**Review of how digital communication works**

Reference ( Link 1 – [Electrical funablog](https://electricalfundablog.com/digital-communication-introduction-basic-components-how-signal-process-works-and-advantages/#:~:text=Digital%20Communication%20is%20defined%20as,are%20normally%20analog%20in%20nature.) )

* Digital devices communicate information digitally
* Normally analog in nature
* If sent over a long distance the analog signal is sent through the wire
* The analog signal has to go through many losses such as
  + Distortion
  + Intervention
  + Interference
  + Security breach concerns
* Digital communication systems consist of these basic components:
  + ***Source***
  + ***Input transducer***
  + ***Analog to digital converter***
  + ***Source encoder***
  + ***Channel encoder***
  + ***Digital modulator***
  + ***Communication channel***
  + ***Digital Demodulator***
  + ***Digital to Analog converter***
  + ***Channel decoder***
  + ***Source decoder***
  + ***Output transducer***
  + ***Output signal***

**Source**

* The source consists of an analog signal

**Input Transducer**

* Takes a physical input and converts it to an electrical signal ( Microphone )
* Is an electronic device which converts energy from one form to another.
* There are two types of transducer an input transducer which is a sensor and an output transducer

**Analog to Digital Converter**

* An ADC converts a continuous time and continuous amplitude analog signal to a discrete time and discrete amplitude digital signal
* Involves quantization of the input, so it necessarily introduces a small amount of error or noise.
* Conversion periodically samples the input, limiting the allowable bandwidth of the input signal
* Performance of an ADC is primarily characterized by its bandwidth and signal to noise ratio
* The bandwidth of an ADC is characterized primarily by its sampling rate
* The SNR of an ADC is influenced by:
  + Resolution
  + Linearity
  + Accuracy
  + Aliasing
  + Jitter
* **Graphical user interface, chart

  Description automatically generated**

**Source Encoder**

* Compresses the data into the lowest number of bits, helps in efficient operation of the bandwidth (Removes unnecessary bits)
* Converts the input symbol sequence into a binary sequence of 0’s and 1’s by assigning code words to the symbols in the input sequence.
* Think about the video that explains the dice game. In this context, if we know what the signal could possibly be and measure to that value.

**Channel encoder**

* Coding is done for error correction
* The channel encoder adds some unnecessary bits to the transmitted data
* Bits are the error correcting bits
* These extra bits do not convey any information but helps the receiver to detect and or correct some of the errors in the information bearing bits

**Digital Modulator**

* Signal is modulated by a carrier
* The carrier is used for effective long distance transmission of data
* Process of varying one or more properties of a periodic waveform, called the carrier signal.
* The carrier is higher in frequency than the modulation signal
* Radio communication modulation techniques
  + AM ( Amplitude modulation ) – amplitude strength of the radio carrier wave is varied by the modulation signal
    - Most commonly for transmitting messages with a radio wave.
    - The amplitude of the of the wave is varied in proportion to that of the message signal, such as an audio signal
    - Envelope (Waves) – an oscillating signal is a smooth curve outlining its extremes
    - Disadvantage of Amplitude modulation is that the receiver amplifies and detects noise and electromagnetic interference in equal proportion to the signal
    - Heterodyne is a signal frequency that is created by combining or mixing two other frequencies
  + FM ( Frequency Modulation ) – the frequency of the radio carrier wave is varied by the modulation signal
  + Phase Modulation -
  + FSK ( Frequency-shifting Keying) – used in wireless digital devices to transmit digital signals, the frequency of the carrier wave is shifted periodically between two frequencies that represent the two binary digits.

**Digital to Analog Convertor**

* The Digital signal is extracted from the carrier is then converted again into analog so that the signal can be passed effectively through the channel or medium

**Channel**

* The channel provides a path for the signal and permits the analog signal to transmit from the transmitter end to the receiver end

**Digital Demodulator**

* Where the data retrieving process is started at the receiver end
* Received signal is demodulated and again converted from analog to digital
* The signal gets rebuilt here

**Channel Decoder**

* The channel decoder does the error corrections post sequence detection
* Addition of these bits help in the complete recovery of the original signal

**Source Decoder**

* Resulting signal is again digitized by sampling and quantizing
* The source decoder creates again the source output

**Output Transducer**

* Final block which converts the signal into its original form
* Converts the electrical signal into physical output

**Advantages of Digital Communication over Analog Communication**

* Specific signal level of the digital signal is not very important
* Configuration process of digital signals is easier than analog signals
* Encryption works better in Digital Signals
* Digital circuits are more consistent and reliable
* Digital circuits are easy to design
* Cost is less for Digital circuits
* Digital signals do not get corrupted by noise, interface, and distortions
* Cross talking is very rare in Digital communication
* Long distance data transmission is easier and cheaper with Digital Signals
* Hardware implementation in digital circuits is much more flexible if compared to analog circuits
* Digital signals can be saved and extracted more easily than analog signals

