11037 SER

Communicate with PIC16 and PIC18 MCUs via the PC Serial Port

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Class Objectives

When you walk out, you will know:

- **Benefits of the PC serial interface**
- **PC to PIC® microcontroller (MCU) hardware interface**
- **PIC MCU USART peripherals**
- **PC Serial interface applications**
  - Built-in Programming Interface Functions
    - C#
    - Visual Basic

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Class Agenda

- **Overview of PC to PIC® MCU Communications Solution**
- **PC to PIC MCU hardware interface**
- **Setup and use of the USART peripheral**
- **Communications Firmware**
- **Serial port methods and properties**
- **PC Software**
  - C#
  - Visual Basic

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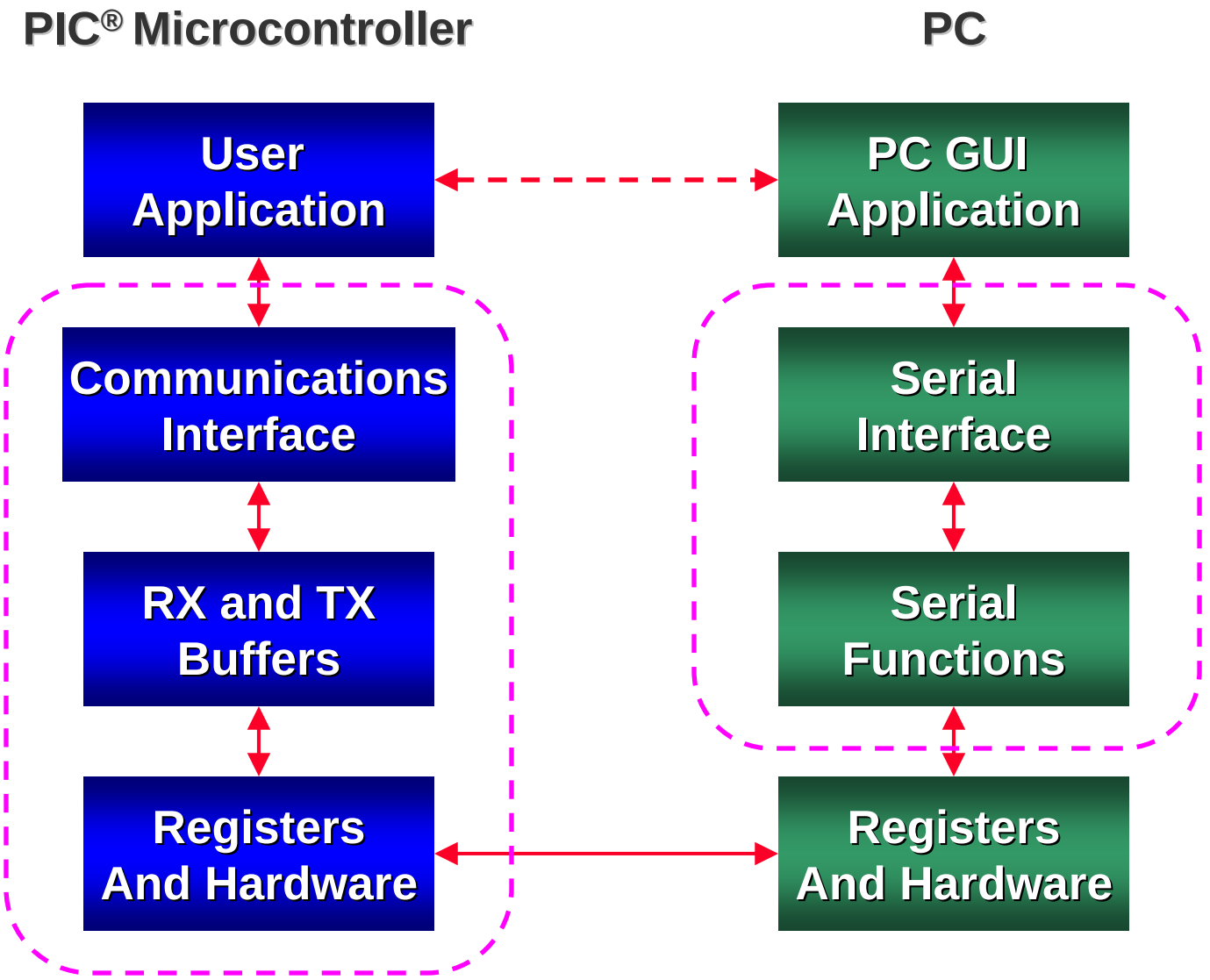
Serial Communications Overview

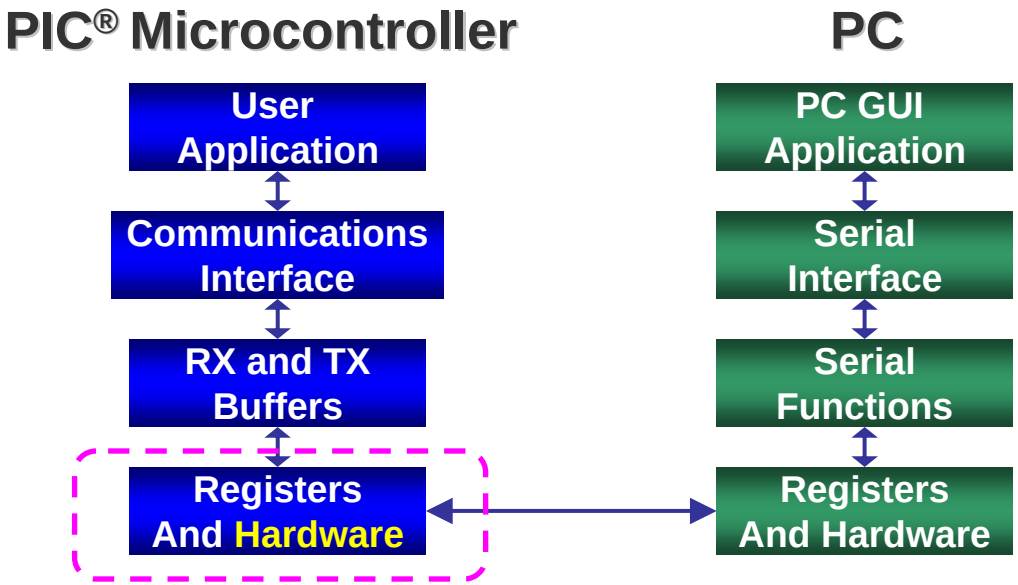
Benefits of Serial

- Universal
- Simple
- Some implementations require only 1 wire
- Easy to troubleshoot
- PCs supplied with Hyperterminal
- No Vendor ID required
- Expandable with USB-to-Serial adapters

