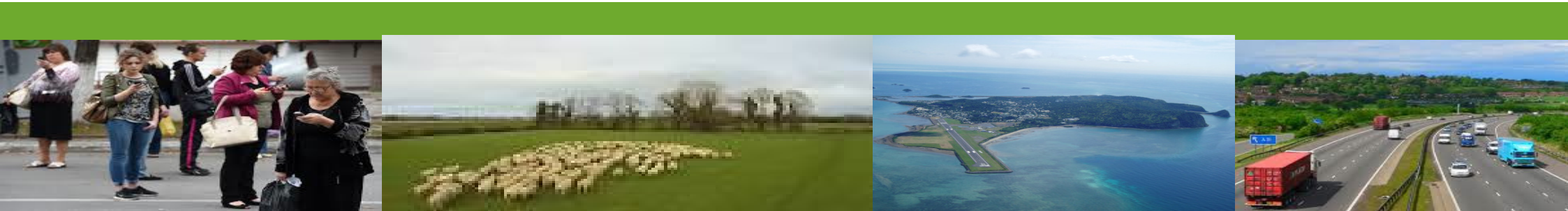




# Octave and LimeSDR

Danny Webster



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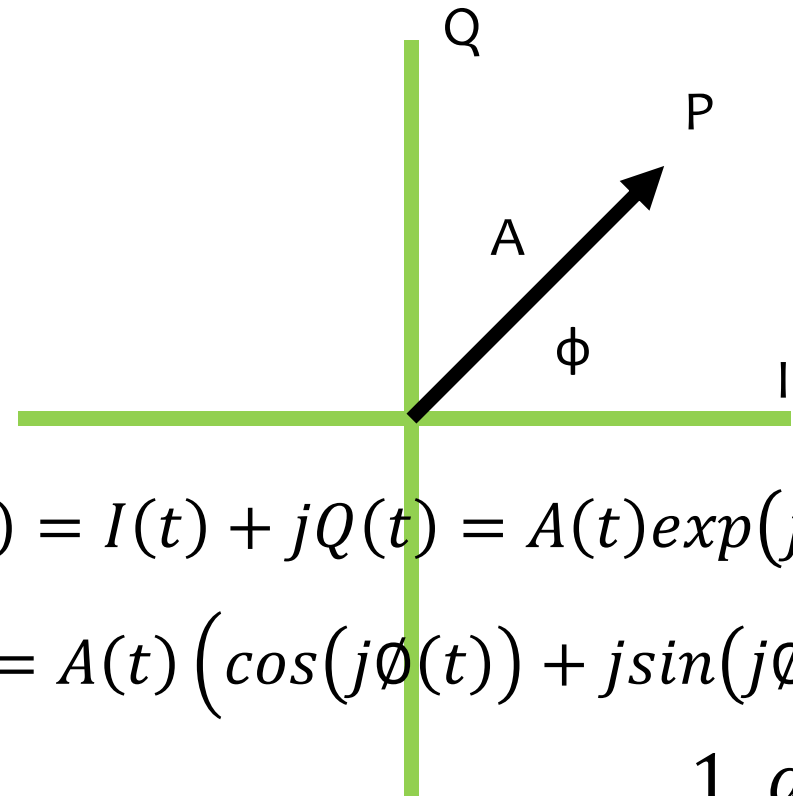
# Getting started with Octave

- **Install Octave 4.0.x**
- **Build Octave-LimeSDR**
  - Windows
    - octave
    - run build.m
  - Linux
    - cd~/LimeSuite/octave/
    - make
- **Copy files into each project**
  - LoadLimeSuite.m
  - LimeSuite.oct
  - LimeSuite.dll (windows)
- **Start Octave**
  - Change directory
  - run build.m % do for each
  - run SSB.m
  - run ASK.m
  - run FSK.m
  - run NumptyText.m
  - run NumptyText2.m
  - run NumptyText3.m



# Representing Modulation in Octave

- **AM, FM and PM can be represented by**
- **Cartesian co-ordinates {x,y}**
  - In Radio, called Inphase and Quadrature
  - Real, Imaginary (Complex Numbers).
  - Programming `real()` `imag()`
  - Note `i` and `j` mean the same.
- **Polar co-ordinates (Vector Modulation)**
  - Natural language for describing Amplitude and Phase modulation.
  - Amplitude `A`, Phase `φ`
  - Phase is usually in radians not degrees.
  - Programming `abs()` `arg()` `exp(i*)`
  - Frequency is a phase that changes at a constant rate.



