Digital Communication Systems Engineering with Software-Defined Radio

Di Pu, Alexander M. Wyglinski
Worcester Polytechnic Institute

Lecture 01

Recommended Background

- A basic understanding of various digital communication techniques
- A basic understanding of probability
- Familiarity with Simulink
- Familiarity with general programming

Course Material

- Digital Signaling and Data Transmission
  - Inphase/quadrature and magnitude/phase representations of digital transmissions, waveform/vector representations, deterministic and probabilistic signals, noise
- Error Performance of Digital Communications in Noise
  - Modulation/demodulation, bit error rate, error bounds, performance between modulation schemes
- Receiver Structures
  - Correlator realization, matched filtering realization, orthonormal basis functions, Gram-Schmidt Orthogonalization
- Multicarrier Data Transmission Techniques
  - Orthogonal frequency division multiplexing, cyclic extension, peak-to-average power ratio, adaptive power allocation, adaptive rate allocation
- Spectrum Sensing and Identification
  - Energy detection, cyclostationary detection, dynamic spectrum access, electromagnetic spectrum characterization

What is Digital Communications?

- A digital communication system is a collection of processes (digital and analog)
- Treatment and manipulation of binary information for transmission/reception
  - Binary digit (i.e., bit) is the fundamental unit of information in digital communications
- Conversion between binary information and analog waveforms
  - Usually sine and cosine waves
  - Binary information encoded in waveform parameters
  - Common parameters: amplitude, phase, frequency

Mapping Binary to EM Wave Emissions

- Binary information can be embedded in electromagnetic waves
- Properties based on unique binary pattern per time interval T