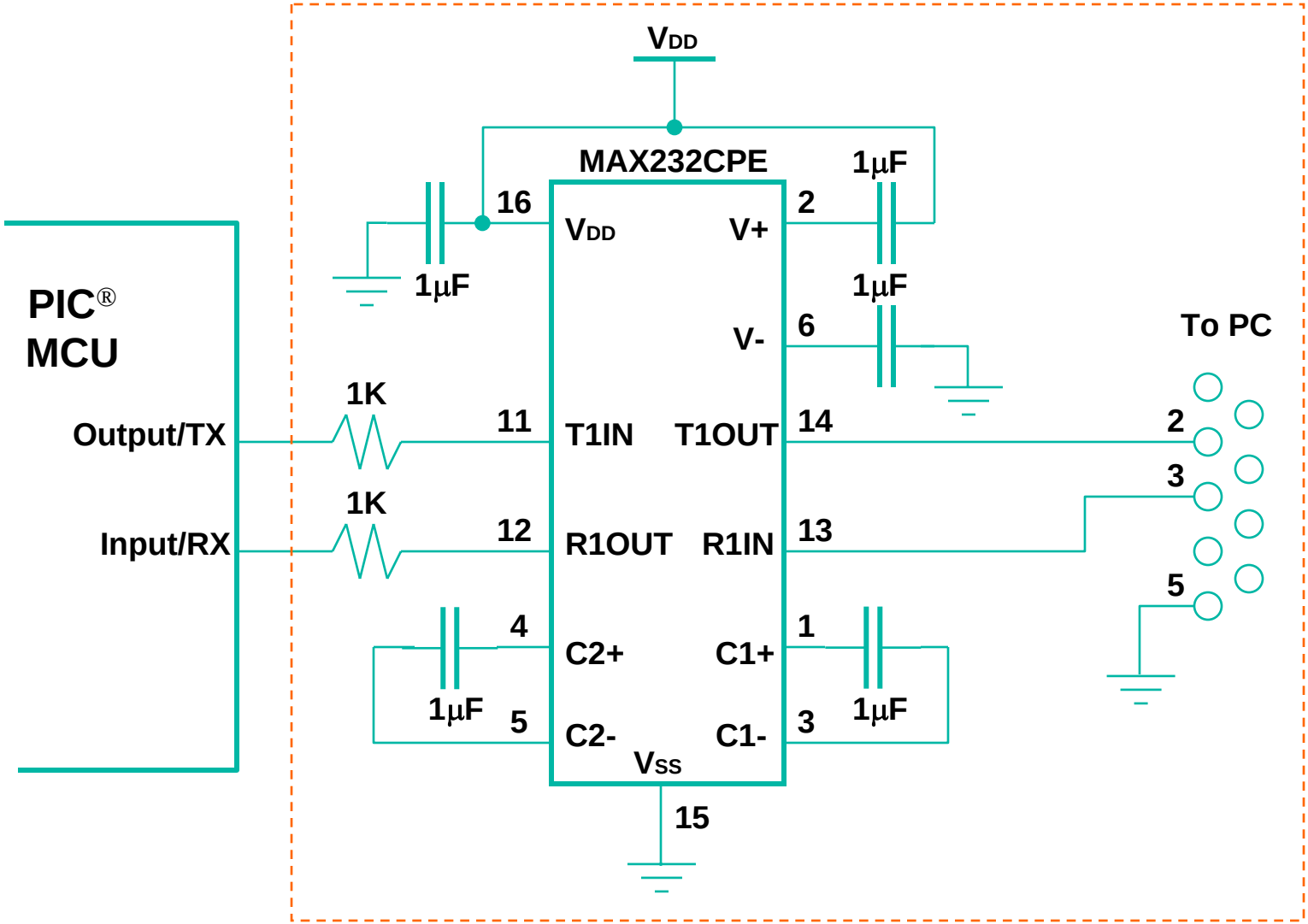
Serial Solution Layers



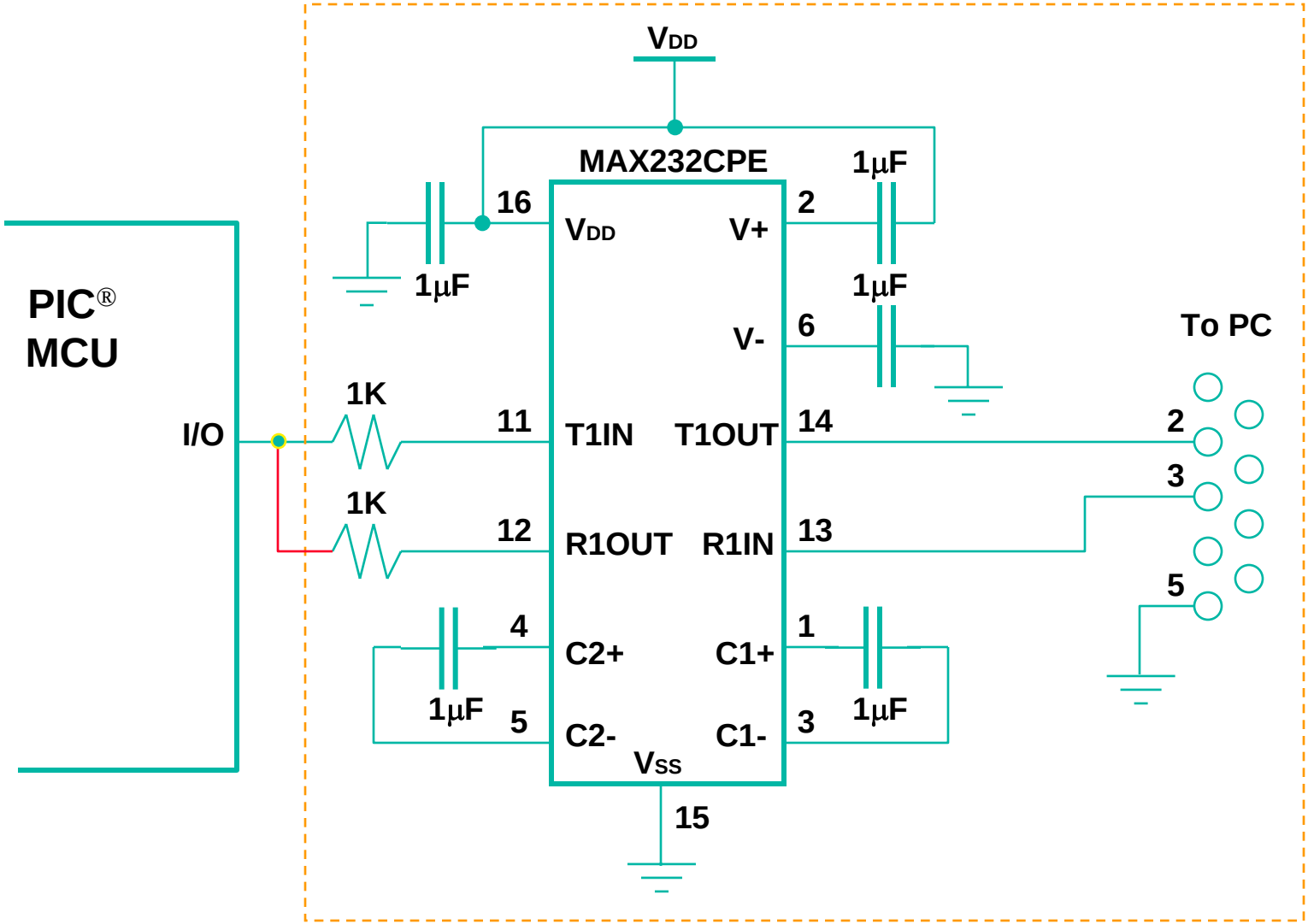
Hardware



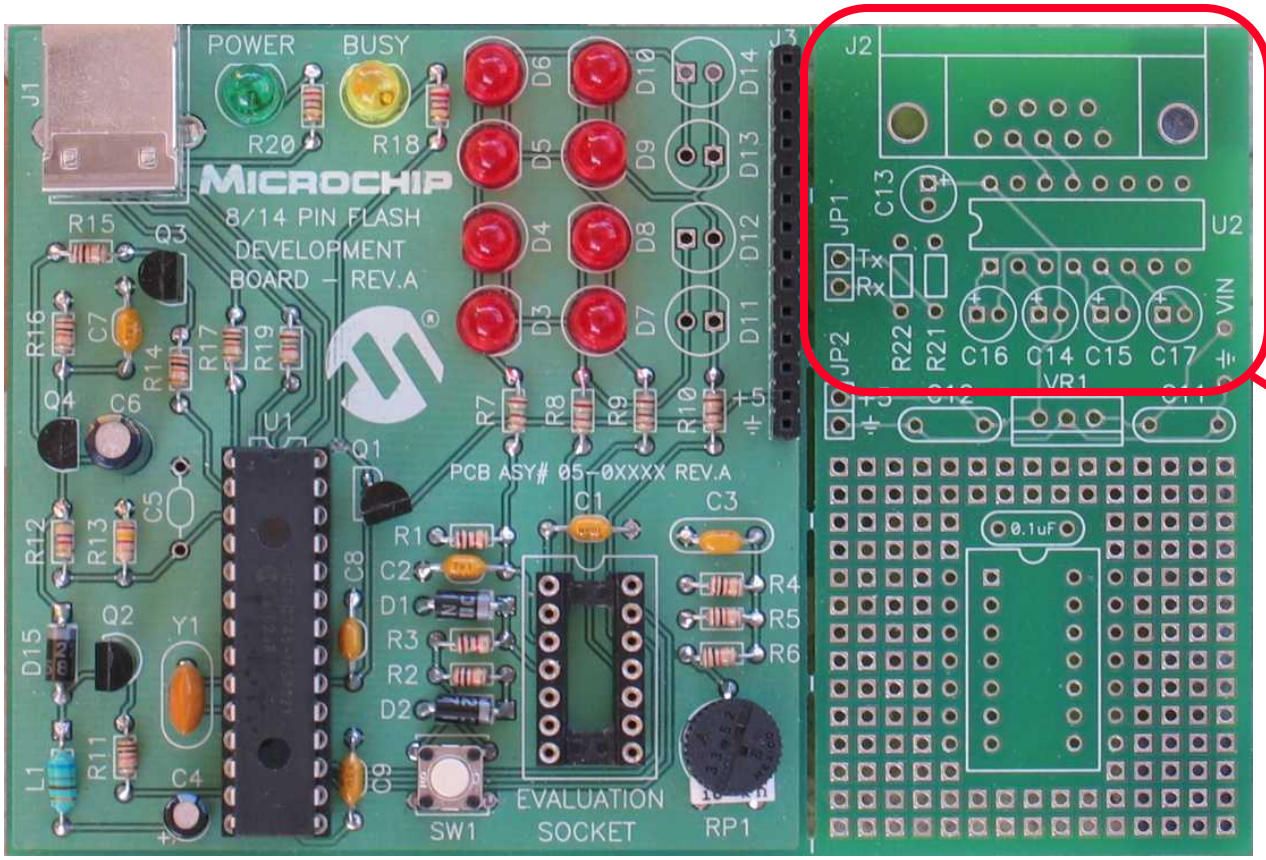
Typical 2 Wire PC Interface



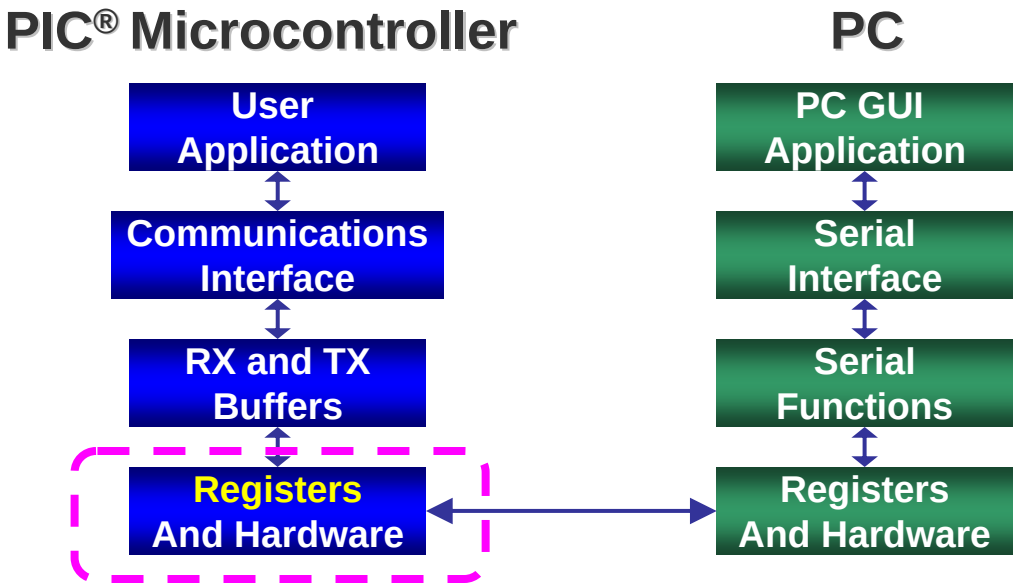
Typical 1 Wire PC Interface



PICkit™ Starter Kit Circuit Board



USART Peripheral



USART Types

- **USART**
  - Universal Synchronous/Asynchronous Receiver Transmitter
- **AUSART**
  - Same as USART with address recognition
- **EUSART**
  - Enhanced - Same as AUSART with
    - Baud rate detection/calibration
    - Wake on break
    - Break character transmit

USART Registers

- RCSTA – Receive status and control
- TXSTA – Transmit status and control
- RCREG – Receive data
- TXREG – Transmit data
- SPBRG – 8 bit baud rate selection
- PIR and PIE – Interrupt status and enable
- SPBRGH – upper 8 bits (EUSART only)
- BAUDCTL – Extended control (EUSART only)

Receive Status and Control

RCSTA

CONTROL

- SPEN – Serial peripheral enable (turns on the USART)
- CREN – Continuous receive enable (turns on the receiver)

STATUS

- FERR – Framing error (cleared by reading RCREG)
- OERR – Overrun error (cleared by clearing CREN)

NOT USED (in this application)

Transmit Status and Control

TXSTA

CONTROL

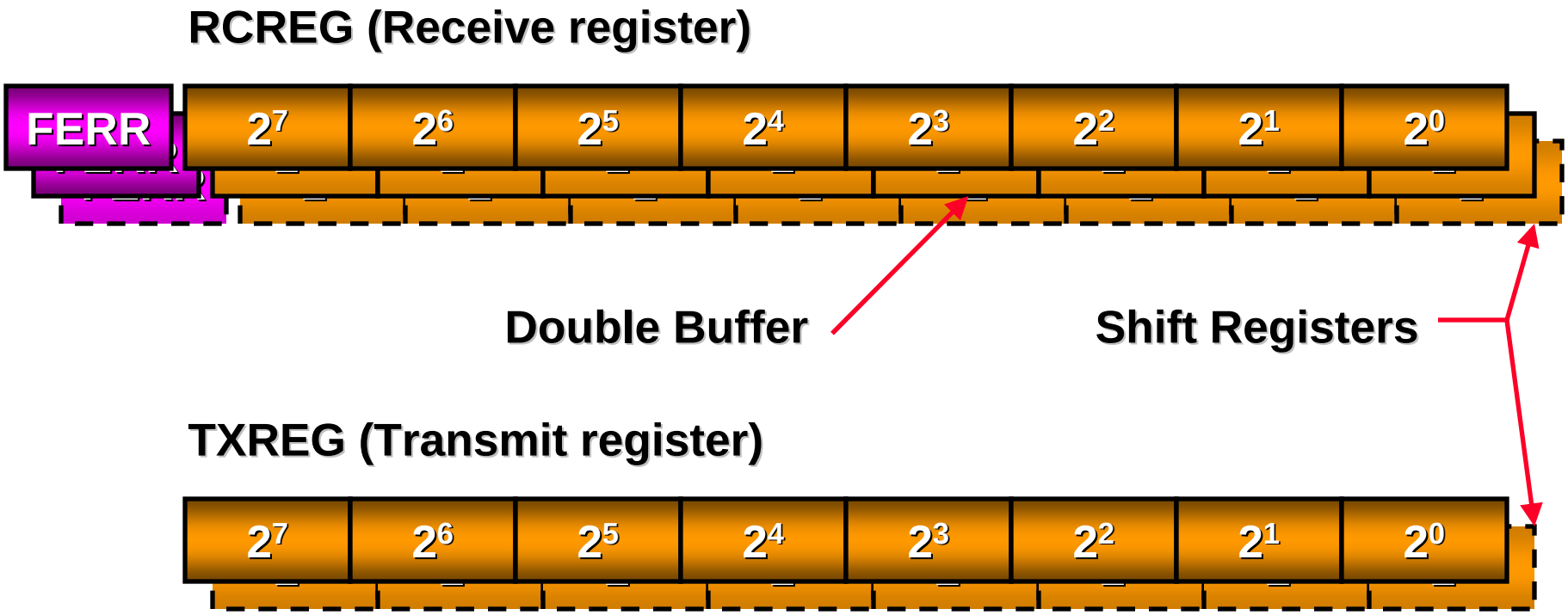
- TXEN – Transmit enable (turns on transmit)
- BRGH – High range baud rate (faster baud rate clock)