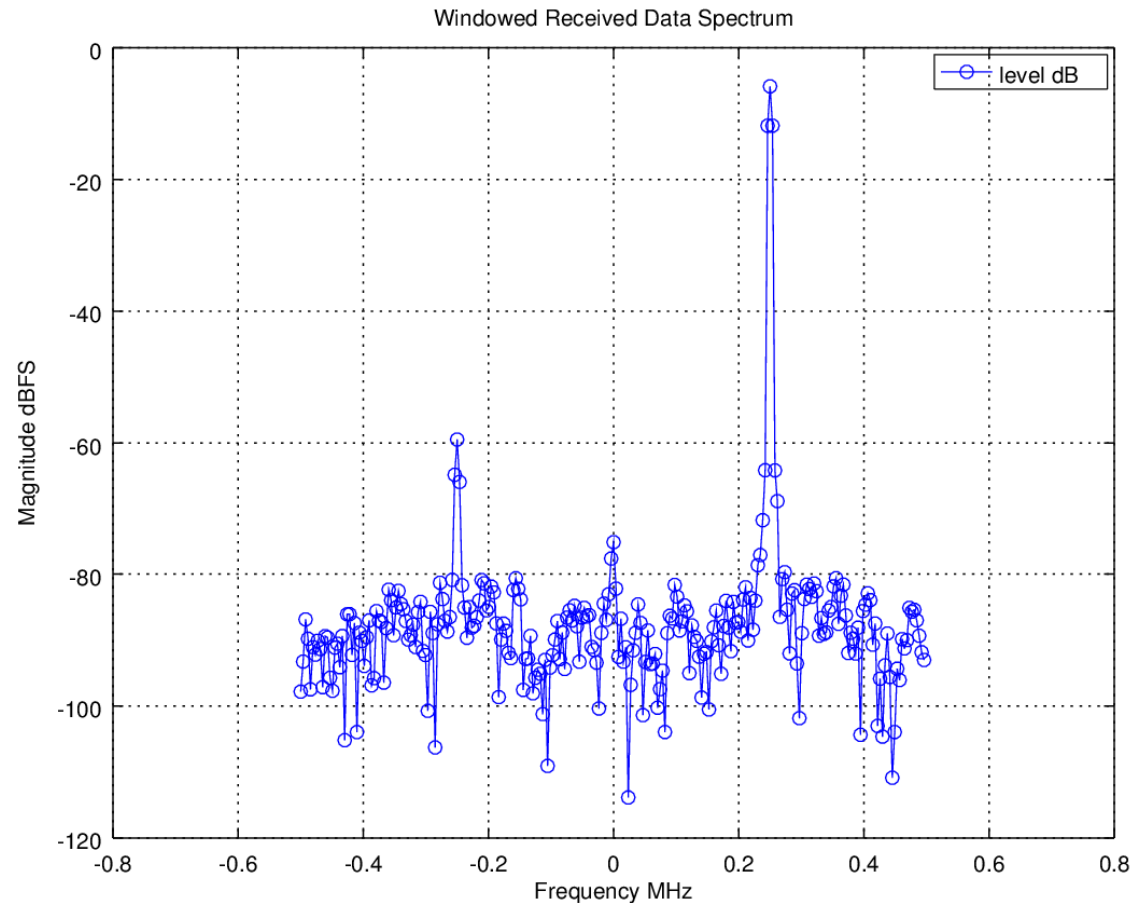
$$P(t) = I(t) + jQ(t) = A(t)\exp(j\phi(t))$$

$$P(t) = A(t) \left( \cos(j\phi(t)) + j\sin(j\phi(t)) \right)$$

$$f = \frac{1}{2\pi} \frac{d\phi(t)}{dt}$$

# Single Sideband Demo

- **Demonstrates**
  - Octave link with LimeSDR
  - SSB Generation
  - FFT with Hanning Window
- **Settings File**
  - .ini generated in LimeSuite
  - 866MHz -50dBm for table top license exempt transmission.



