ITU/ASBU Workshop on Frequency Planning and Digital Transmission

Damascus

DVB-T Transmission Systems

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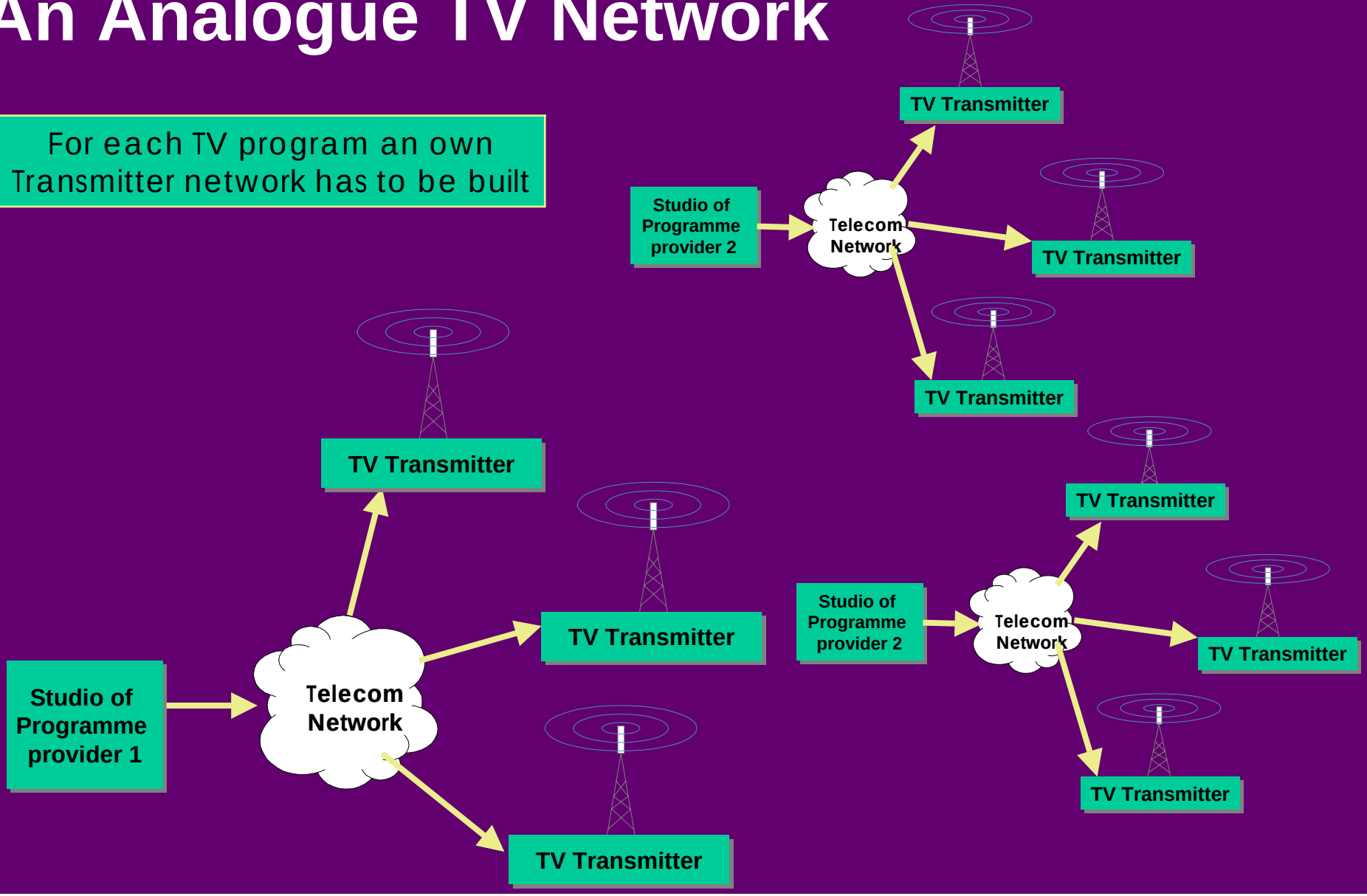
An Analogue TV Network

For each TV program an own Transmitter network has to be built



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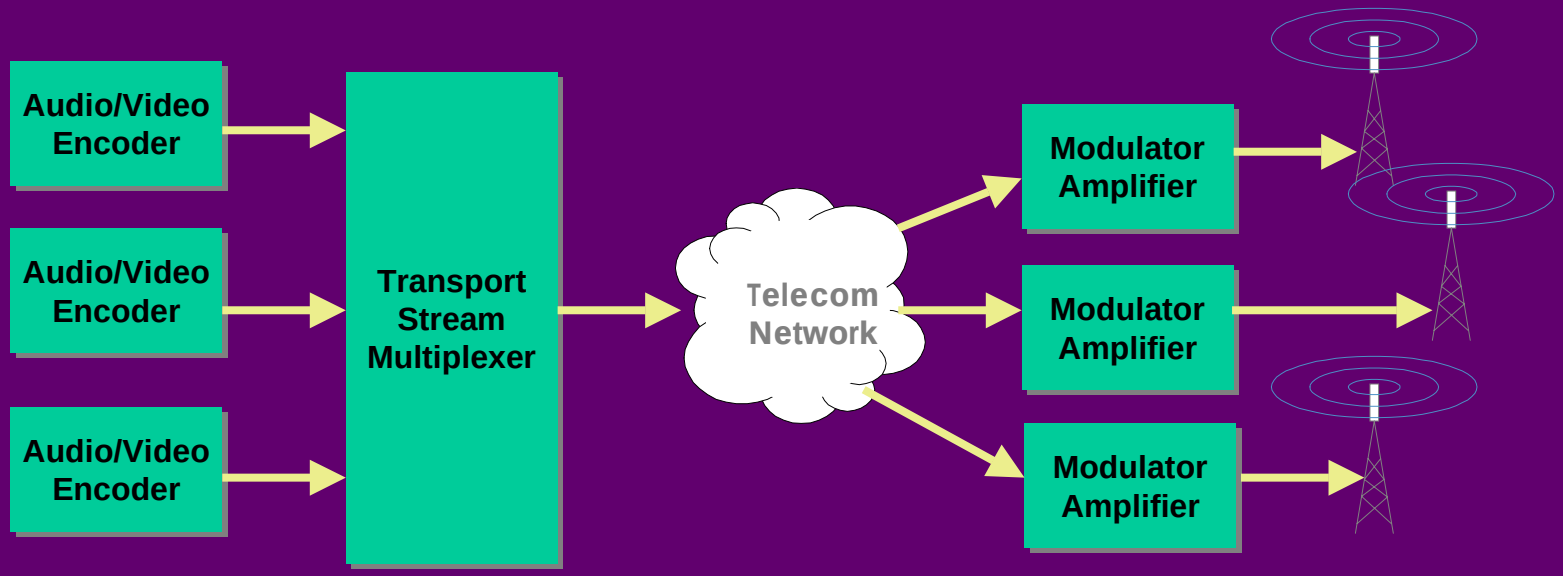
Digital TV Network



In a DVB-T structure several TV and Radio programs can share a common transmitter network