STATUS

- TRMT – Transmit shift register empty

NOT USED (in this application)

Serial Data Registers



Interrupt Status and Enable

PIR1

CONTROL

- **TXIF – TXREG is empty (read only)**
- **RCIF – RCREG is full (read only)**

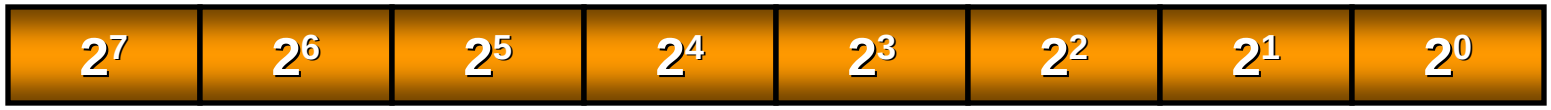
PIE1

CONTROL

- **TXIE – Enable TXIF interrupts**
- **RCIE – Enable RCIF interrupts**

Baud Rate Generator

SPBRG



CONTROL

SPBRG = Number of clocks in one bit period

SPBRG = [Fosc/(DataRate·Div)] -1

When BRGH = 0: Div = 64

When BRGH = 1: Div = 16

SPBRGH (EUSART only)

NOT USED (in this application)

Baud Rate Control

BAUDCTL (EUSART only)

CONTROL

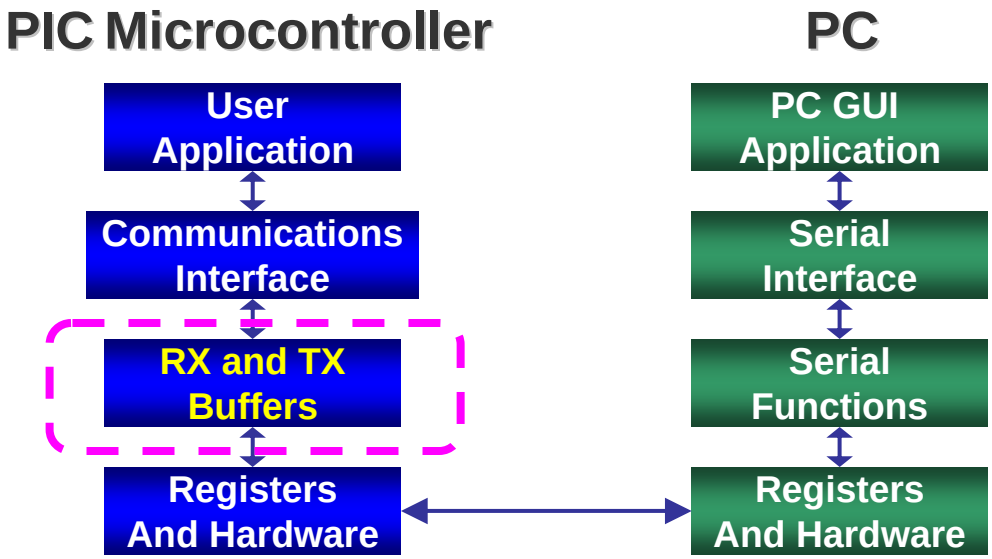
ABDEN = Autobaud detect enable

STATUS

ABDOVF = Autobaud detect overflow

NOT USED (in this application)

PIC® MCU Firmware Buffer Level



Receive and Transmit Buffering

- **Circular buffers**
  - All communications via buffer fill and empty routines
  - Allows back to back messaging
- **Receive buffering**
  - Entire command received before processing
  - Host PC doesn't need to wait
  - Permits typing corrections
- **Transmit buffering**
  - Allows multi-byte conversions in one step

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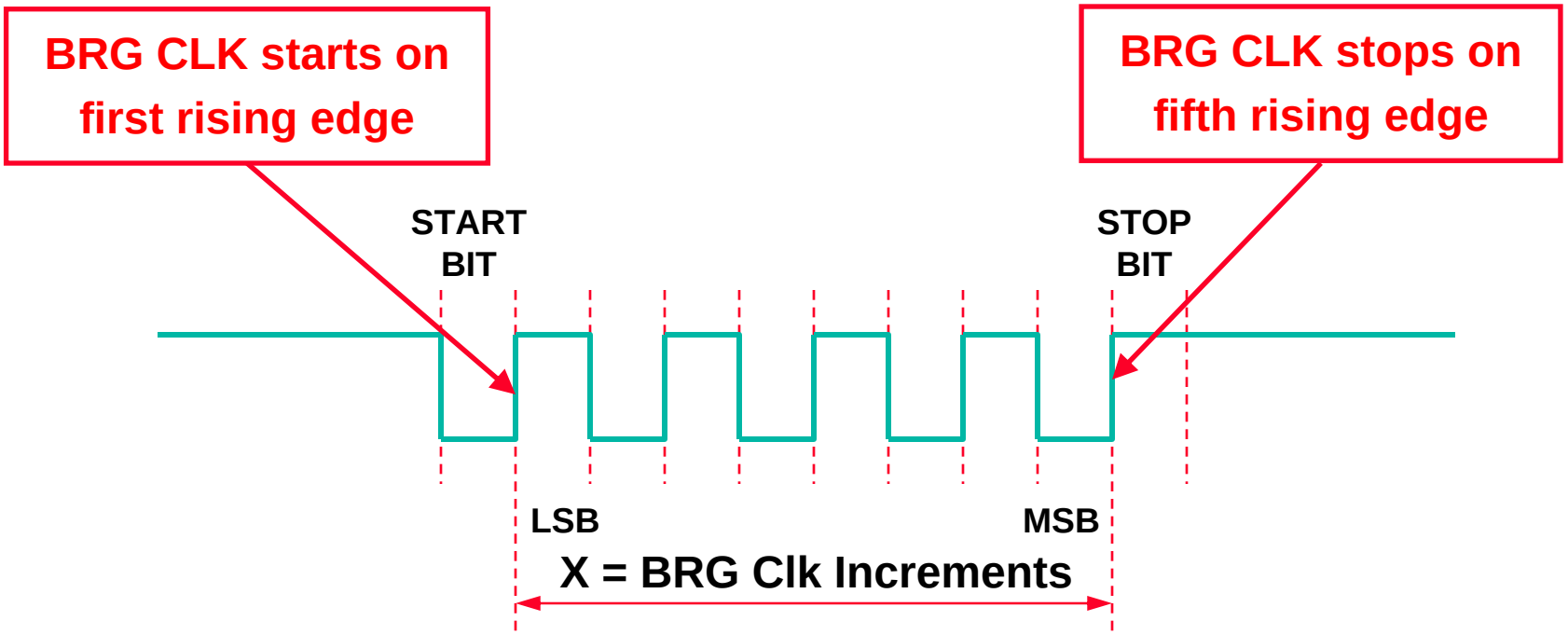
Buffer Functions

- **UARTInit:** Initialize SFRs and pointers
- **ResetRXPointers:** Set PutRX to GetRX
- **Autobaud:** Measure cal char and set SPBRG
- **TXService:** Transfer TX buffer to TXREG
- **RXService:** Transfer RCREG to RX buffer
- **GetRX:** Get character from RX buffer
- **PutTX:** Put character in TX buffer

Autobaud

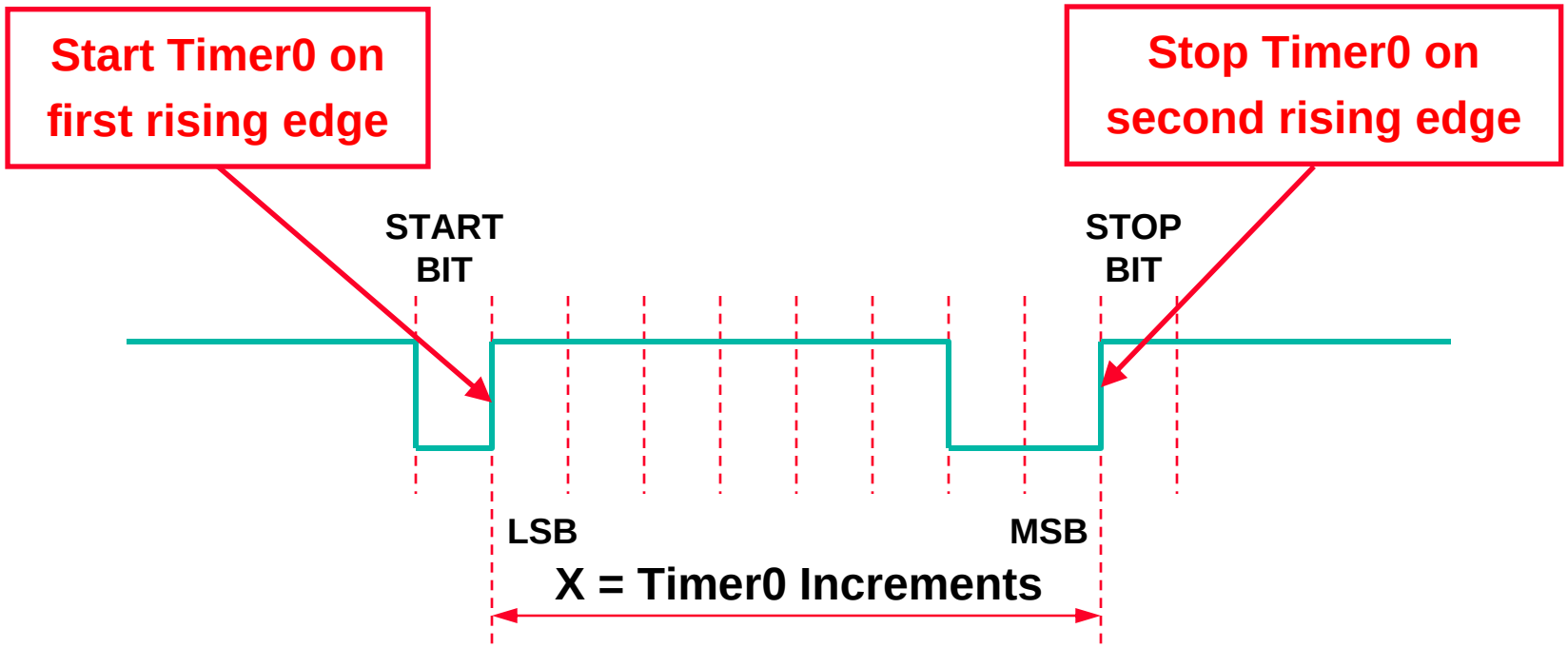
- **Adjust SPBRG based on calibration character**
- **Precludes the need for a crystal**
- **RC Oscillator**
  - Low cost solution
  - Frees I/O pins
- **LIN bus requirement**