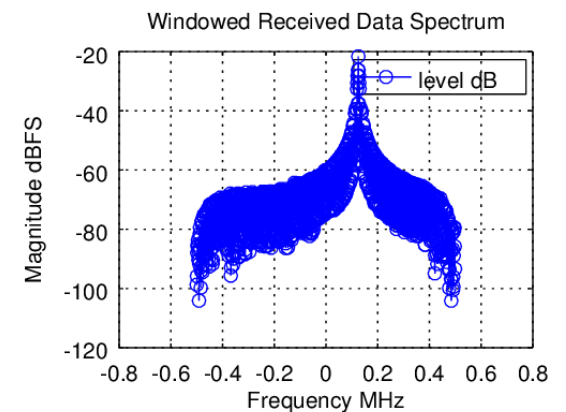
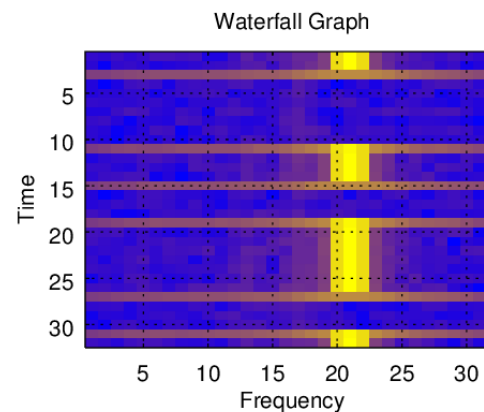
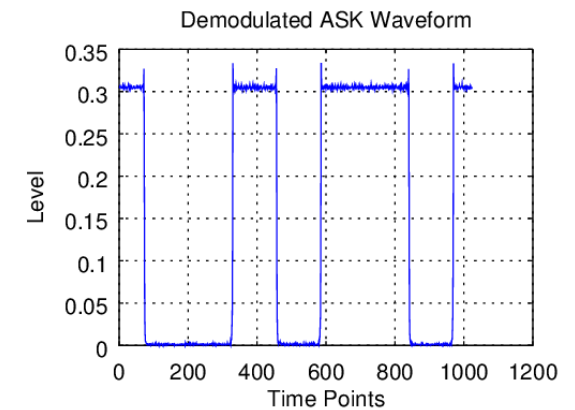
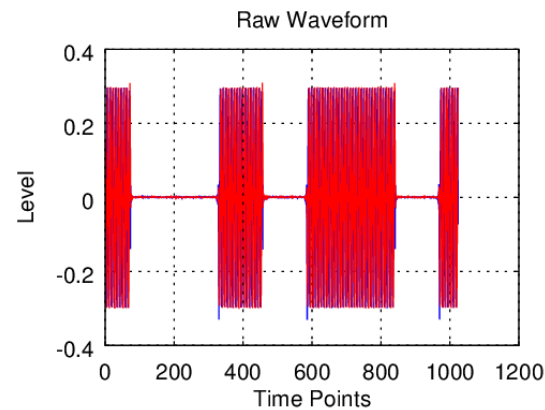
# Amplitude Shift Keying Demo

- **Demonstrates**

- Octave link with LimeSDR
- ASK generation
- AM/ASK demodulation.
- Waterfall type graphs

- **Settings File**

- .ini generated in LimeSuite
- 866MHz -50dBm for table top license exempt transmission.



