Radiodifusão de TV

PTC2547 – Princípios de Televisão Digital

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10/2016

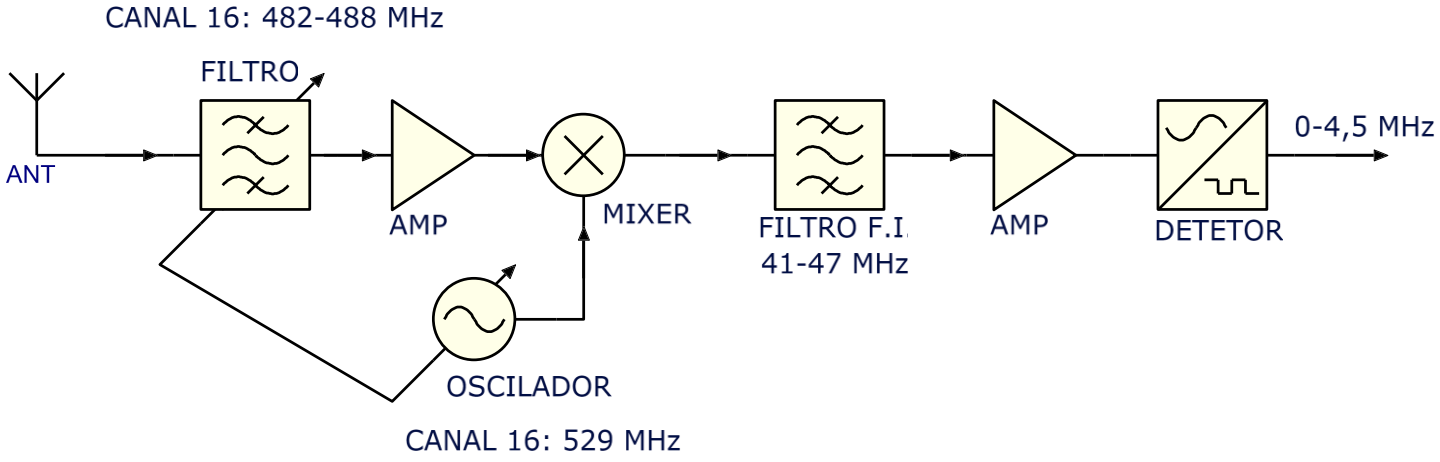
Ref.: NAB Engineering Handbook

Tópicos Abordados

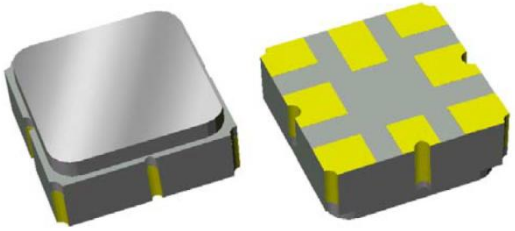
- Características Relevantes dos Receptores
- Interferências entre Canais
- Transmissores de TV
- Filtros e Combinadores
- Antenas Transmissoras

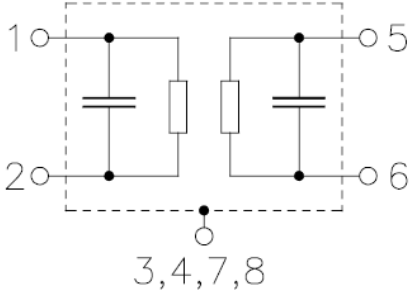
Características dos Receptores que Afetam a Transmissão

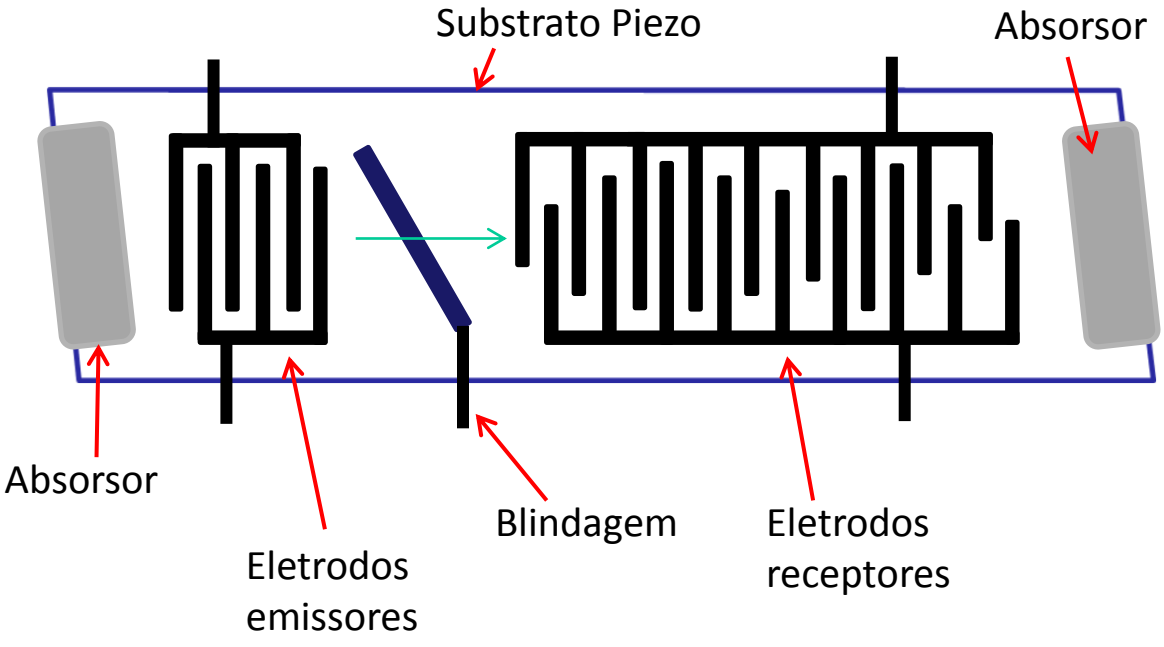
Topologia do Receptor Super-Heterodino



Filtro para F.I. de TV – Tecnologia SAW

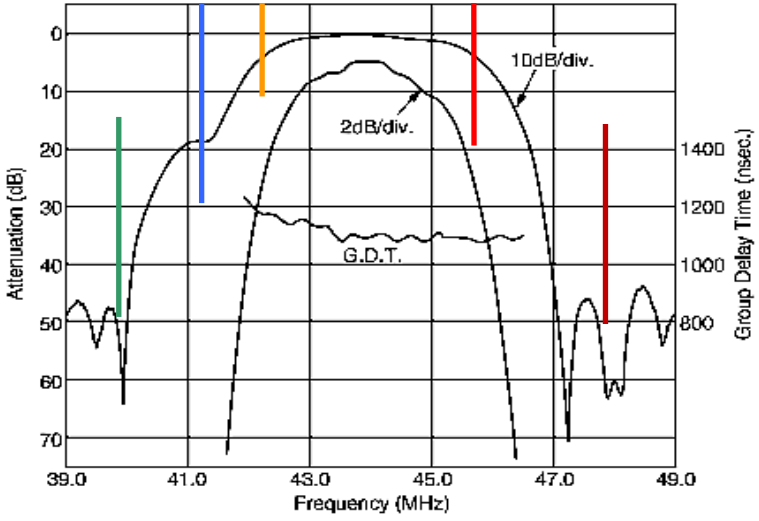






SAW = Surface Acoustic Wave

Filtro para F.I. de TV Analógica – Tecnologia SAW



Sinal	Frequência (MHz)	Atenuação (dB)
Portadora de Vídeo	45,75	6
Portadora de Áudio	41,25	18
Portadora de Croma	42,17	3
"Trap" de Video Adjacente	39,75	> 45
"Trap" de Áudio Adjacente	47,25	> 45
Fora da Banda	> 47, < 40	> 35

Exemplo de Interferências

Canal 16:

Freq. da Portadora de Vídeo: **483.25 MHz**

Oscilador Local: 483.25 + 45.75 = **529 MHz**

Portadora de Áudio do Canal 23: **529.75 MHz**

Portadora de Vídeo do Canal 24: **531.25**

Freq. Imagem: 529+[41.25 a 45.75] = **[570.25 a 574.75] MHz**

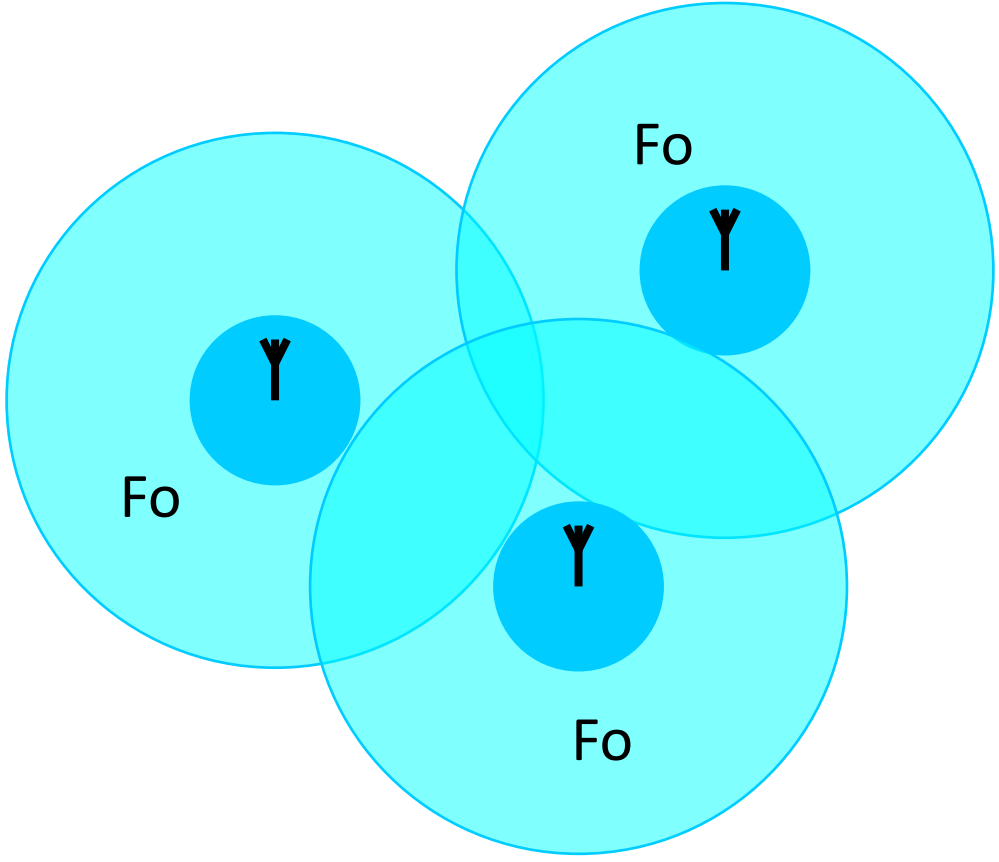
Portadora de Vídeo do Canal 31: **573.25 MHz**

Portadora de Áudio do Canal 30: **571.75 MHz**

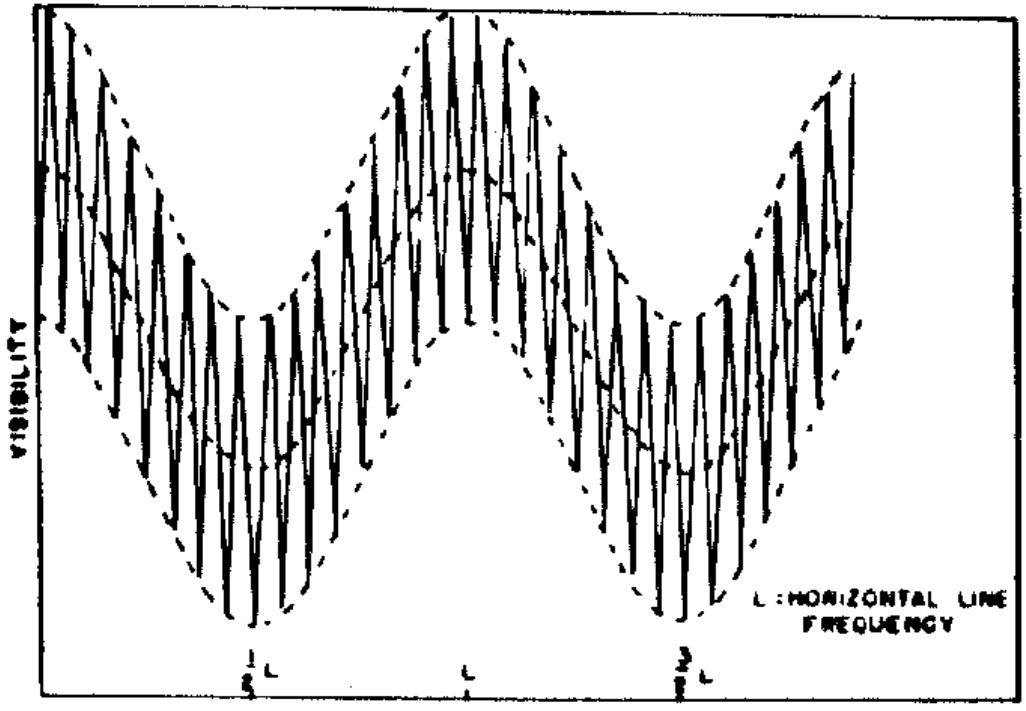
Interferências na Transmissão Analógica de TV

Tipo de Interferência	Canais Interferentes / Interferidos	Separação em Frequência (MHz)	Distância Mínima entre Emissoras (km)
Co-canal	N	0	250 a 300
Canal Adjacente (VHF)	N ± 1	6	100
Canal Adjacente (UHF)	N ± 1	6	90
Freq. Imagem (Vídeo)	N ± 15	90	120
Freq. Imagem (Áudio)	N ± 14	84	100
Oscilador Local (UHF)	N ± 7	42	100
Batimento com F.I. (UHF)	N ± 8	48	30
Intermodulação (UHF)	N ± 2 a N ± 5	12 a 30	30