EUSART Autobaud - Timing



- Only possible calibration character: 0x55 = “U”
- BRG Clock is 1/8 base BRG clock rate during AUTOCAL
- RCIF flag is set at completion. RCIF is cleared by reading RCREG

Autobaud - Timing



All possible calibration characters

0x01 = SOH
0x03 = ETX
0x07 = ACK
0x0F = SI
0x1F = US
0x3F = "?"
0x7F = DEL

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Autobaud - Derivation

SPBRG = [(Timer0 Counts*Timer0Prescale)/(4*Bits)] -1

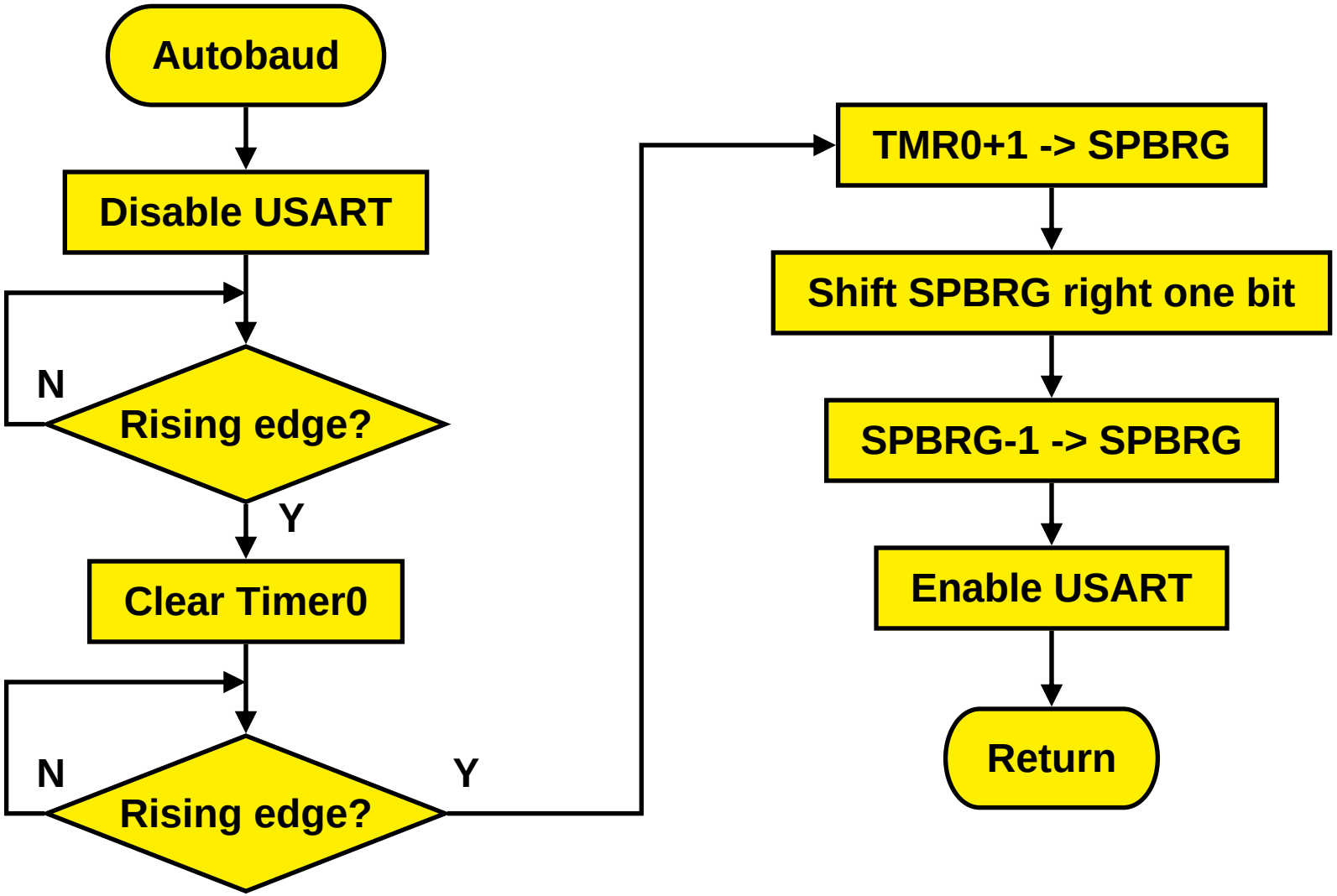
Assuming Timer0 Prescale = 2*Bits

SPBRG = (Timer0 Counts/2) -1

(X/2 allows rounding up resulting in an uncertainty of +/- 0.5 counts)

Full derivation can be found in code listings.

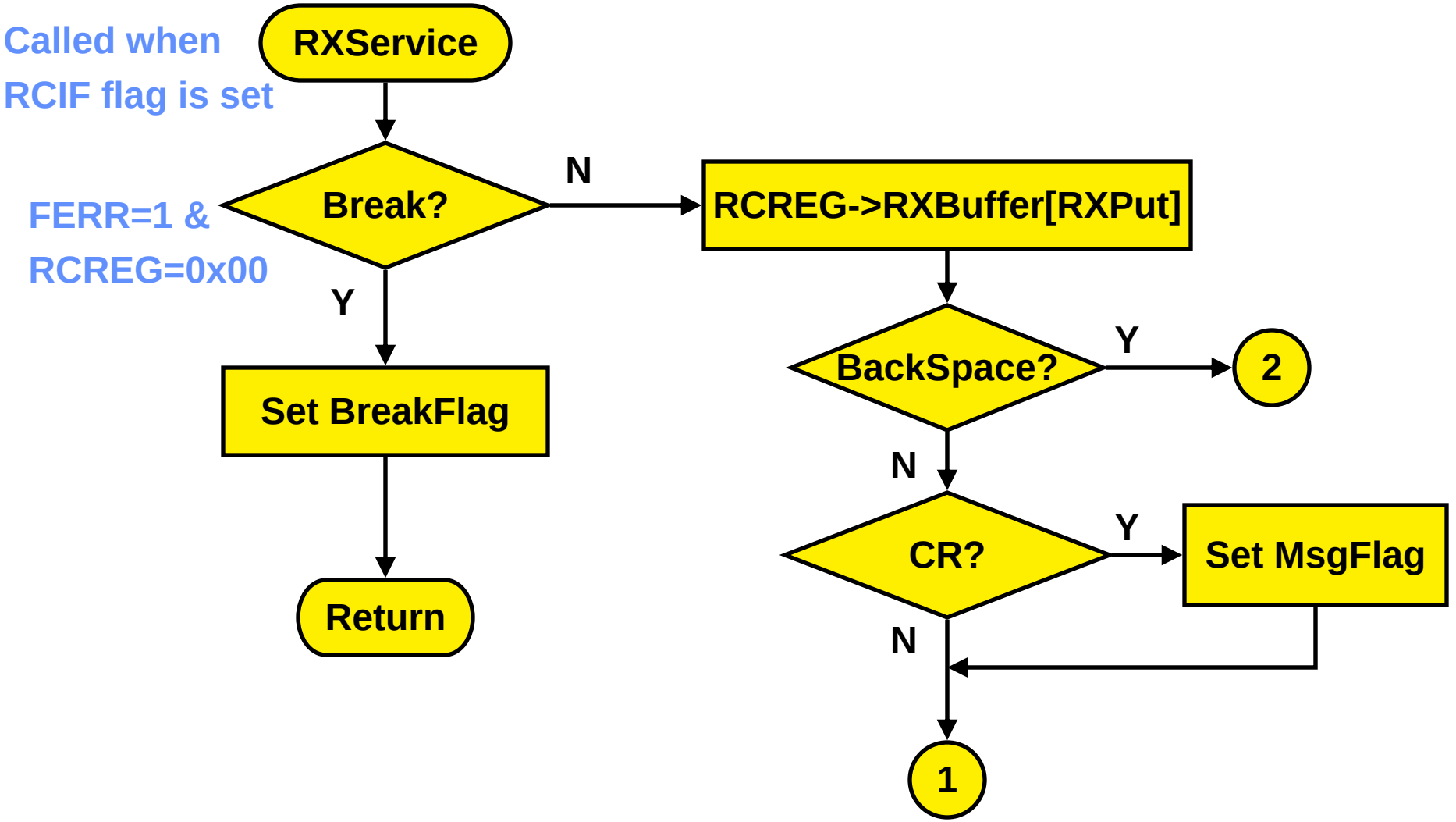
Autobaud



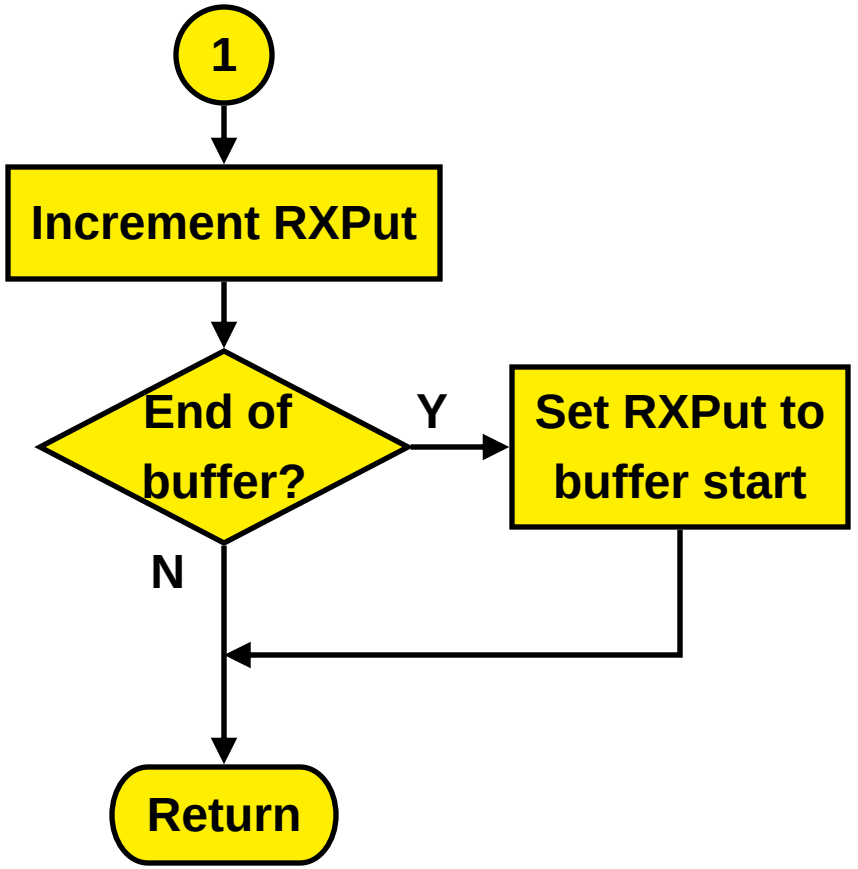
Receive Buffer

- **As large as longest command plus margin**
- **Two pointers**
  - RXPut
    - Put pointer for inserting bytes from RCREG
  - RXGet
    - Get pointer for removing bytes
- **Flags**
  - RCIF invokes RXService
  - GetMsg invokes GetRX
  - BreakFlag invokes recalibration