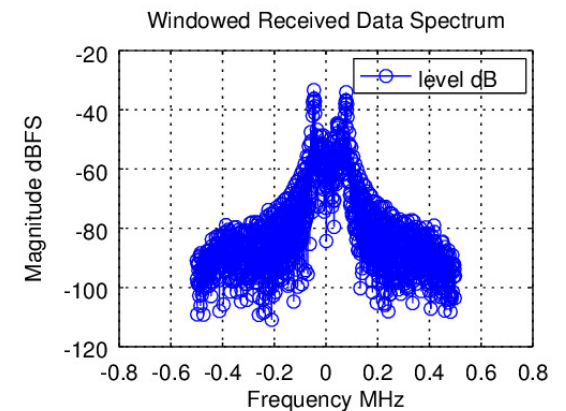
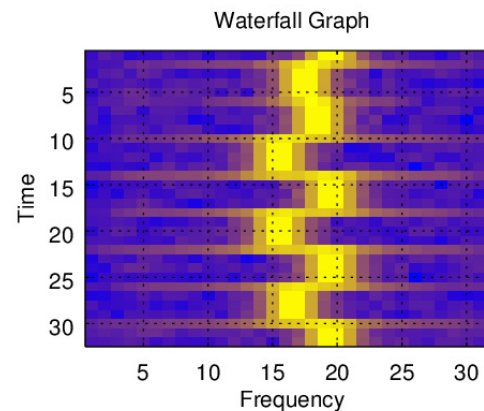
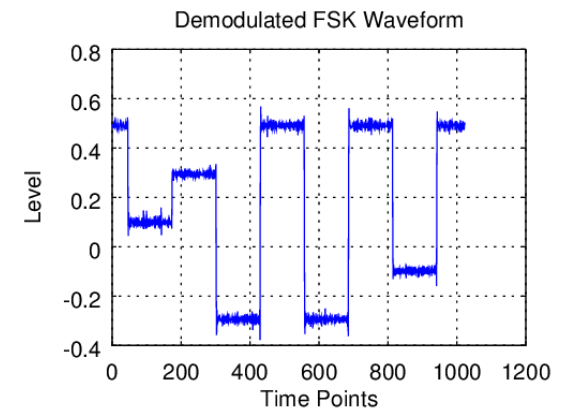
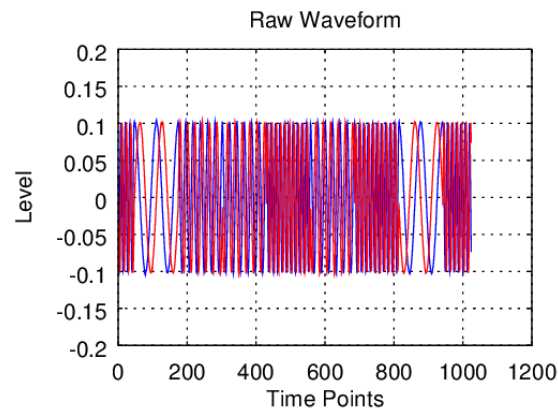
# Frequency Shift Keying Demo

- **Demonstrates**

- Octave link with LimeSDR
- FSK generation
- FM/FSK demodulation.
- Waterfall type graphs