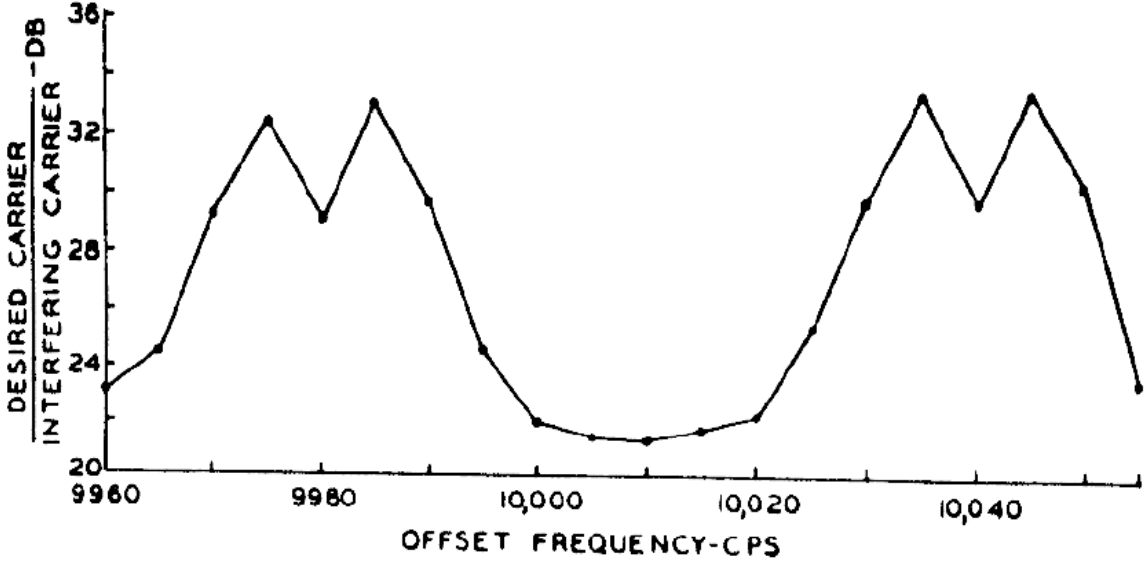
Interferências Co-Canal



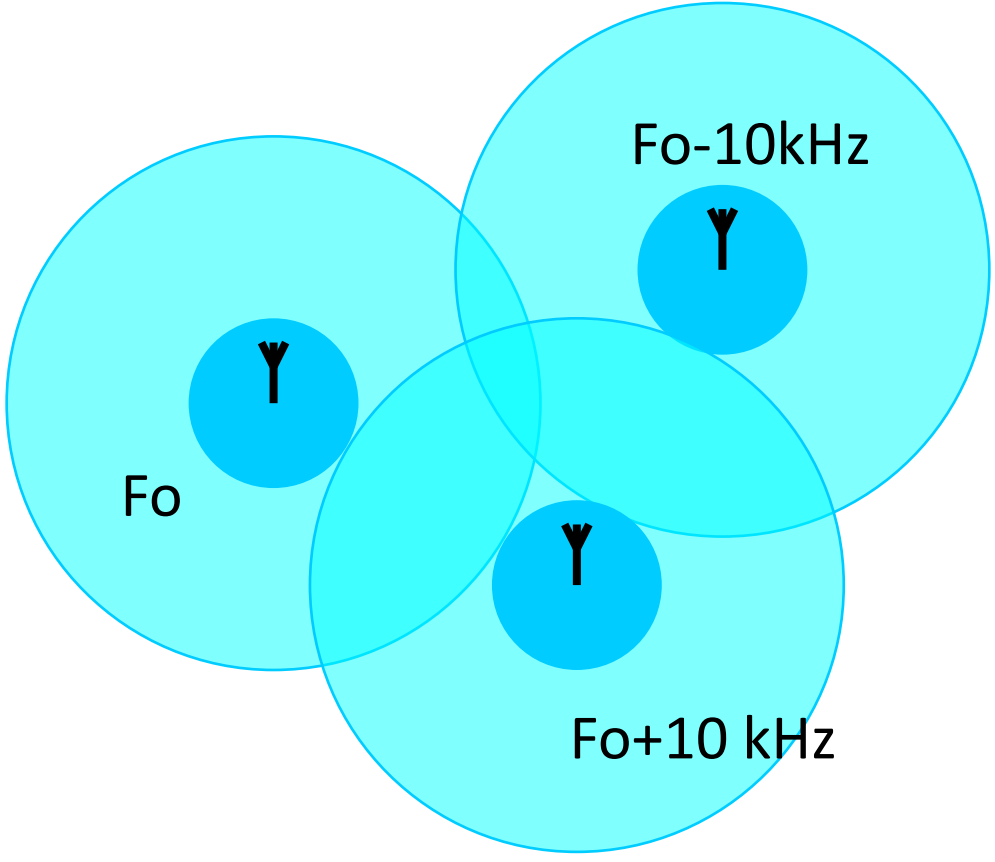
Visibilidade de Interferências Co-Canal



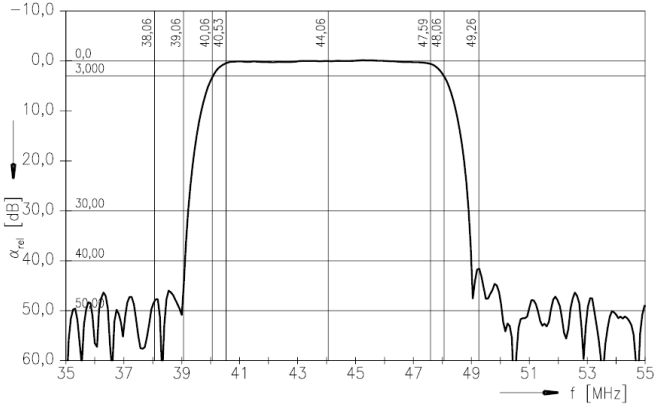
Visibilidade de Interferências Co-Canal

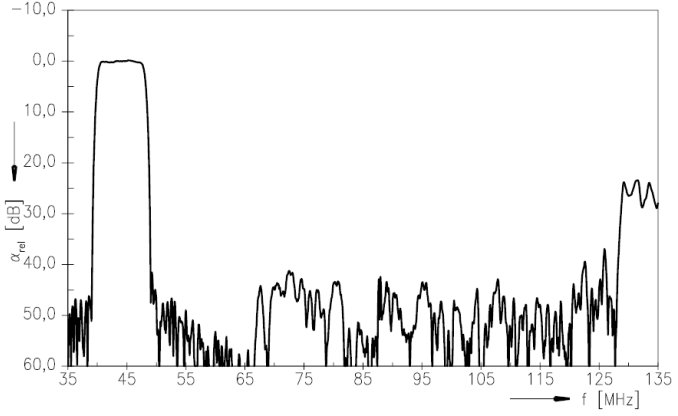


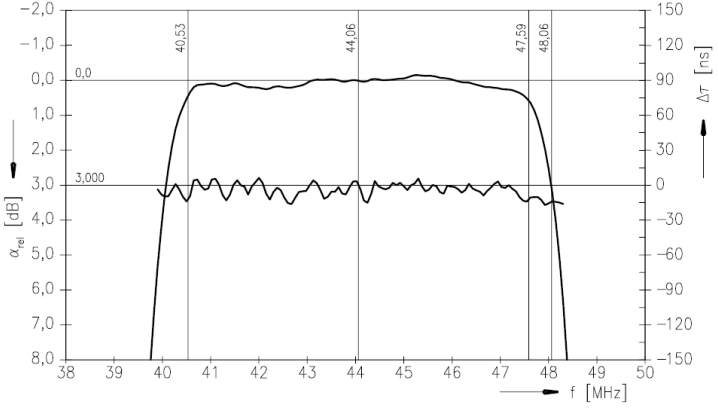
“Off-set” de Frequência para Minimizar Interferências Co-Canal



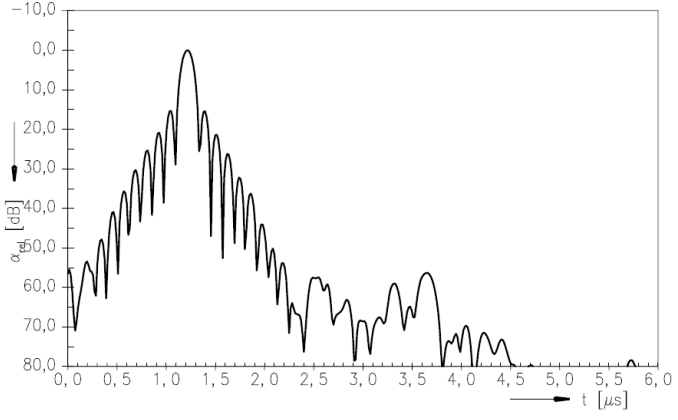
Filtro F.I. para TV Digital





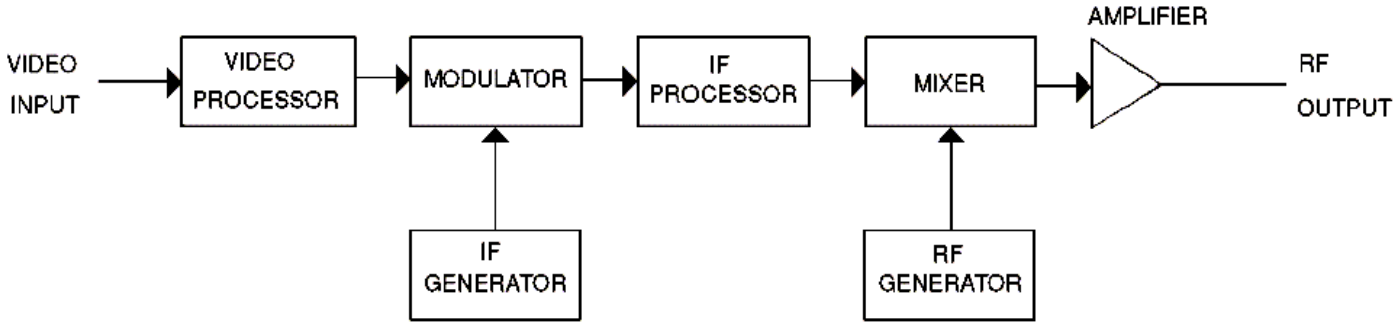


Time domain response



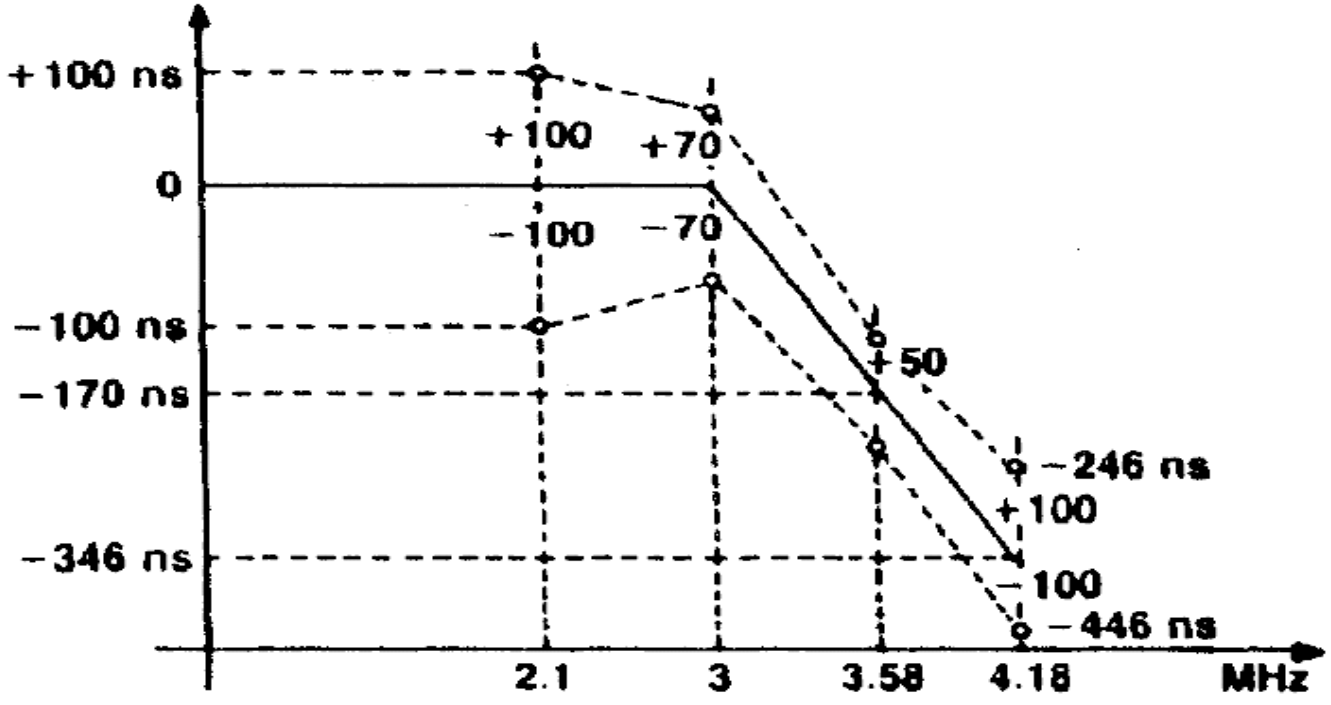
Transmissores de TV

Diagrama de Blocos de um Transmissor de TV



- Ajustar amplitude do sincronismo
- Grampeamento de nível CC
- Limitador para evitar sobremodulação
- Correção de resposta em frequência

Compensador de Atraso de Grupo

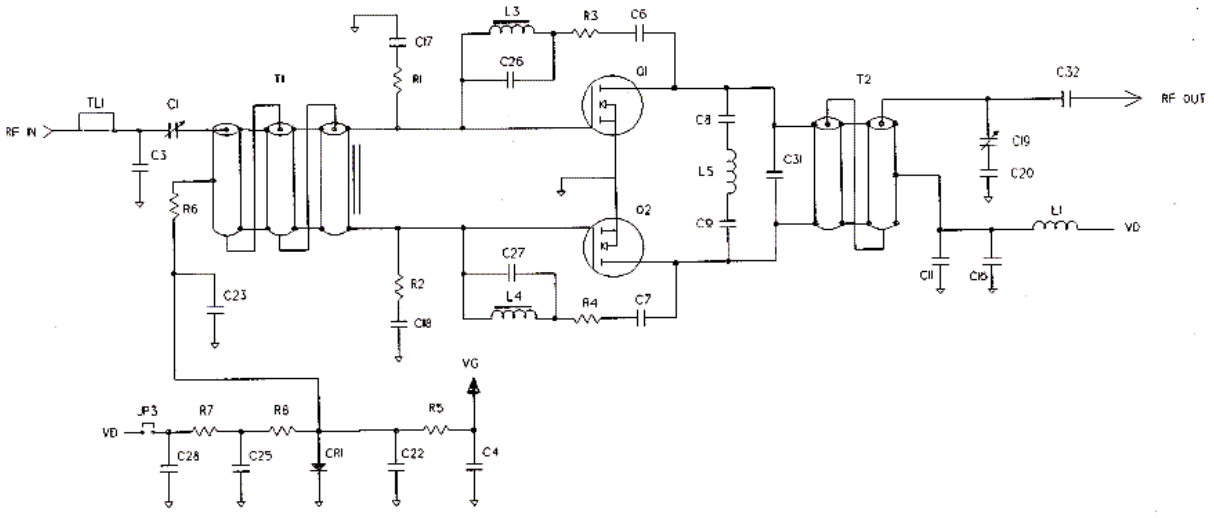


Tecnologias para Transmissores de TV

- Estado Sólido: VHF; UHF baixo
  - Combinações de módulos (~1 kW cada)
  - 100 a 200 W por transistor

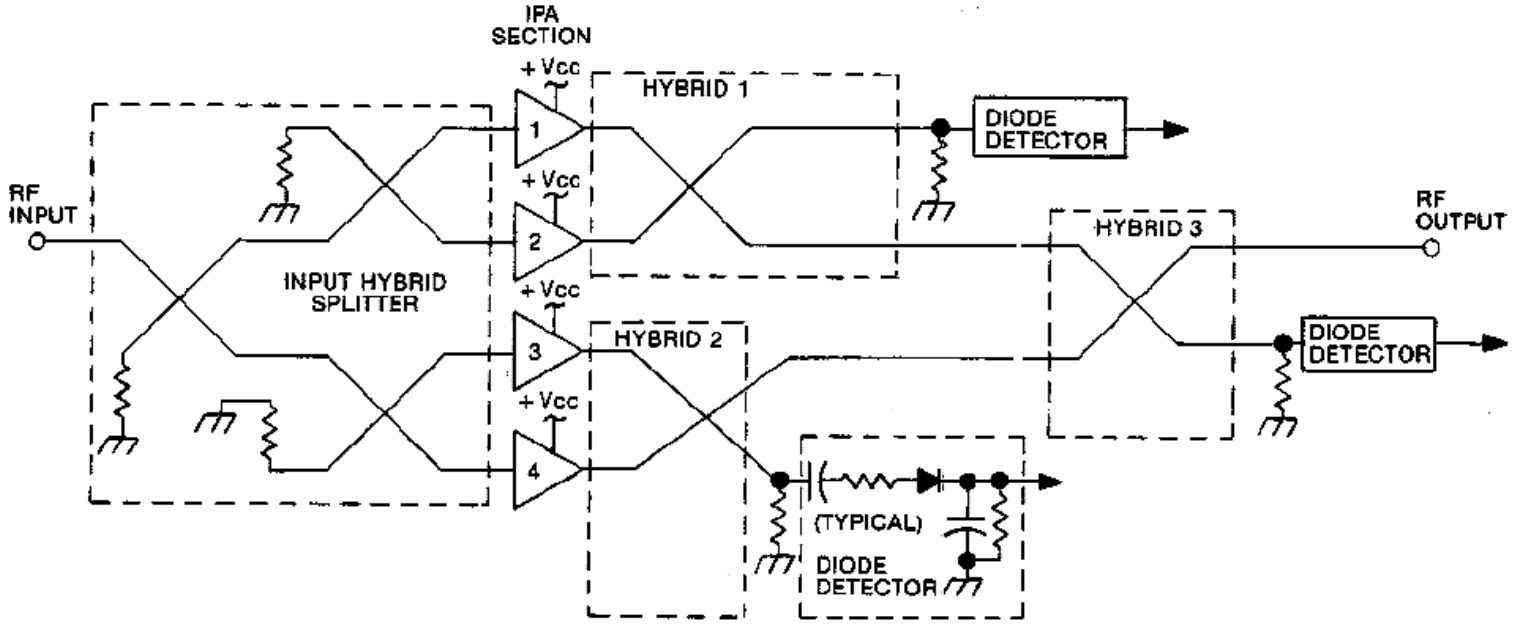
- Válvula: VHF, UHF até 1 MW
  - Tetrodo (VHF)
  - Klystron, IOT (UHF)
  - 1 ou 2 válvulas (Push-pull)

Módulo Amplificador de RF

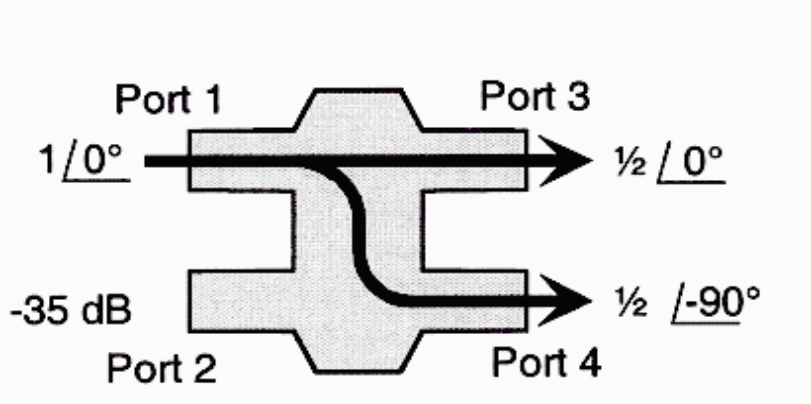


Amplificador MOSFET 400W Push-Pull

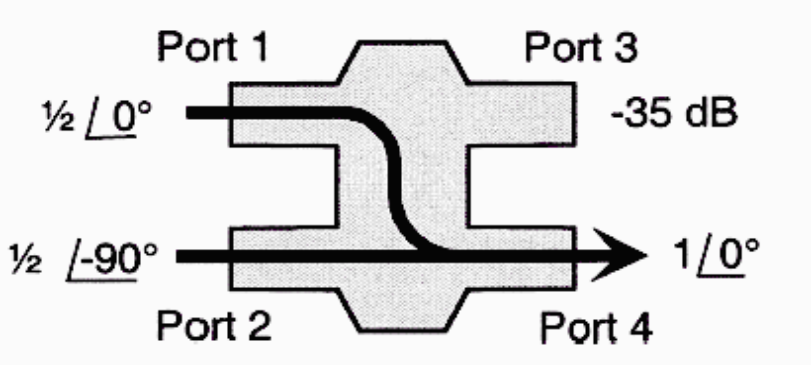
Conjunto Paralelo (Combinador c/ Híbrida 90º)



