Electromagnetics:
Electromagnetic Field Theory

Coupled-Mode Theory and Devices

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Lecture Outline
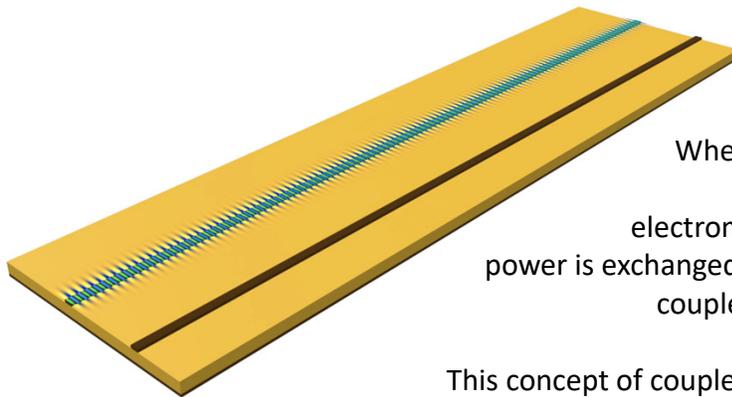
- Coupled-Mode Theory
- Applications

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Coupled Mode Theory

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What is Coupled-Mode Theory?

When two transmission lines are brought into close proximity, they become electromagnetically coupled. When coupled, power is exchanged between the lines. The more tightly coupled, the faster the exchange of power.

This concept of coupled modes applies to waveguides, free space waves, and virtually everything.
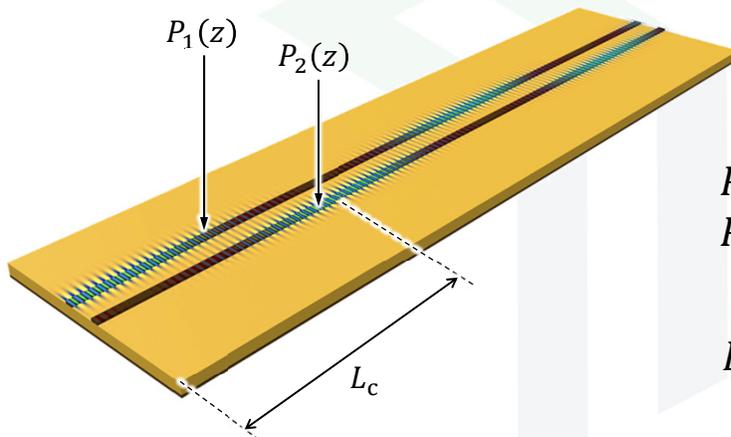
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2

Math of Coupled-Mode Theory

$P_1(z)$

$P_2(z)$
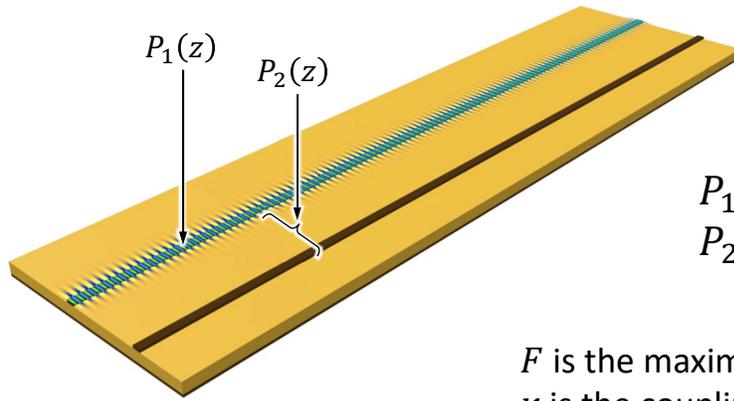
$$P_1(z) = 1 - F \sin^2(\kappa z)$$
$$P_2(z) = F \sin^2(\kappa z)$$

F is the maximum coupling efficiency
κ is the coupling coefficient

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Coupling Length (or Beat Length)

$P_1(z)$

$P_2(z)$

L_c

$$P_1(z) = 1 - F \sin^2(\kappa z)$$
$$P_2(z) = F \sin^2(\kappa z)$$

$$L_c = \frac{\pi}{2\kappa} \overset{\text{def}}{=} \begin{array}{l}\text{Distance for maximum} \\ \text{power transfer}\end{array}$$
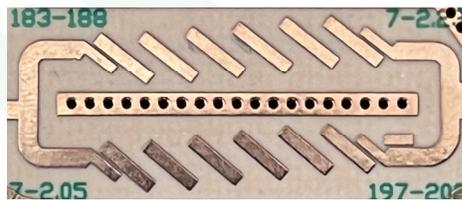
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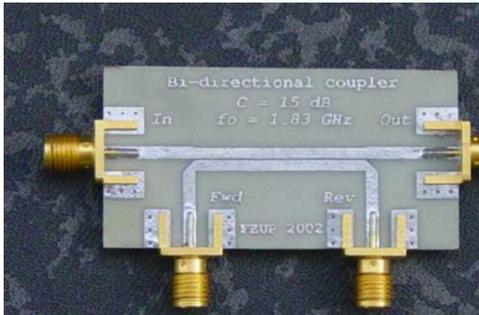# Applications

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Coupled-Line Filters
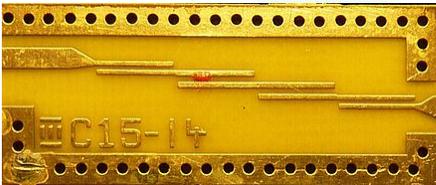
https://www.wikiwand.com/en/Distributed-element_filter

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Splitters

http://www.ittc.ku.edu/~jstiles/723/handouts/section_7_1_
Properties_of_dividers_and_couplers_package.pdf

https://www.digikey.com/en/products/detail/knowles-dielectric-
labs/FPC07182/7596196?utm_adgroup=RF%20Directional%20Coupler&ut
m_source=google&utm_medium=cpc&utm_campaign=Shopping_Product_
RF%2FIF%20and%20RFID_NEW&utm_term=&utm_content=RF%20Directio
nal%20Coupler&gclid=Cj0KCQjw8qmhBhClARIsANAtbocN3jRvTxkGJh3kyCKl
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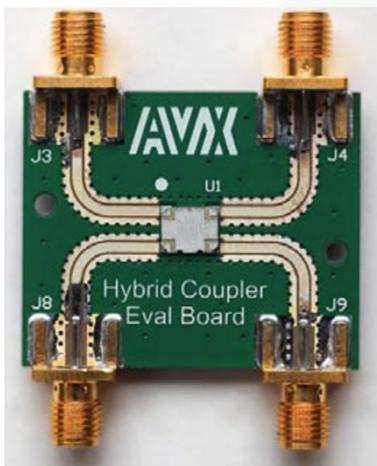
Hybrid Coupler

Hybrid couplers are a four-port devices
design to split power equally (3 dB coupler)

90° Hybrid couplers shift the phase of the
outputs by 90°.

180° Hybrid couplers shift the phase of the
outputs by 180°.

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