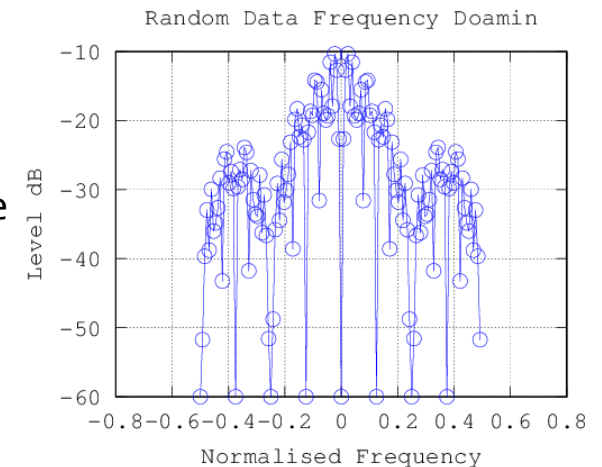
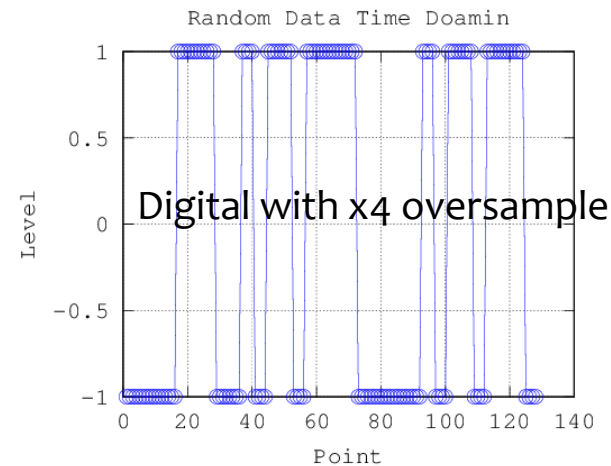
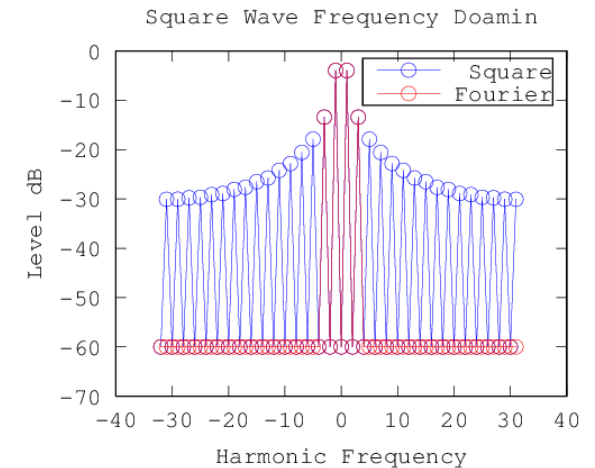
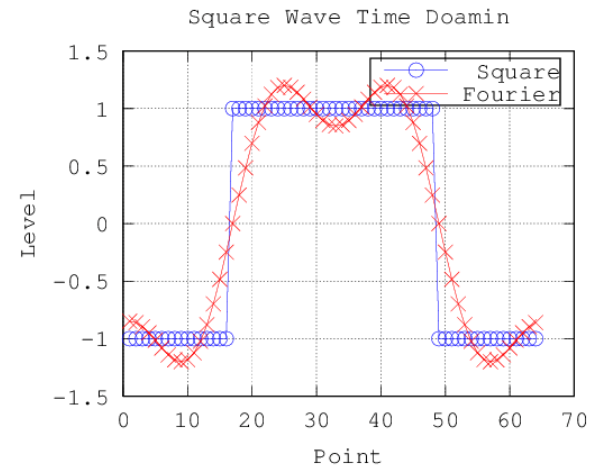
- **Settings File**

- .ini generated in LimeSuite
- 866MHz -50dBm for table top license exempt transmission.



