Computer Hardware

2018 Session 1

Lecture: RS-232
"Not R2D2"

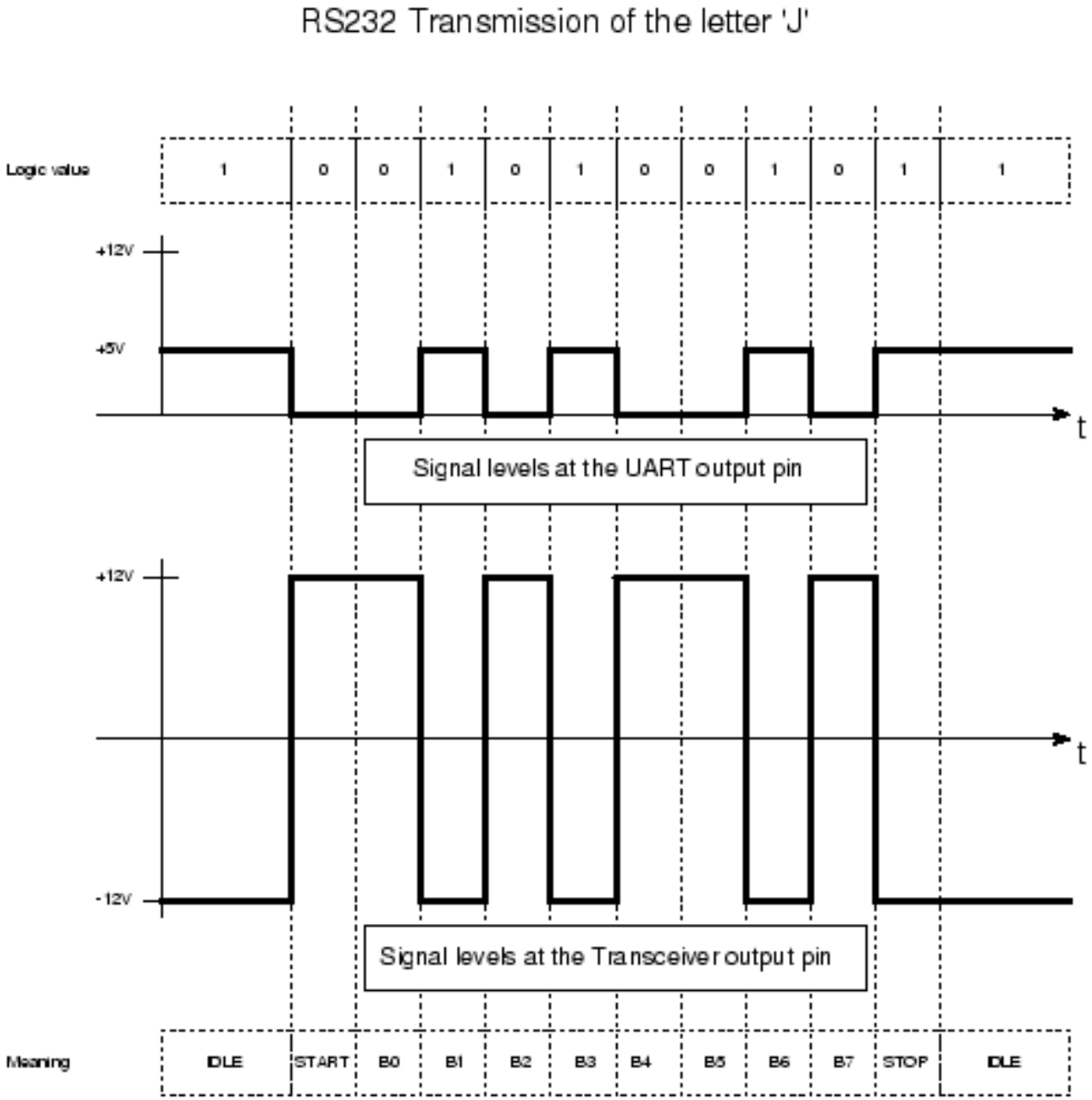
RS-232

- Recommended Standard 232
  - RS-232 → EIA-232 → TIA-232
- Connects Data Communications Equipment (DCE) and
- Data Terminal Equipment (DTE)
- Common data communication protocol
  - Console ports on many embedded devices are accessed through RS-232
  - Modems talk RS-232
    - Modem on phone line to remote equipment

