



ENGINEERS
AUSTRALIA

Communications

Teacher Development Program
Bringing Schools and Engineering together

Dr Steve Mitchell





My Background

- 7 year Engineering Traineeship after my HSC at A.Goninan & Co Pty Ltd
- Bachelor of Electrical Engineering in 1994
- Worked in various industries with a focus on electronics
- Began my PhD in 2002 whilst at University of Newcastle (Awarded 2011)
- Lectured Electrical engineering Australia + Singapore for several years
- Currently the Engineering Manager at Ampcontrol CSM
- Also a Conjoint Senior Lecturer at University of Newcastle with a few postgrad students



Definition of Telecommunication

- “Transmission of signals over a distance for the purpose of communication”
- The word telecommunication is adapted from a compound of the Greek prefix *tele*, meaning 'far off', and the Latin verb *communicare*, meaning 'to share'
- Consists of 3 parts:
 - Transmitter
 - Medium
 - Receiver



Some history...

- 1799 Alessandro Volta : Invented electric battery,
- 1837 Samuel Morse : Demonstrated telegraph and 1844 first telegraph line
- 1831 Faraday : Demonstrates electromagnetic induction
- 1864 J. Maxwell : Theory of electromagnetic Fields, wave equations
- 1876 Alexander Graham Bell : Awarded the first U.S. patent for the telephone
- 1887 H. Hertz : Demonstrates existence of electromagnetic waves





Some history...

- 1895 Guglielmo Marconi : First demonstration of long distance radio transmission
- 1907 Commercial transatlantic connections => 100m high antennas
- 1915 Wireless voice transmission New York - San Francisco
- 1928 TV broadcast trials (across Atlantic)
- 1933 Frequency modulation (E. H. Armstrong)
- 1958 A-Netz in Germany, analog, connection setup only from the mobile station, no handover, 80% coverage, 1971 11000 customers



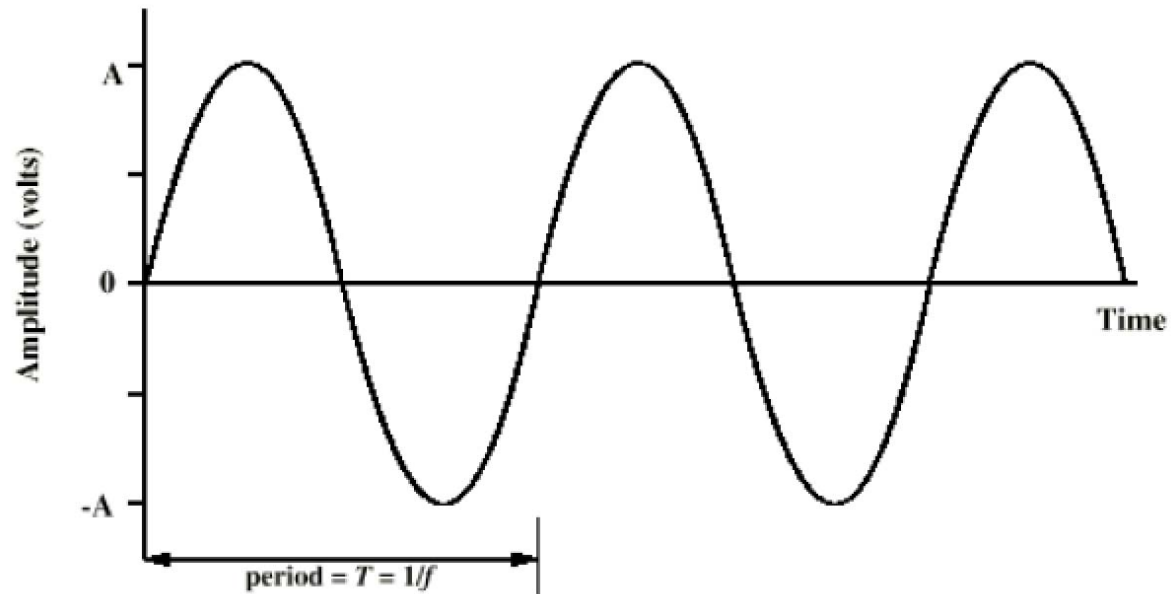
Some history...

- 1982 : Start of GSM-specification (Global System for Mobile communication)
- 1990 : Tim Berners-Lee begins writing WorldWideWeb, the first web browser
- 1992 : CSIRO patents key technology needed for Wi-Fi
- 1998 : 3G telecommunication networks (3rd generation mobile) 22Mbit/s peak
- 1998 : Bluetooth short range wireless technology
- 2008 : 4G telecommunication networks (4th generation mobile) 1Gbit/s peak
- 2013 : Fibreoptic cable experiment recorded a throughput of 73.7 Tbit/s
- 2020? : 5G telecommunication networks (5th generation mobile) 35Gbit/s peak



A bit of theory...