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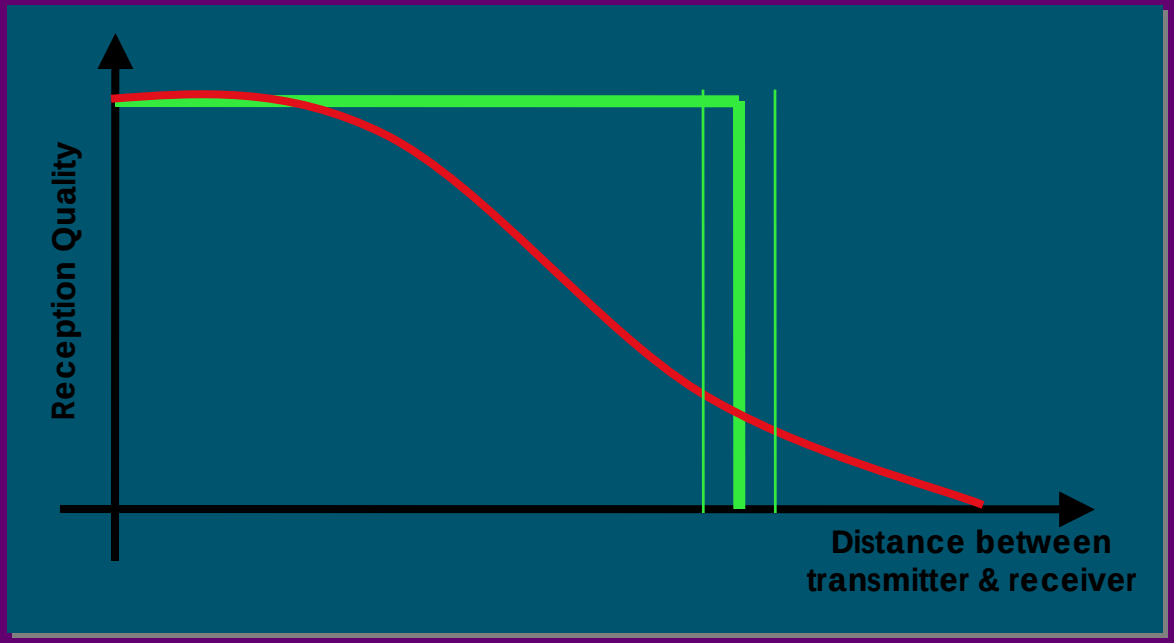
The Brick Wall effect



Analogue TV

The reception quality directly depending on the field strength. With growing distance the reception quality continuously decreases.

DVB-T

The transition from covered to not covered area is very sharp. The position can slightly vary according to atmospherical (weather) changes.

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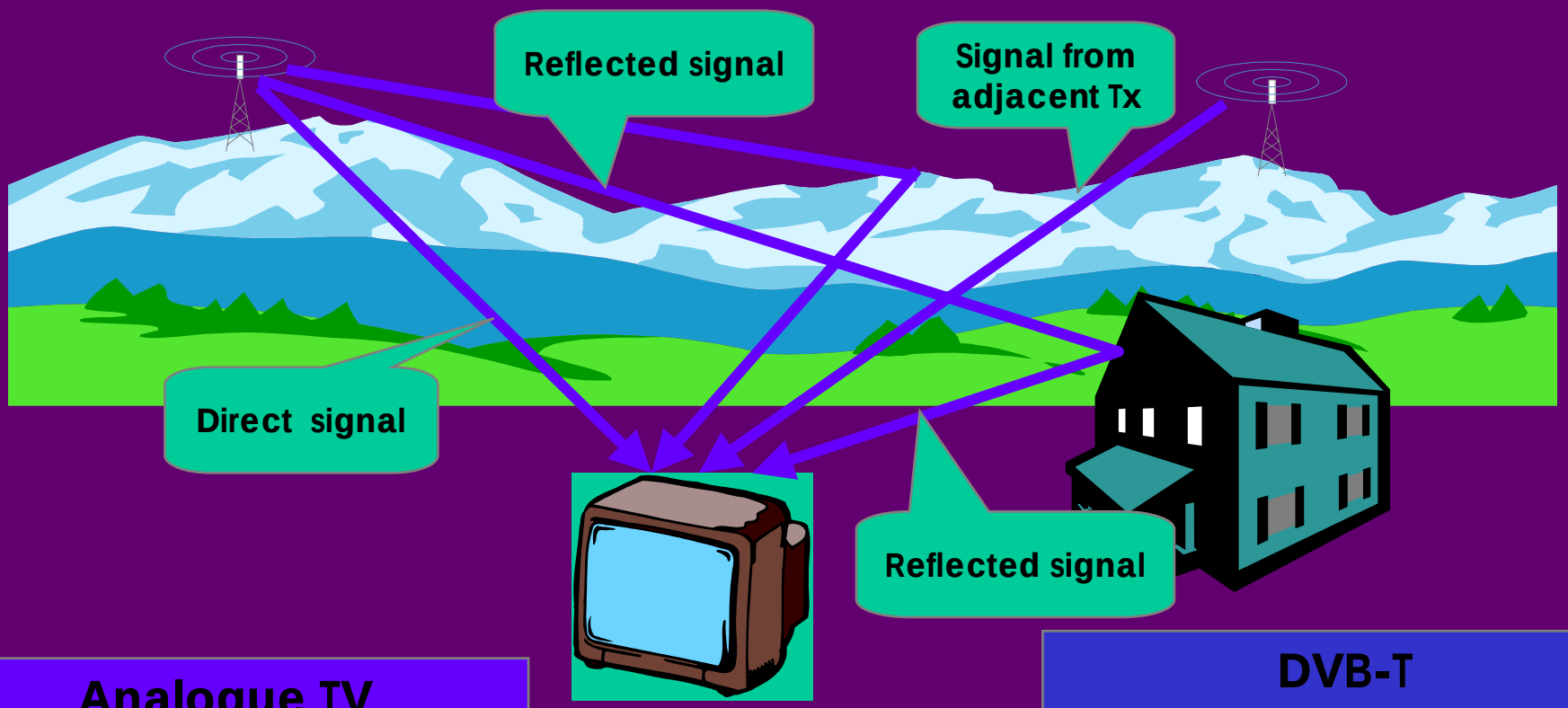
Multi path reception



Analogue TV

Multi path reception causes distortions (ghosting, signal loss)

DVB-T

Multi path reception does not influence the signal quality. Reflected signals can increase the received signal strength

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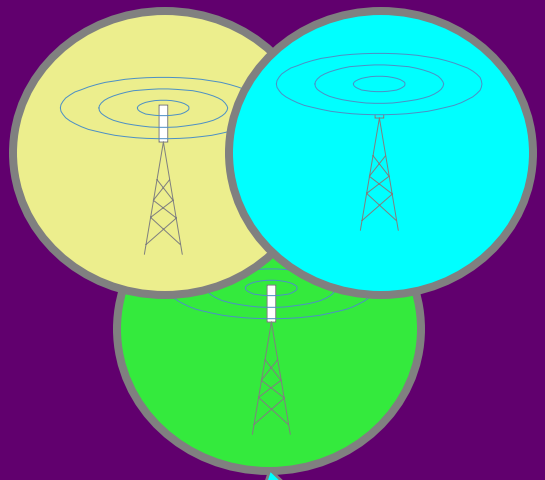
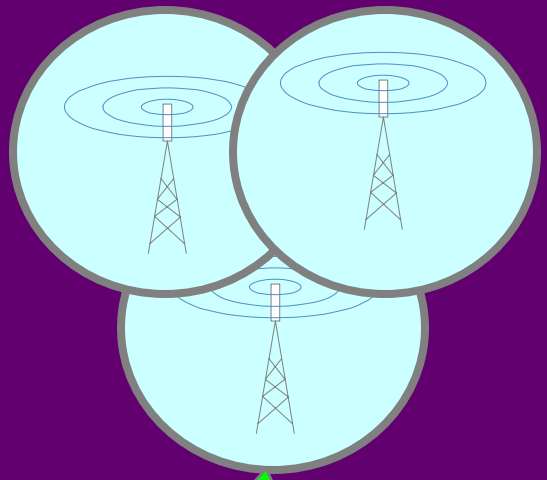
Frequency selection



