Receive Side of System

- Reliably discriminate flag byte from noise
- Synchronize receiver clock to the incoming packet
- Store incoming data until CRC can be determined and compared
- CRC Match -> pass data to higher level application
- CRC Mismatch -> discard data

Simple Receiver Design

- Sample input channel 4x per bit period (TMRn ISR)
- Continuously shift data into storage registers (1 register per bit-period sample)
- After each new bit is shifted in, XOR register with 0x7E to test for flag
- After successfully identifying a flag byte, use the timing data to determine phase of bit stream clock

Simple Receiver Design contd...

- Continue to shift data into storage registers, sampling near center of bit period
- Test for stop flag after each bit is shifted in
- Contemporaneously calculate CRC
- When stop flag is identified, compare CRC calculated at receiver to that sent from transmitter – forward or discard data
- Continue to monitor channel (flag can serve as both start and stop flags, so new data may be coming immediately)

Decoding 0x7E Flag

High-level Data Link Control (HDLC) Protocol

- OSI Layer 2 – data link layer
- Generic packet form
- Ubiquitous protocol – though a bit old, it’s a workhorse
  - Ethernet
  - PPP/SLIP
  - FAX
  - NOAAPORT
  - X.25

Ex: A Modern Phy/MAC Protocol

- 802.15.4 – recently (2003) ratified standard
- 900 MHz and 2.4 GHz
- 2.4 GHz transceivers available for < $4 in unit quantity! Includes FW protocol stack
- Complex – not suitable for 55:036 projects ;-) (27 page app. note to blink an LED)
IEEE 802.15.4 Basics

- 802.15.4 is a simple packet data protocol for lightweight wireless networks
  - Channel Access is via Carrier Sense Multiple Access with collision avoidance and optional time slotting
  - Message acknowledgement and an optional beacon structure
  - Multi-level security
  - Three bands, 27 channels specified
    - 2.4 GHz: 16 channels, 250 kbps
    - 902-928 MHz: 10 channels, 40 kbps
  - Works well for
    - Long battery life, selectable latency for controllers, sensors, remote monitoring and portable electronics
  - Configured for maximum battery life, has the potential to last as long as the shelf life of most batteries

IEEE 802.15.4 MAC Overview

- Employs 64-bit IEEE & 16-bit short addresses
  - Ultimate network size can reach 2^64 nodes (more than we’ll probably need…)
  - Using local addressing, simple networks of more than 65,000 (2^16) nodes can be configured, with reduced address overhead
- Three devices specified
  - Network Coordinator
  - Full Function Device (FFD)
  - Reduced Function Device (RFD)
- Simple frame structure
- Reliable delivery of data
- Association/disassociation
- AES-128 security
- CSMA-CA channel access
- Optional superframe structure with beacons
- Optional GTS mechanism

Data Frame format

- One of two most basic and important structures in 15.4
- Provides up to 104 byte data payload capacity
- Data sequence numbering to ensure that packets are tracked
- Robust structure improves reception in difficult conditions
- Frame Check Sequence (FCS) validates error-free data

Acknowledgement Frame Format

- The other most important structure for 15.4
- Provides active feedback from receiver to sender that packet was received without error
- Short packet that takes advantage of standards-specified “quiet time” immediately after data packet transmission
MAC Command Frame format

- Mechanism for remote control/configuration of client nodes
- Allows a centralized network manager to configure individual clients no matter how large the network

Beacon Frame format

- Beacons add a new level of functionality to a network
- Client devices can wake up only when a beacon is to be broadcast, listen for their address, and if not heard, return to sleep
- Beacons are important for mesh and cluster tree networks to keep all of the nodes synchronized without requiring nodes to consume precious battery energy listening for long periods of time

ZigBee is Mesh Networking

- ZigBee Coordinator (FFD)
- Zigbee Router (FFD)
- Zigbee End Device (RFD or FFD)
- Mesh Link
- Star Link

Protocol Limitations

- Yes – channel access constraints!
- Yes – collision avoidance strategy!
- Yes – addressing!
- Yes – frequency agility for multipath avoidance!
- Yes – error correction mechanism!
- Yes – encryption!
- No – data compression!

Chipcon CC2420

- QLP-48 SMT package (7mm x 7mm)
- 2.4 GHz Direct Sequence Spread Spectrum (DSSS) transceiver
- 10 dBm RF input power
- 250 kbps data rate
- 3.6V (max) power supply
- Bundled 802.15.4 protocol stack