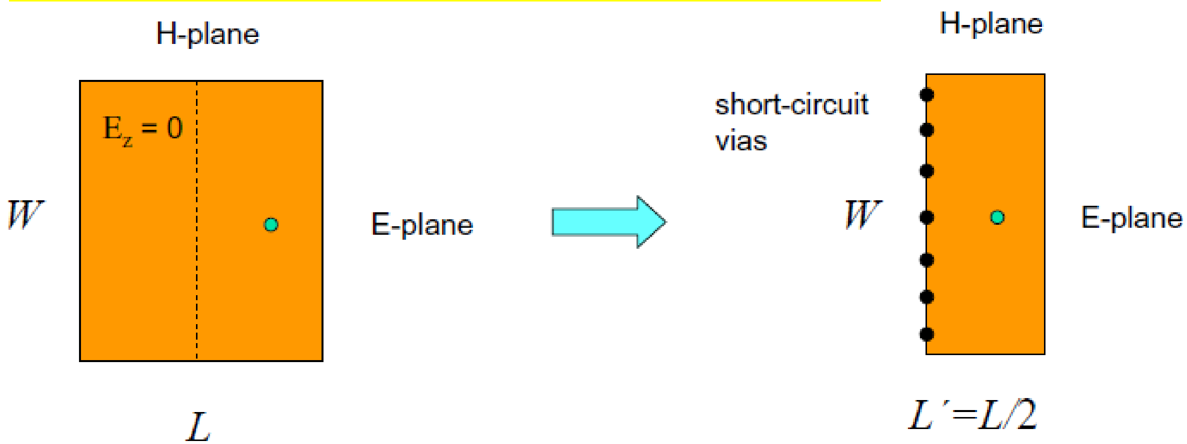
Miniaturization patch Antenna

Miniaturization: High Permittivity



It has about **one-fourth** the bandwidth of the regular patch (Bandwidth is inversely proportional to the permittivity)

Miniaturization: Quarter-Wave Patch

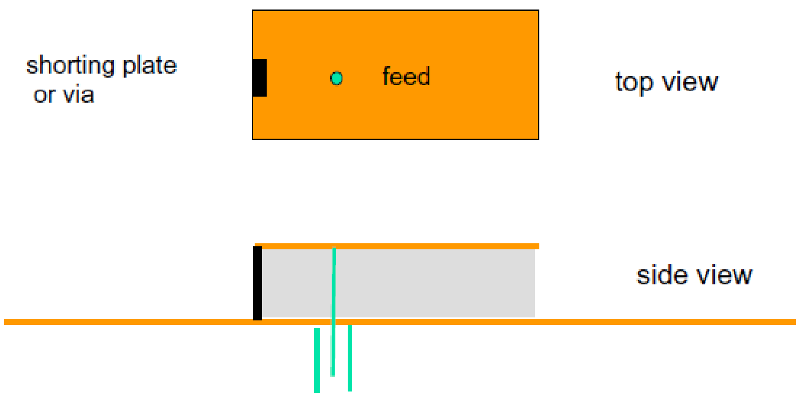


It has about **one-half** the bandwidth of the regular patch.

Miniaturization patch Antenna

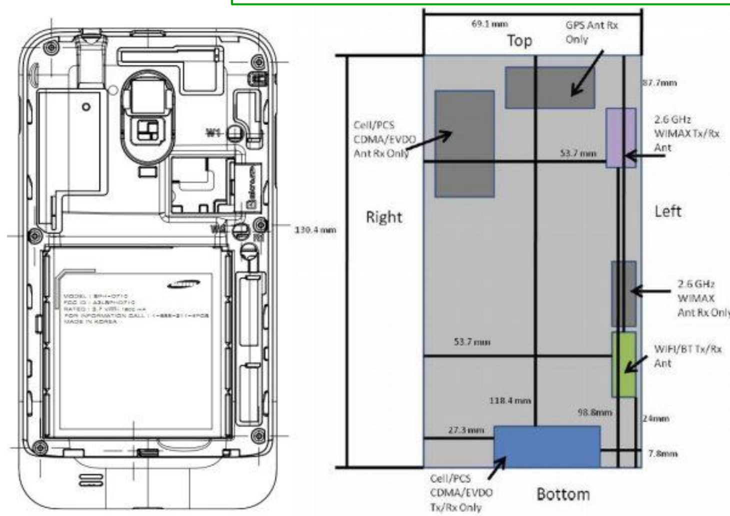
Miniaturization: Planar Inverted F Antenna (PIFA)