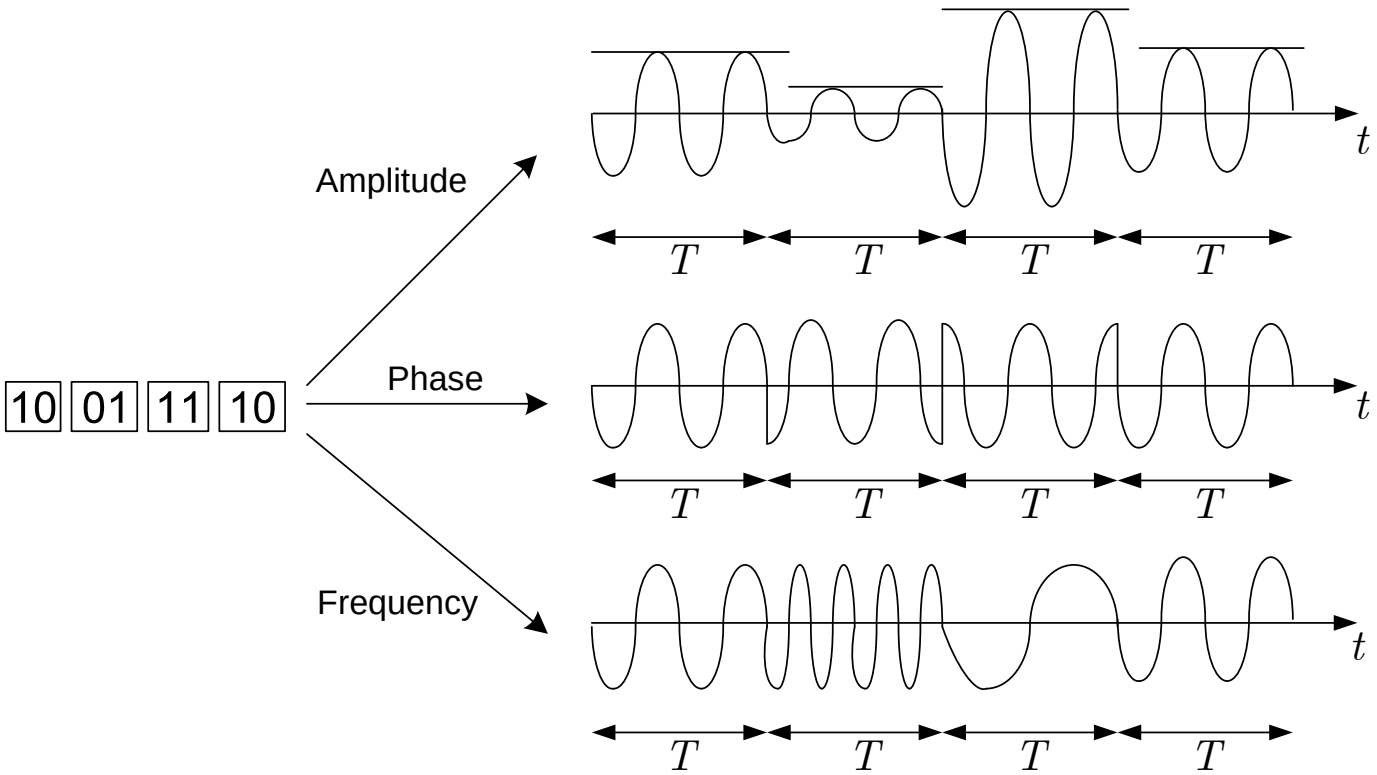

Figure : Possible mappings of binary information to EM wave properties.