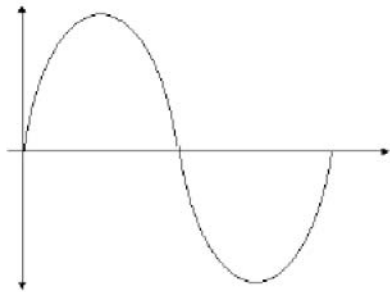
- Analogue signal => continuous in time



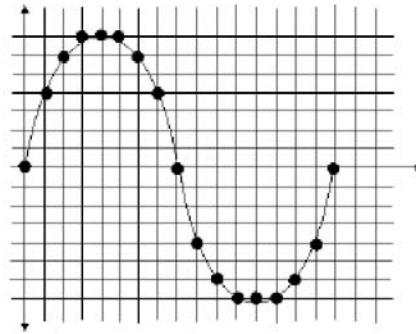


A bit of theory...

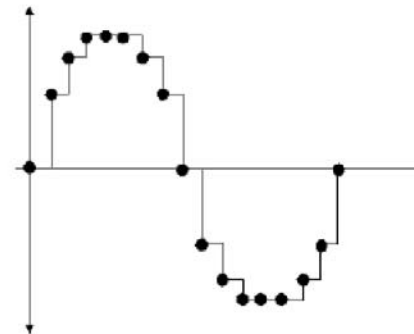
- Analogue to digital (note the fixed sampling steps)



Analogue



Sampling and quantisation

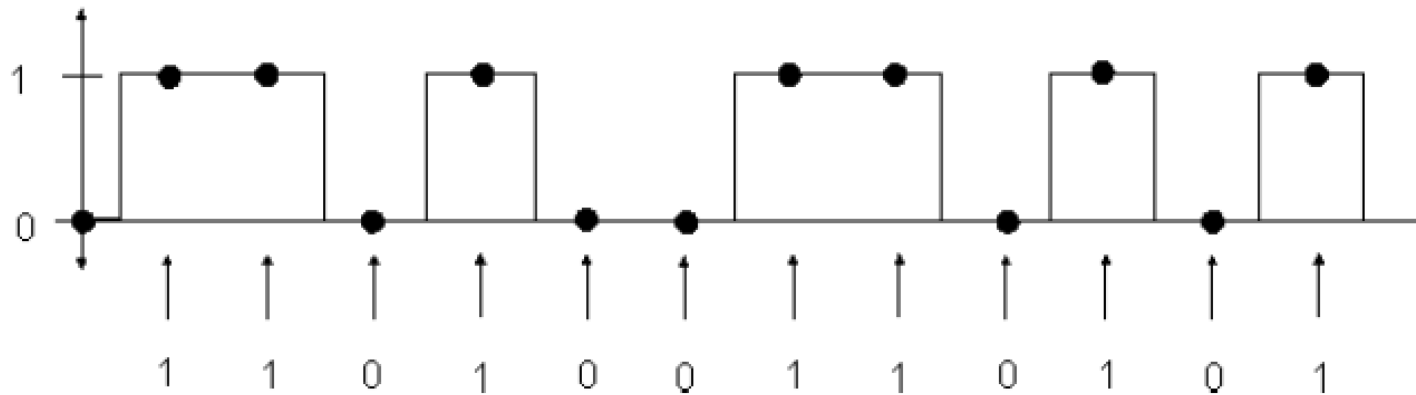


Digital



A bit of theory...

- Digital signals (eg Binary signal measured at fixed sample times)