Híbrida de 3 dB, 90º

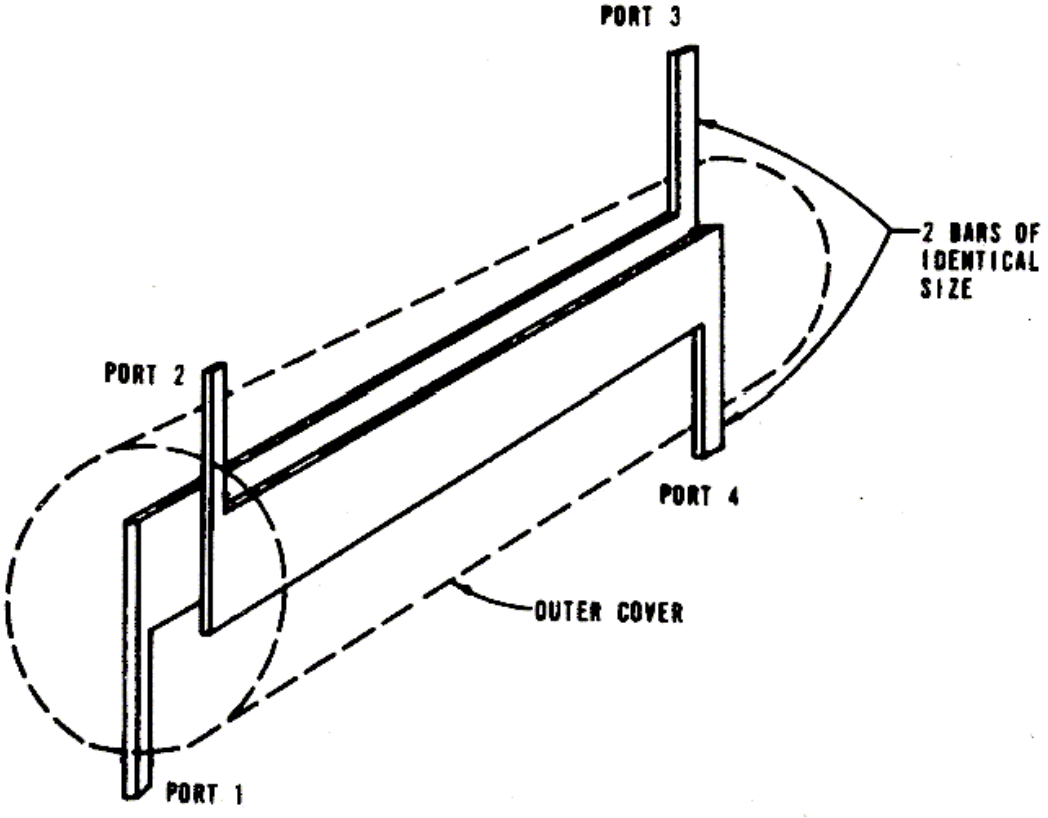


Divisor

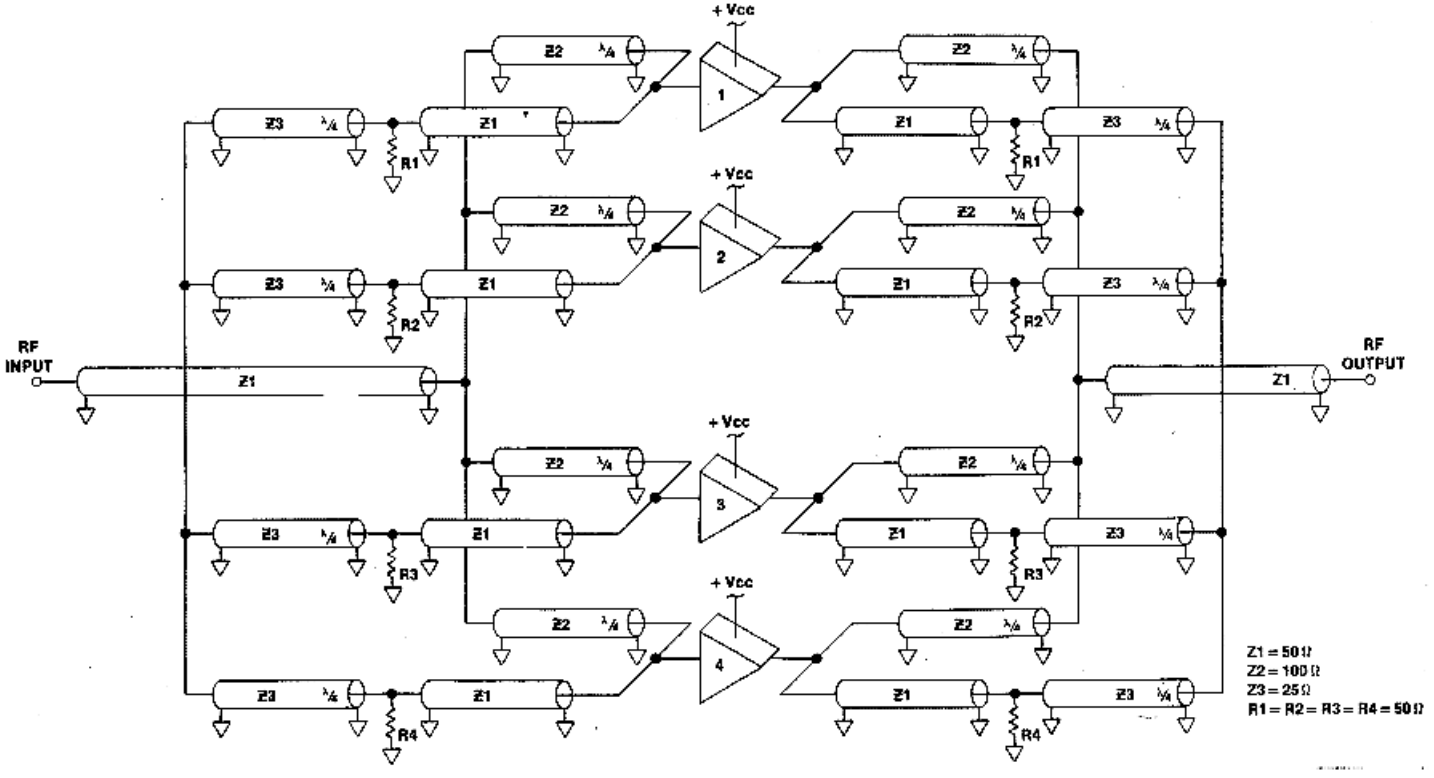


Combinador

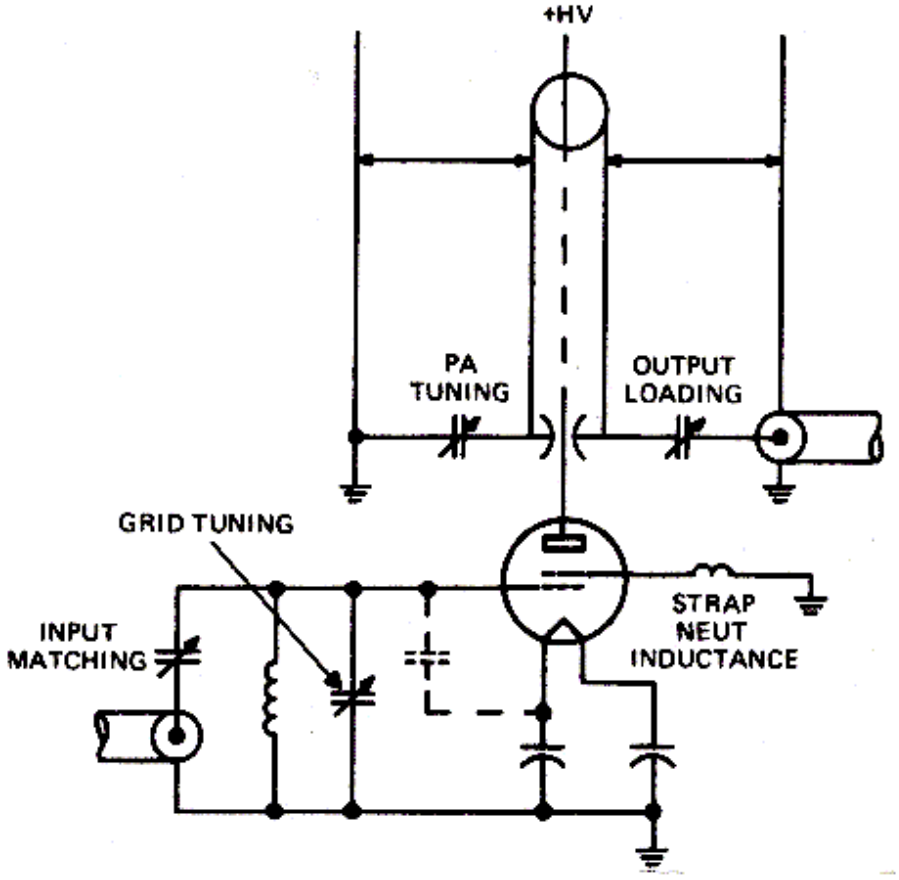
Híbrida de 3 dB, 90º



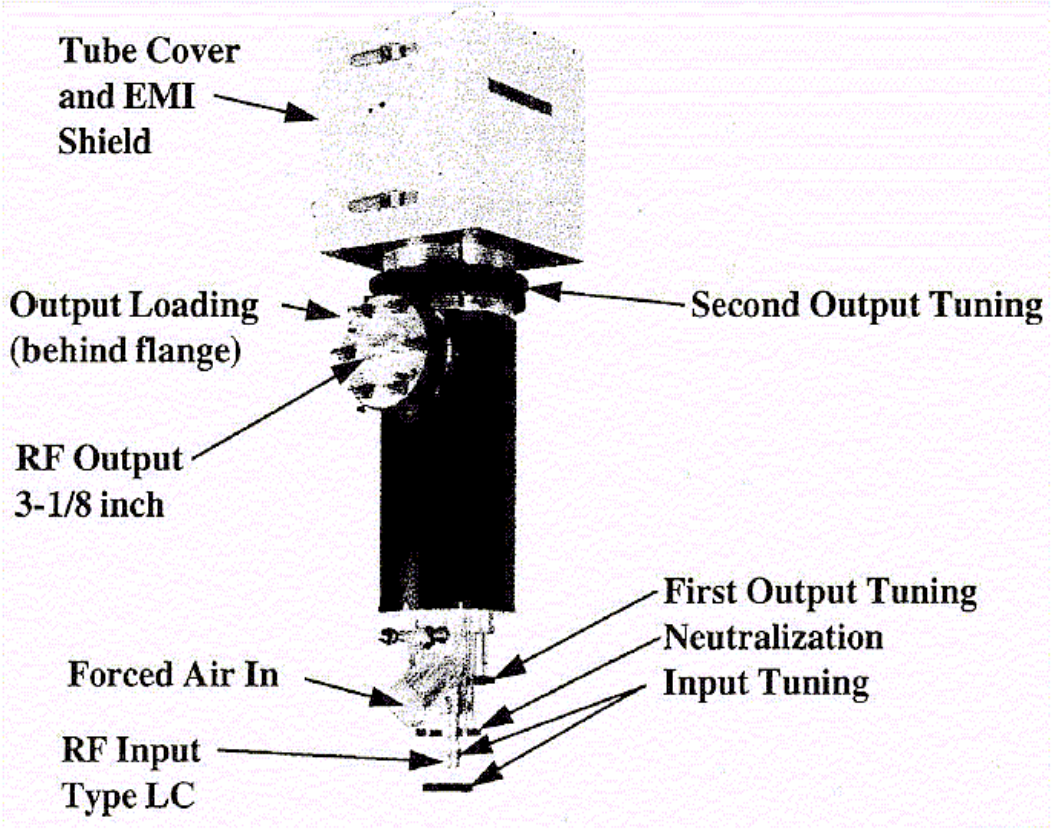
Combinador Wilkinson / Gysel (0º)



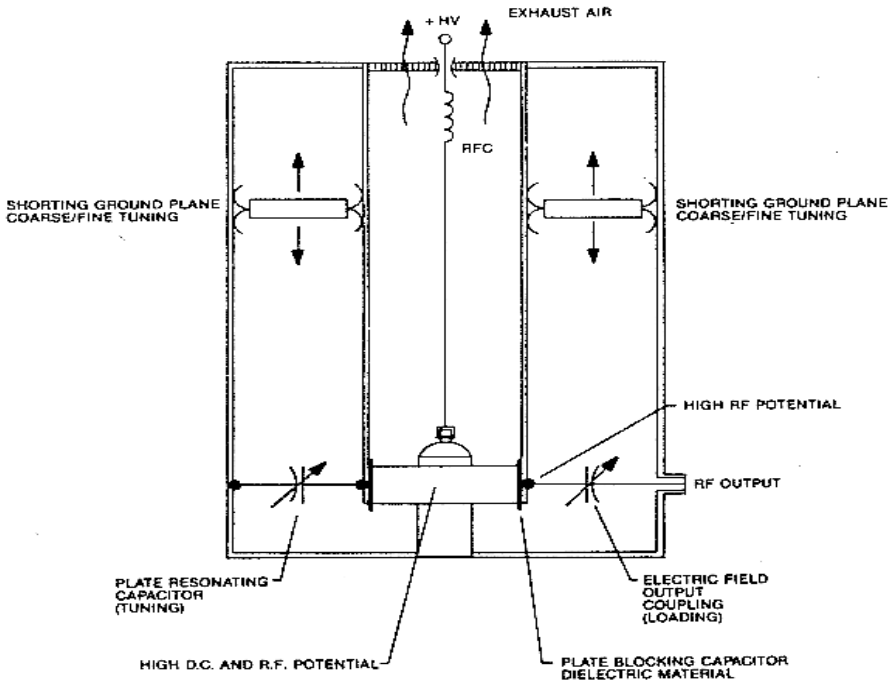
Amplificador a Válvula (Tetrodo)