Anatomy of a Typical Digital Communication System

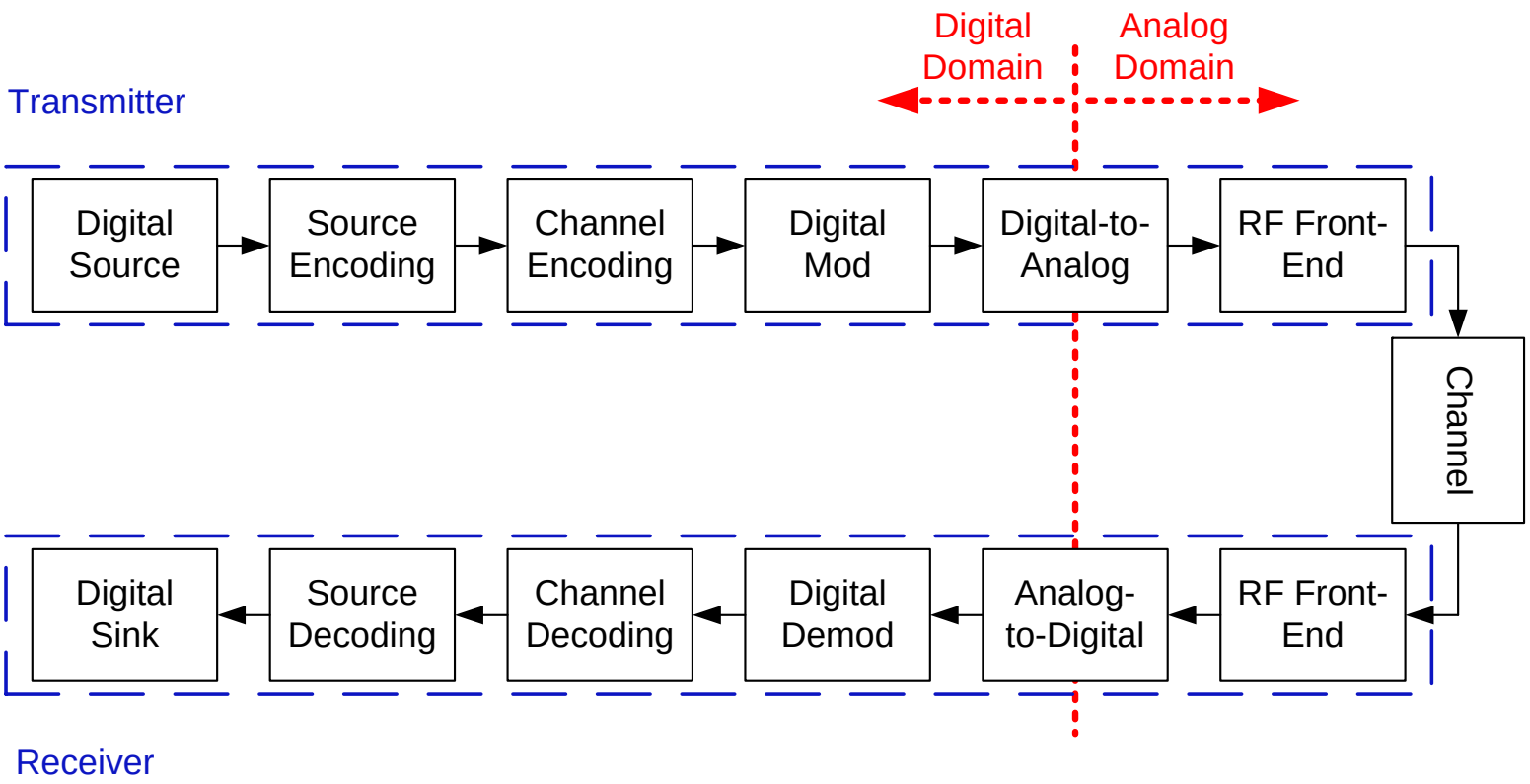

Figure : Generic representation of a digital communication transceiver.