**Things to review from Job Posting**

* Work as a team member in Datalink Engineering and participate in development of state-of-the-art Beyond Line Of Sight (BLOS) SATCOM datalink and Line-Of-Sight (LOS) datalink for GA-ASI Unmanned Aircraft Systems (UAS).
* Participate in company-wide RF and satellite communications projects.
* Perform sub-contractor technical review to ensure technical requirements are satisfied.
* Apply technical knowledge to analyze, investigate, and resolve assigned engineering problems.
* Perform RF communications systems integration/testing with aircraft and ground control stations (GCS).
* Support System Integration Lab (SIL) integration, aircraft level ground and flight test of satellite terminals and various aircraft components (such as modems, Vortex, IFF, TCAS, Radios).
* Work with other engineering disciplines on test plan, procedure, and report. Work with other GA-ASI organizations to assist or lead datalink flight tests.
* Work within a group of RF Datalink Engineers to support GA-ASI datalink roadmap and multiple datalink projects. Coordinate segments of a project and may have frequent inter-organization and/or customer contact on difficult technical issues.
* Coordinate and interface with customers on requirements and flow down the requirements to the corresponding engineering groups.
* Work with the aircraft component vendors, analyze and compare available capabilities vs. customer’s requirements, document findings, and communicate results to engineering staff.
* May assist with technical presentations to the customer and senior management as required.
* Performs other duties as assigned or required.

# Datalink Engineering

* The means of connecting one location to another for the purpose of transmitting and receiving digital communication
* Simplex communications most commonly meaning all communications in one direction only
* Half duplex communications, meaning communications in both directions, but not both ways simultaneously
* Duplex communications, communications in both directions simultaneously

# Beyond Line Of Sight (BLOS) SATCOM datalink

* Usually requires alternative paths or multipath propagation methods
* Utilize active repeaters, groundwave propagation, tropospheric scatter links, and ionospheric propagation
  + Ionospheric propagation
    - Propagation of radio waves reflected or refracted back toward earth from the ionosphere, an electrically charged layer of the upper atmosphere
    - Can be used to communicate beyond the horizon , at intercontinental distances
    - Short wave frequency
      * 3 -30 mhz
    - Low angle skywaves
      * The ionosphere is a region of the upper atmosphere , where neutral air is ionized by solar photons and cosmic rays
      * When high frequency signals enter the ionosphere at a low angle they are bent back towards the earth by the ionized layer
        + If the peak ionization is strong enough for the chosen frequency a wave will exit the bottom of the layer earthwards – as if obliquely reflected from a mirror
      * Bouncing from the ionosphere zone and ground/water enables shortwave broadcasts to travel all over the world
    - Near Vertical Skywaves
      * Skywaves directed vertically will be reflected directly back towards the ground. When the wave returns to ground it is spread out over a wide area , allowing communications within several hundred miles
  + Tropospheric Scatter
    - An alternative method of achieving over the horizon transmission at higher frequencies
    - Requires high antenna gain
  + Groundwave propagation
    - Where radio waves travel along the earth’s surface without being reflected or retracted by the atmosphere- the dominant propagation mode at lower frequencies
  + Repeater
    - Can alter its method of transmission, for example on another frequency or baud rate
  + Surface Wave

# Line-Of-Sight (LOS) datalink

* Type of propagation that can transmit and receive data only where transmit and receive stations are in view of each other without any sort of an obstacle between them.

# RF and Satellite communications projects

# Perform RF communications systems integration/testing

# modems, Vortex, IFF, TCAS, Radios

* Modem
  + Modulator demodulator is a computer hardware device that converts data from a digital format into a format suitable for an analog transmission medium
  + Transmits data by modulating one or more carrier wave signals to encode digital information while the receiver demodulates the signal to recreate the original digital information
  + Modulation
    - Digital carrier
      * Analog data
        + Pulse amplitude (PaM)
        + Pulse width (PWM)
        + Pulse position (PM)
      * Digital data
        + Pulse coding (PCM)
    - Analog carrier
      * Analog data
        + Carrier amplitude (AM)
        + Carrier frequency (fm)
        + Carrier phase (PM)
      * Digital Data
        + Carrier amplitude (ASK)
        + Carrier frequency (FSK)
        + Carrier phase (PSK)
        + Carrier amplitude and phase (QAM)
* TCAS ( traffic collision avoidance )
  + Aircraft collision avoidance system designed to reduce the incidence of mid air collision between aircraft

# Datalink flight tests

# datalink roadmap