Analogue TV

Multi path reception causes distortions or total signal loss adjacent transmitters have to be operated on different frequencies



DVB-T

Multi path reception does not influence the DVB-T signal quality, therefore adjacent transmitters can be operated on the same frequency

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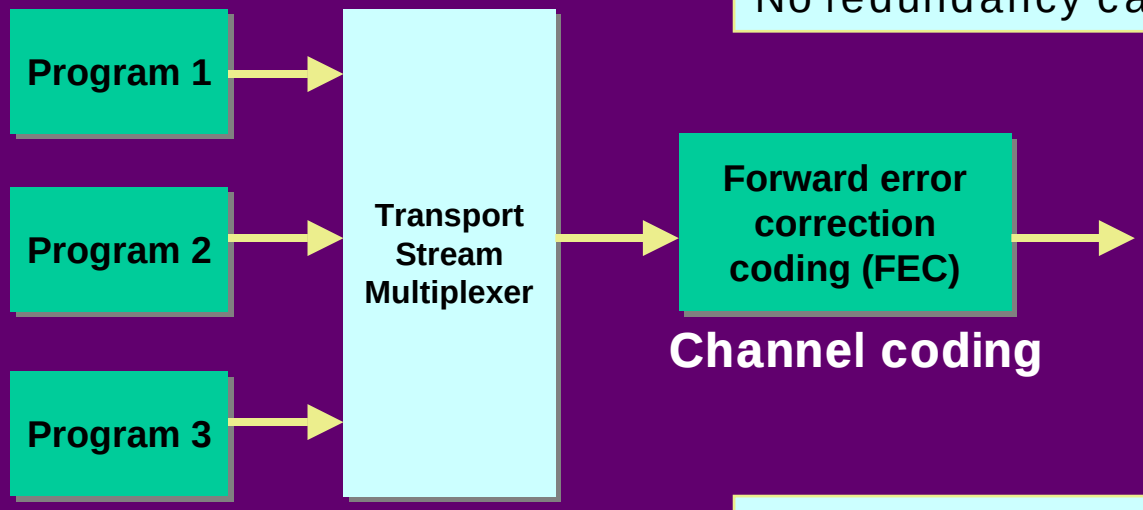
Channel coding & error protection

Analogue TV
Analogue modulation used.
No redundancy can be added to the signal



DVB-T
Redundancy can be added to digital signals for Forward error correction

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Modulation

- Key difference Digital v. Analogue transmission is the MODULATION

- **Digital uses COFDM**
  - (coded orthogonal frequency division multiplex)
- **Designed to be very rugged for terrestrial transmission**
  - Tolerant to echoes due to multipath, selective fading across the channel, even co-channel interference…
- **Achieved by spreading the data across very many closely spaced carriers in a normal VHF/UHF channel – either 2k or 8k**

COFDM

- Several possible modulation modes for COFDM are defined in ETSI EN-300744

  - **Choice to be made between available data rate against ruggedness of system**
    - **portable or mobile reception requires more error protection**
    - **more programmes in multiplex require higher bit rate**

  - **If a mode with high error protection is used, then the usable data rate is lower….**

Modes & usable bit rates (MB/S) in 8MHz channel

•Modulation	•Code Rate	•Guard •Interval			
		•1/4	•1/8	•1/16	•1/32
•QPSK	•1/2	•4.98	•5.53	•5.85	•6.03
	•2/3	•6.64	•7.37	•7.81	•8.04
	•3/4	•7.46	•8.29	•8.78	•9.05
	•5/6	•8.29	•9.22	•9.76	•10.05
	•7/8	•8.71	•9.68	•10.25	•10.56
•16-QAM	•1/2	•9.95	•11.06	•11.71	•12.06
	•2/3	•13.27	•14.75	•15.61	•16.09
	•3/4	•14.93	•16.59	•17.56	•18.10
	•5/6	•16.59	•18.43	•19.52	•20.11
	•7/8	•17.42	•19.35	•20.49	•21.11
•64-QAM	•1/2	•14.93	•16.59	•17.56	•18.10
	•2/3	•19.91	•22.12	•23.42	•24.13*
	•3/4	•22.39	•24.88	•26.35	•27.14
	•5/6	•24.88	•27.65	•29.27	•30.16
	•7/8	•26.13	•29.03	•30.74	•31.67

*

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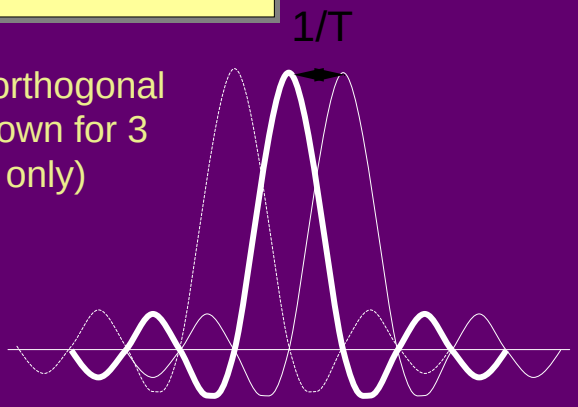
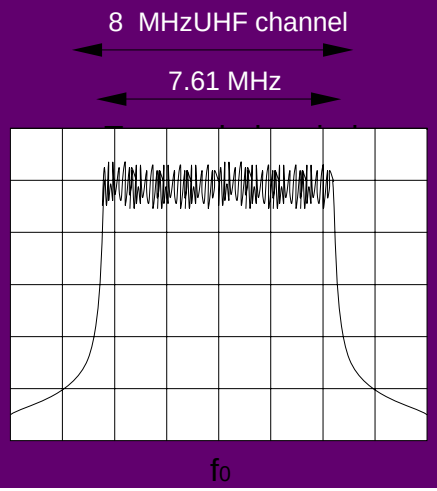
Typical Transmission Parameters

Coded Orthogonal Frequency Division Modulation (COFDM) is used for transmission, the 2k version is used for UK DTT

Number of carriers	1705
Number of pilot carriers	193
Modulation	64 QAM (6 bits per carrier)
Outer coding	2/3
Duration T	224us
Guard Interval	1/32
Guard duration	7us
Total Symbol duration	231us
Carrier spacing	4464 Hz
Overall spacing (kmin to kmax)	7.61 MHz
Offset frequencies	-167kHz, 0, +167kHz

Example of orthogonal carriers (shown for 3 carriers only)