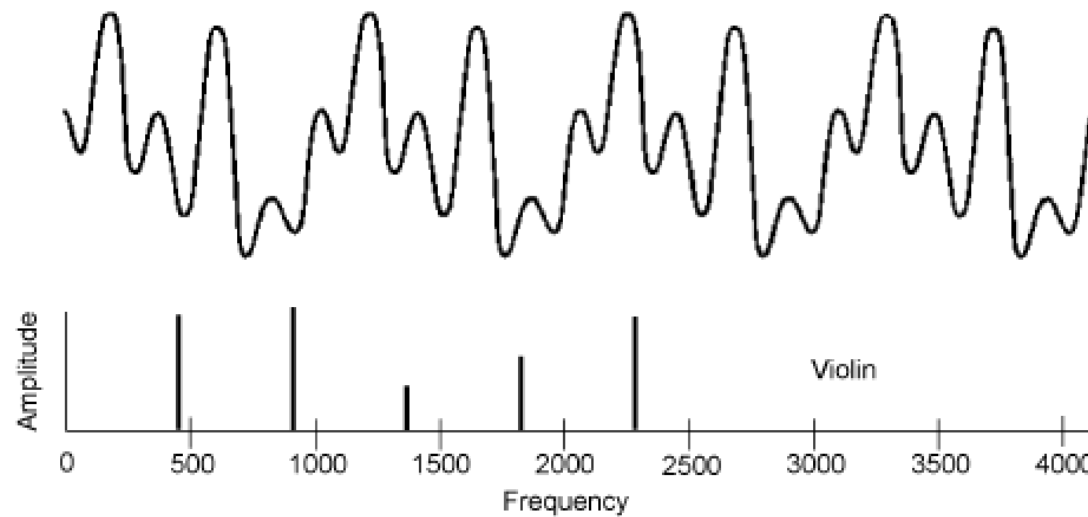




A bit of theory...

- What about the relationship between time and frequency?

Violin





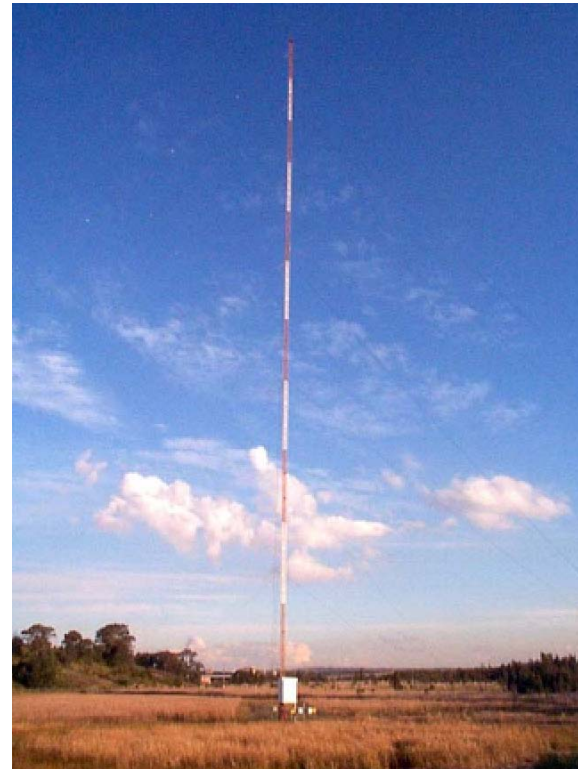
Theory to practice...

- Wave speed = Frequency x wavelength
- Wavelength determines size and efficiency of antenna
 - 2HD operates at 1143kHz, 262 metres wavelength
 - 2NUR operates at 103.9MHz, 2.9 metres wavelength
 - Mobile phone at 900MHz, 30cm wavelength
- Antennas smaller than the signal wavelength can be used but will impact on efficiency and performance.



Theory to practice...

- What do we have here..?





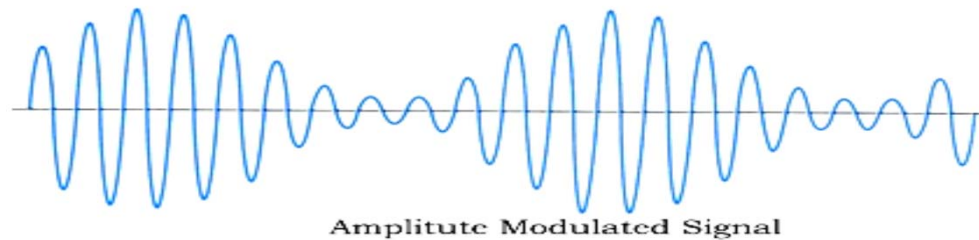
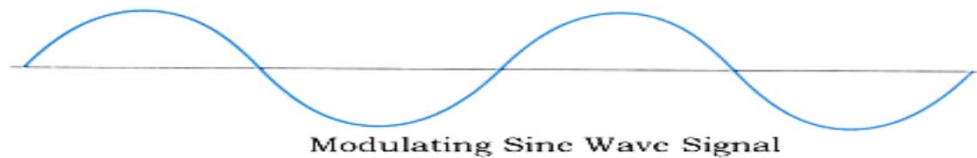
Modulation types

- It is often convenient or necessary to 'translate' the signal from one region in the frequency domain to another region
 - Frequency 'multiplexing' => lots of different channels
 - Practical antenna => Not too large..
- An auxiliary signal called 'carrier' determines the amount of frequency translation