Serial Communications Protocol

- Defines voltage levels
  - 0, SPACE, asserted, +3 to +15V
  - 1, MARK, deasserted, -3 to -15V
- Defines slew rates
  - 30V/µs
- Defines cable characteristics
  - Max Length 50 feet.
- Defines transmission format
  - Non-Return-Zero (NRZ)

J=0x4A


RS232 Transmission of the letter 'J'
Logic value
1 0 0 1 0 1 0 0 1 0 1 1
+12V
+5V
t
Signal levels at the UART output pin
+12V
t
-12V
Signal levels at the Transceiver output pin
Meaning
IDLE START B0 B1 B2 B3 B4 B5 B6 B7 STOP IDLE

Signal Characteristics

- An RS-232 signal varies between +15V and -15V, commonly we would use +/- 12V as these were commonly available in computer systems to bias electronic circuits. Higher voltages gave higher noise immunity, but slower speeds. Lower voltage swings allowed higher speeds.

- RS-232 was limited (by the standard) to 20Kbits/sec.

- Higher speeds violate the standard, but are in common use over very short cable runs and high voltages.

- Communications starts with a start bit, followed by the bits of data (least significant bit first) followed by an optional parity bit, and 1, 1.5 or 2 stop bits.
- The use of the stop and start bits guarantees at least one signal transition, otherwise it is possible that no signal transitions occur.
- Invalid transmissions may occur from:
  - Framing errors
  - Break conditions
  - Parity errors
- An RS-232 decode should report on these three syndromes

Communications Agreement

Both the transmitter and receiver have to be configured, out of band, about the baud rate, the number of data bits, the parity, and the number of stop bits. If they are misconfigured errors will occur on the data link.

The most common configuration is:

- 9600 baud
- 8 data bits
- No parity
- 1 Stop bit

Parity Errors

After the data bits have been transmitted an optional parity bit is transmitted. The parity is one of:

- mark - always transmit a 1
- space - always transmit a 0
- odd - transmit a 0 if the number of 1s is odd, otherwise 1
- even - transmit a 0 if the number of 1s is even, otherwise 1
- none - no parity is transmitted

The receiver verifies the parity is correct on reception of the parity bit (if any). If not, a parity error is generated.

Framing Errors

If we do not see the stop bit at the expected time there has been a transmission error. This error is called a framing error, and is due to either noise on the cable, or mismatched baud rates.

Framing errors can be used to try and auto-baud, where we start at a high baud rate and drop it until we do not receive framing errors. This works if we are expecting a standard opening character.

A special case of a framing error is called a break condition.