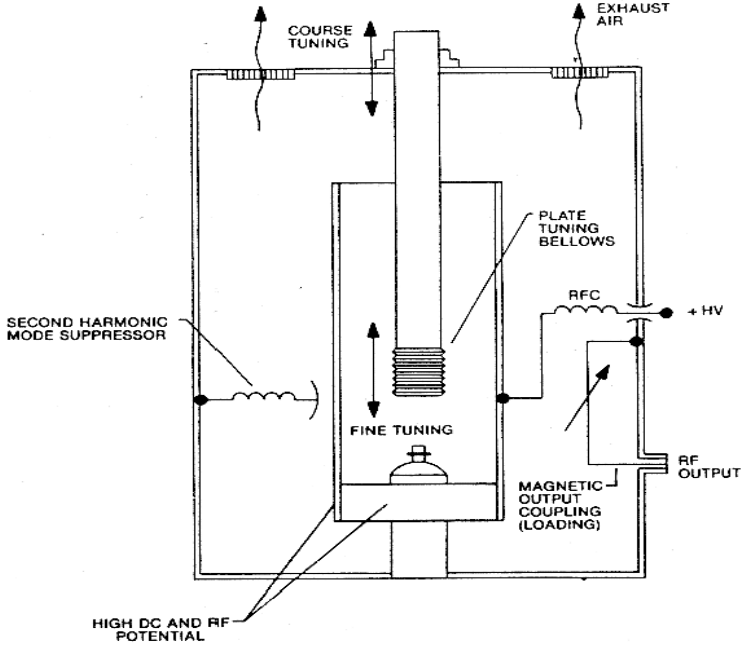
Cavidade para Tetrodo



Cavidades Ressonantes para Válvulas

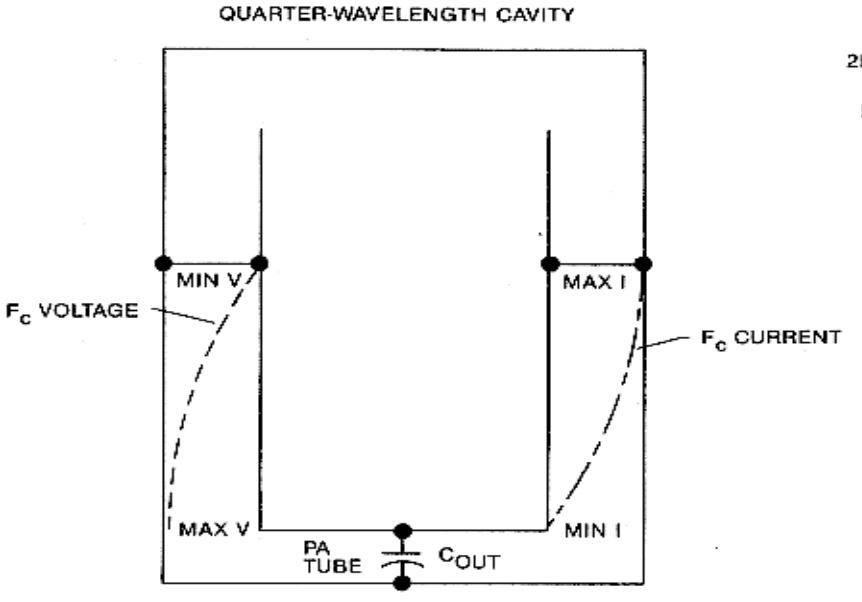


Cavidade ¼ de Onda

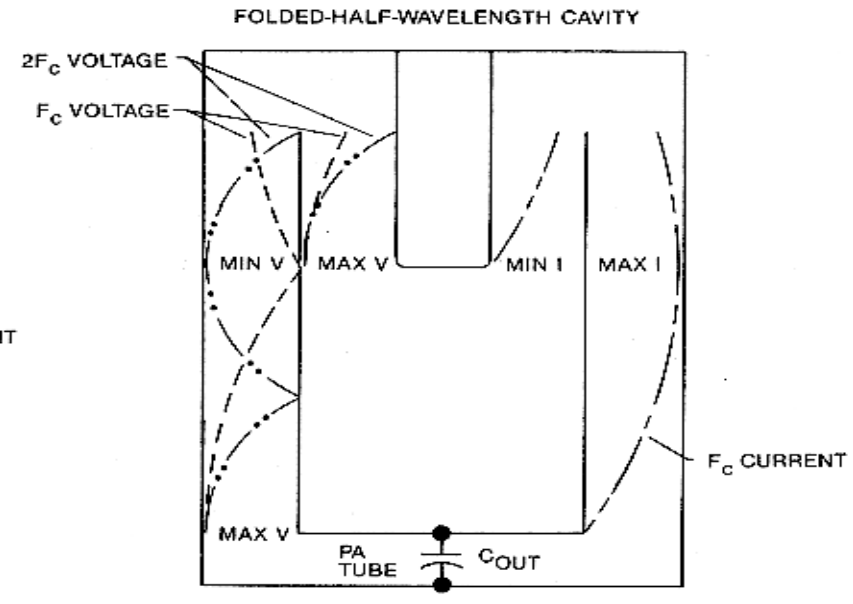


Cavidade ½ Onda Dobrada

Tensões e Correntes nas Cavidades



Cavidade ¼ de Onda



Cavidade ½ Onda Dobrada

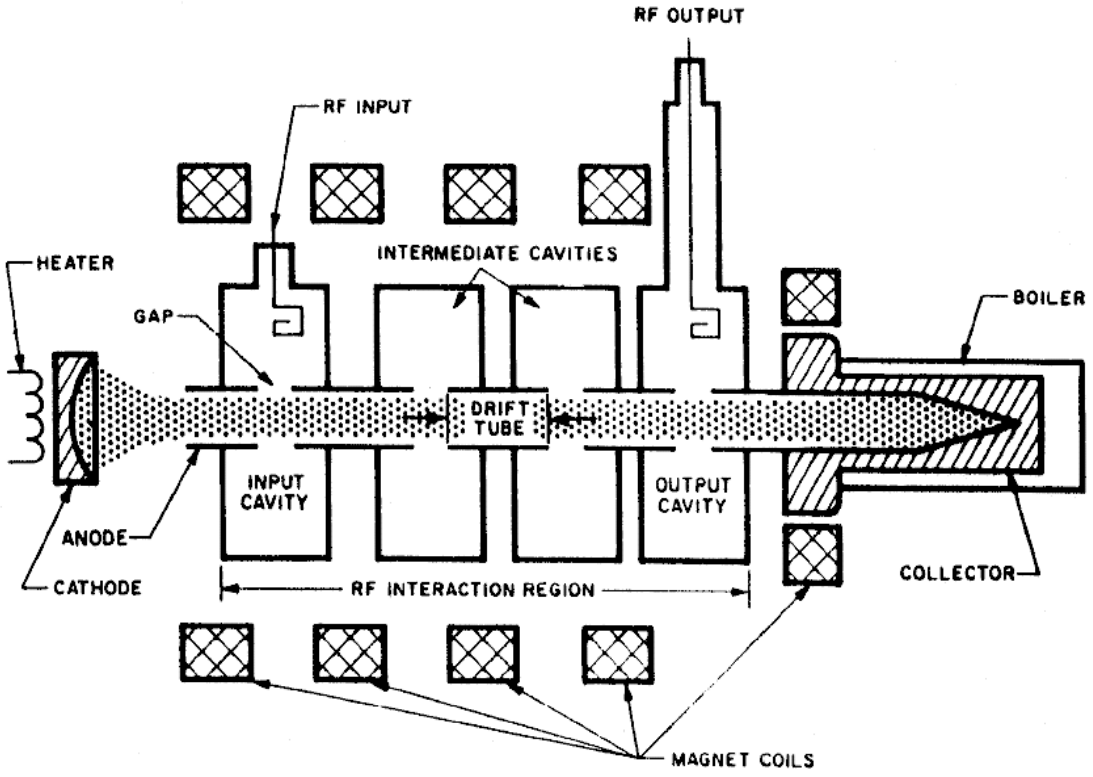
Válvulas para Transmissão

Tetrodo 1 kW, refr. a ar

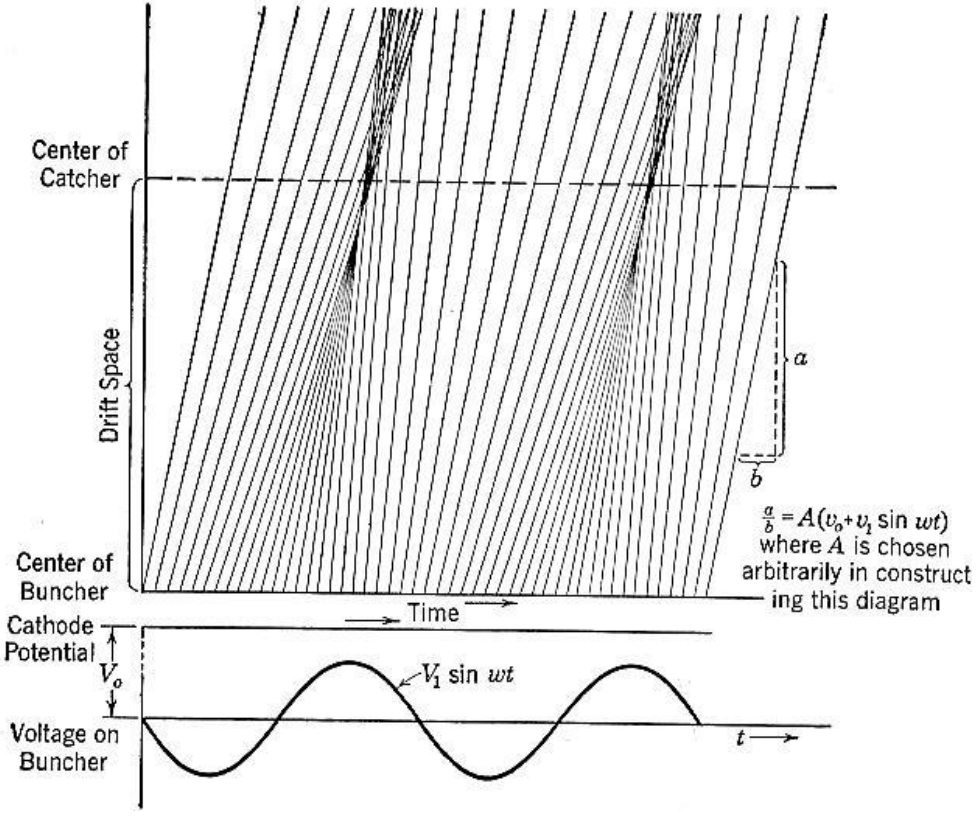
Tetrodo 3.5 kW, refr. a ar

Triodo 50 kW, refr. a água

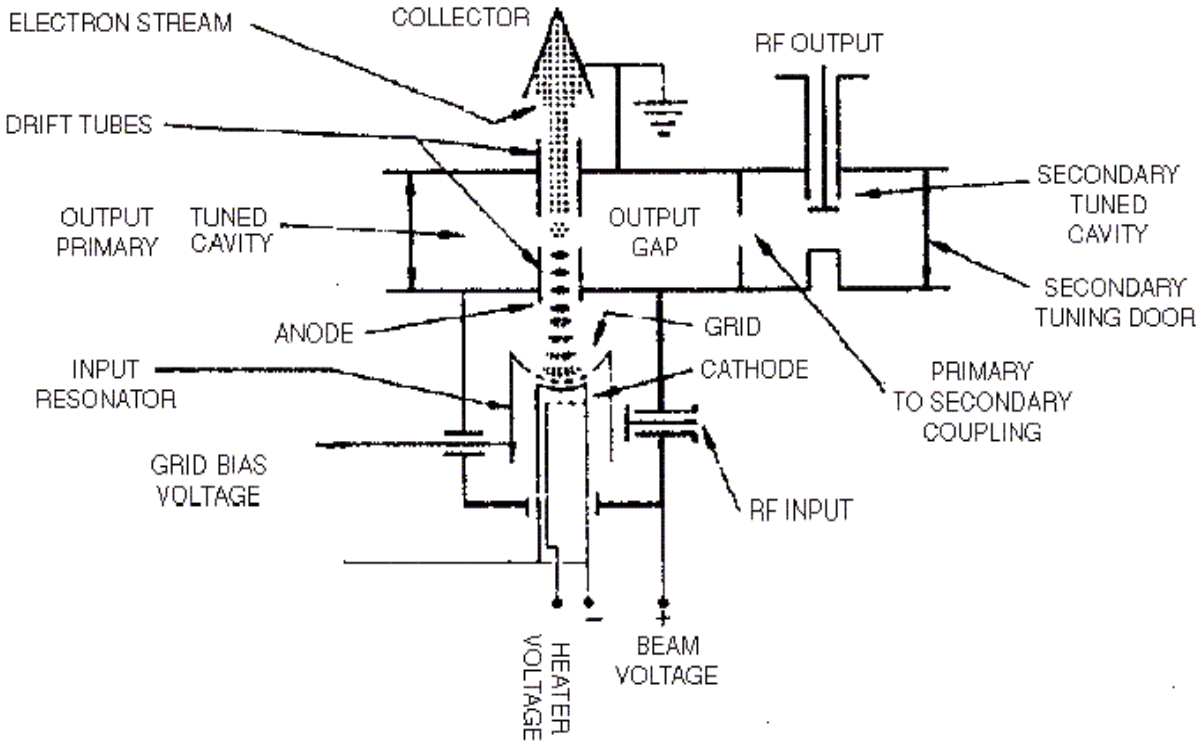
Klystron


RF OUTPUT
RF INPUT
INTERMEDIATE CAVITIES
HEATER
GAP
BOILER
DRIFT TUBE
INPUT CAVITY
OUTPUT CAVITY
ANODE
CATHODE
RF INTERACTION REGION
COLLECTOR
MAGNET COILS

Modulação de Velocidade dos Elétrons



Transmissor com IOT (Inductive Output Tube)



Válvula IOT (Klystrode)

~50 cm

80 kW PEP, 470-860 MHz

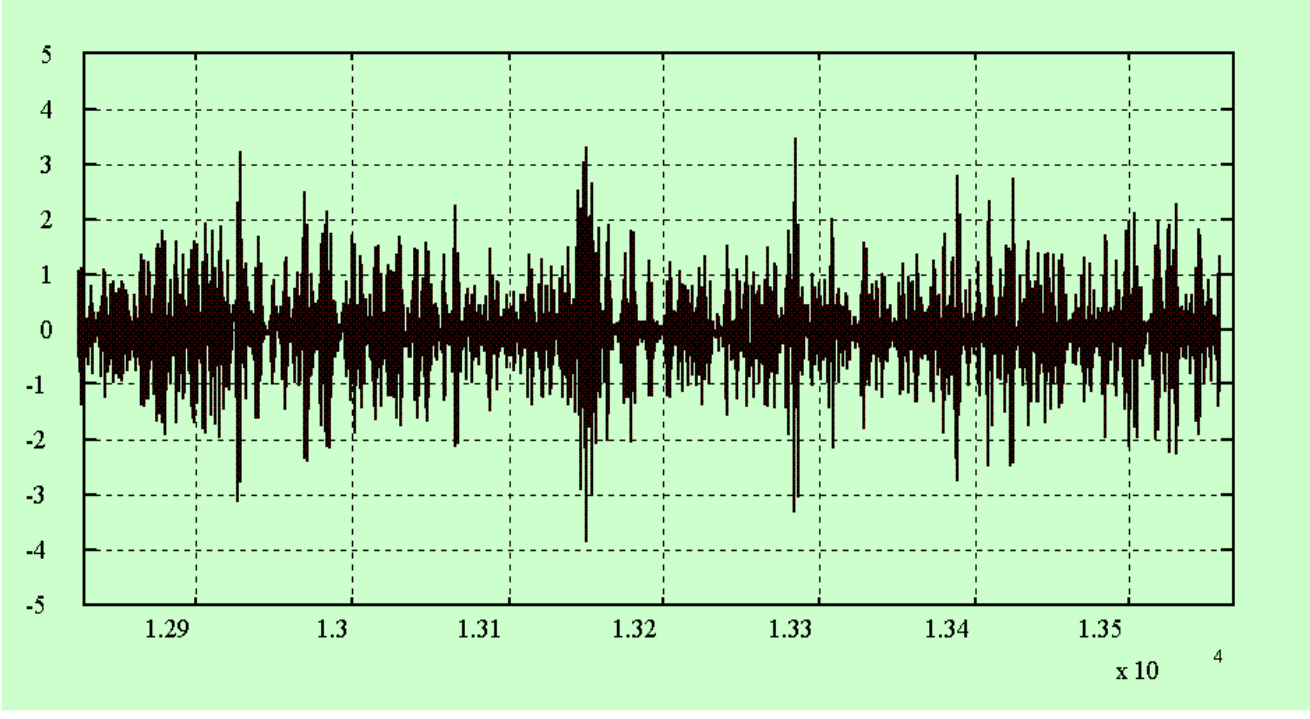
PEP= Peak Envelope Power

Transmissores Estado Sólido e Válvula (IOT)

7 kW Digital, VHF, Transistor

30 kW Digital, UHF, IOT

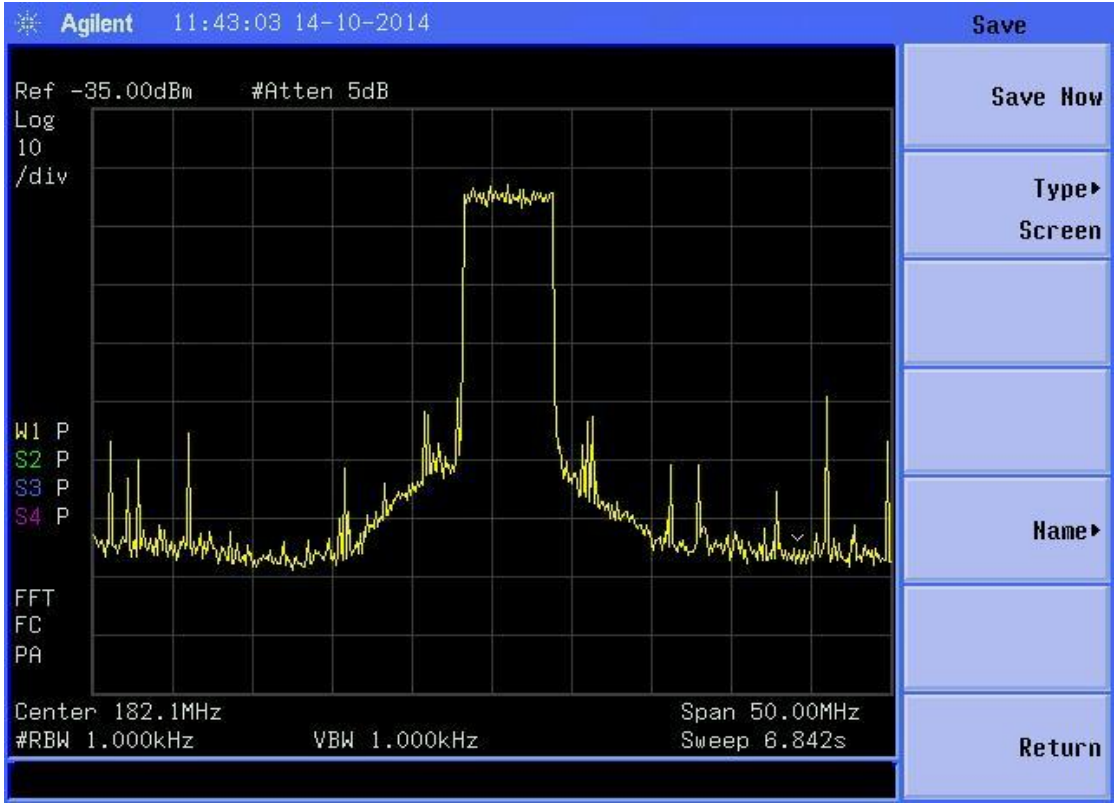
Transmissão de Sinal Digital



PAPR (fator de crista) > 10 dB => Eficiência menor que 25%

PAPR= Peak to Average Power Ratio

Espectro de Emissão com Distorções



Máscaras de Transmissão

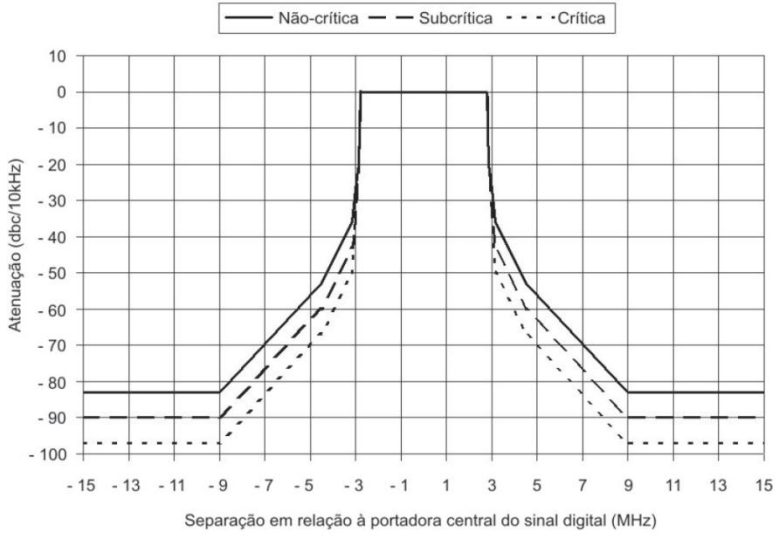


Tabela 43 — Potência máxima de cada classe

Classes	Máxima potência ERP (Hsnmt = 150 m) kW	
	VHF alto	UHF
Especial	16	80
A	1,6	8
B	0,16	0,8
C	0,016	0,08

