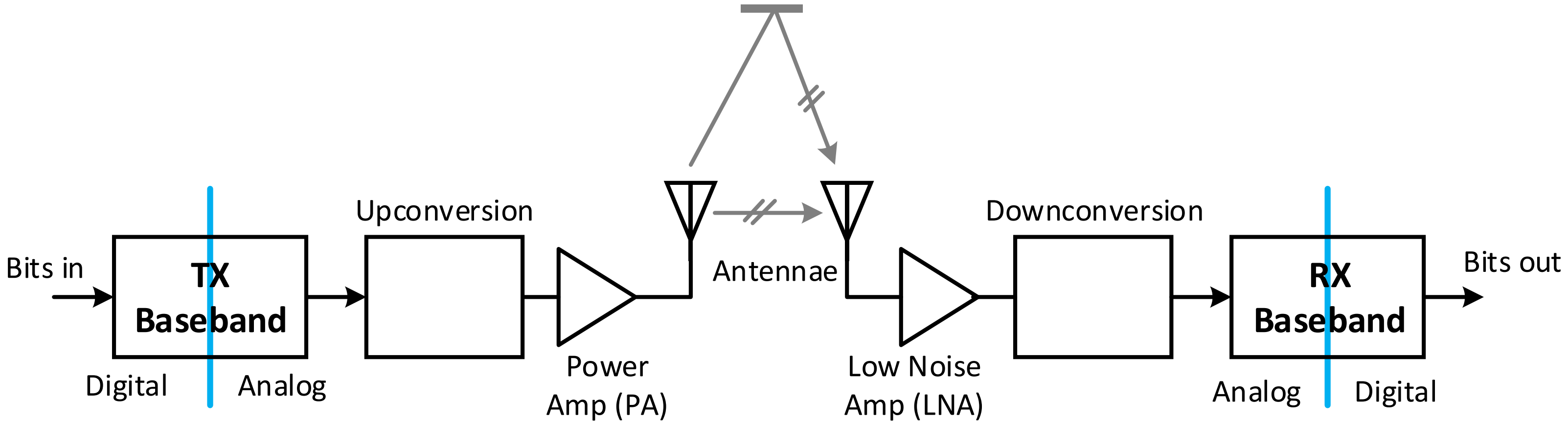
ECE 413/513 –RADIO FREQUENCY IC DESIGN

MODULATION TECHNIQUES

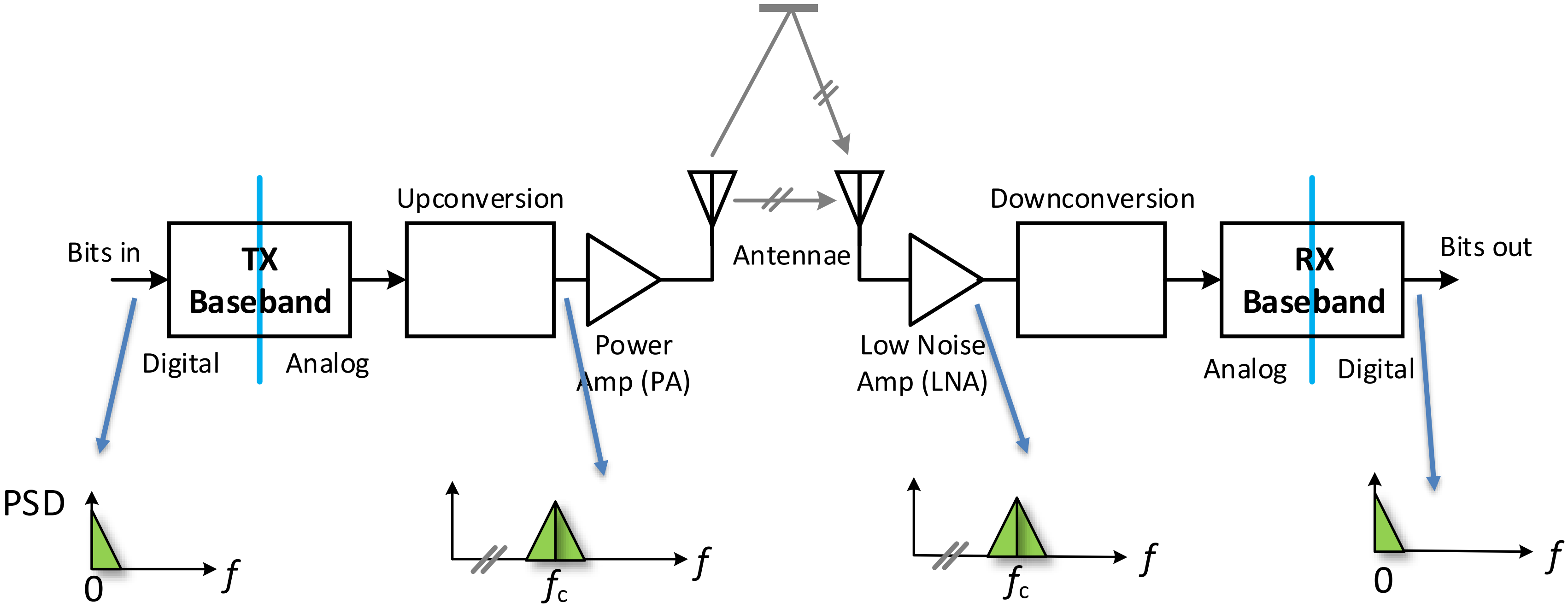
VISHAL SAXENA
VSAXENA@UIDAHO.EDU

University of Idaho
College of Engineering

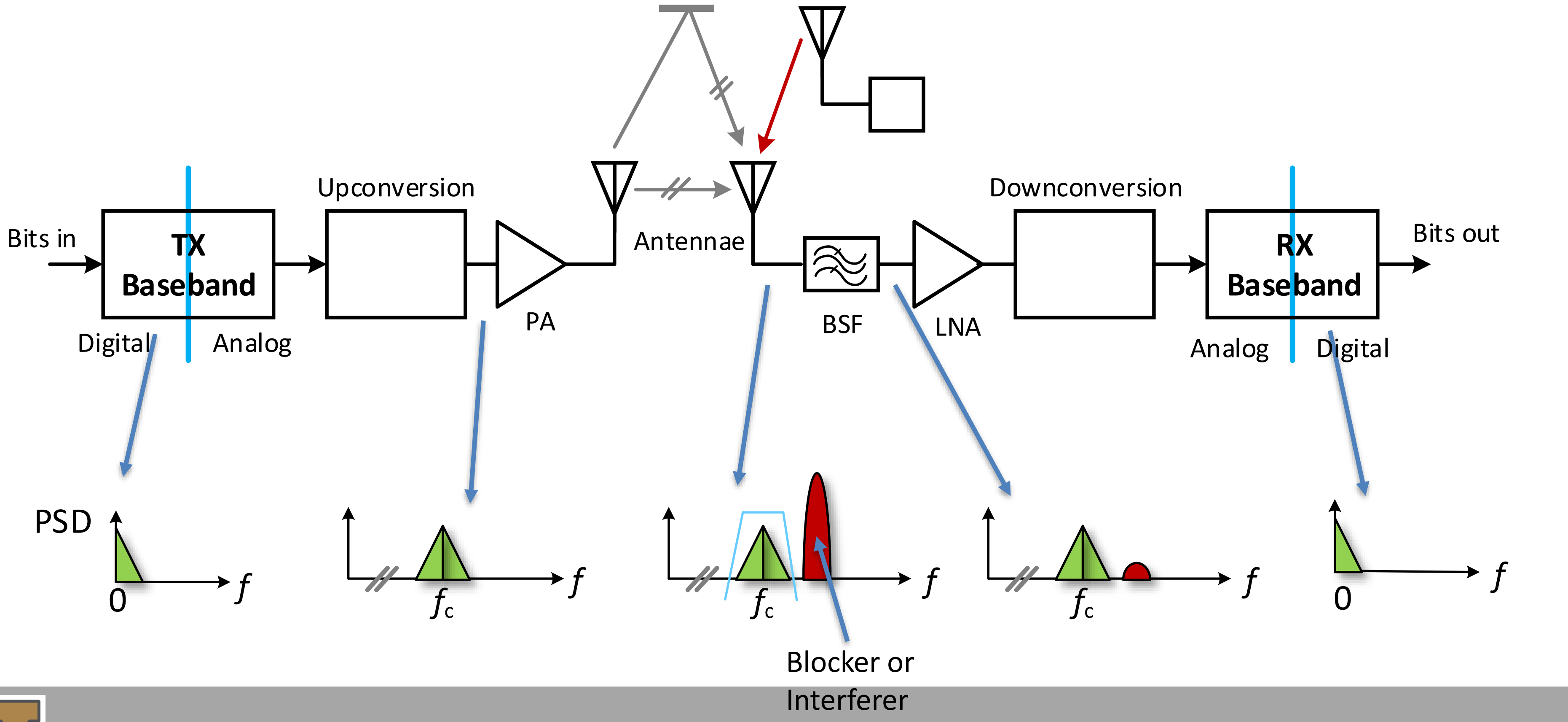
RF TRANSCEIVERS



RF TRANSCEIVERS

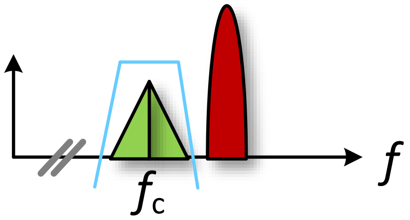


RF TRANSCEIVERS



RADIO TRANSCEIVERS

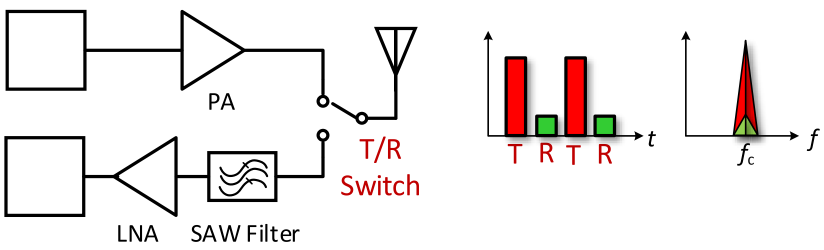