Complete COFDM spectrum

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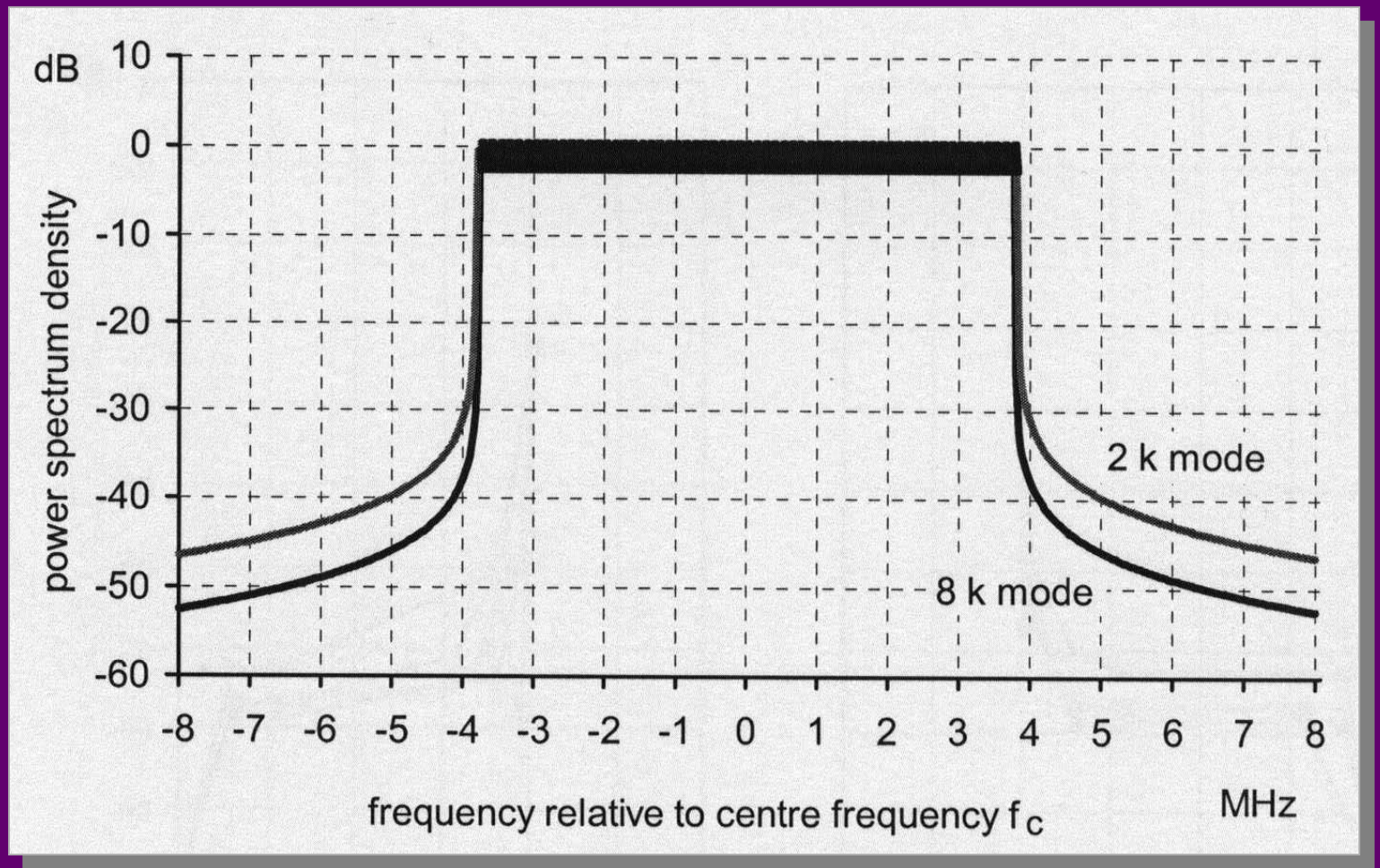
Theoretical COFDM spectrum shape



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Choice of channels

- Channels in the same part of the band…
  - are more suitable for sharing the same antenna (both transmit and receive)
    - impedance match across channels
    - horizontal & vertical patterns similar
    - coverage similar
      - important for viewers to easily receive all services

- But *adjacent* channels require great caution to minimise interference
    - We have seen how an ideal cofdm spectrum spreads
    - Non-linearity in a transmitter causes significant Intermodulation Products (IPs) over a wide bandwidth
      - these must be minimised and filtered

Transmitter performance requirements

- DTT transmitter basic requirements are similar to analogue:
  - Accept baseband signal and produce modulated r.f. at the required output channel and power
  - Have adequate linearity to minimise IPs
    - A combined Vision & Sound analogue amplifier must be de-rated by approximately 4dB for adequate DTT linearity
    - Must have a pre-corrector followed by enough bandwidth through the system to enable IPs over at least ±12MHz to be corrected
  - Have adequate Group Delay
    - <500nS, a small percentage of the symbol's Guard interval
  - Have local oscillator with good phase noise

Monitoring Transmitter performance (MER)

- Modulation Error Ratio (MER) measures the constellation *positions*, so it does not depend on modulation *content*
  - can be measured during normal programme
  - measured over several symbol periods so provides a quick and repeatable result
  - ideal for checking if main transmitter is faulty
  - ~29dB MER = transmitter failure point (too much END)

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Analogue Transmitter at Crystal Palace (Klystron Amplification)

80kW peak sync Vision

1MW ERP

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Digital Transmitter at Crystal Palace (Solid State Amplification)

1kW mean OFDM

10kW ERP

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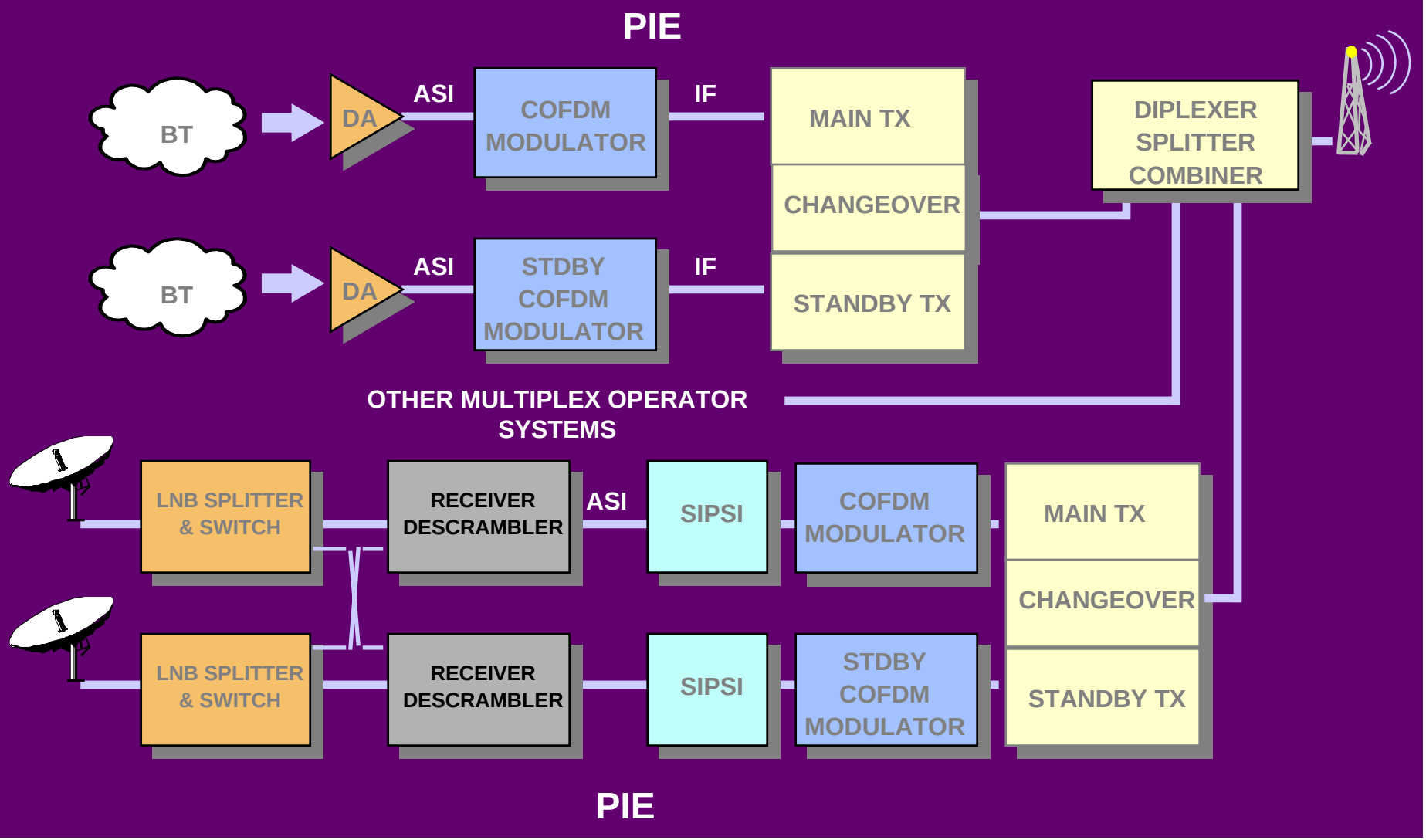
Transmitter PIE