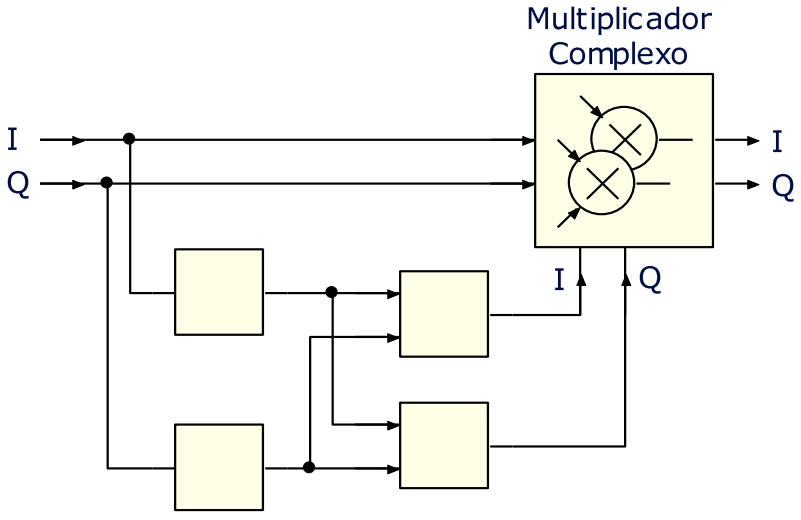
Tabela 44 — Critérios para aplicação das máscaras crítica, subcrítica e não-crítica

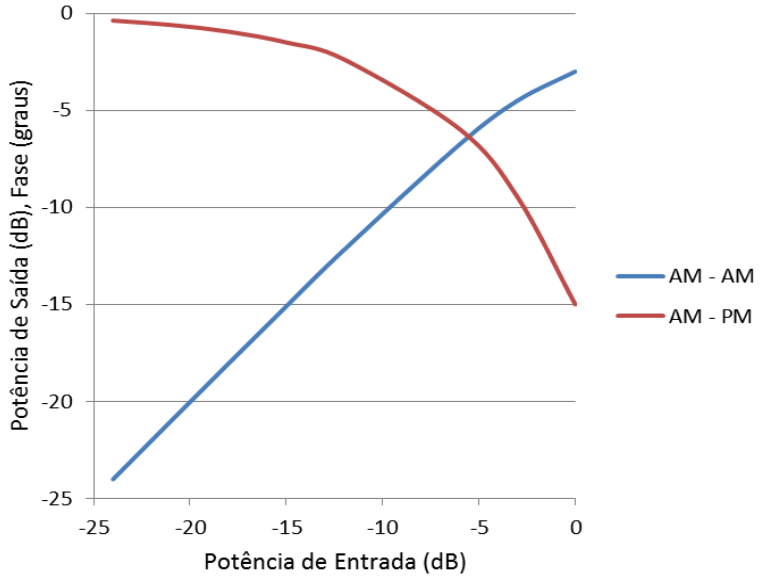
Classe da estação digital	A, B e C					Especial	
Distância em relação à estação de canal adjacente instalado na mesma localidade	< 400 m		> 400 m		Ausência de canal adjacente previsto ou instalado na mesma localidade	Existência de canal adjacente previsto ou instalado na mesma localidade	Ausência de canal adjacente previsto ou instalado na mesma localidade
Tipo de modulação do canal adjacente previsto ou instalado na mesma localidade	Analógica	Digital	Analógica	Digital			
$P_{digital} < P_{adjacente} + 3$ dB	Crítica	Subcrítica	Crítica		Não-Crítica	Crítica	
$P_{digital} > P_{adjacente} + 3$ dB		Crítica					

$P_{digital}$ = Potência ERP da estação digital
$P_{adjacente}$ = Potência ERP da estação em canal adjacente