Modulation types

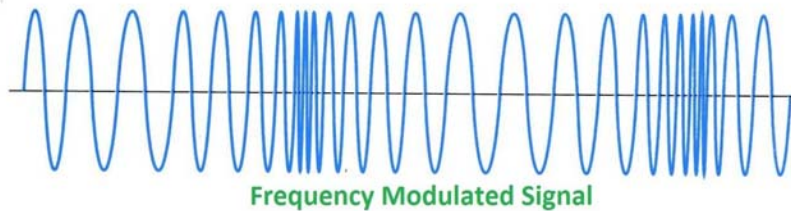
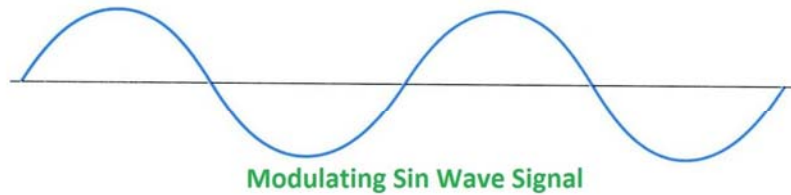
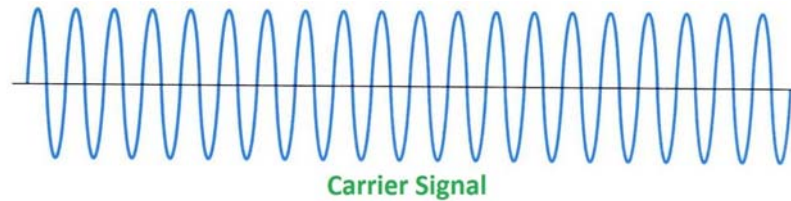
- Amplitude Modulation- Varies the amplitude of the carrier wave (eg: 2HD)





Modulation types

- Frequency Modulation – Varies the frequency of the carrier wave (eg: NewFM)





Multiplexing (de-Multiplexing)

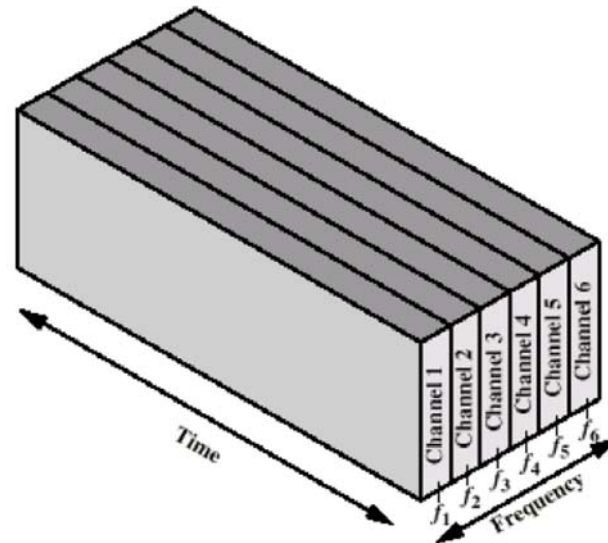
- Sharing a communications link or medium (ie cable, fibre, wireless band)
- Analogy : Many people in same room trying to talk at once
- How can you hear one conversation when others are talking?





Frequency Division Multiplexing (FDM)

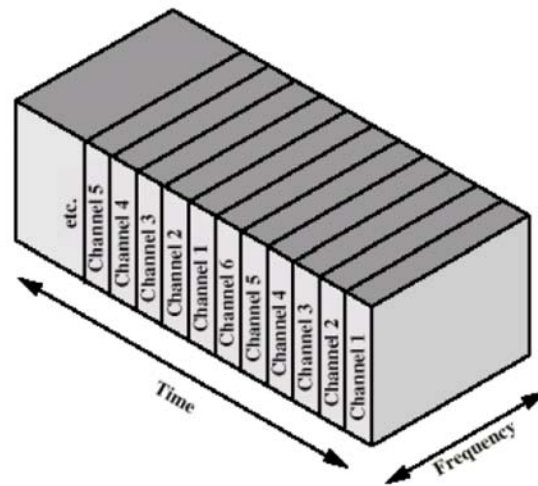
- Modulating each signal with different carrier frequencies (ie Could use AM, FM, ..)
- Analogy : Each person to talk (and listen) at a different 'pitch', ie high or low voice





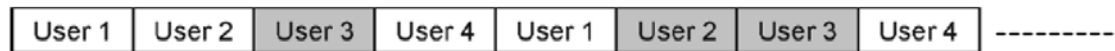
Time Division Multiplexing (TDM)