Binary Source and Sink

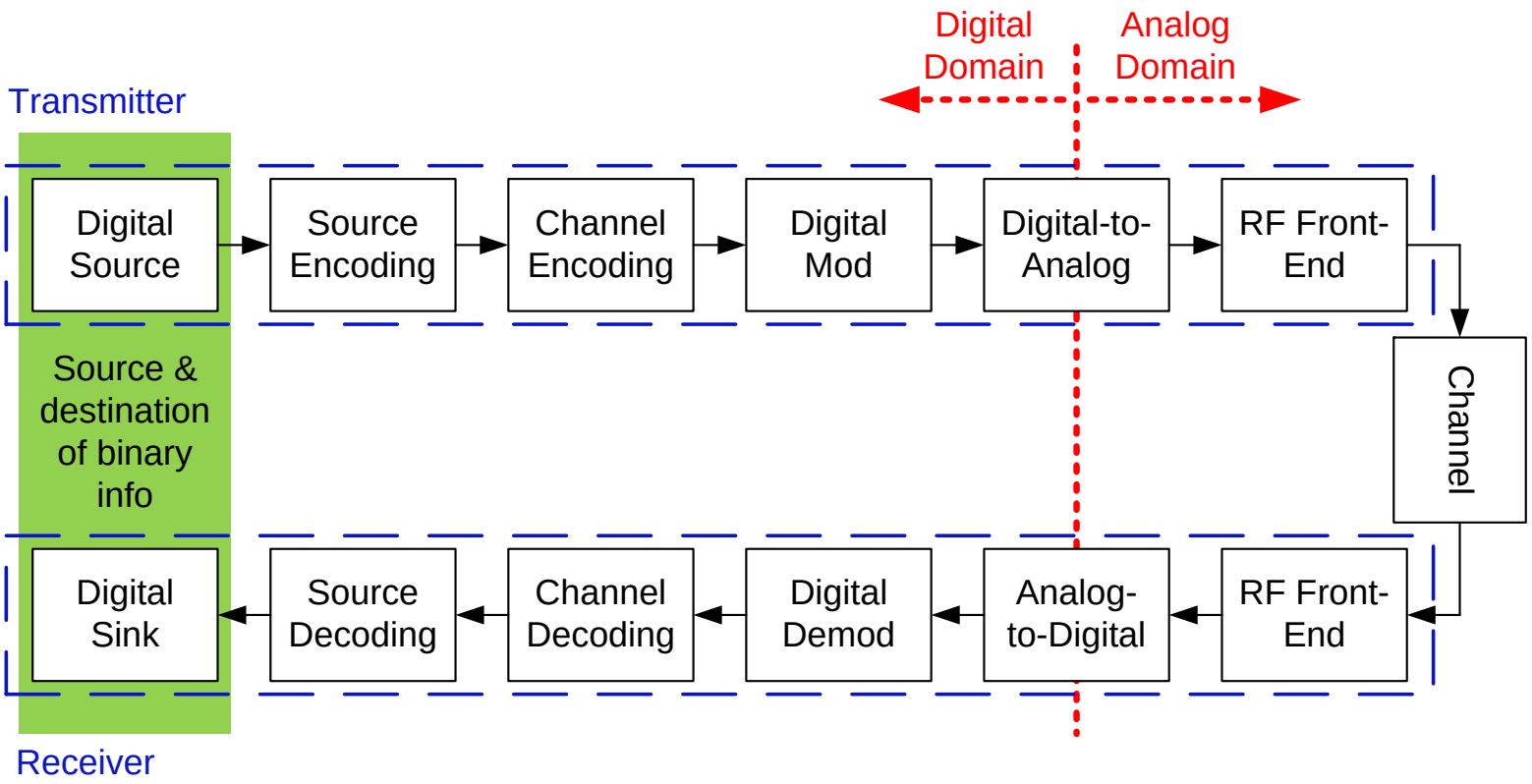

Figure : Generic representation of a digital communication transceiver.

Source Encoding and Decoding

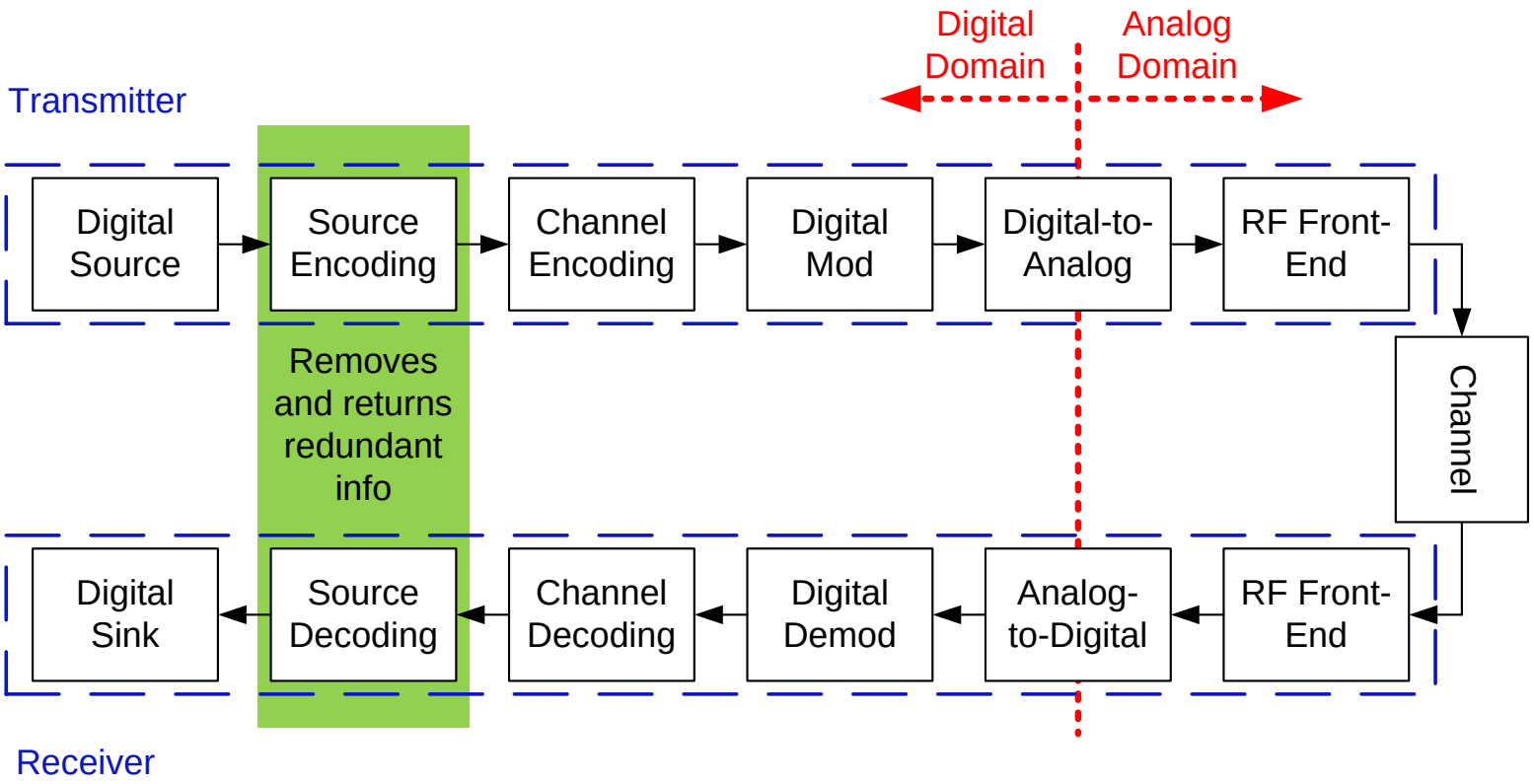

Figure : Generic representation of a digital communication transceiver.