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Availability of Service

- **One of a Broadcaster's main requirements is *Availability of Service* to his viewers**
  - must be able to receive programmes with as few interruptions as possible
- **One reason for losing service is *loss of signal level***
- **Unlike analogue pictures, demodulated digital pictures do not become increasingly noisy as the S/N ratio falls**
  - **The error rate increases very slowly, until a point is reached where the picture fails very quickly…**

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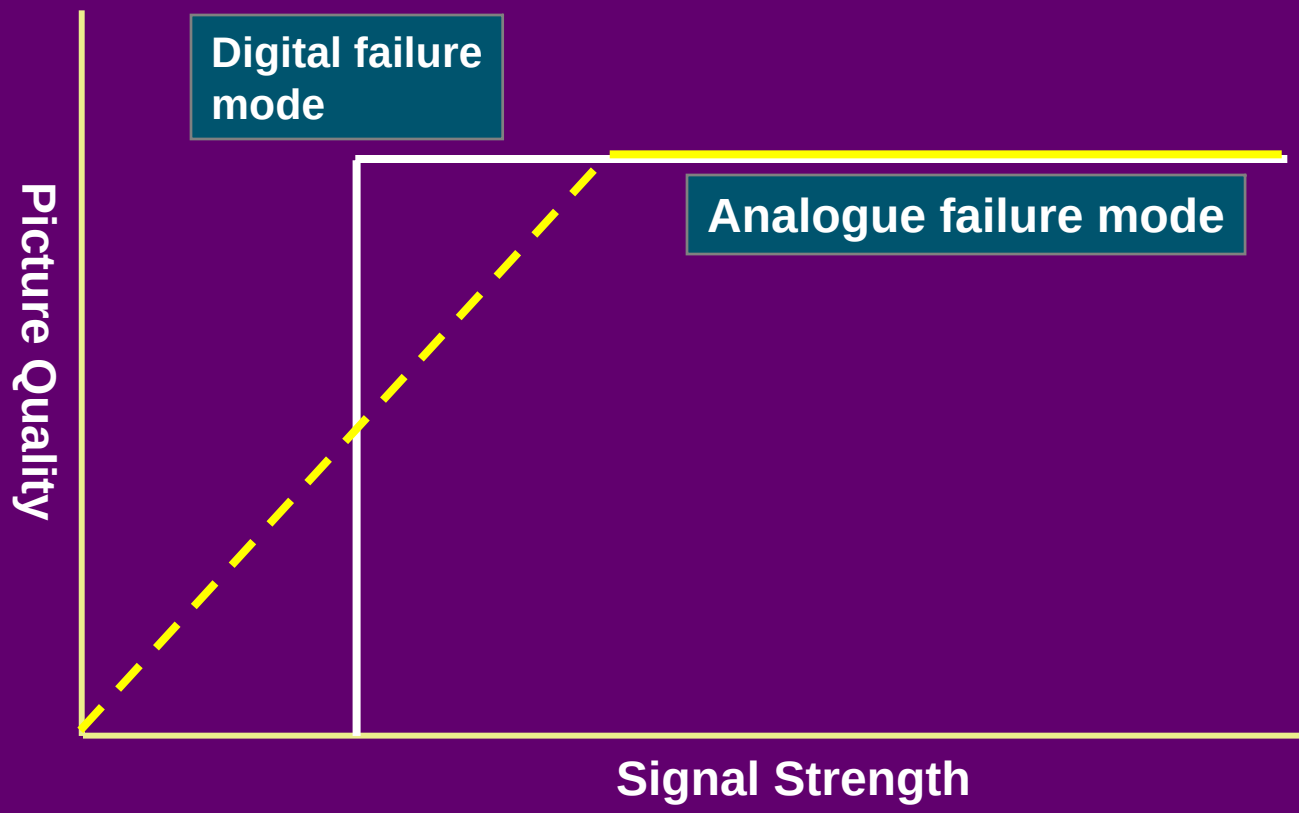
DIGITAL / ANALOGUE FAILURE MODES



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Antenna system requirements

- Build in two halves
- Share analogue antenna if possible!
  - Best position on mast
  - Probably omni-directional Horizontal Radiation Pattern
  - Provides similar coverage to existing services
- Check both power and voltage ratings
  - COFDM carriers can add in phase, producing high voltages
  - Peaks limited by amplifier, but expect 12dB peak - mean

Antenna system restrictions

- It may be necessary to include restrictions in HRP
- If several Multiplexes require different HRPs then a separate antenna for each may be best
  - Coverage of each MUX is optimised
  - results in locations which cannot receive all MUXs
  - shown in the following slides...

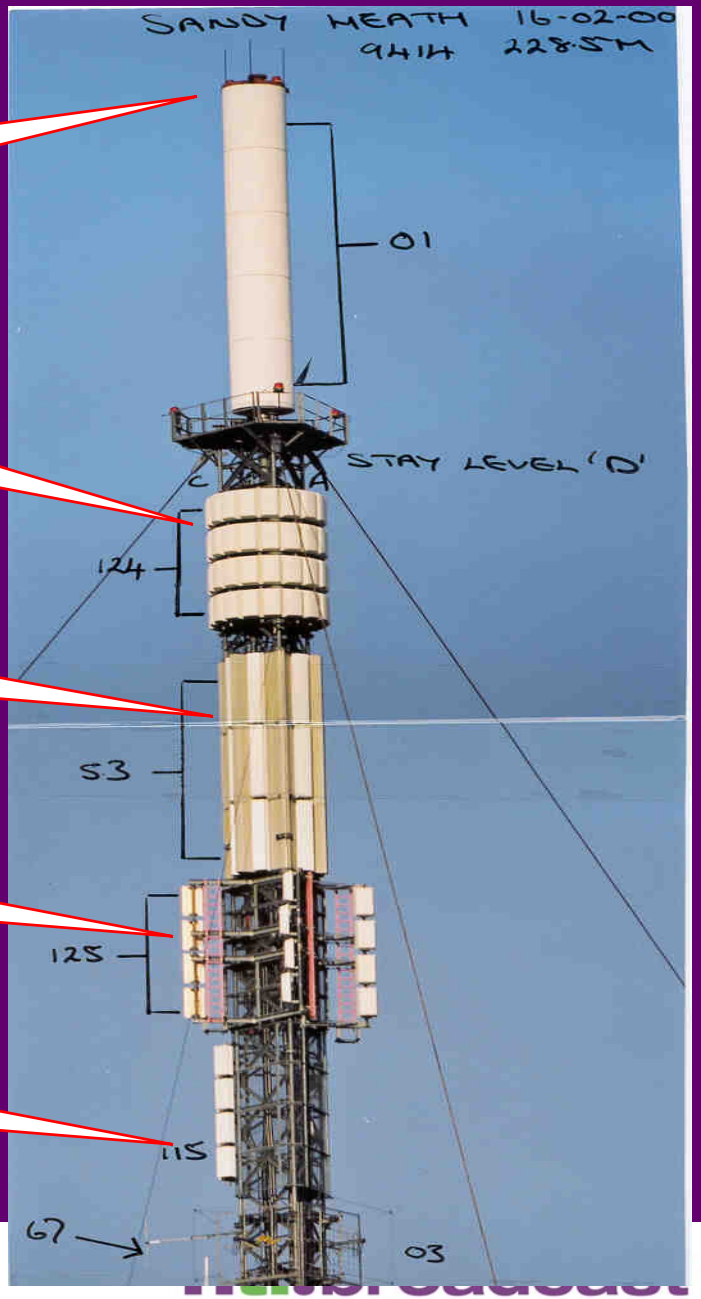
UHF ANALOGUE MAIN CANTILEVERED ANTENNAS (BBC1/BBC2/ITV/C4)

UHF DTT 4 CHANNEL RADIAL FIRE 16T x 4T (KATHREIN) D1 ANTENNA.