$$L < \lambda_d / 4$$

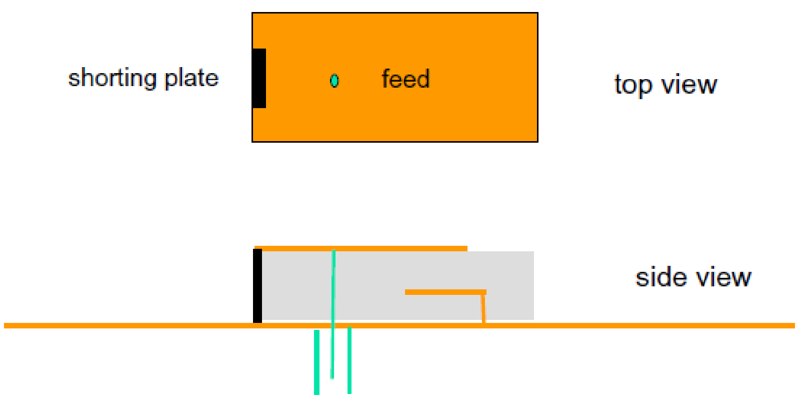


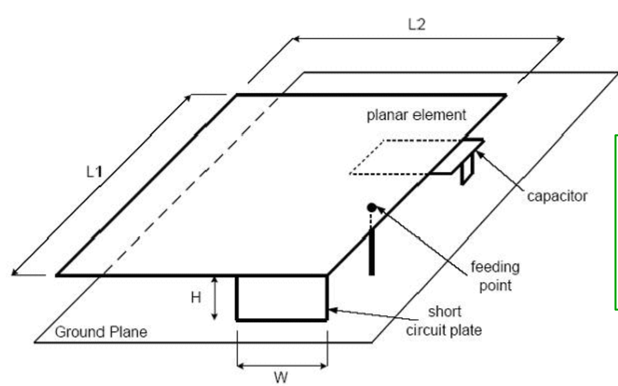
A single shorting plate or via is used.

The antenna types and locations on the Samsung Galaxy S.



Miniaturization: Planar Inverted F Antenna (PIFA) with Capasitive Loading

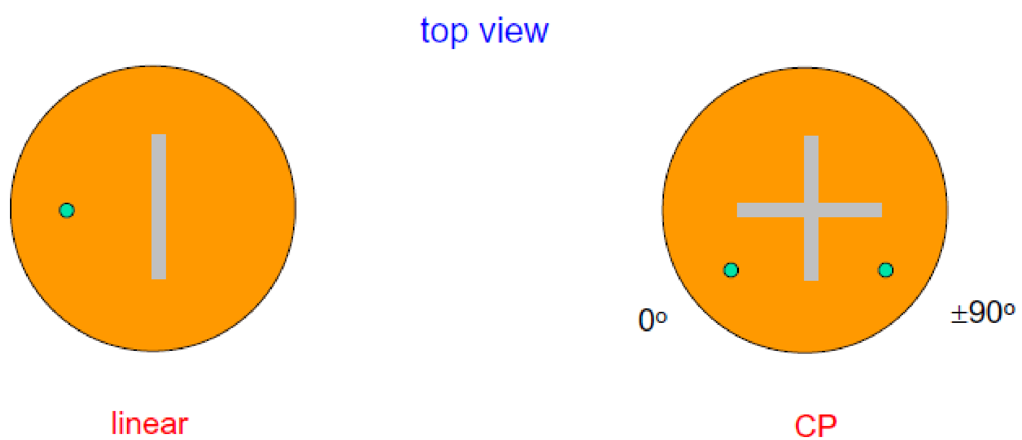




The capacitive loading allows for the length of the PIFA to be reduced.

Miniaturization patch Antenna

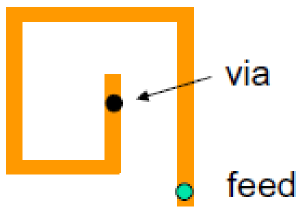
Miniaturization: Slotted Patch



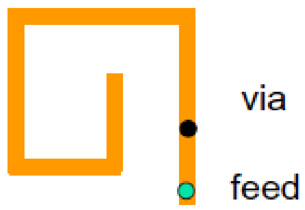
The slot forces the current to flow through a longer path, increasing the effective dimensions of the patch.