Break Condition

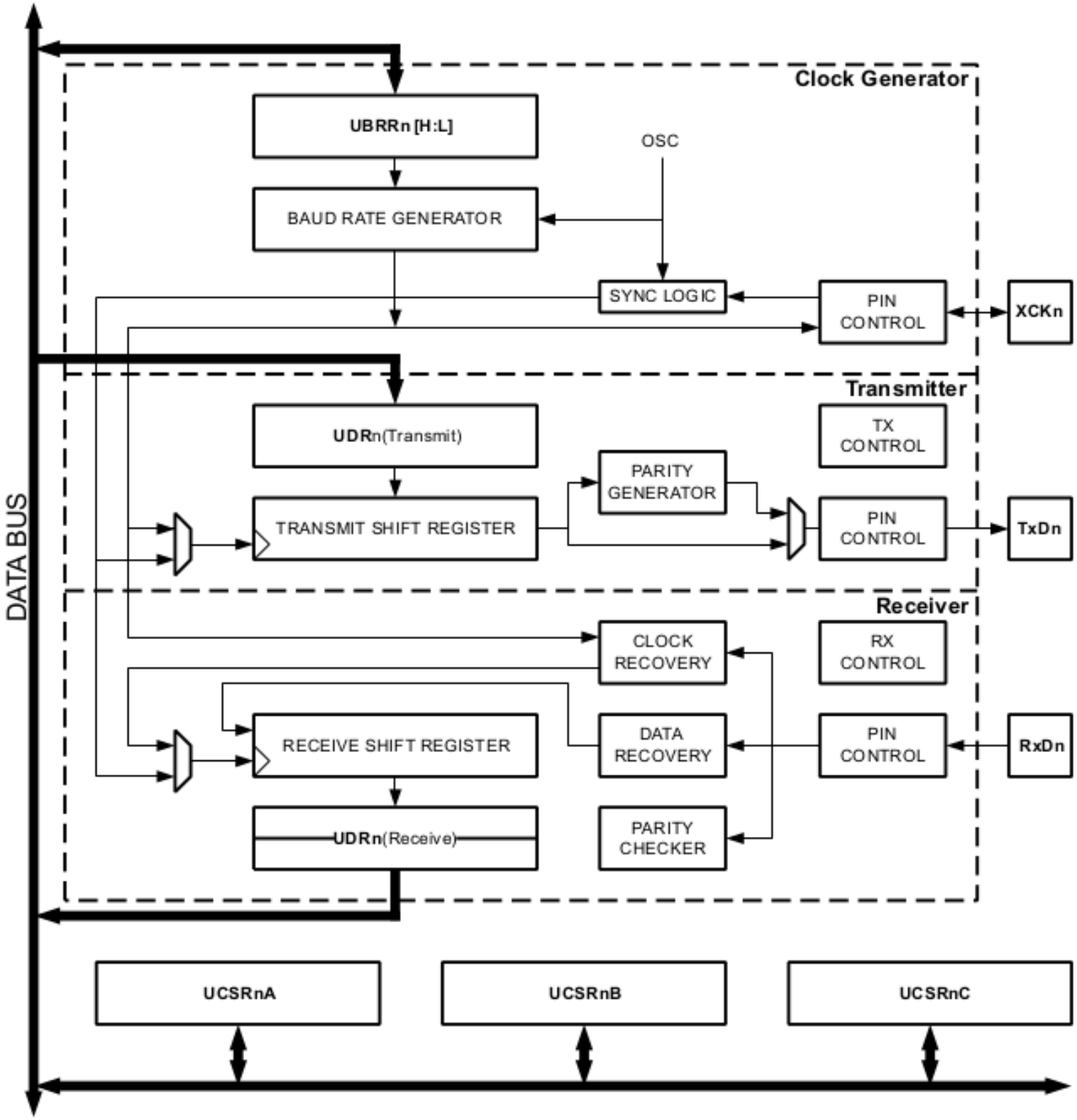
A break condition occurs when all data bits, the parity bits and the stop bits are low.

In a break condition the start bits goes low and the signal stream just stays low.

The break condition is used to identify an exceptional condition, such as line disconnection or reset.

ATMEL ATmega USART (Serial Communication Interface)

Provides hardware to implement RS-232, RS-422, LIN, style serial communication. Allows fully controllable baud rate generation, 8 or 9 bit (parity) character transmission and reception. Multi-character buffers are provided for reception and interrupts on transmit and receive.


Clock Generator
UBRRn [H:L]
OSC
BAUD RATE GENERATOR
SYNC LOGIC
PIN CONTROL
XCKn
Transmitter
UDRn(Transmit)
TX CONTROL
PARITY GENERATOR
TRANSMIT SHIFT REGISTER
PIN CONTROL
TxDn
Receiver
CLOCK RECOVERY
RX CONTROL
RECEIVE SHIFT REGISTER
DATA RECOVERY
PIN CONTROL
RxDn
UDRn(Receive)
PARITY CHECKER
DATA BUS
UCSRnA
UCSRnB
UCSRnC

Baud Rate Generation

- Baud rate is calculated by dividing the system clock by the baud rate divisor.
- Baud rate is the rate at which data symbols are transmitted or received.
- In RS-232 1 bit = 1 baud.
- We define the count to allow 16 sample times for each baud time.
  - This allows a multi sampling circuit.
  - Samples always occur at the middle of the character time

Counters and Shift-registers

Notice how much we are seeing counters and shift registers?

We use them all over the place.