- A transmitter modulates a baseband signal to a higher carrier frequency and feeds and antenna with sufficient power
  - Should not distort the TX signal too much
- A well-designed receiver should perform
  - High-gain amplification of the received signal
  - Highly selective filtering of the desired signal
    - Reject adjacent channels, interferers, and image signal
  - Recovery of the intended information within error limits
- Processing narrowband analog signals with high selectivity and dynamic range

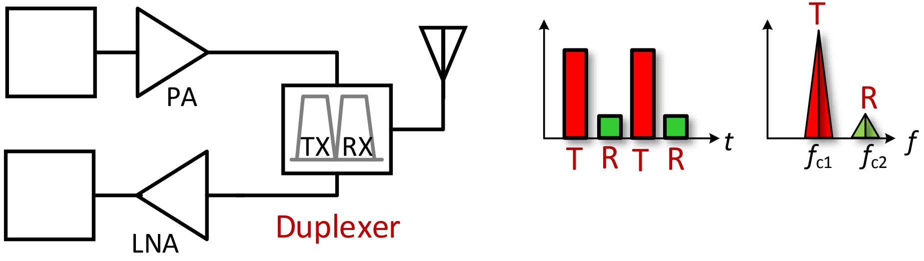


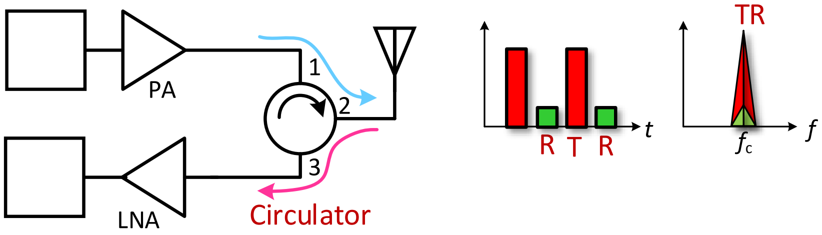
RADIO TRANSCEIVERS: ISOLATION

- Usually TX and RX don't operate simultaneously at the same carrier frequency
  - Frequency-division multiplexing (FDD) or
  - Time-division multiplexing (TDD) schemes used
  - Other methods of isolation
- Selectivity achieved using off-chip filters (SAW or MEMS)
- Isolation between TX and RX achieved using off-chip diplexers and isolators/circulators