Channel Encoding and Decoding

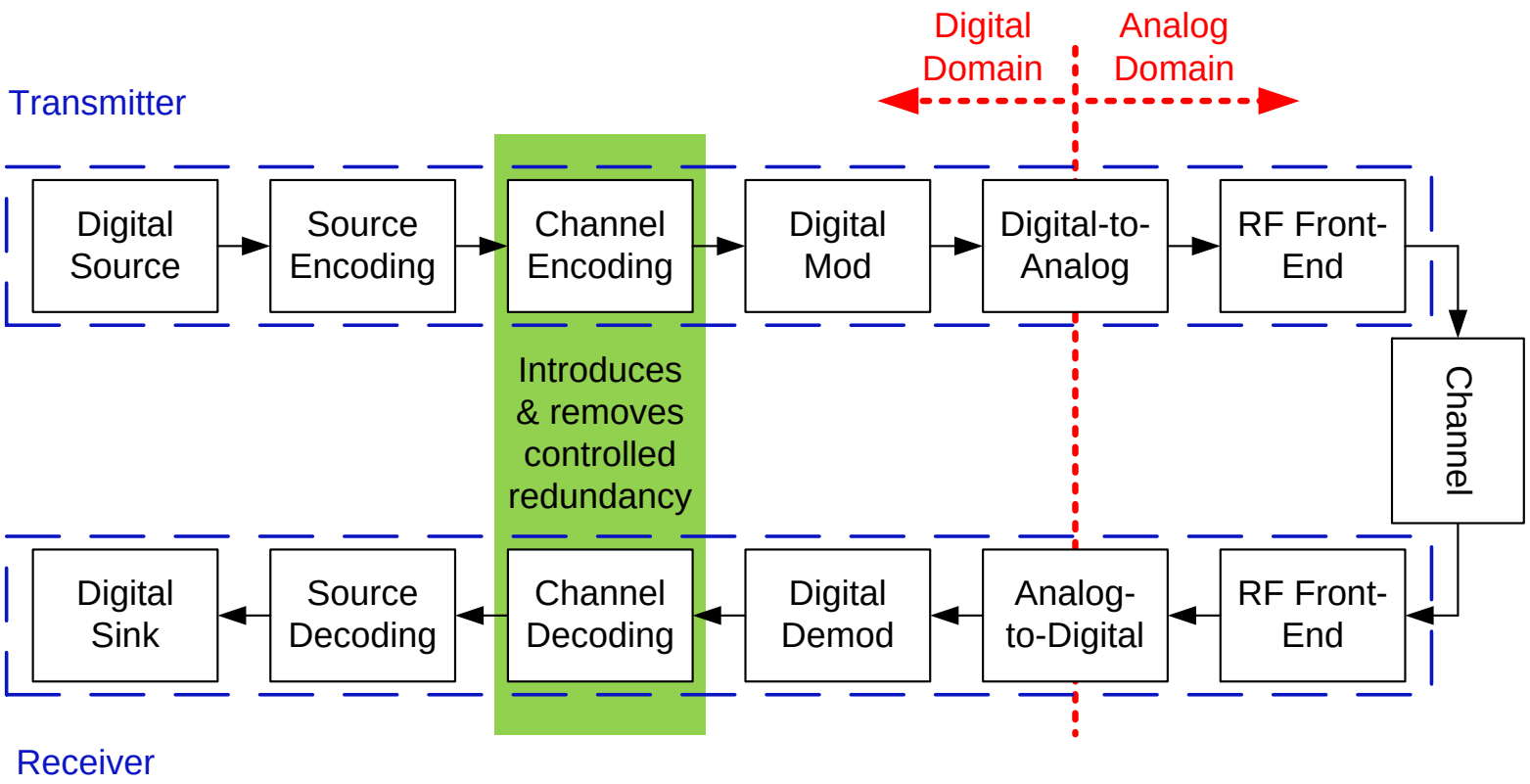

Figure : Generic representation of a digital communication transceiver.