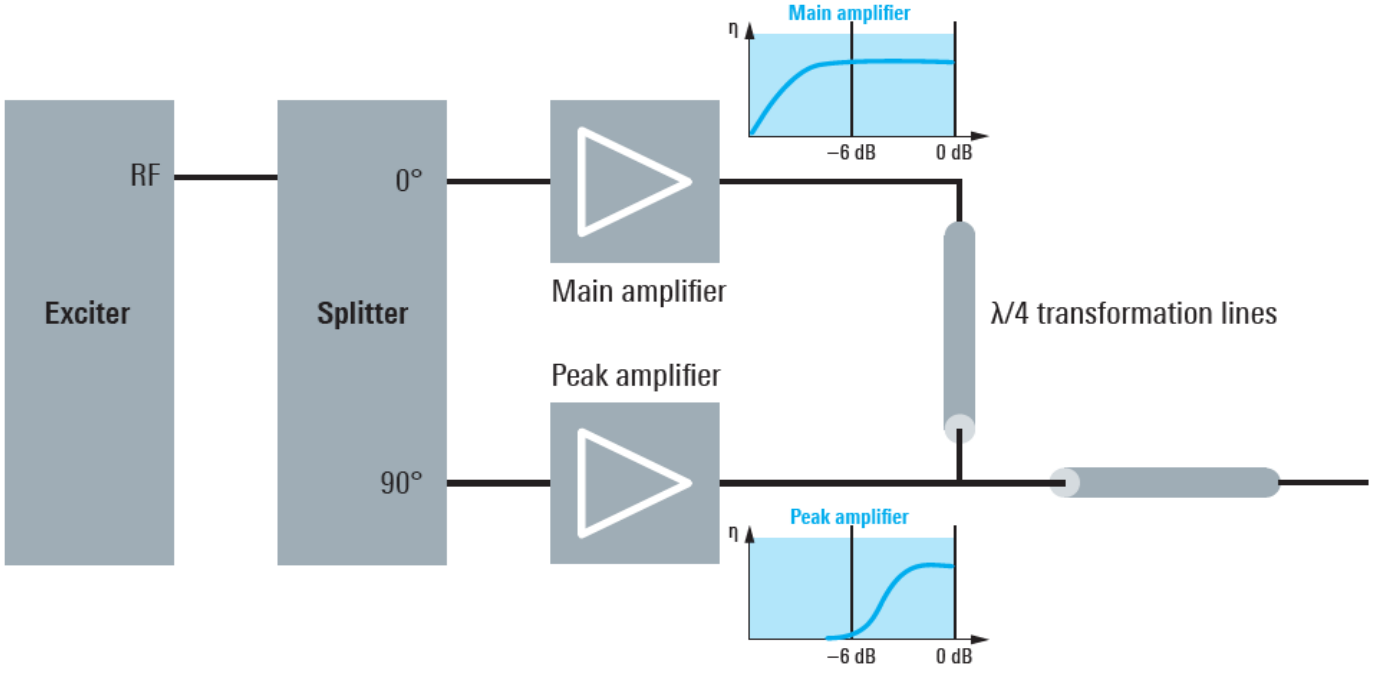
ABNT NBR 15601-2007

Pré-Distorção

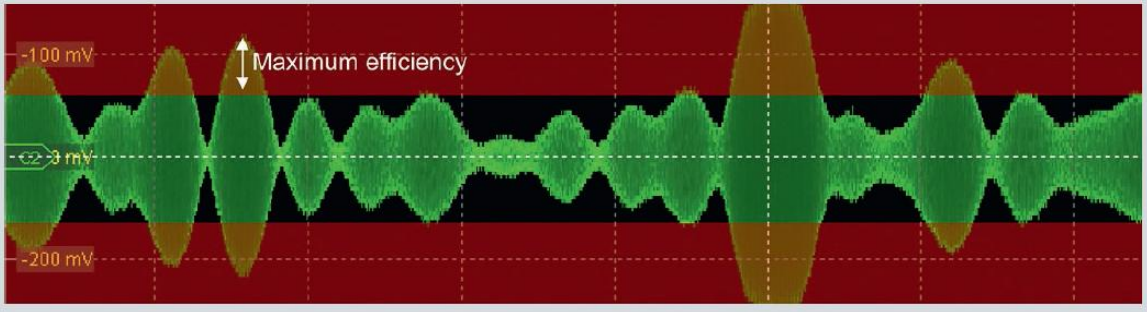


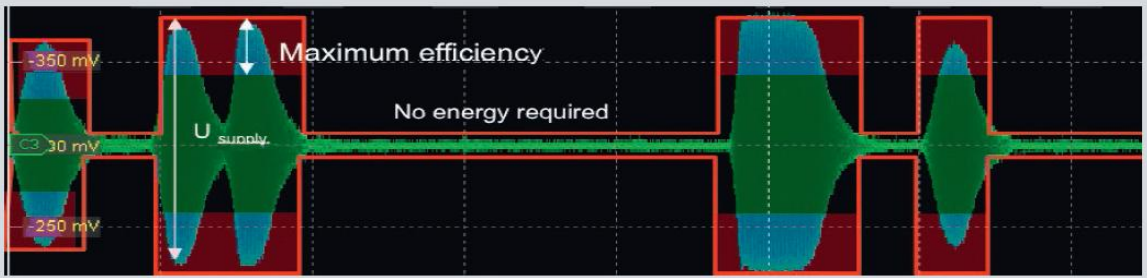


Eficiência de Energia: Amplificador Doherty



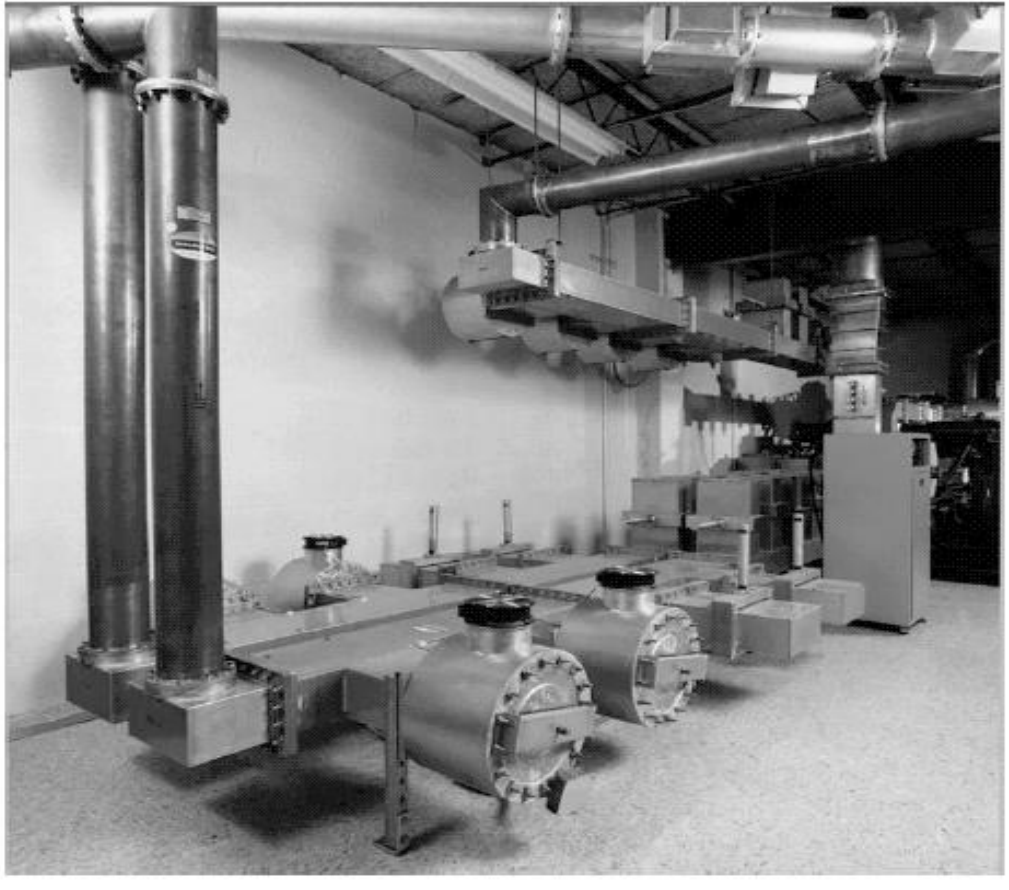
Amplificador Doherty





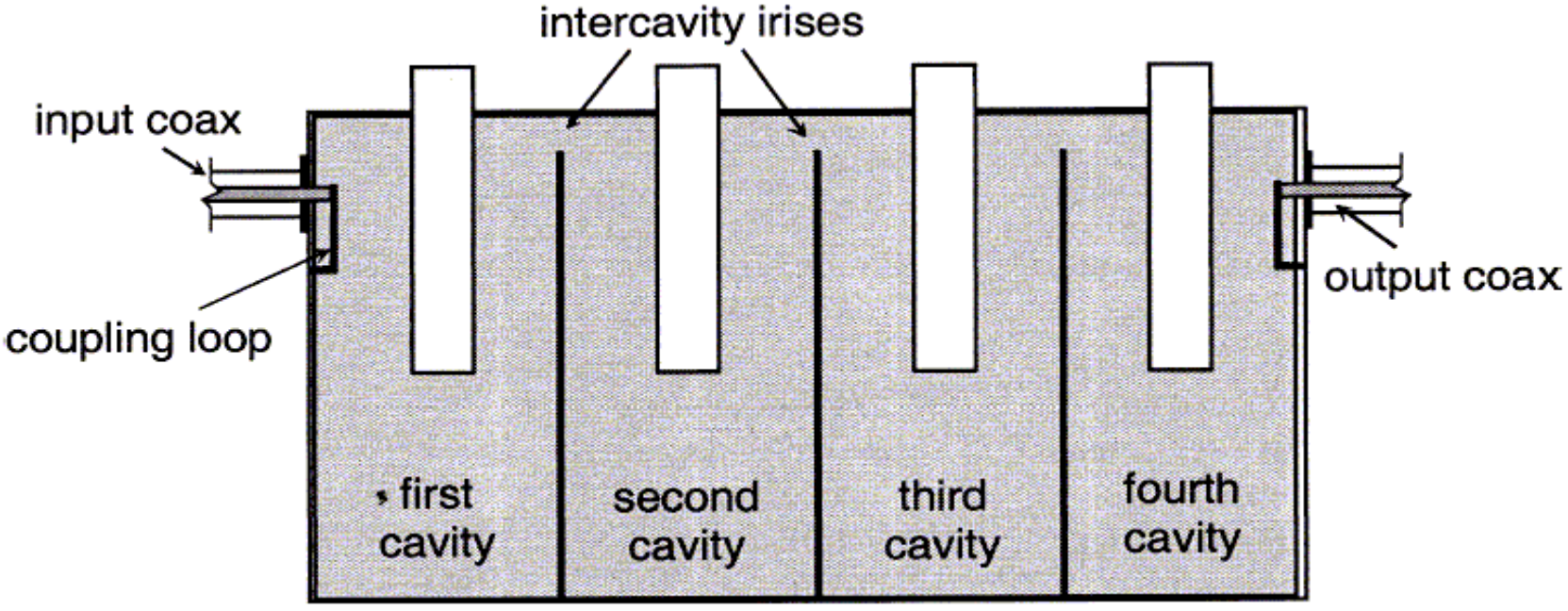
Filtros e Combinadores

Filtros “Notch” para Rejeição de Harmônicas

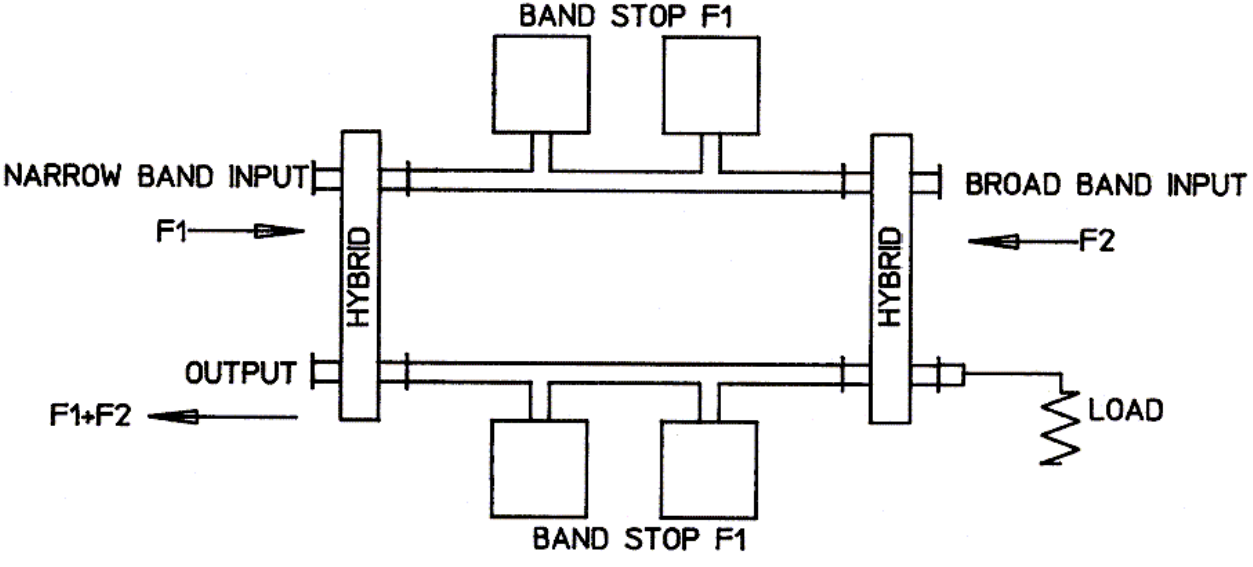


Filtro Passa-Bandas a Cavidades Acopladas

Filtro Passa-Bandas a Cavidades Acopladas

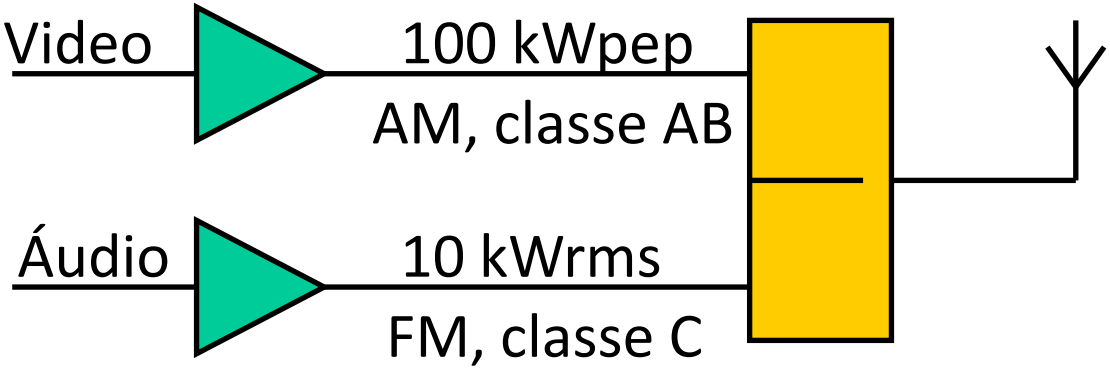


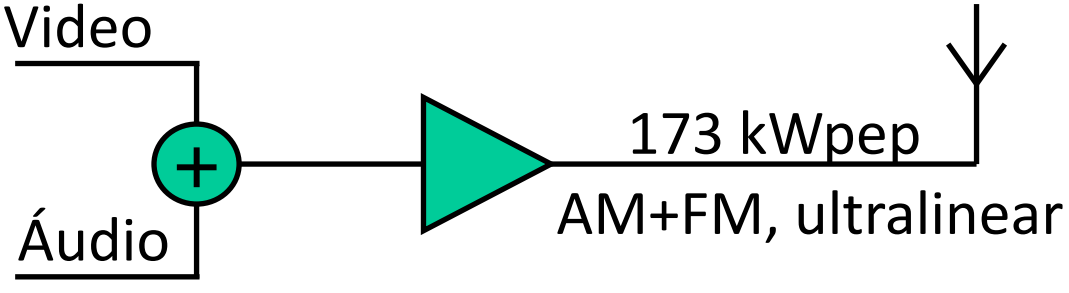
Diplexadores “Notch”: Aural + Visual



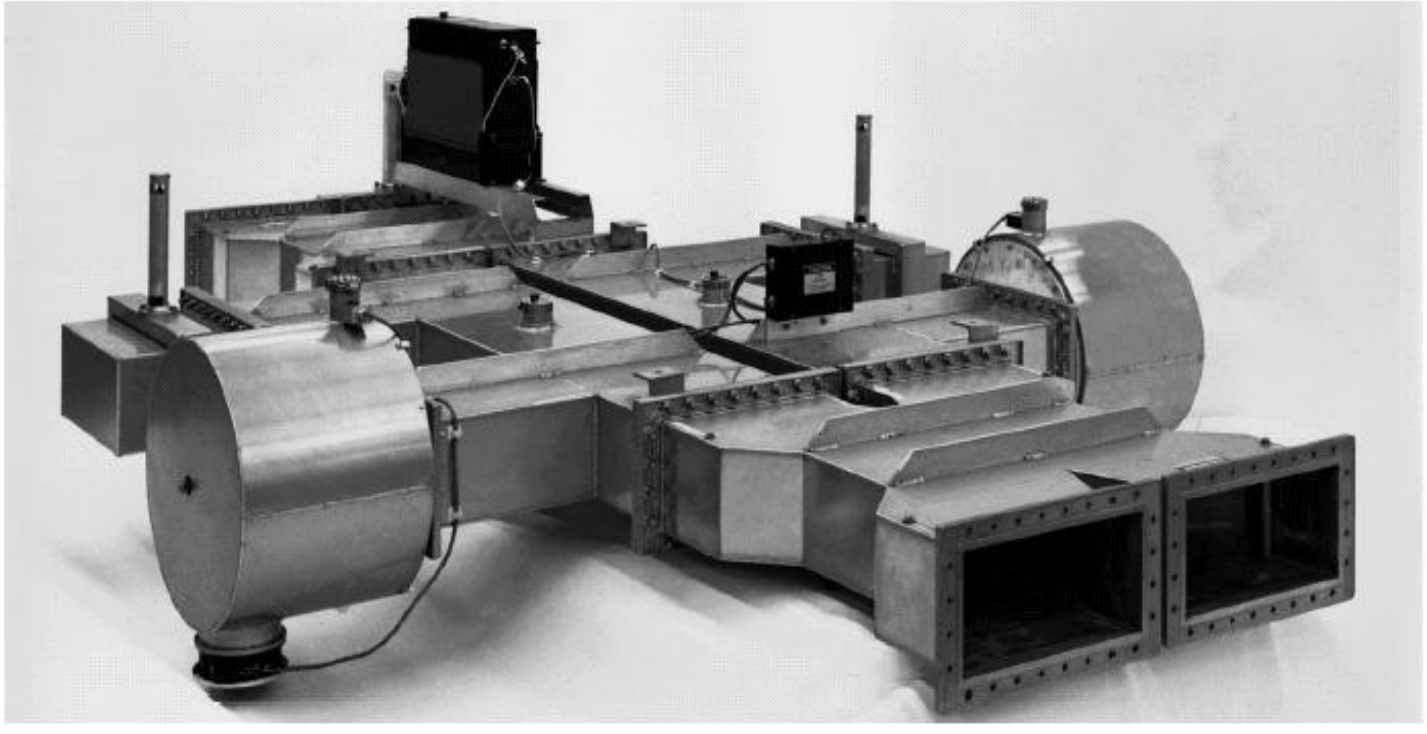
F1 = Portadora de Áudio F2 = Portadora de Vídeo

Porque 2 Transmissores Separados?

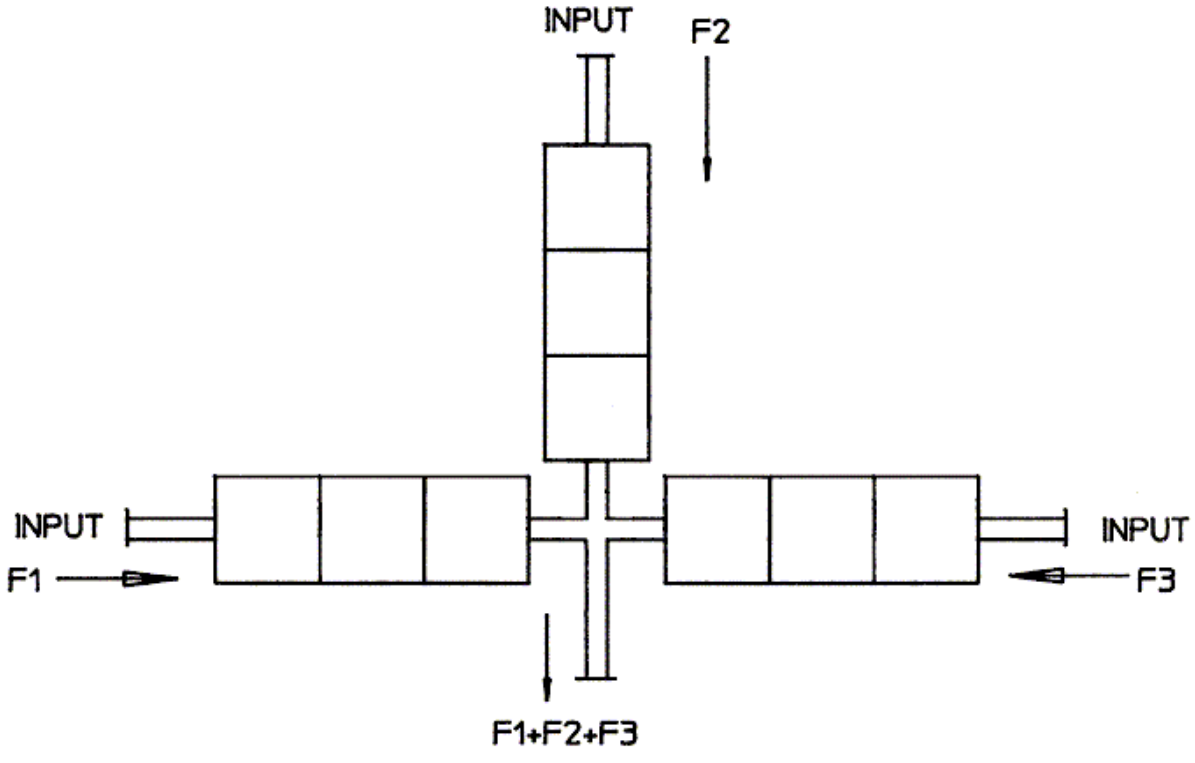




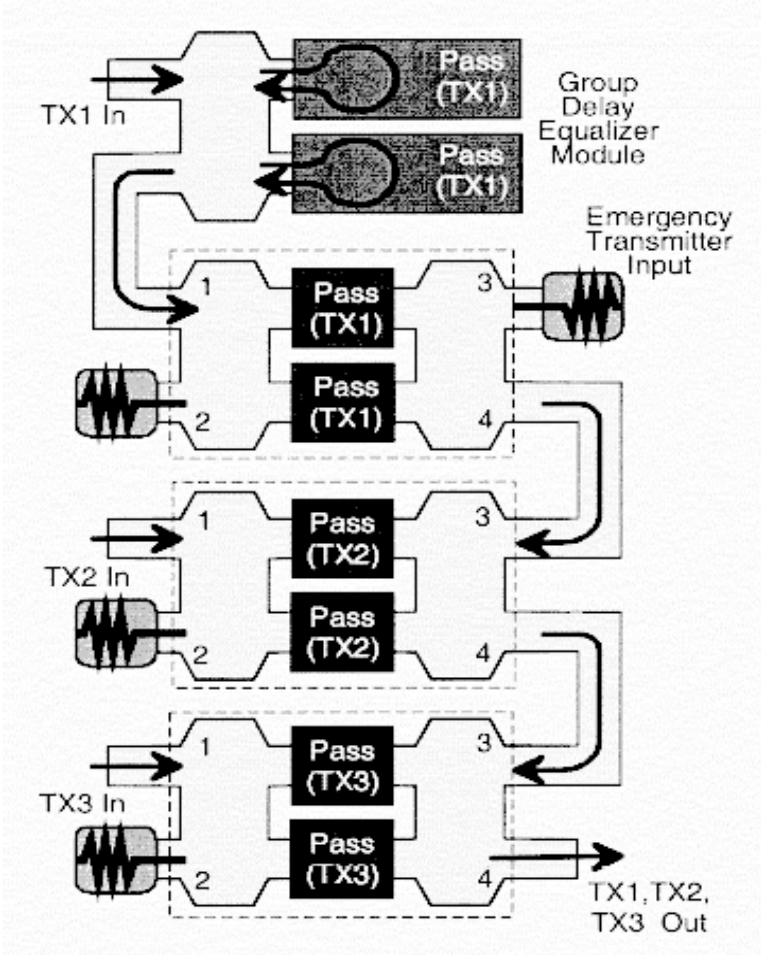
Diplexador por Guia de Onda



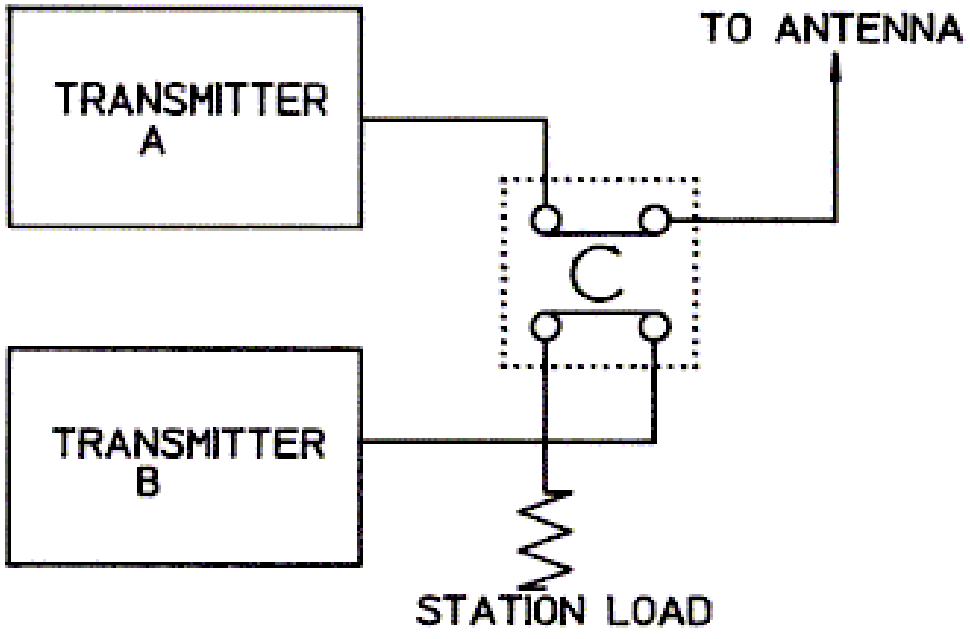
Combinadores para Frequências Diferentes