# Digital Modulation and Bandwidth

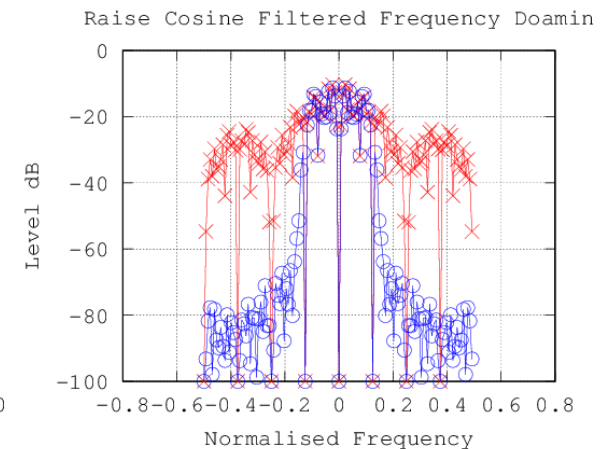
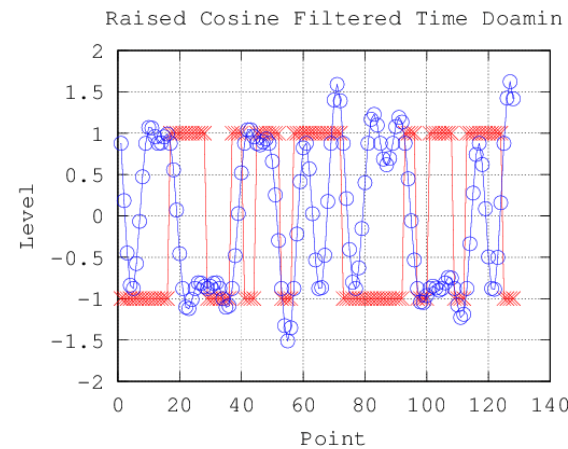
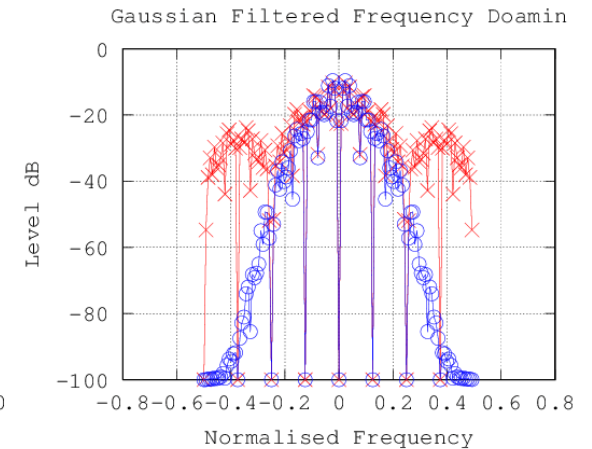
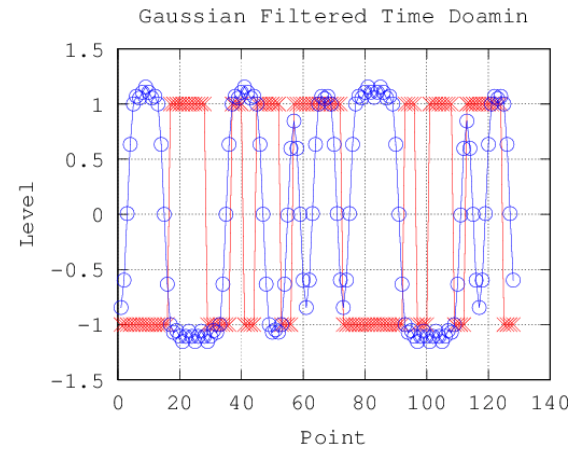
- **Data changes with time.**
  - Looks like sequence of square waves.
- **Fourier Analysis**
  - Complex signals are made of harmonics.
  - Reducing harmonics lead to more gentle rise and fall behaviour.
- **Harmonics of random data**
  - Adjacent channel interference.
  - Must be filtered.