- Send “slices” of each information stream consecutively along media channel
- Analogy : Allow each person their own timeslot in which to speak.
- Optical fibres can carry millions of simultaneous ‘conversations’

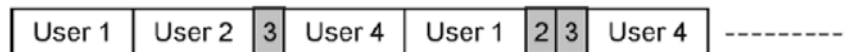




Time Division Multiplexing



Synchronous Time Division Multiplexing



Statistical Time Division Multiplexing



Data slot
in use

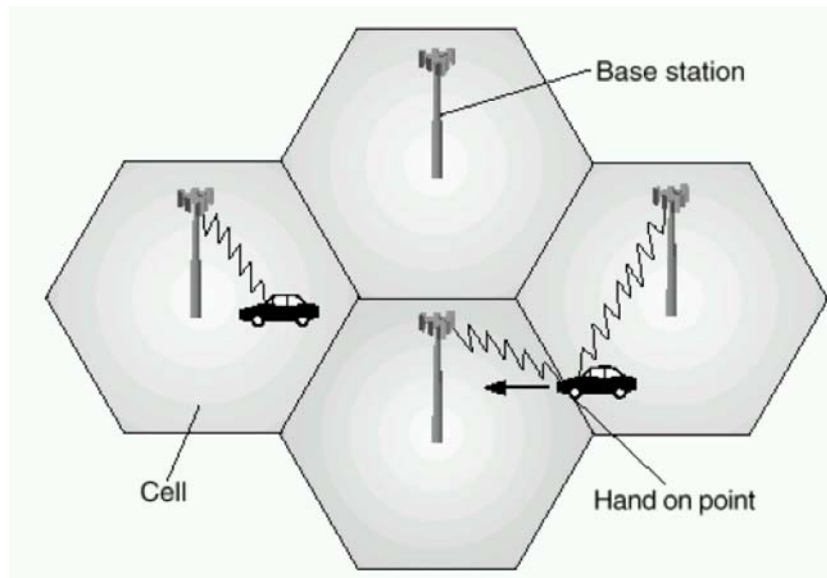


Data slot
not used



Space Division Multiplexing (SDM)

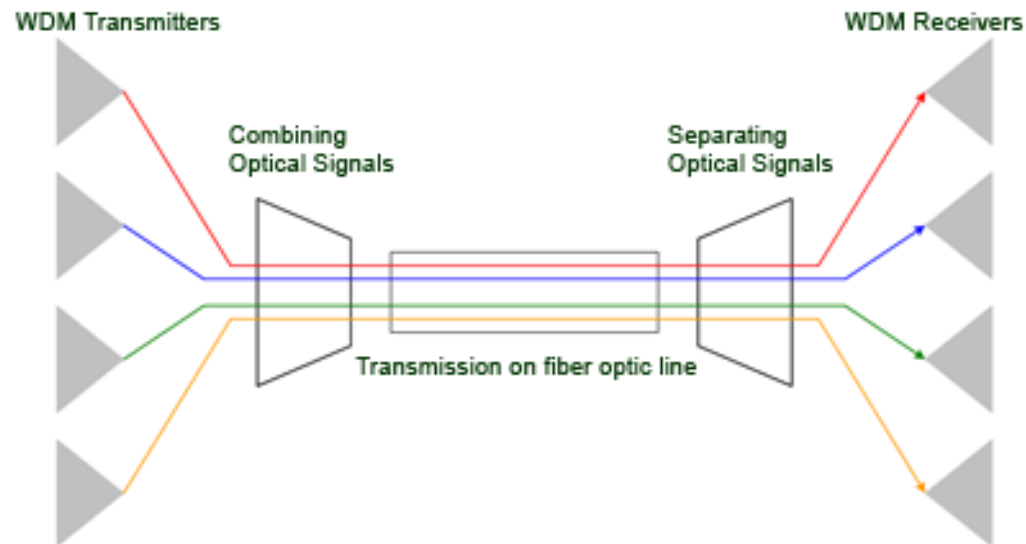
- Analogy: Separate people around the room ...
- 'Cell' division in mobile telephone network





Wavelength Division Multiplexing (WDM)

- Different colours of light are different wavelengths
- Simply use the different wavelength carriers to transmit different signals





Applications

- Can use combinations of techniques to hold multiple 'conversations':
 - Mobile phones use SDM and FDM in adjacent cells
=> i.e. Use different mobile cells + different frequencies
 - Optical fibres use TDM and WDM
=> i.e. Use time 'slices' + different 'colours'



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Thank you