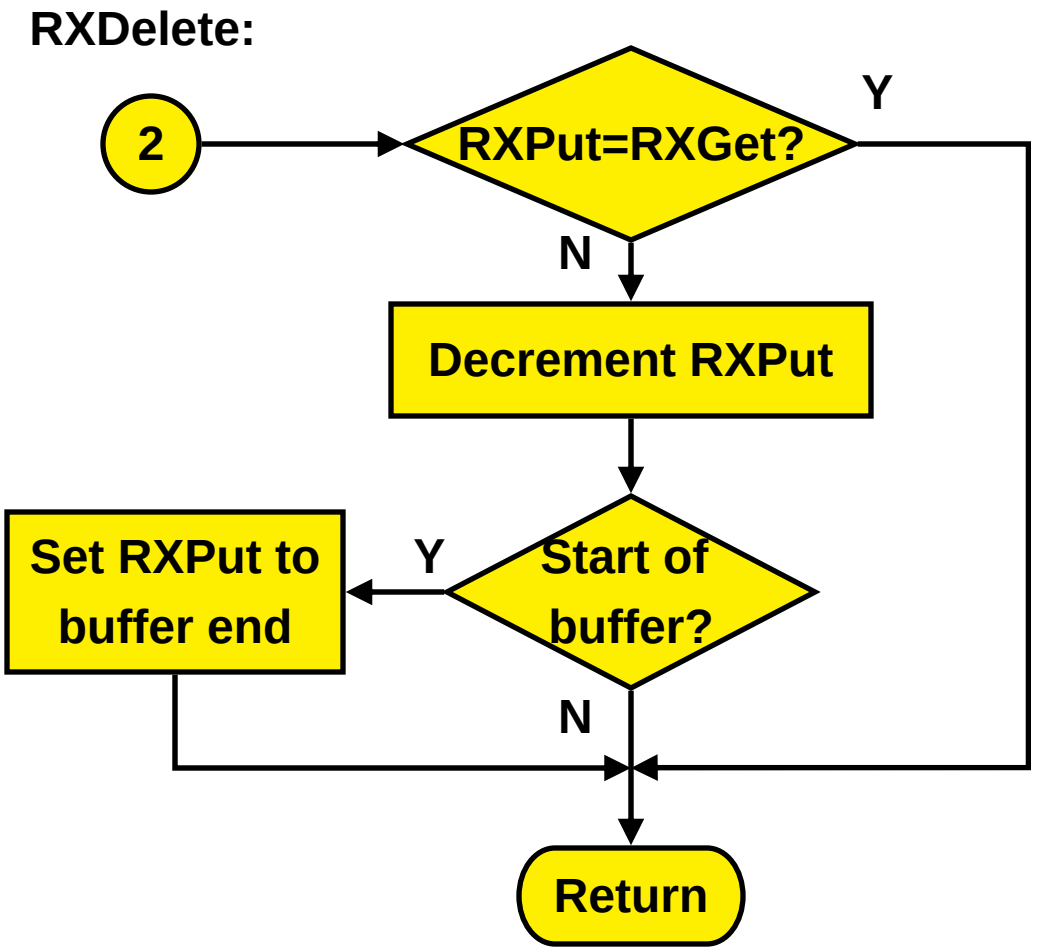
Fill Receive Buffer



Fill Receive Buffer (cont)

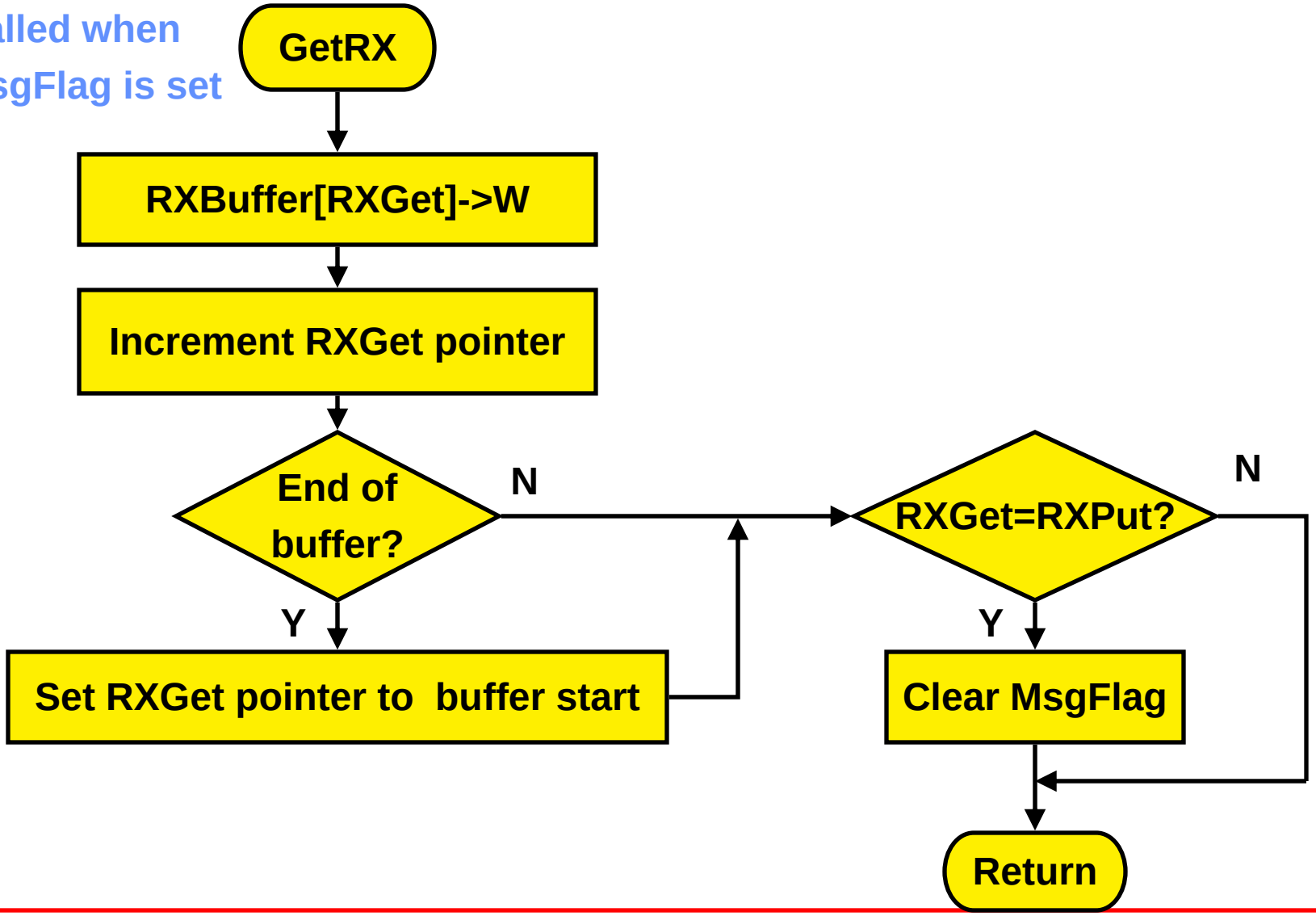


Fill Receive Buffer (cont)