ANALOGUE RESERVE SINGLE ENDED ANTENNA (BBC1/BBC2ITV/C4)..

UHF DTT 1 CHANNEL SKEW FIRE D2 ANTENNA

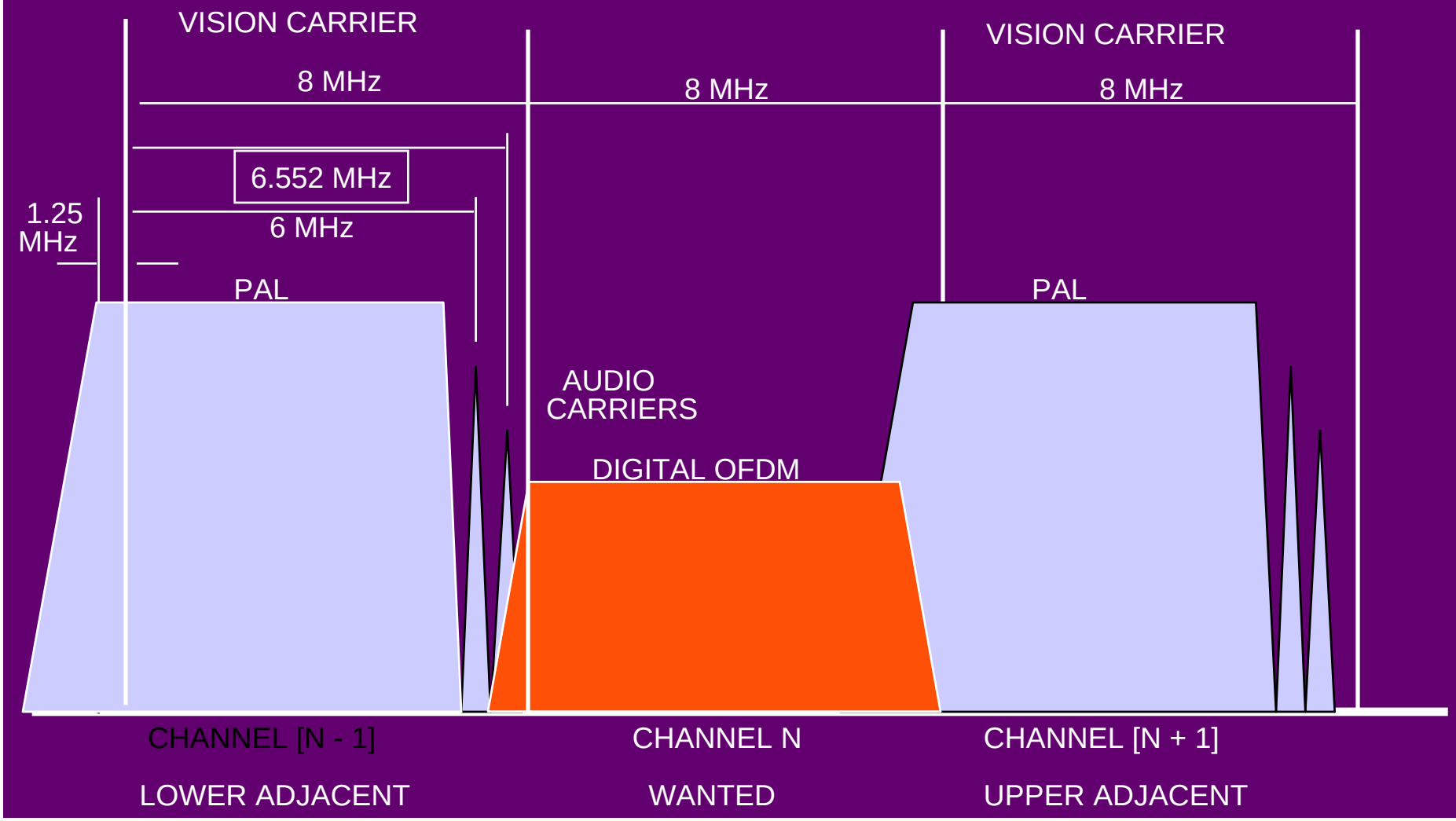
UHF C5 ANALOGUE ANTENNA



Issues with adjacent channels

- As already seen, cofdm spectrum spreads across adjacent channels, even when linearity pre-corrected
- Frequency spacing between adjacent channel services is very small
- If an Analogue service is upper adjacent to Digital MUX, then its vestigial sidebands must be filtered too...

Signal Spectrum In Adjacent Channels



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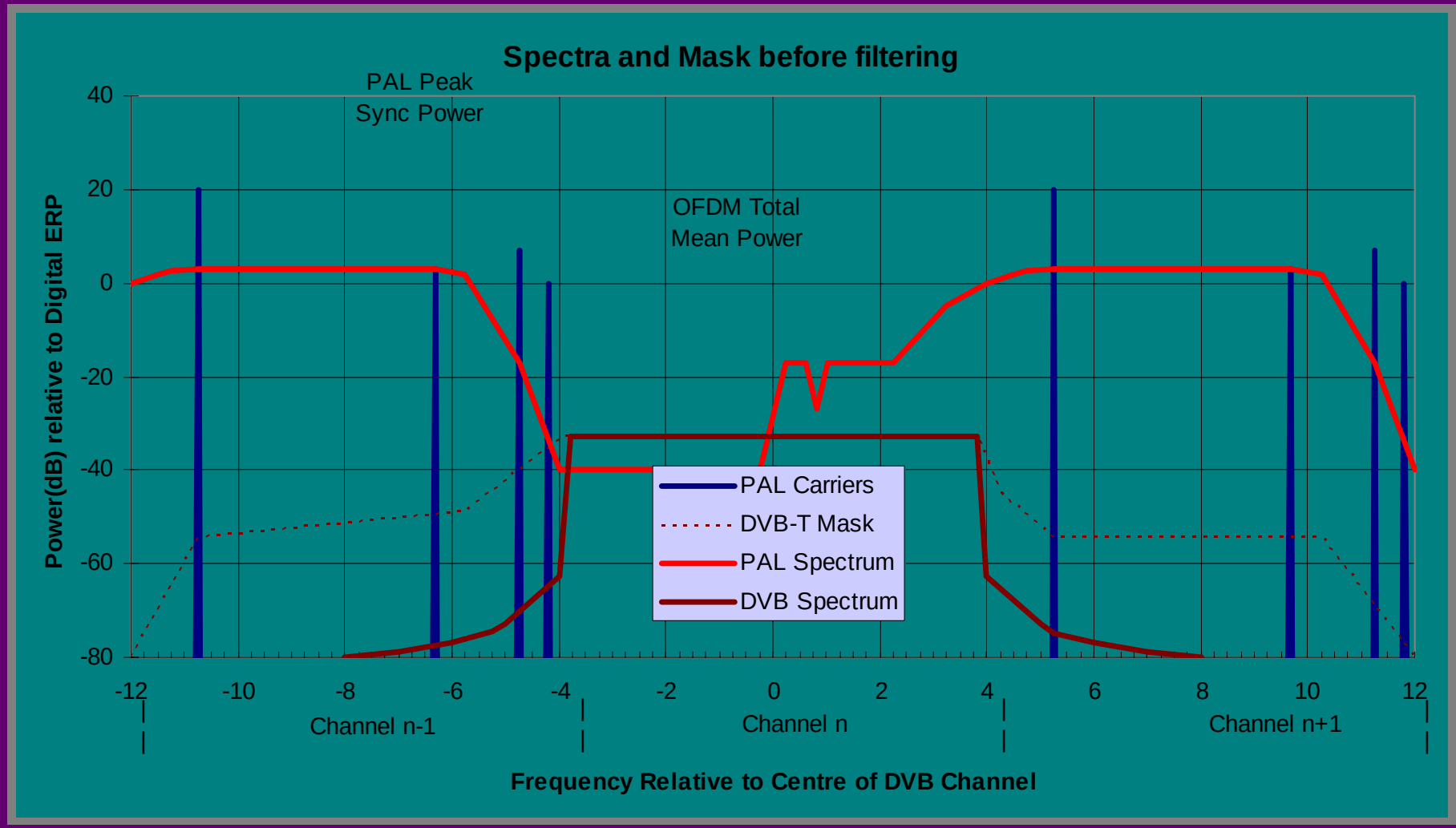
Adjacent DTT/Analogue before filtering