RF TX/RX ISOLATION

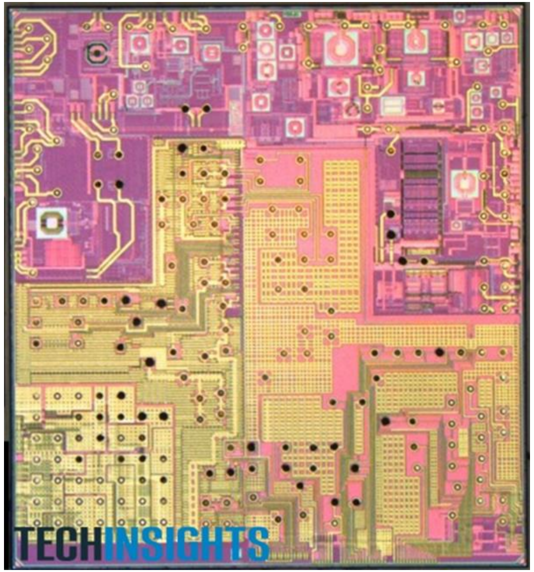






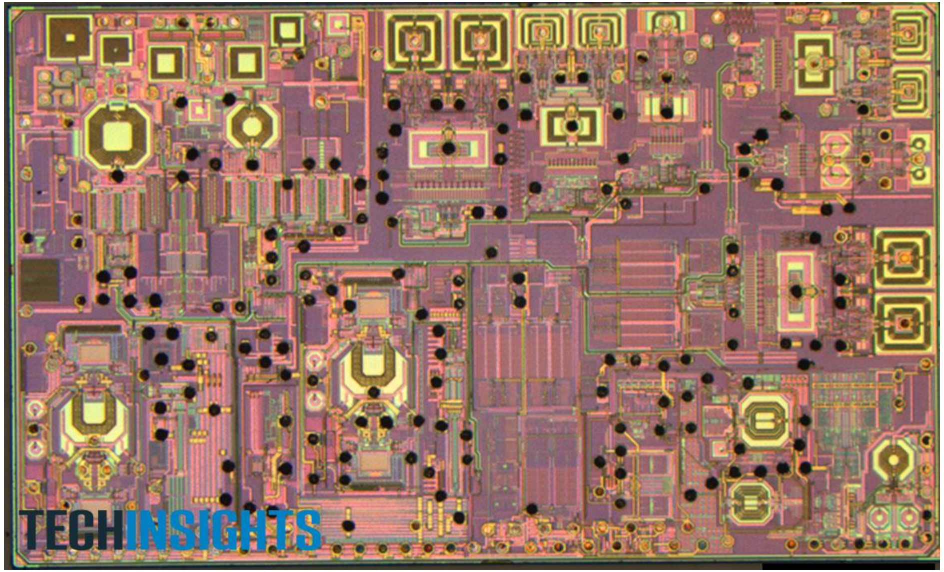
- Isolation usually not sufficient for simultaneous TX and RX
  - TX leaks to RX through package coupling and reflections
- Search full-duplex radios online for recent advances!

COMMERCIAL RFICS



BCM 4330 – Mobile Wireless

Single-band 2.4 GHz 802.11 b/g/n or dual-band 2.4 GHz and 5Ghz 802.11 a/b/g/n Integrated ARM® Cortex™-M3 processor and on-chip memory.



Qualcomm RTR8600 chip

Multi-band Multi-mode RF transceiver found in prominent Smartphones

ANALOG MODULATION

- Simple analog modulation is achieved by modulating a carrier by the message signal, m(t)

$$s(t) = m(t) \cdot A_c cos(2\pi f_c t)$$

- Since, $A_c cos(2\pi f_c t) = \frac{A_c}{2}(e^{j2\pi f_c t} + e^{-j2\pi f_c t})$
- In frequency domain

$$S(f) = \frac{A_c}{2}(M(f + f_c) + M(f - f_c))$$

- See lecture notes on analog modulation