Digital Modulation and Demodulation

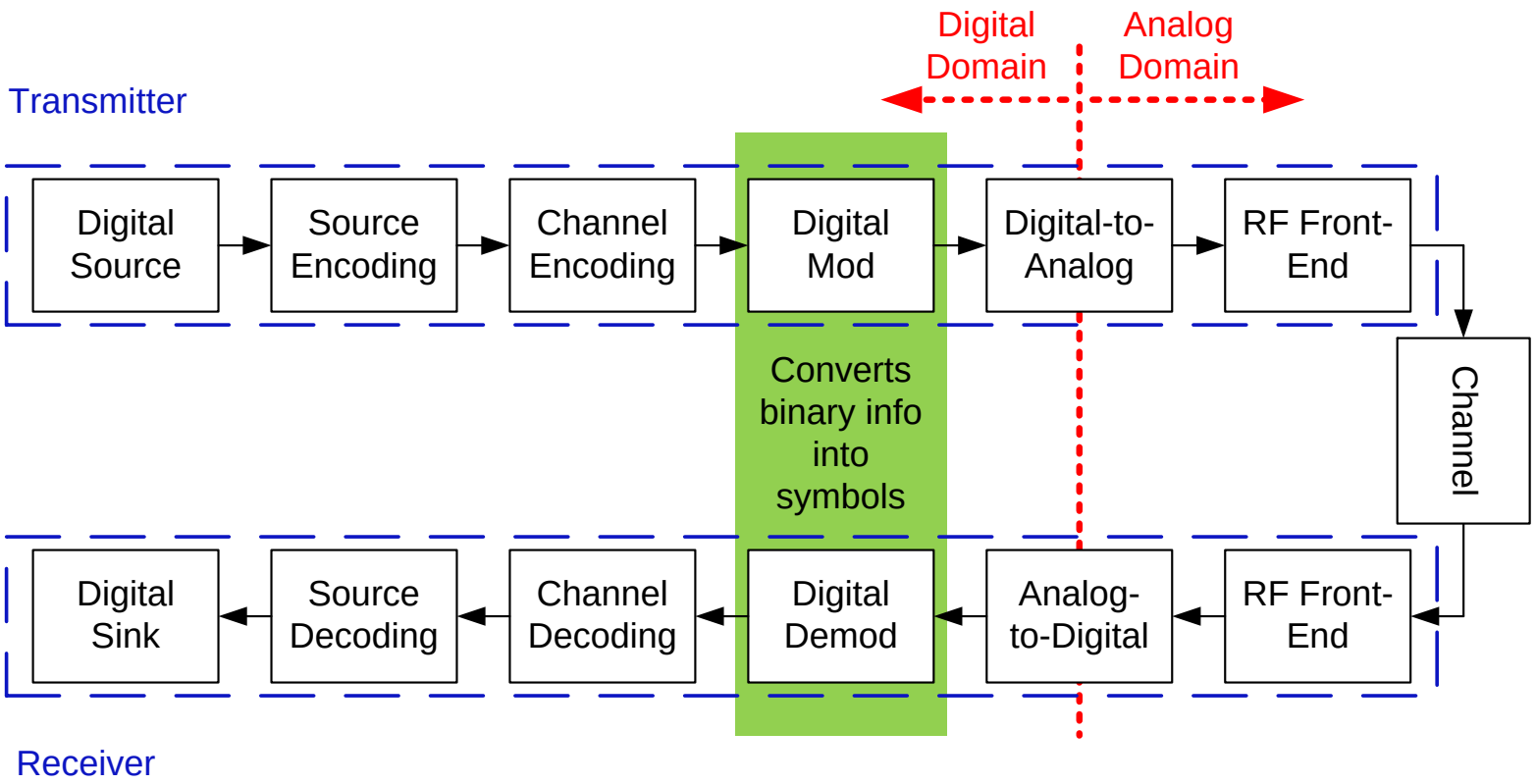

Figure : Generic representation of a digital communication transceiver.