Empty Receive Buffer

Called when MsgFlag is set

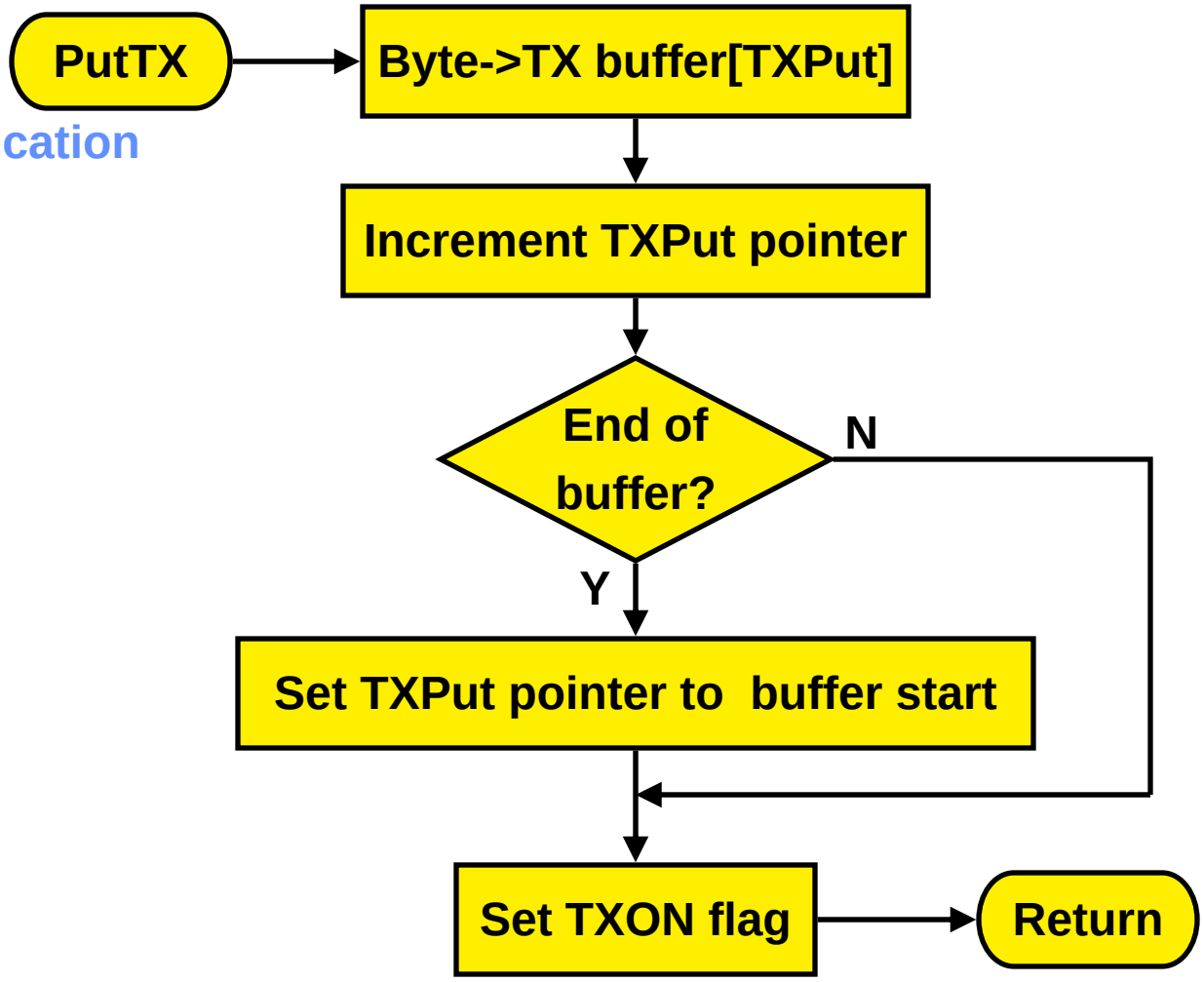


Transmit Buffer

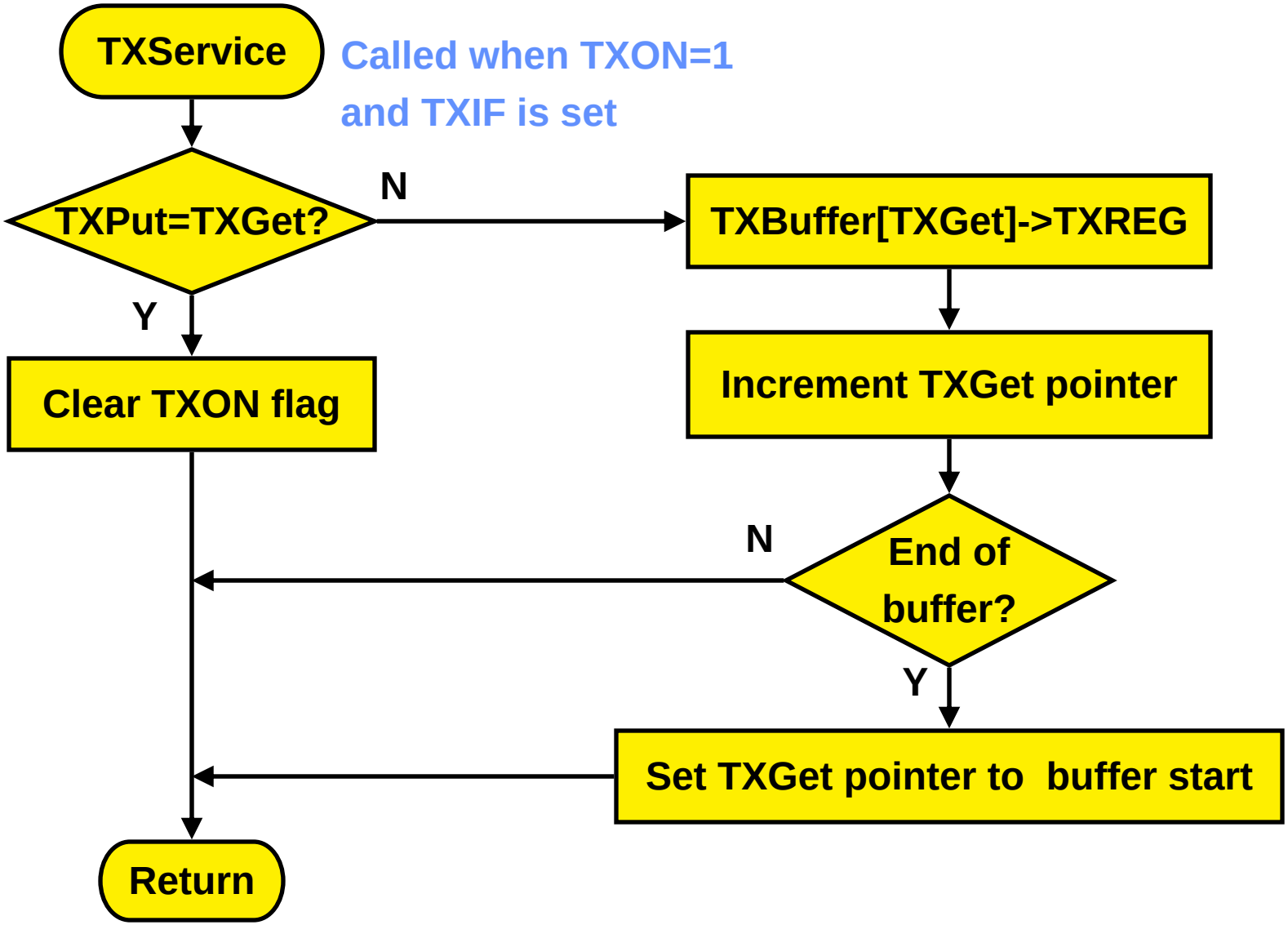
- **As large as longest transmit burst plus margin**
- **Two pointers**
  - TXPut
    - Put pointer for inserting bytes
  - TXGet
    - Get pointer for transferring bytes to TXREG
- **Flags**
  - TXON indicates bytes waiting to be sent
  - TXIF indicates transmit hardware ready

Fill Transmit Buffer

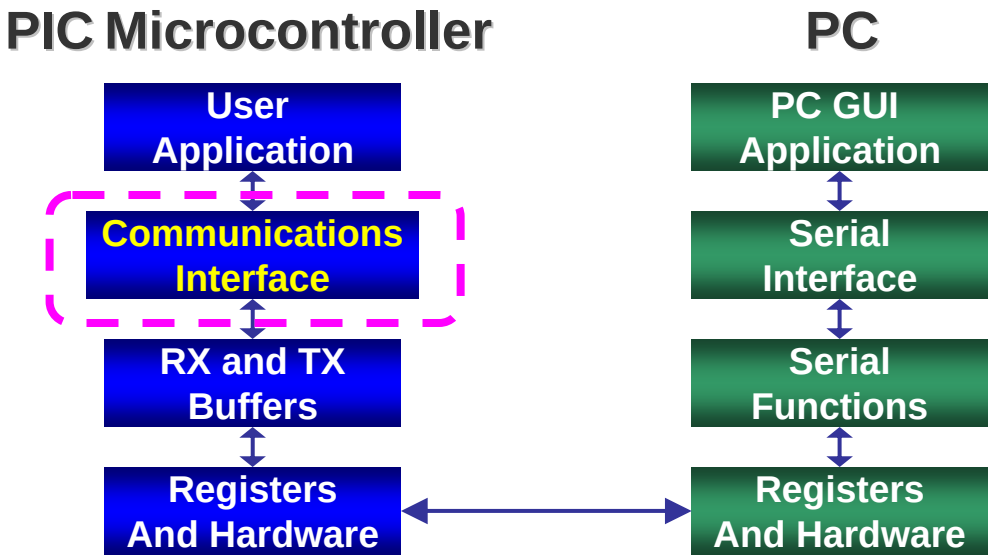
Called at will by application



Empty Transmit Buffer



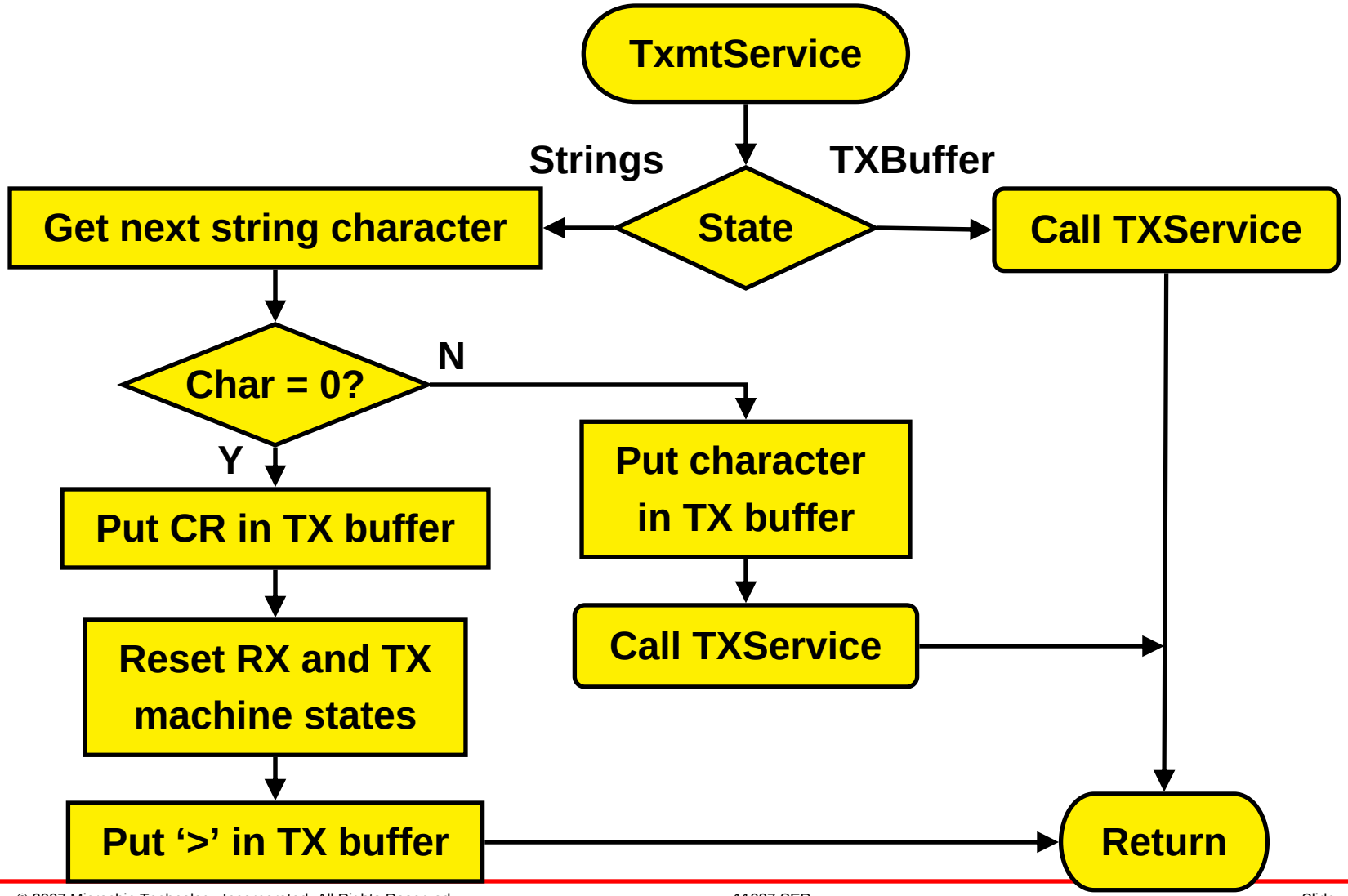
PIC® MCU Firmware Command Interpreter



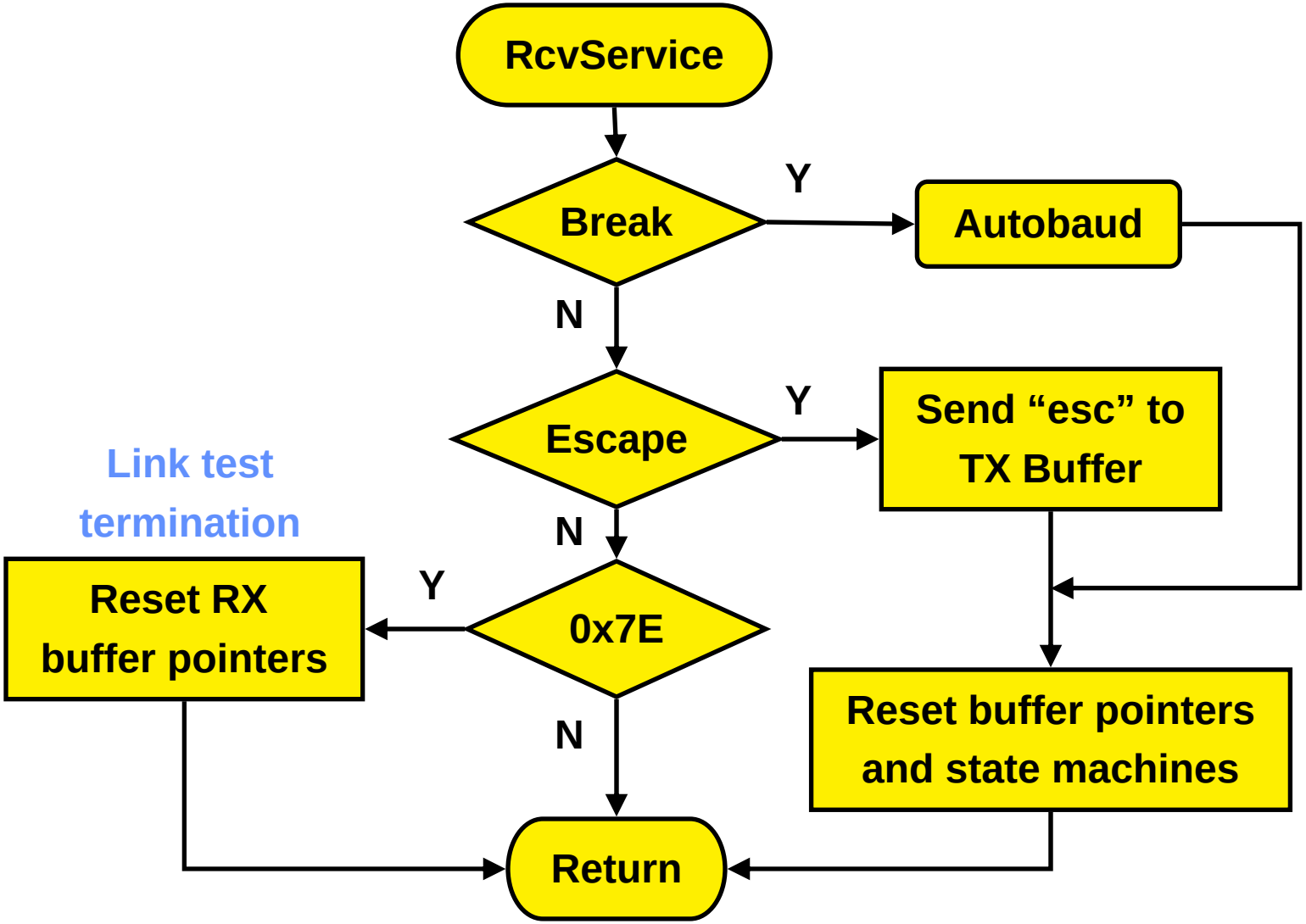
Generic Interface Entry Points

- **MonitorInit**
  - Initialize state machines and call buffer init
- **TxmtService**
  - Transmit strings without overflowing buffer
  - Recognize when TXREG is ready for next char
- **RcvService**
  - Conduit to RXService of buffer level
  - Process BREAK, ESCAPE, and CR characters
- **CmdService:**
  - Decode and process commands in RX buffer

