Section 6. Wireless Communication

Wireless Communication with ZigBee Protocol

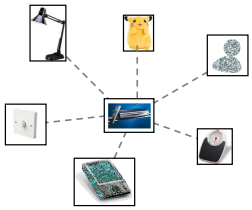
Different Wireless Protocols

1. Why ZigBee?
- We have WiFi, Cellular, Bluetooth, Why another Standard?

Standard	Bandwidth	Power Consump	Protocol Stack Size	Advantages	Applications
Wi-Fi	Up to 54Mbps	400+mA TX, standby 20mA	100+KB	High data rate	Internet browsing, PC networking, file transfers
Bluetooth	1Mbps	40mA TX, standby 0.2mA	~100+KB	Interoperability, cable replacement	Wireless USB, handset, headset
ZigBee	250kbps	30mA TX, standby 3uA	4-32KB	Long battery life, low cost	Remote control, battery-operated products, sensors

Home Area Network/Personal Area Network

- Home Networking
- Automotive Networks
- Industrial Networks
- Interactive Toys
- Remote Metering



ZigBee Physical Layer Overview

- The IEEE 802.15.4 is a standard developed for Wireless Personal Area Networks (WPANs).
- An over the air data rate of 250 kbit/s in the 2.4 GHz band.
- 16 independent communication channels in the 2.4 GHz band.
- Large networks (up to 65534 devices).
- Devices use carrier sense multiple access with collision avoidance (CSMA-CA) to access the medium.
- Two topologies: star and p2p, both topologies use one and only one central device, the PAN coordinator, that is the principal controller of the network:
- Low power consumption.
- Devices use Energy Detection (ED) for channel selection.
- Devices inform the application about the quality of the wireless link - Link Quality Indication (LQI).

MC13192 System Structure

Data Transfer Modes

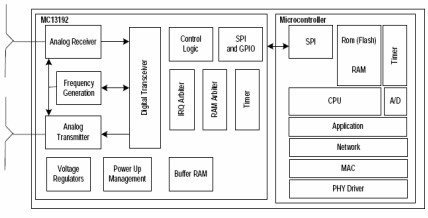


Figure 2. System Level Block Diagram

4 bytes 1 byte 1 byte 125 bytes Max 2 bytes

Interfacing MC13192 with a MCU

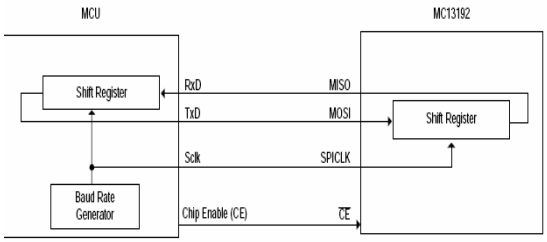
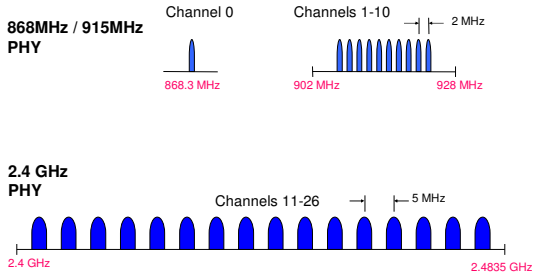


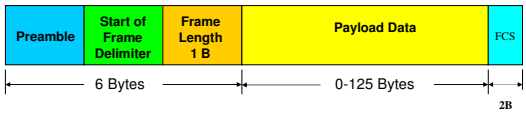
Figure 4. SPI Interface

Operating Frequency Bands



Packet Structure

- Preamble (4 bytes) – synchronization
- Start of Frame Delimiter (1 byte)
- Frame Length (1 byte)
- Data field up to 125 Bytes



Physical Layer Primitives

PHY Data Service

- PD-DATA – exchange data packets between MAC and PHY

e.g.

```
/***************************************
*Function: Transmit data packet
*Parameters: packet pointer
*Return:status
***************************************/
int pd_data_request(tx_packet_t *packet)
```