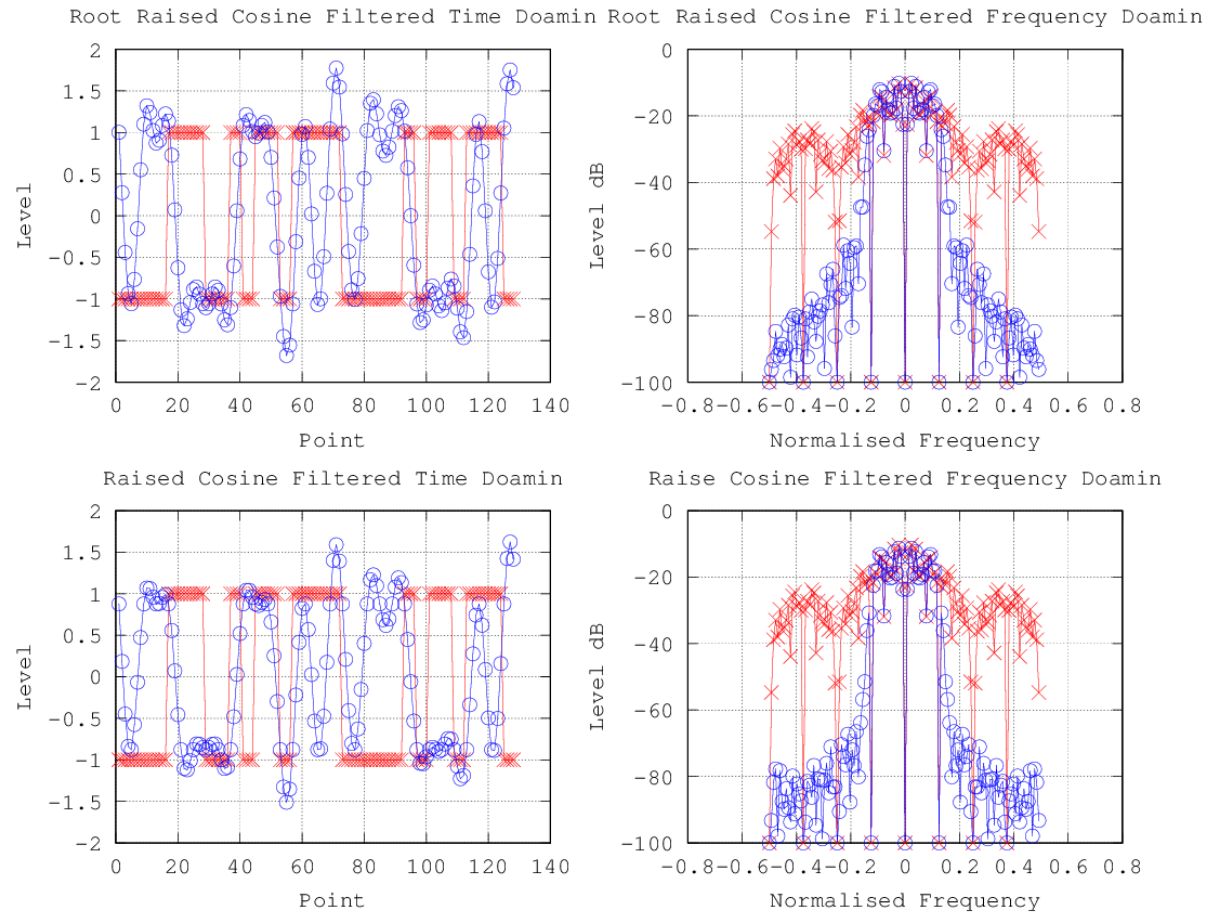
# Pulse Shaping Filters and Digital Modulation

- Pulse shaping has two purposes.
- To reduce the bandwidth of a digital signal.
  - Reduce adjacent channel interference.
  - Increase capacity of available bandwidth.
- To minimise interference from previous bits.
  - Intersymbol interference (ISI)
- Two common types
  - Gaussian (2G and Bluetooth)
  - Root Raised Cosine (3G)
  - Implemented as FIR Filters



# Matched Pulse Shaping Filters

- **Raised Cosine filter split into two Filters**
  - 2x Root Raised Cosine.
  - Combined have same effect as original Raised Cosine filter on the data.
- **RRC used before TX DAC**
  - Reduce noise in adjacent channels when transmitting.
- **RRC used after RX ADC**
  - Prevent receiver adding noise from adjacent channels.