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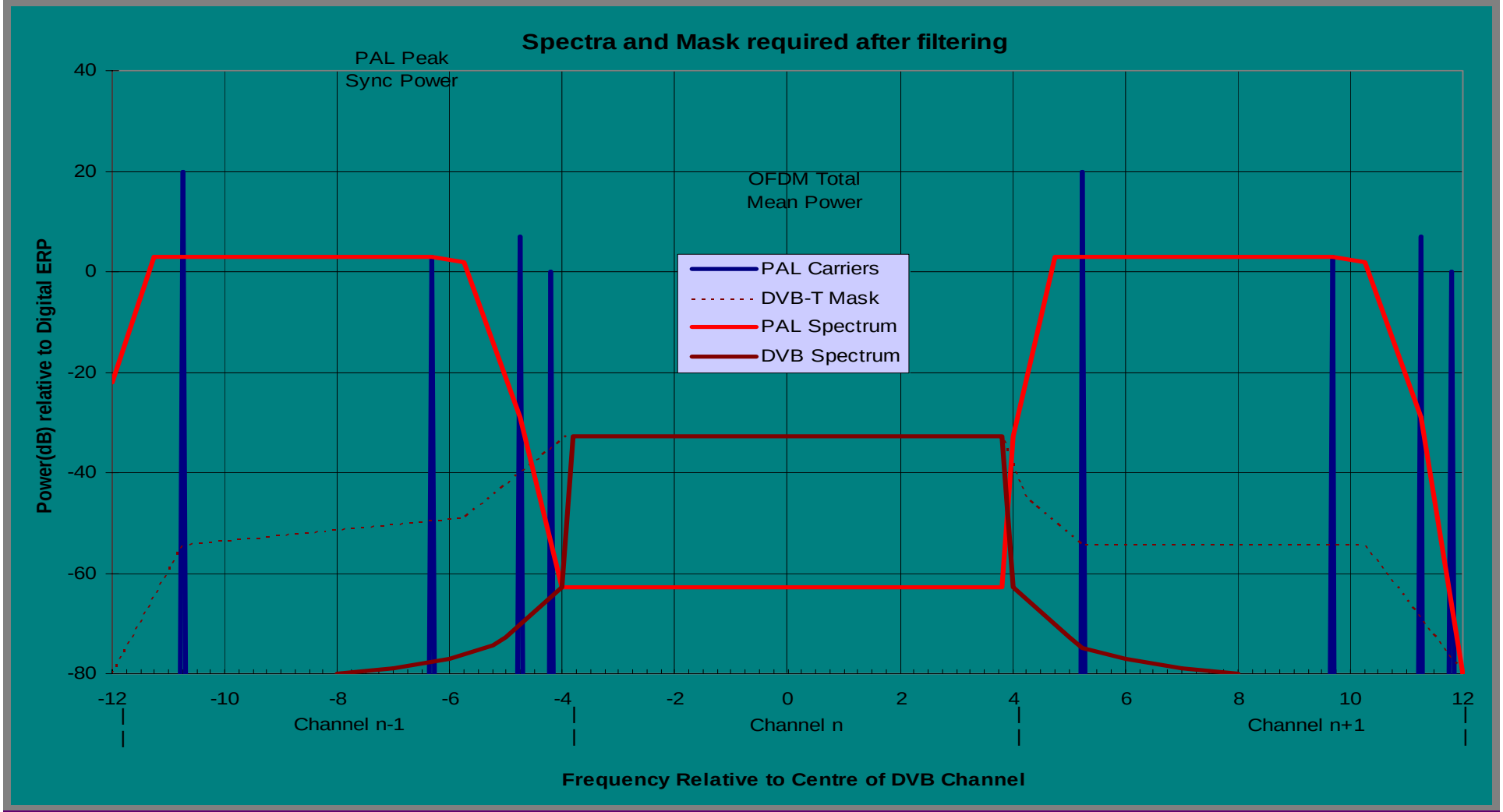
Adjacent DTT/Analogue after filtering



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Belmont DTT building

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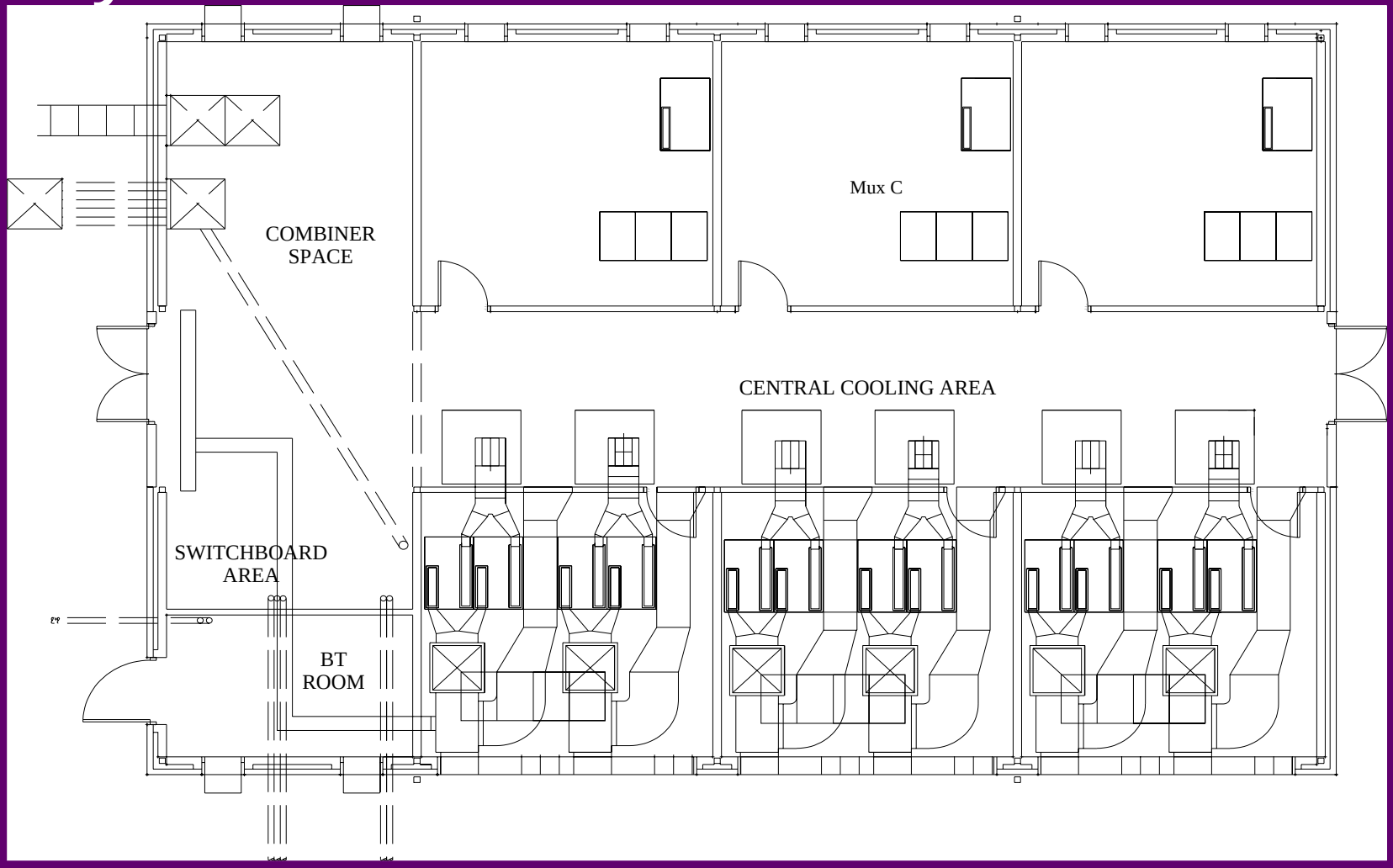
Typical main station layout