Transmit Service



Receive Service



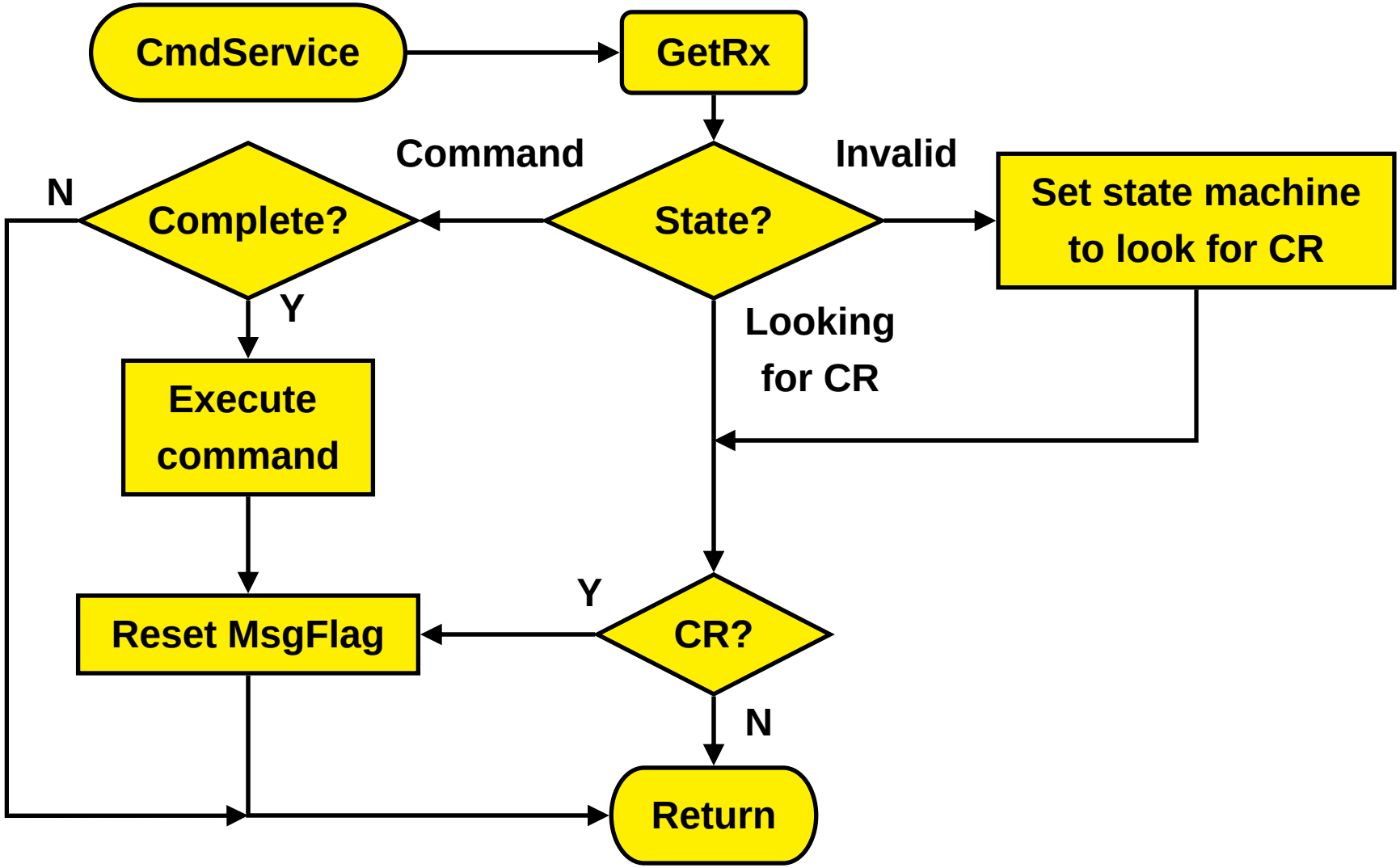
Generic Commands

- Control and monitor application by a few simple generic commands
- Axxx : Display byte at address xxx
- Axxx=yy : Set address xxx to yy
- V : Show firmware version
- ? : Show command menu

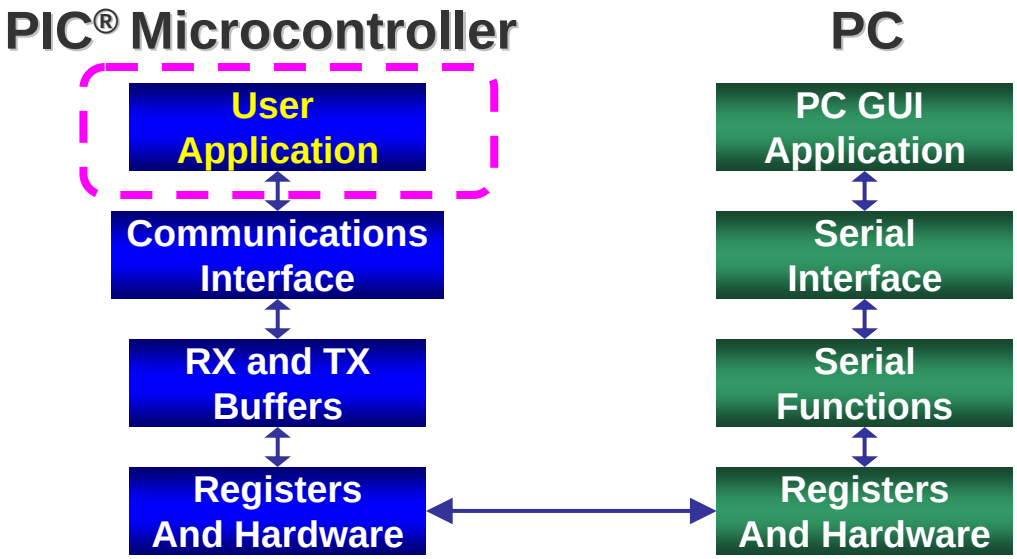
Command Protocol

- Every character received is echoed
- Any invalid character in command invalidates the entire command
- All commands are terminated by CR
- CR is also echoed followed by “>”

Command Service



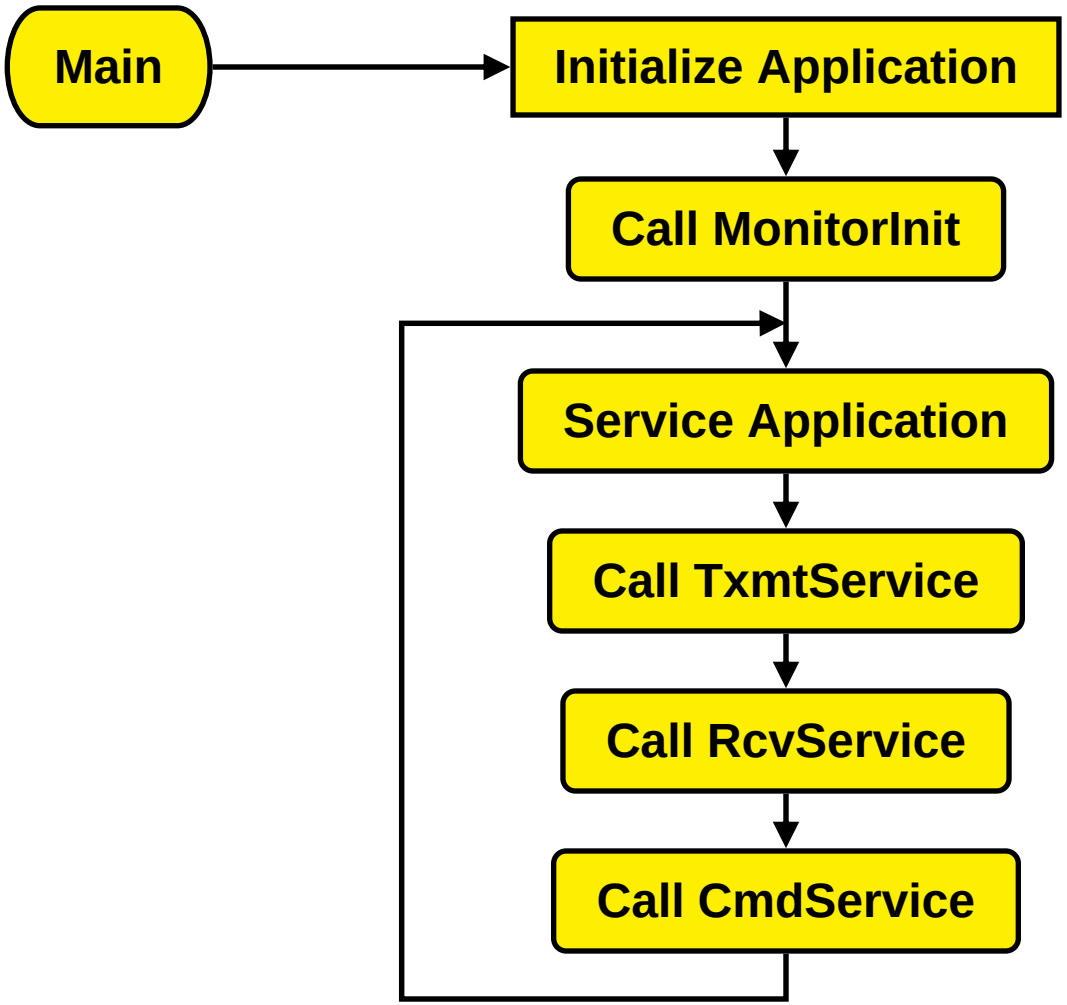
Interfacing User Application to Serial Communications