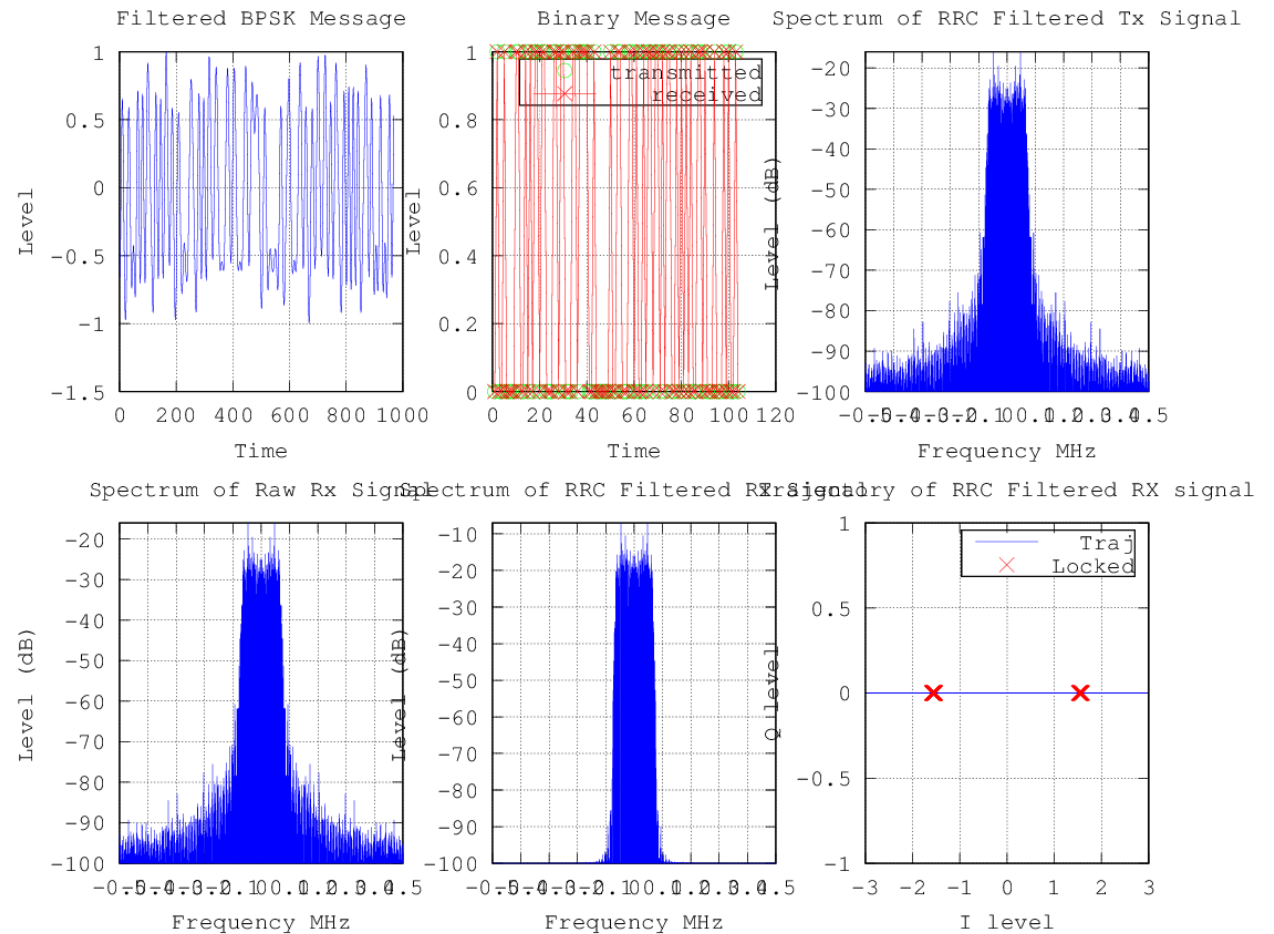
# NumpyText1 Demo

- **Demonstrates**

- Transmit ASCII message from TX to RX
- ASCII /Binary conversion
- Auto Correlation Function for sync detection and phase correction
- BER Calculation
- Root Raised Cosine Filtering for pulse shaping

- **Variations**

- Try with SMA Adapter
- Try with Antenna
- Change Antenna angle



# NumpyText2 Demo

- **Demonstrates**

- ASCII to Binary conversion
- Forward Error Correction with BCH(7,4,1) code
  - Works easily with 8 bit ASCII
- BER Calculation
- Auto Correlation Function for sync detection and phase correction
- Root Raised Cosine Filtering for pulse shaping

- **Variations**

- Try with unfavourable antenna alignment
- Try with BCH(15,7,2)
  - with 7 bit ASCII
  - 2 bit errors
- Try with BCH(63,21,2)
  - With padded 7 bit ASCII
  - 2 bit errors
- Try with BCH(63,16,3)
  - With padded 8 bit ASCII
  - 3 bit errors
- Try unscrewing one antenna!!!

# NumpyText3 Demo

- **Demonstrates**

- ASCII to Binary conversion
- Forward Error Correction with BCH(7,4,1) code
  - Works easily with 8 bit ASCII
- BER Calculation
- CDMA Type Spread Spectrum
  - Spread code unique random
  - Pilot channel orthogonal to data
  - Code spreading and despreading
- Using ACF for Frame synchronisation.

- Root Raised Cosine Filtering for pulse shaping

- **Variations**

- Try unscrewing both antennas!!!!
  - Alter spread factor to restore link!