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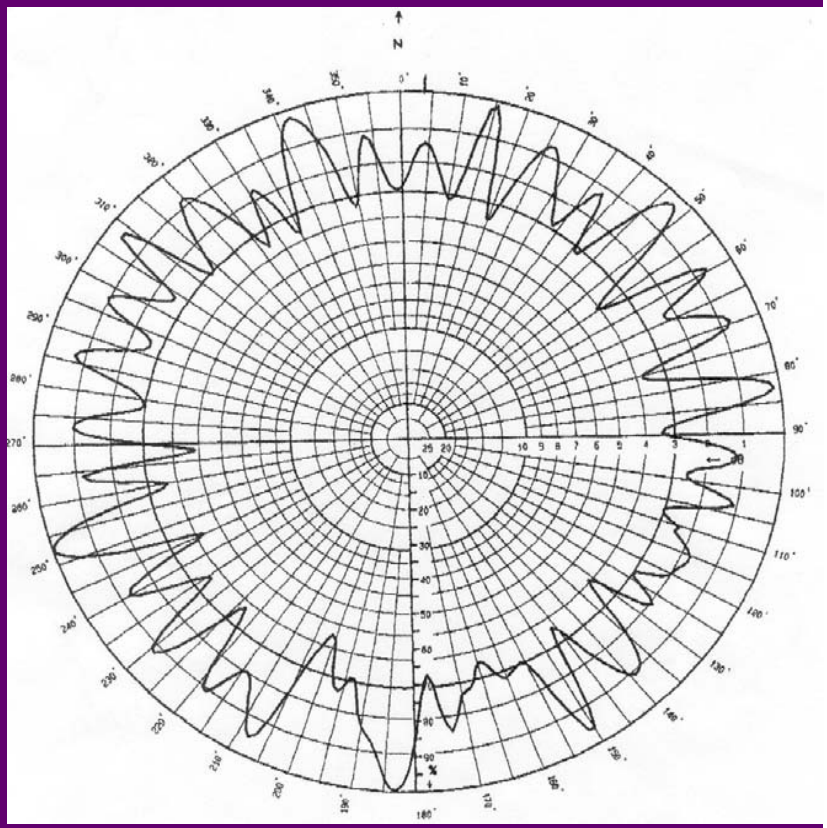
Skew Fire Antenna



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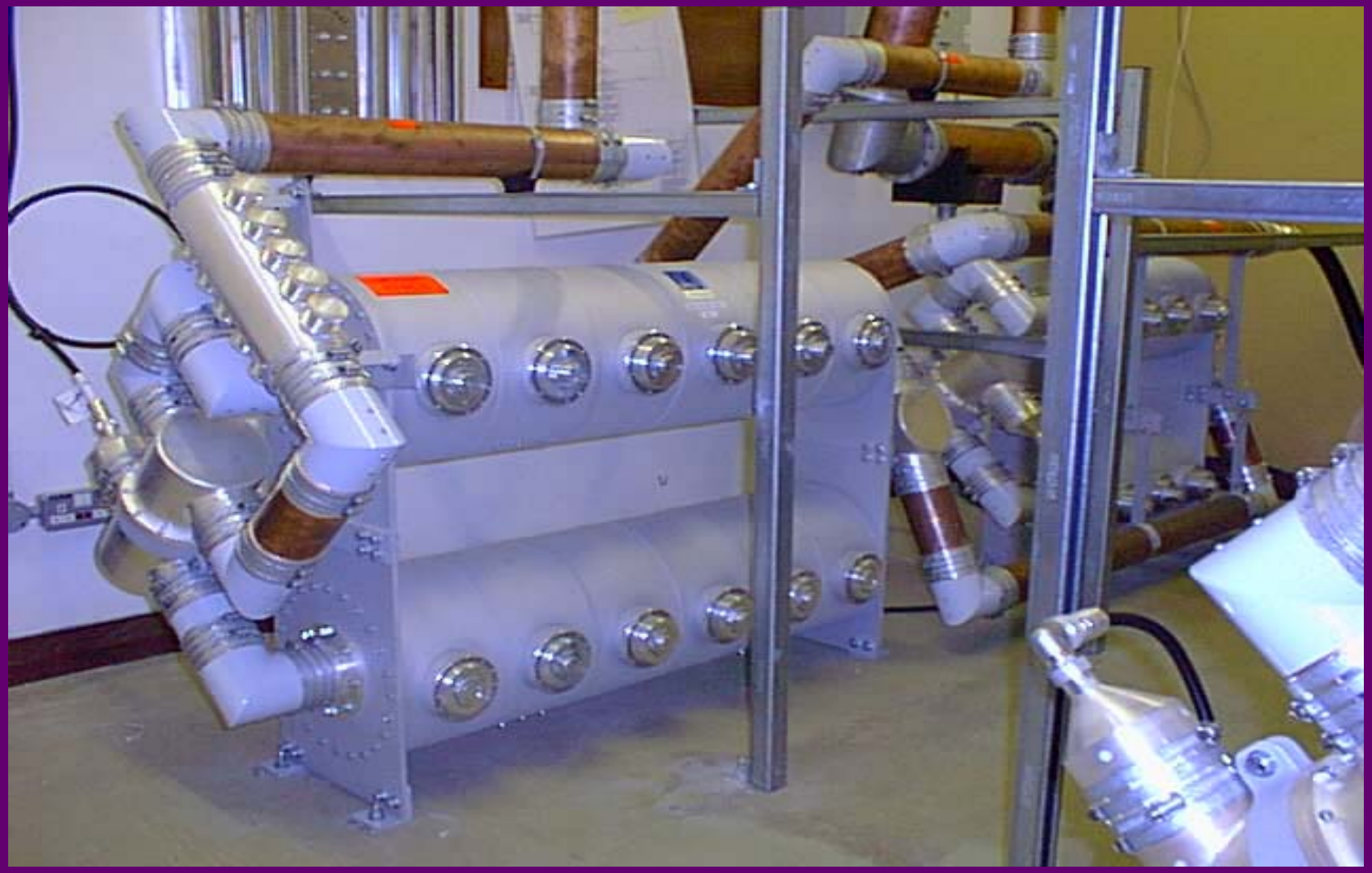
PONTOP PIKE ANALOGUE/DTT CU



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