Miniaturization: Meandering

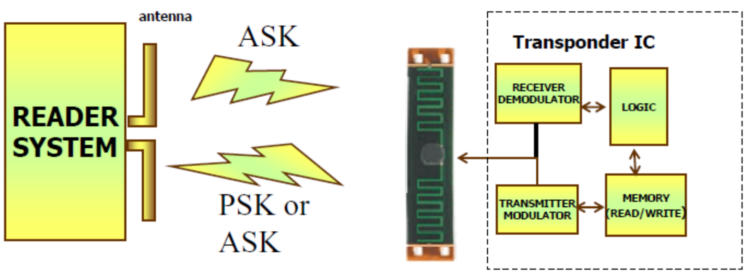
Meandering forces the current to flow through a longer path, increasing the effective dimensions of the patch.



meandered quarter-wave patch



meandered PIFA



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2 Prinsip Kerja Antena dan Karakteristik Mikrostrip
3 Metoda Pencatuan Antena Mikrostrip
5 Peningkatan Performansi Antena Mikrostrip
4 Arah Penelitian Terkini
6 Contoh Prosedur Design Antena Mikrostrip

Recent and Future Potential Development

- New Material and Metamaterial
- RFID antennas
- MIMO Application
- Wearable Antennas
- Reflectarray and Phased-arrays
- UWB antennas
- Reconfigurable and multifunction antenna
- Wideband and Multiband antennas
- Miniaturisation Techniques (nano antennas)
- medical applications
- Active and Integrated antennas

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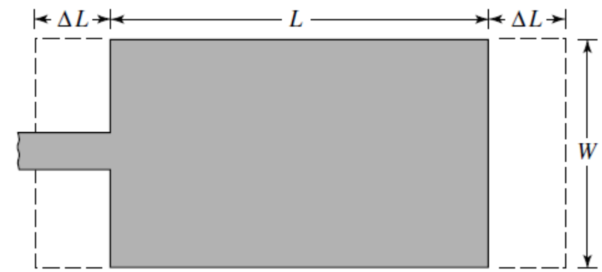
Contoh Procedure Design

Dimensi Rectangular patch Antenna Transmission Line Model Formulation



Desain Untuk Mode Dominan

1. menghitung lebar patch **W**

$$W = \frac{c}{2 f_r}\left(\frac{\varepsilon_r + 1}{2}\right)^{-\frac{1}{2}}$$

2. menghitung konstanta dielektrik efektif **ε_{eff}**

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + \frac{12h}{W}\right]^{-\frac{1}{2}}$$

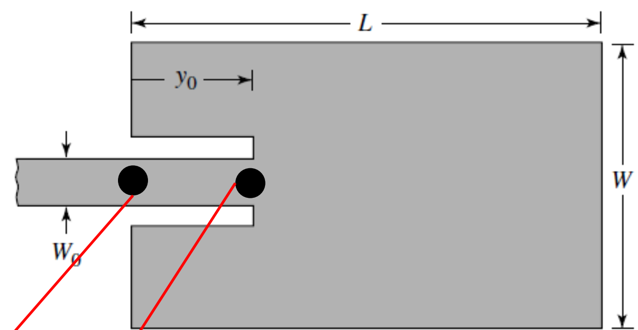
3. Menghitung panjang extention patch **ΔL**

$$\Delta\ell = 0.412h\left(\frac{\varepsilon_{eff} + 0.3}{\varepsilon_{eff} - 0.258}\right)\left(\frac{\frac{W}{h} + 0.264}{\frac{W}{h} + 0.8}\right)$$

4. Menghitung panjang patch **L**

$$L = \frac{c}{2 f_r \sqrt{\varepsilon_{eff}}} - 2\Delta\ell$$

Impedansi Input Rectangular patch Antenna



$$Z_{in} = R_{in} = \frac{1}{2(G_1 \pm G_{12})}$$

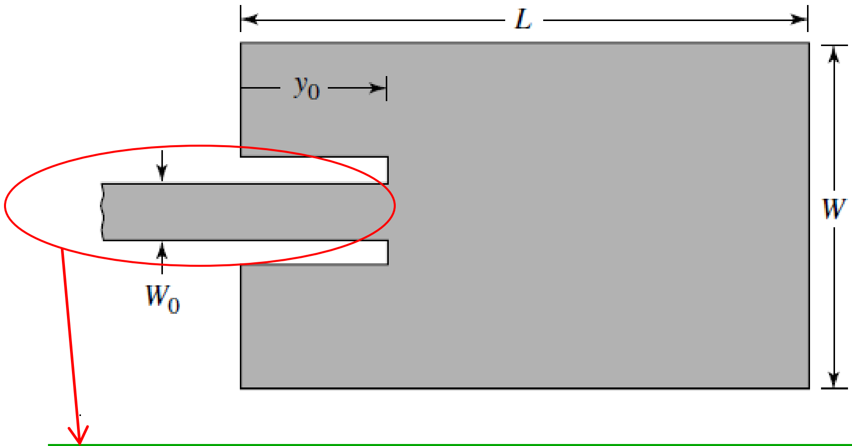
$$G_1 = \begin{cases} \frac{1}{90}\left(\frac{W}{\lambda_0}\right)^2 & W << \lambda_0 \\ \frac{1}{120}\left(\frac{W}{\lambda_0}\right) & W >> \lambda_0 \end{cases}$$