PHY Management Service

- PLME-CCA – clear channel assessment
- PLME-ED - energy detection
- PLME-GET / -SET– retrieve/set PHY PIB *(PAN Info Base)* parameters
- PLME-TRX-ENABLE – enable/disable transceiver

3. MAC Layer System Overview

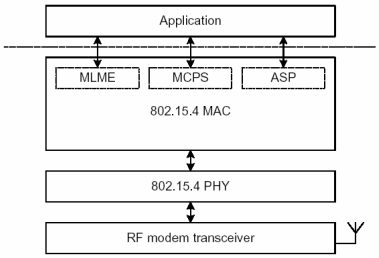


Figure 1-4. System Block Diagram

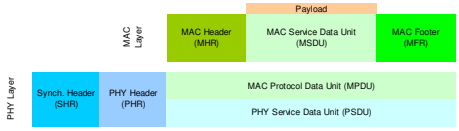
Two Types of Devices

- Full function device (FFD)
  - Any topology: Star, P2P (both use one and only one central device: the PAN coordinator)
  - Network coordinator capable
  - Talks to any other device
- Reduced function device (RFD)
  - Limited to star topology
  - Cannot become a network coordinator
  - Talks only to a network coordinator
  - Very simple implementation

Long Addresses and Short Addresses

- All devices have 64 bit IEEE addresses
- Short addresses (2 bytes long) can be allocated
- Addressing modes:
  - Network + device identifier (star)
  - Source/destination identifier (peer-peer)

MAC Frame Structure



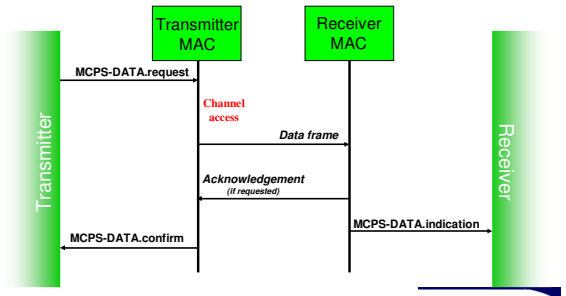
4 Types of MAC Frames:

- Data Frame
- Beacon Frame
- Acknowledgment Frame
- MAC Command Frame

Two Operation Modes

- **Beacon Mode:**
  Beacon Frames Transmitted by network coordinator to synchronize data transfers.
- **Non Beacon Mode**:
  Data transmission can take place at any time
- **Traffic Types:**
  Periodic data
  Application defined rate (e.g. sensors)
  Intermittent data
  Application/external stimulus defined rate (e.g. light switch)
  Repetitive low latency data
  Allocation of time slots (e.g. mouse)

MAC Data Service



MAC Primitives

MAC Data Service

- MCPS-DATA – exchange data packets between MAC and PHY
- MCPS-PURGE – purge an MSDU from the transaction queue

- **MAC Management Service**
- MLME-ASSOCIATE/DISASSOCIATE – network association
- MLME-SYNC / SYNC-LOSS - device synchronization
- MLME-SCAN - scan radio channels
- MLME- COMM-STATUS – communication status
- MLME-GET / -SET– retrieve/set MAC PIB parameters
- MLME-START / BEACON-NOTIFY – beacon management
- MLME-POLL - beaconless synchronization
- MLME-GTS - GTS management
- MLME-RESET – request for MLME to perform reset
- MLME-ORPHAN - orphan device management
- MLME-RX-ENABLE - enabling/disabling of radio system

Example Functions:

```
/*****************************************************
*Function: Transmit data packet
*Parameters: packet pointer
*Return:status
*****************************************************/
int MCPS_data_request(tx_packet_t *packet)

/*****************************************************/
int MCPS_data_indication
/*****************************************************
*Function: Receive data packet indication
*Parameters: data packet pointer
*Notes: This function return should be located in the application
*****************************************************/
```

MLME examples

```
/*****************************************************
*Function: Hibernate the MC13192 (very low current, no CLKO)
*Return:status
*****************************************************/
int MLME_hibernate_request(void)
{
    uint8 status;
    status = PLME_hibernate_request();
    return status;
}
/*****************************************************
*Function: Doze the MC13192 (Low current, CLKO <= 1MHz)
*Return:status
*****************************************************/
```