Digital-to-Analog and Analog-to-Digital Conversion

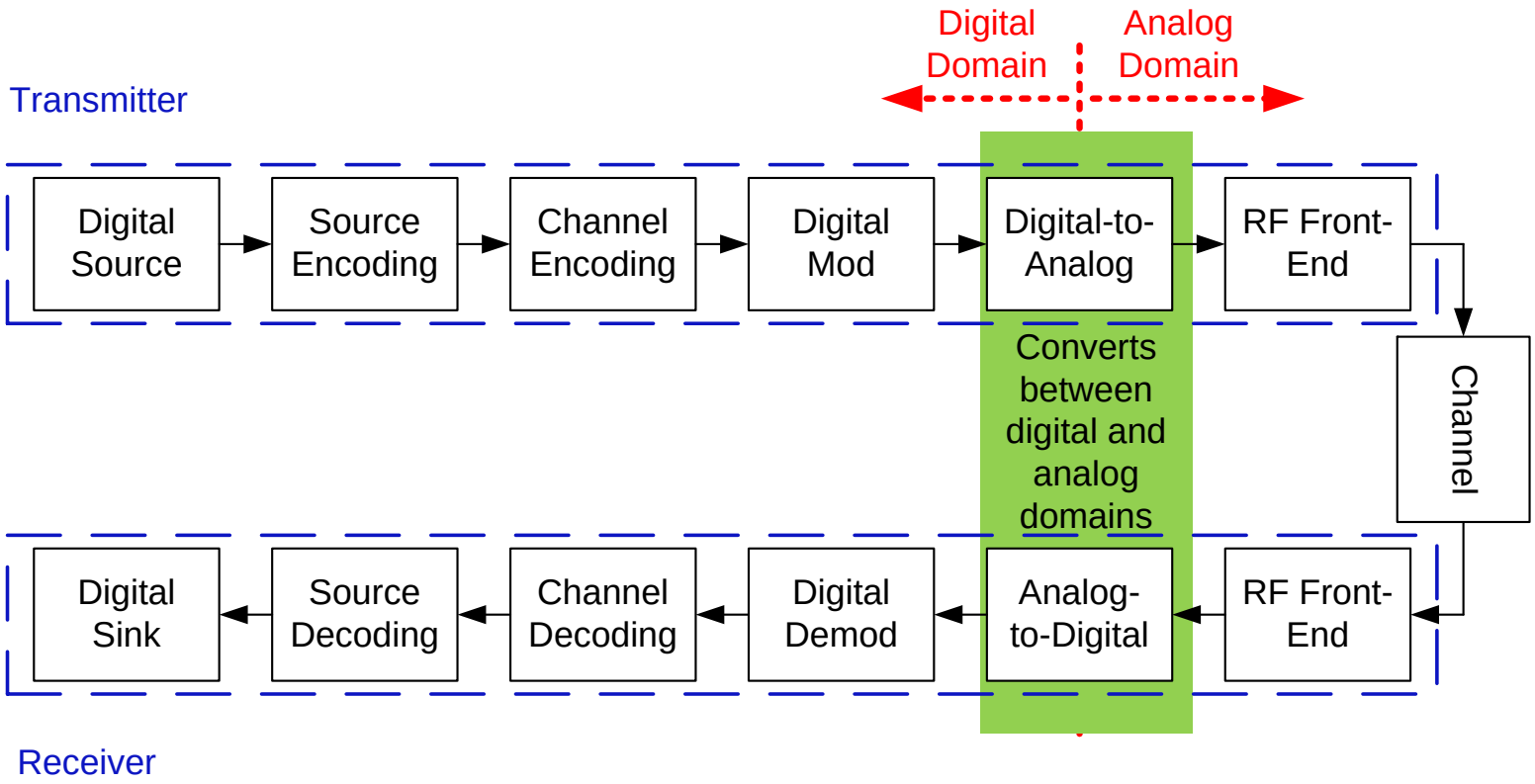

Figure : Generic representation of a digital communication transceiver.