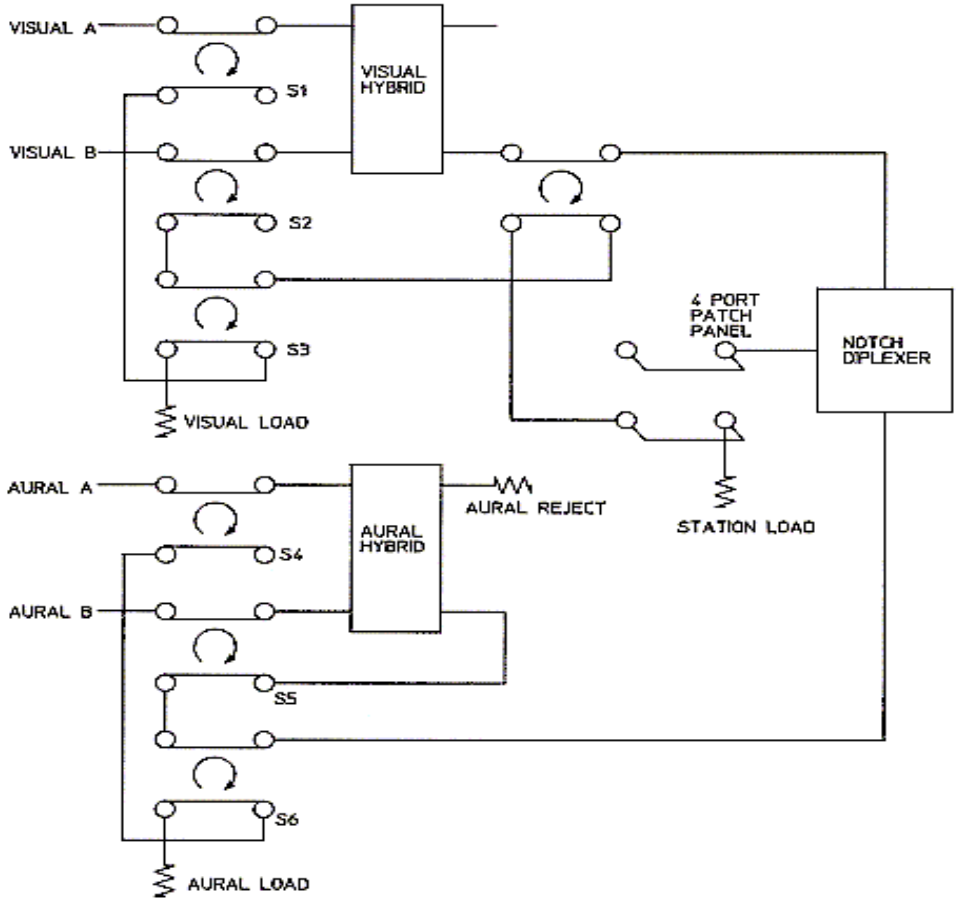
Combinador a Híbridas e Filtros Passa-Banda



Chaveamento de Transmissor de Reserva



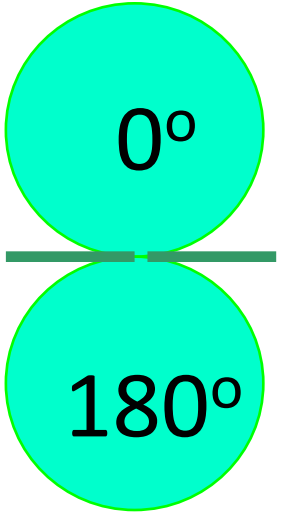
Transmissor Completo com Reserva/Paralelo



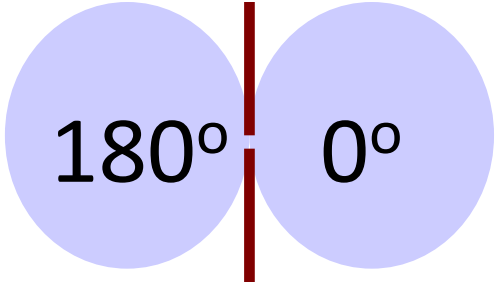
Antenas Transmissoras

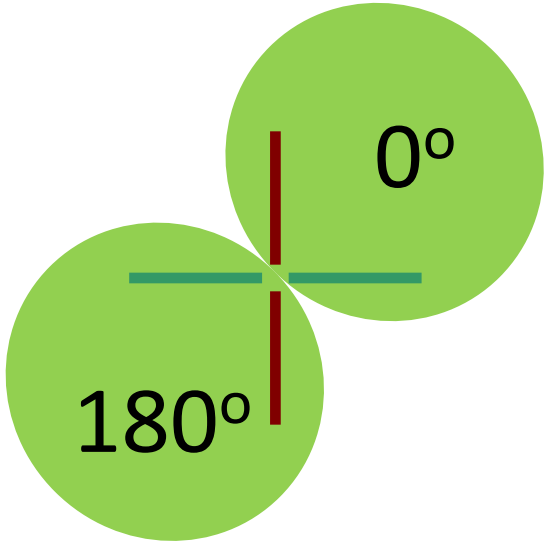
Antena Omnidirecional de Polarização Horizontal

Dipolo 1



Dipolo 2

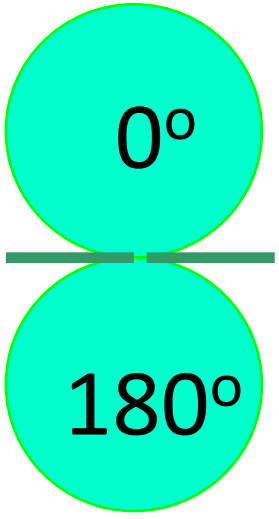




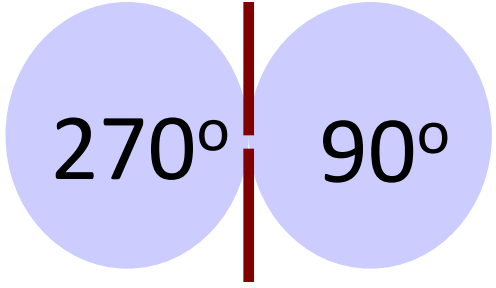
Dois Dipolos em Conjunto

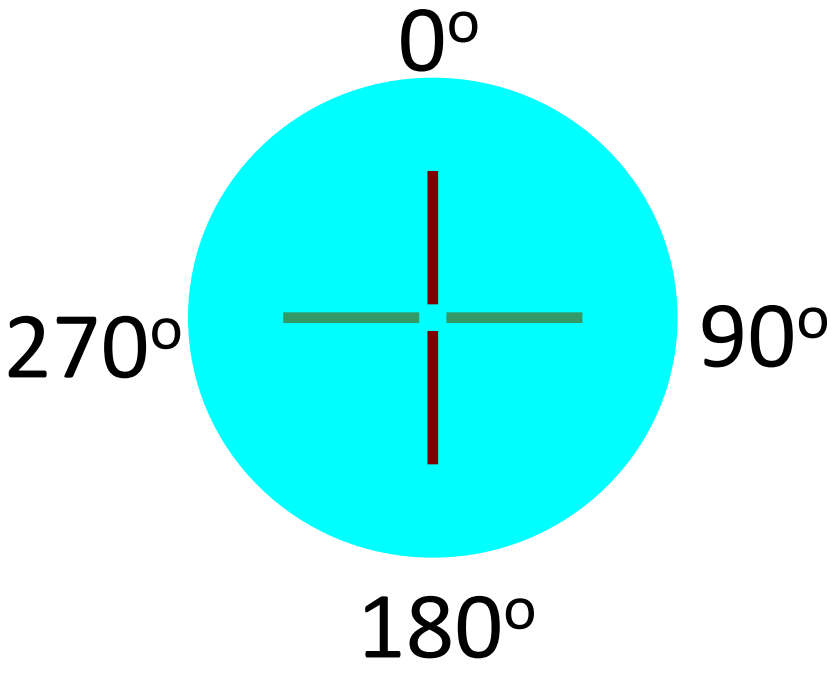
Antena Omnidirecional de Polarização Horizontal

Dipolo 1



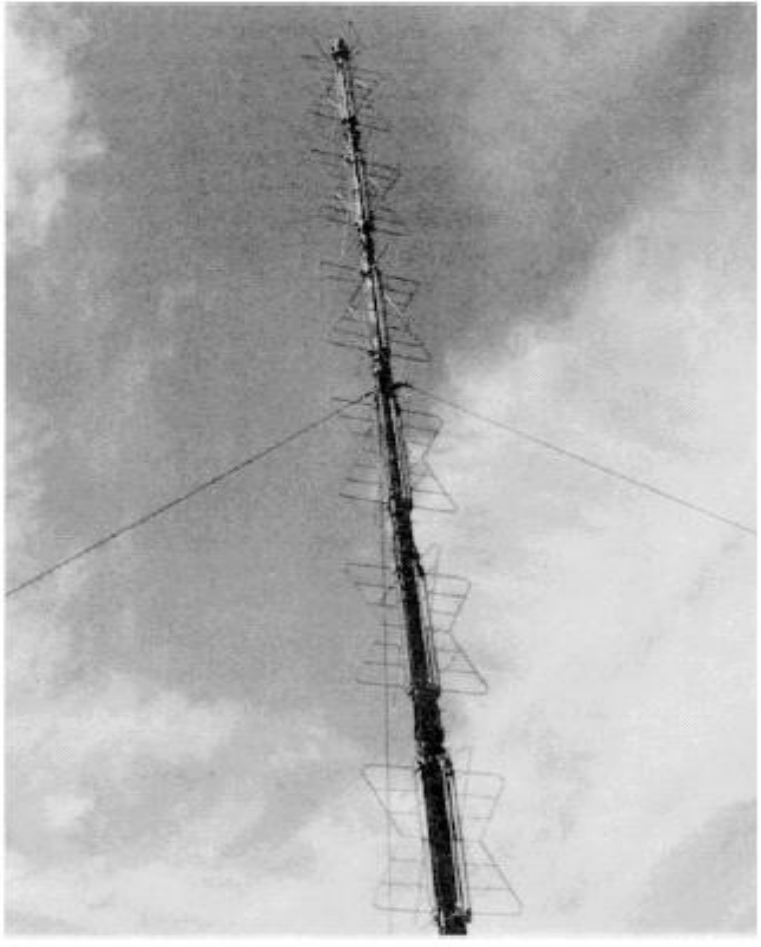
Dipolo 2
(quadratura)



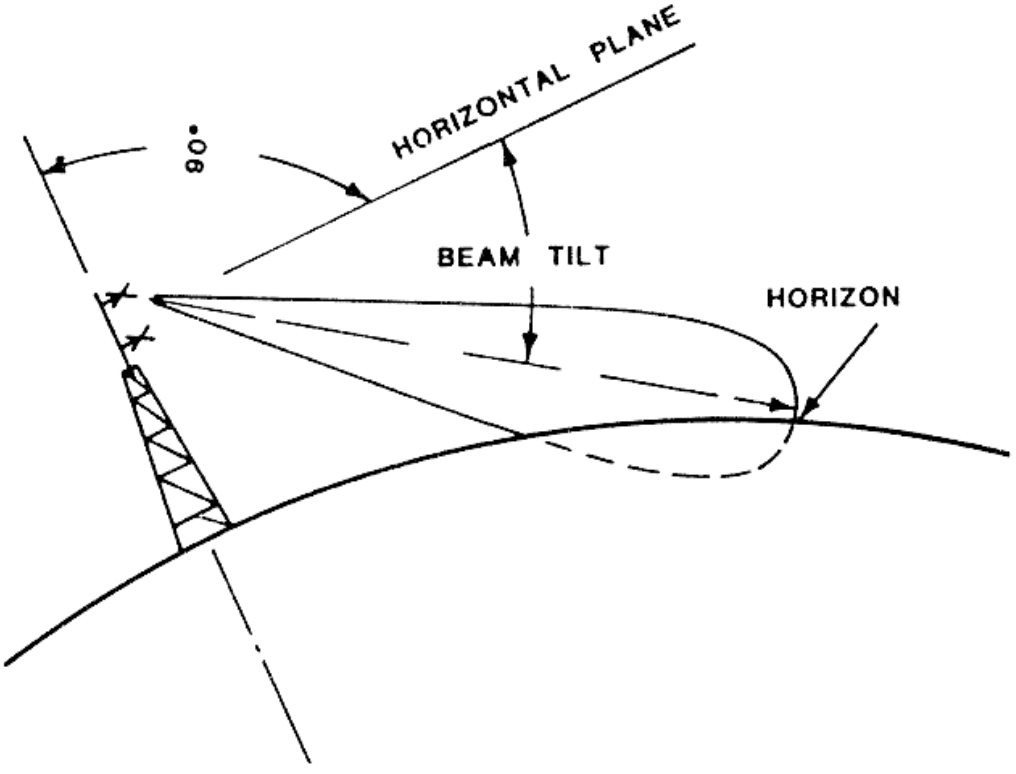


Dois Dipolos em Conjunto

Antena “Borboleta” de Múltiplas Seções



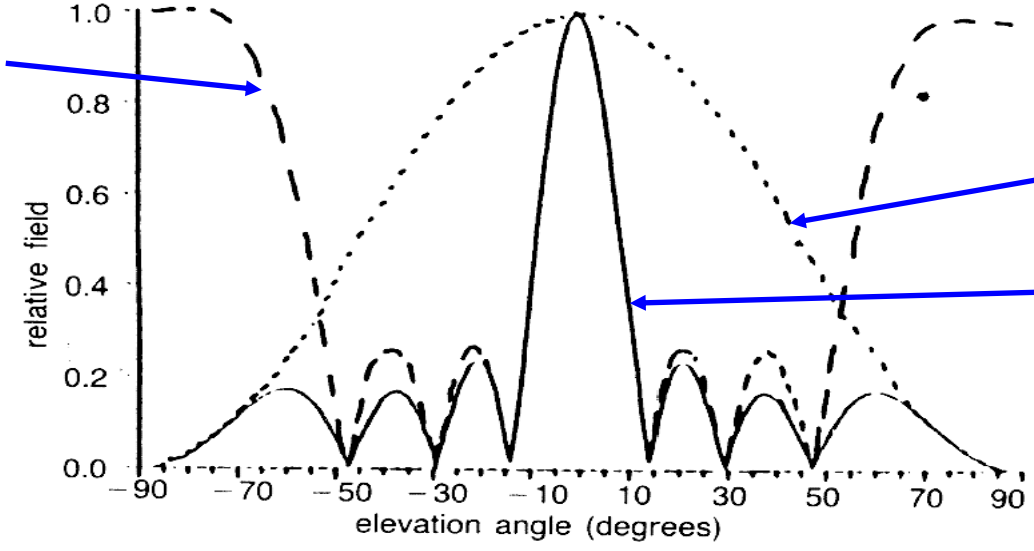
Padrão de Irradiação Vertical (Elevação)



Padrão de Irradiação Vertical

$$F(\theta) = E_n(\theta)\sum_{n=1}^{N} A_n e^{j\left[2\pi n s \operatorname{sen}\theta + \delta_n\right]}$$

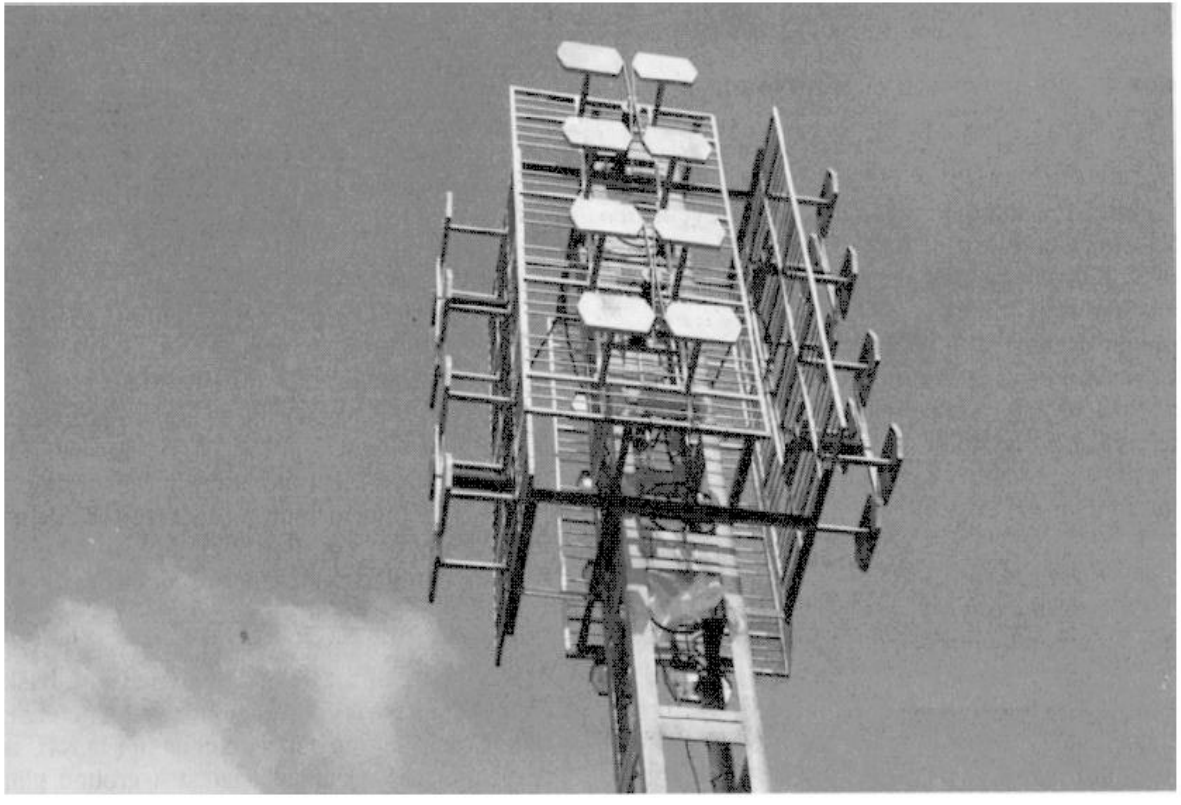
Padrão de Interferência (4 elementos)