$$Z_{in}(y = y_0) = Z_{in}(y = 0)\cos^2\left(\frac{\pi}{L} y_0\right)$$

$$G_{12} = mutual\ Conducrance\ antar\ slot$$
$$= biasanya\ G_{12} << G_1$$

Contoh Procedure Design

Impedansi Karakteristik MikrostripLine



$$Z_c = \begin{cases} \dfrac{60}{\sqrt{\epsilon_{\text{reff}}}} \ln\left[\dfrac{8h}{W_0} + \dfrac{W_0}{4h}\right], & \dfrac{W_0}{h} \leq 1 \\ \dfrac{120\pi}{\sqrt{\epsilon_{\text{reff}}}\left[\dfrac{W_0}{h} + 1.393 + 0.667\ln\left(\dfrac{W_0}{h} + 1.444\right)\right]}, & \dfrac{W_0}{h} > 1 \end{cases}$$

Contoh

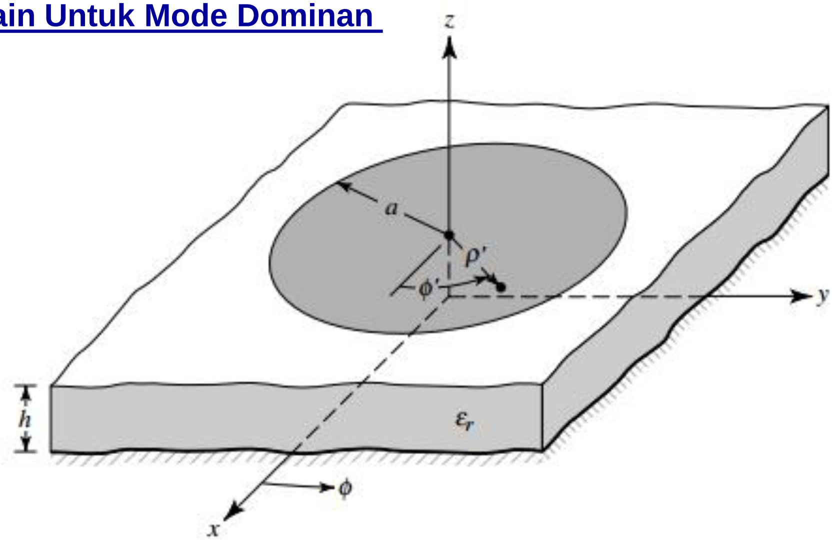
1. Design a rectangular patch. RT/Duroid 5880 substrate (εr = *2.2 and d* = *1.588* mm) is to be used to make a resonant rectangular patch antenna of linear polarization
   a) Design such an antenna to work at 2.45 GHz for Bluetooth applications.
   b) Estimate its directivity.
   c) If it is to be connected to a 50 ohm microstrip using the same PCB board, design the feed to this antenna.
   d) Find the fractional bandwidth for *VSWR* < *2.*

Prosedur Design Bisa dibaca di Constantine A. Balanis "Antenna Theory Analysis and Design"

Contoh Procedure Design

Dimensi Circular patch Antenna Cavity Model Formulation

Desain Untuk Mode Dominan



$$a = \frac{F}{\left\{1 + \frac{2h}{\pi \epsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{1/2}}$$

$$F = \frac{8.791 \times 10^9}{f_r \sqrt{\epsilon_r}}$$

Catatan : f_r dalam Hz
h dalam cm

Design a circular microstrip antenna using a substrate (RT/duroid 5880) with a dielectric constant of 2.2, $h = 0.1588$ cm (0.0625 in.) so as to resonate at 10 GHz.

Solution: Using (14-69a)

$$F = \frac{8.791 \times 10^9}{10 \times 10^9 \sqrt{2.2}} = 0.593$$

Therefore using (14-69)

$$a = \frac{F}{\left\{1 + \frac{2h}{\pi \epsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{1/2}} = 0.525 \text{ cm } (0.207 \text{ in.})$$

Questions???

Telkom University

Thank You !