Radio Frequency Front-Ends

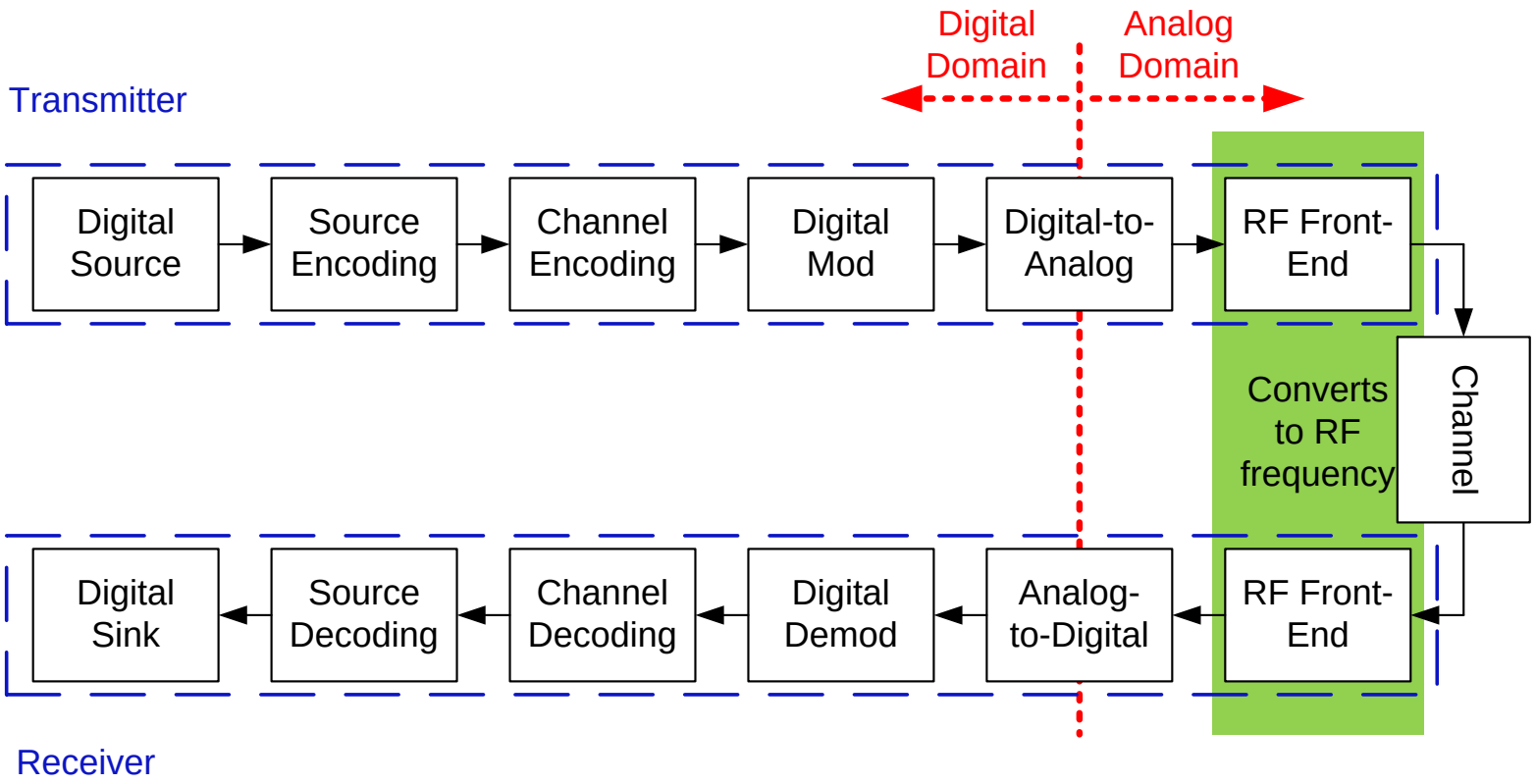

Figure : Generic representation of a digital communication transceiver.

What Makes Digital Communications Challenging?

- Digital communications would be trivial if the channel was *ideal*
- Randomness of the channel in terms of impairments affects correct reception of waveforms
  - Difficult to identify parameters
  - Time-varying phenomena
  - Requires overhead information between transmitter and receiver