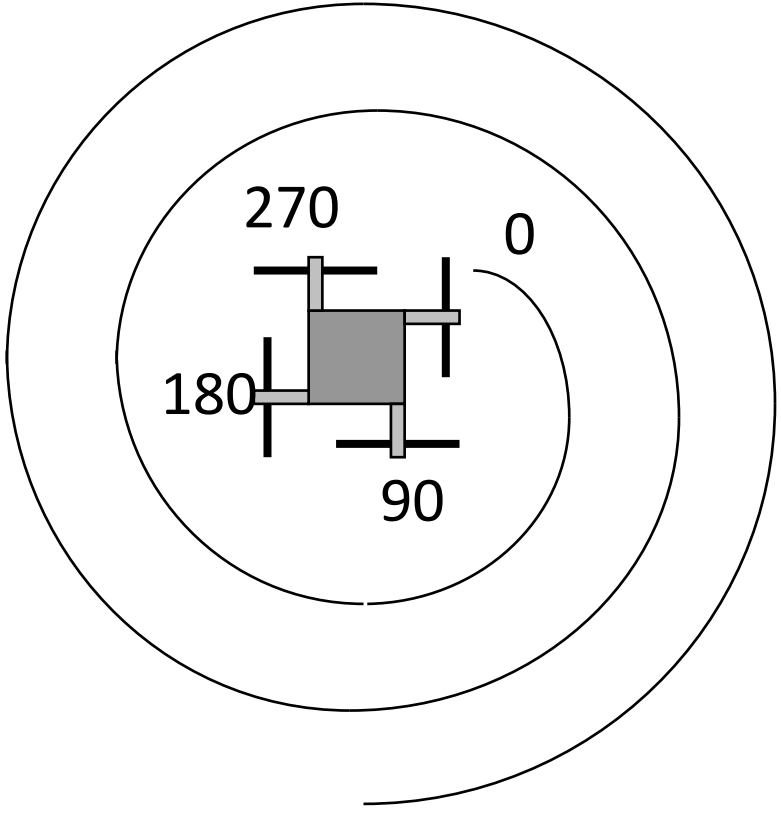
1 elemento

4 elementos
$s = 1.02\lambda$

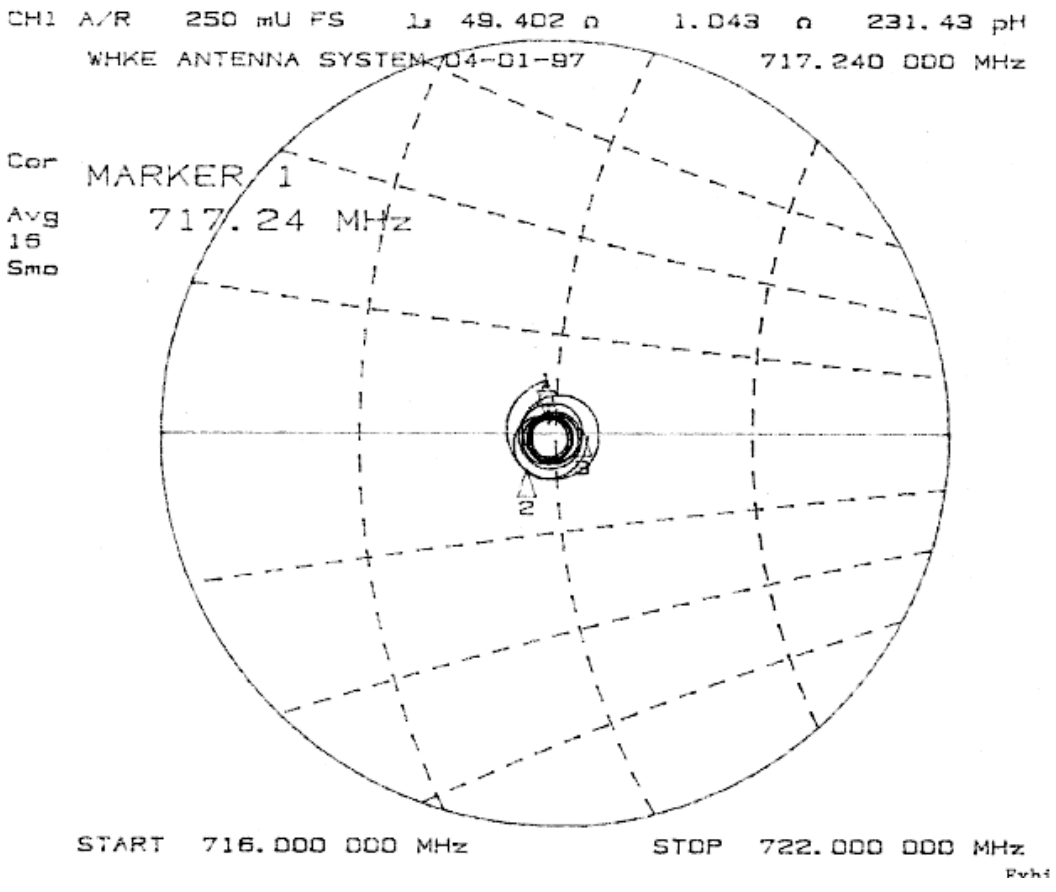
Antena tipo Painel com Dipolos Duplos



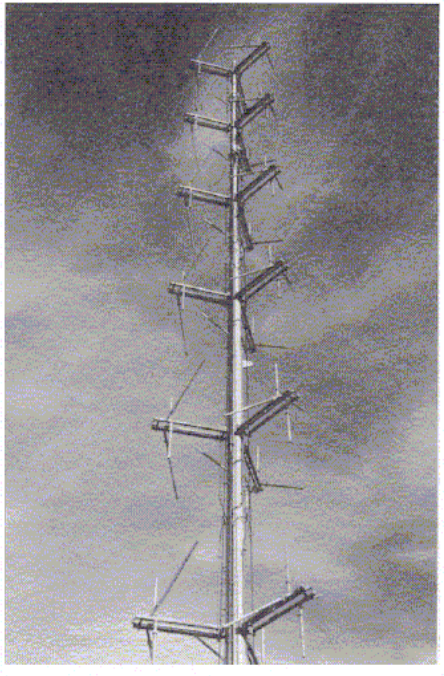
Radiação da Antena tipo Painel



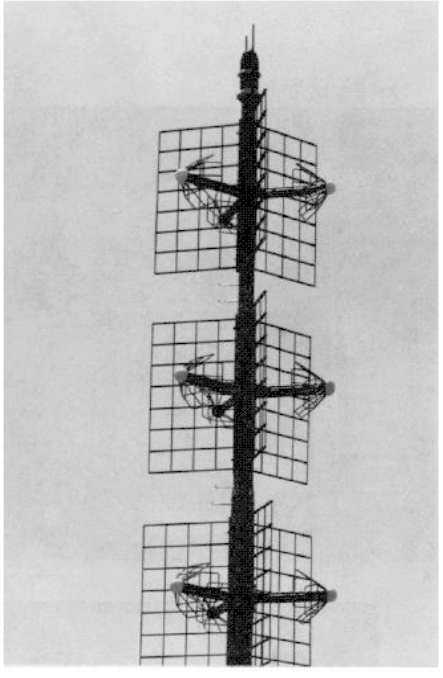
Casamento de Impedância na Antena



Antenas de Polarização Circular



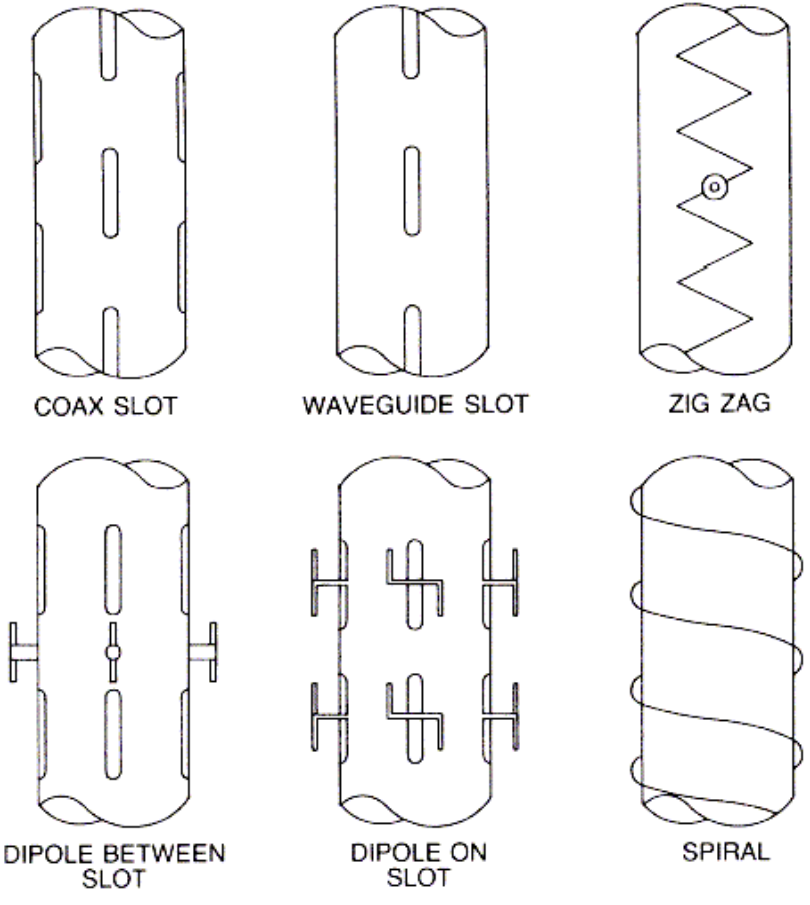
TDM



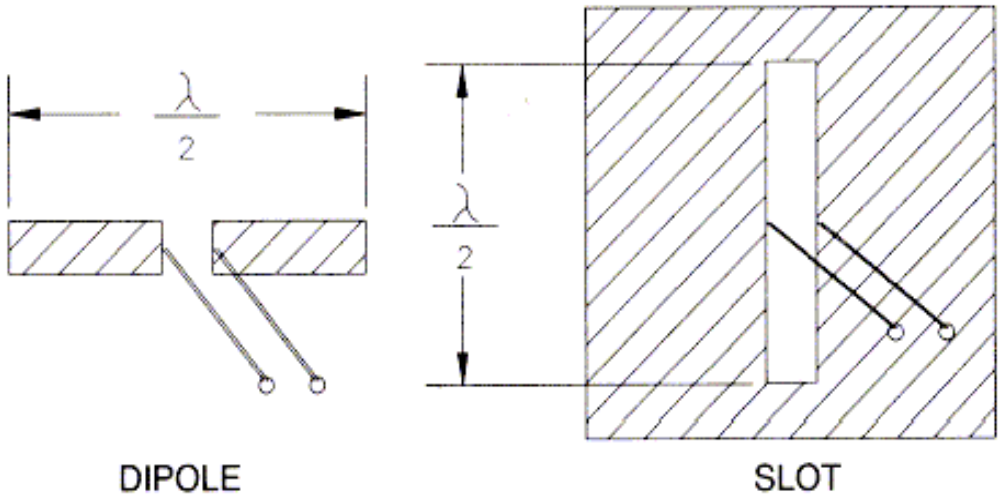
CPV

TDM= Transmission Dual Mode
CPV = Circularly Polarized "V"

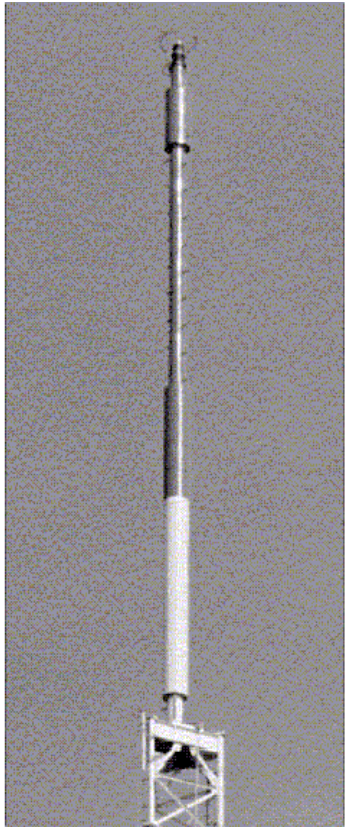
Antenas Fendidas (“Slot”)



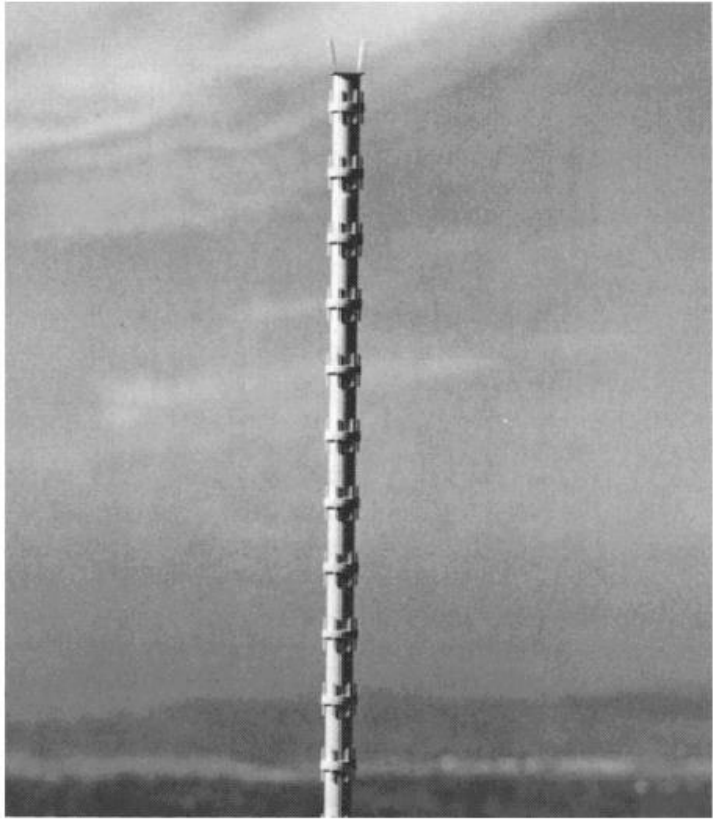
Equivalência do “Slot” com um Dipolo



Antenas Coaxiais

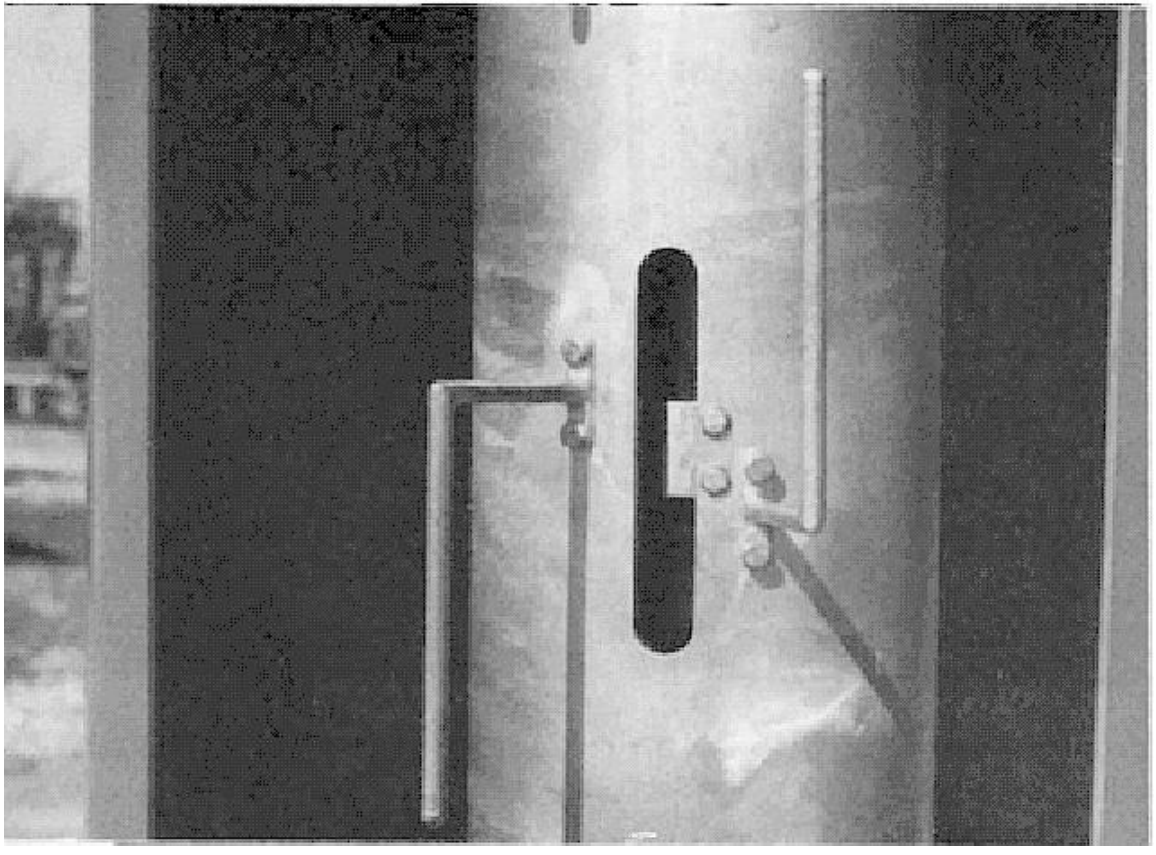


Polarização Linear



Polarização Circular

Detalhe de Antena “Slot” com Dipolo Auxiliar

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