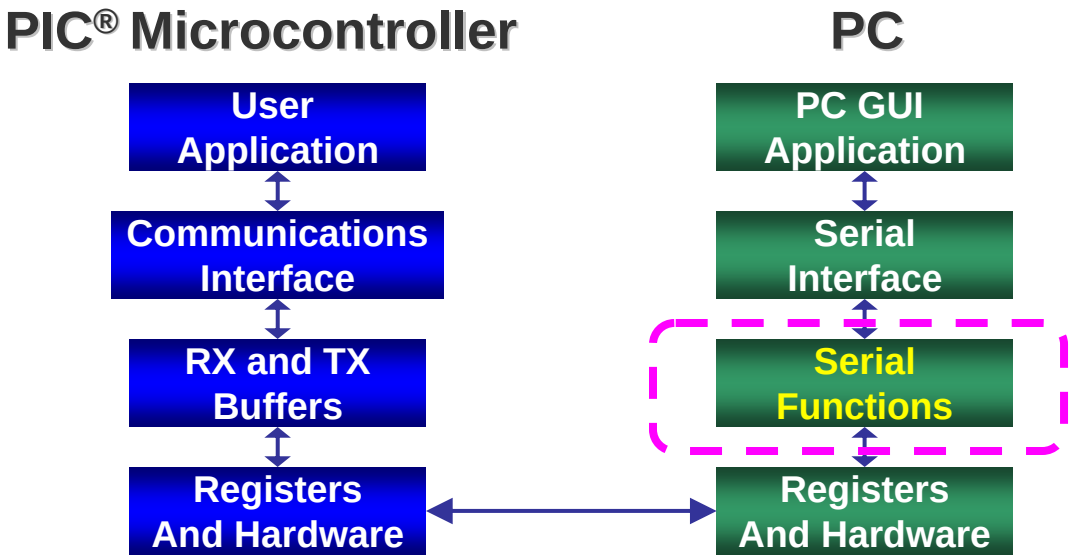
Additions to User Application

- Include call to command interpreter initialization as part of the main application initialization
- Include calls to all three command interpreter services in main application loop
- Average main loop time must be less than one serial character time, otherwise multiple calls to RcvService must be inserted

Example Main Application



Built-In Functions for Serial Communications



Visual Basic (VB) vs C#

- **Both use same .NET serial functions**
- **Same wrappers as C# written in VB**
- **Header references:**
  - C#: using System.IO
  - VB: Imports SYS = System.IO.Ports

System.IO.Ports.SerialPort Methods

- Open()
- Write(buf,ofset,cnt)
- BaseStream.WriteByte(byte)
- ReadByte()
- DiscardInBuffer()
- DiscardOutBuffer()
- Close()
- Dispose()

System.IO.Ports.SerialPort Properties

- BaudRate
- PortName
- BreakState
- ReadBufferSize
- WriteBufferSize
- WriteTimeout
- ReadTimeout
- IsOpen
- Parity
- StopBits
- DataBits
- DtrEnable
- RtsEnable
- Handshake

Finding Available Ports

- **Easy way**
  - VB and C#:

```
MyComboBox.Items.AddRange
  (System.IO.Ports.SerialPort.GetPortNames())
```

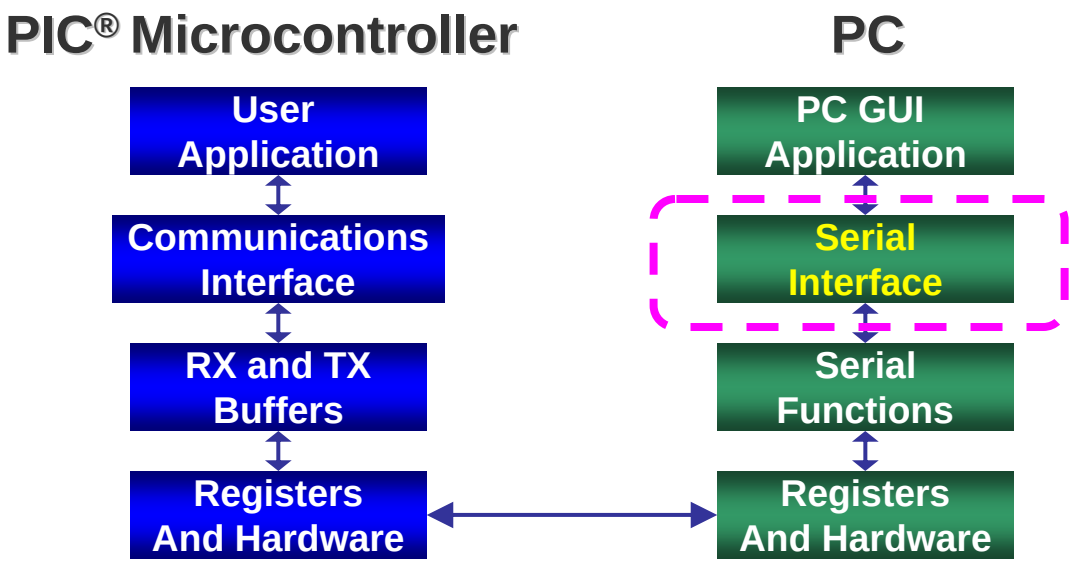
- **Better way**
  - Read registry directly to avoid modems
  - See code listings for example

Opening a Comm Port

- **Allocate memory space by declaring the serial port**
  - VB: Private SPort as SYS.SerialPort

    SPort = new System.IO.Ports.SerialPort()
  - C#: System.IO.Ports.SerialPort SPort = new System.IO.Ports.SerialPort()
- **Initialize the serial port properties**
  - SPort.BaudRate = 9600
- **Open() the port**
  - SPort.Open()

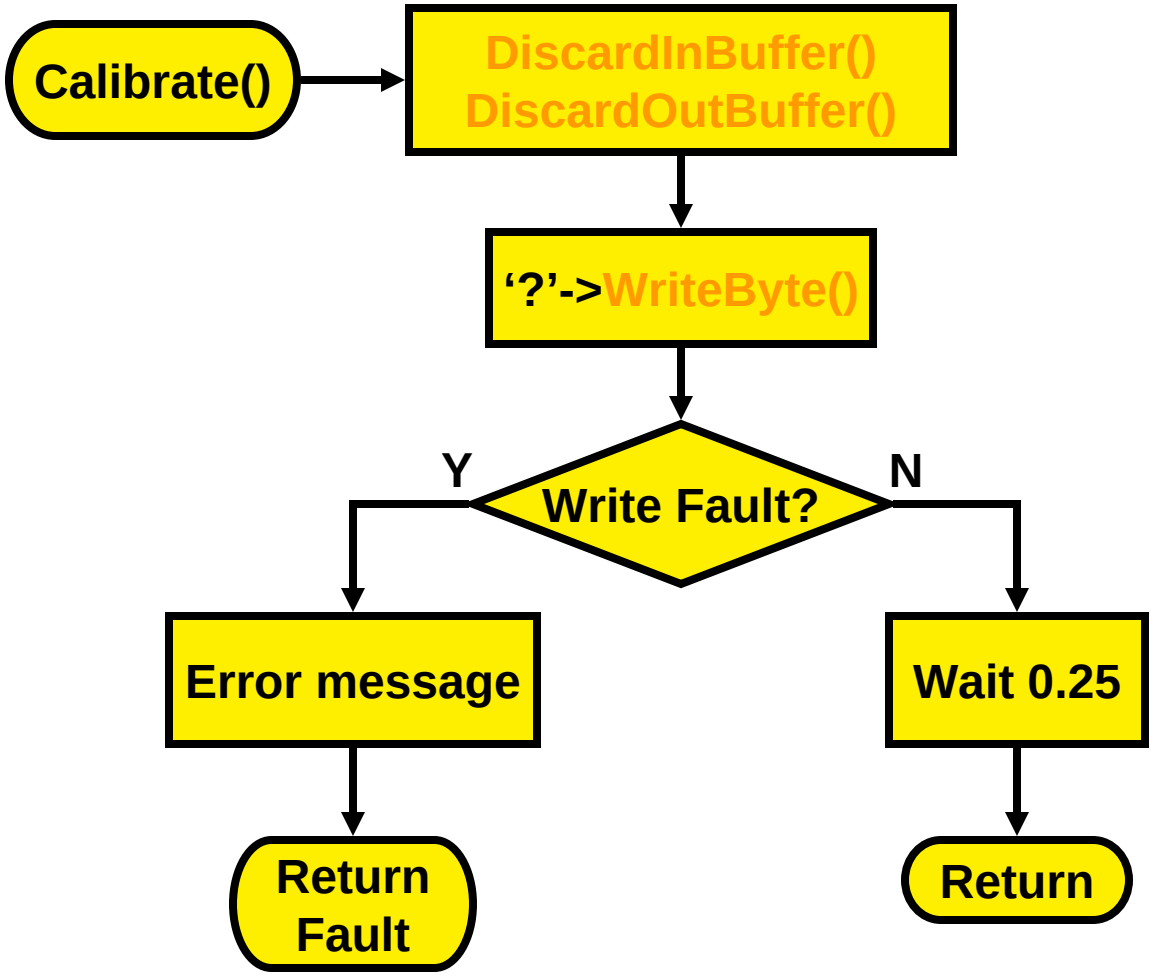
Visual Basic and C# Wrappers For the Serial Port



Serial Interface Functions

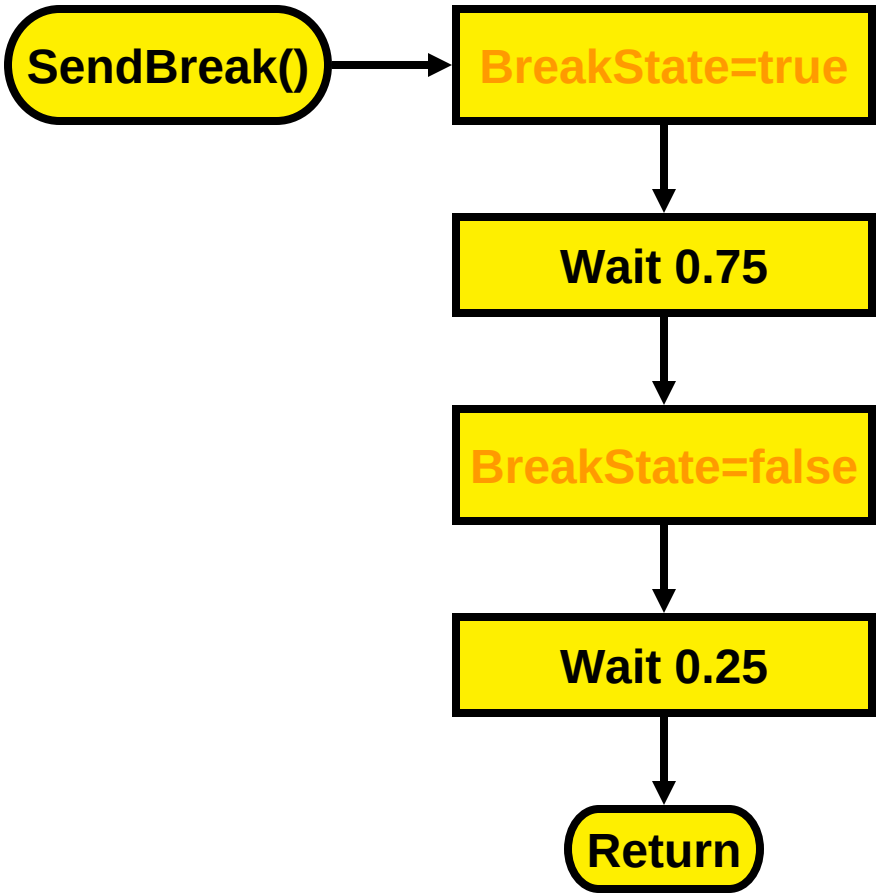
- **Calibrate:** Send calibration character to slave
- **SendBreak:** Request re-calibration
- **Test:** Verify proper communication link
- **SendChar:** Transmit one character
- **ReceiveChar:** Receive one character
- **SendString:** Transmit a string of characters

Calibrate()



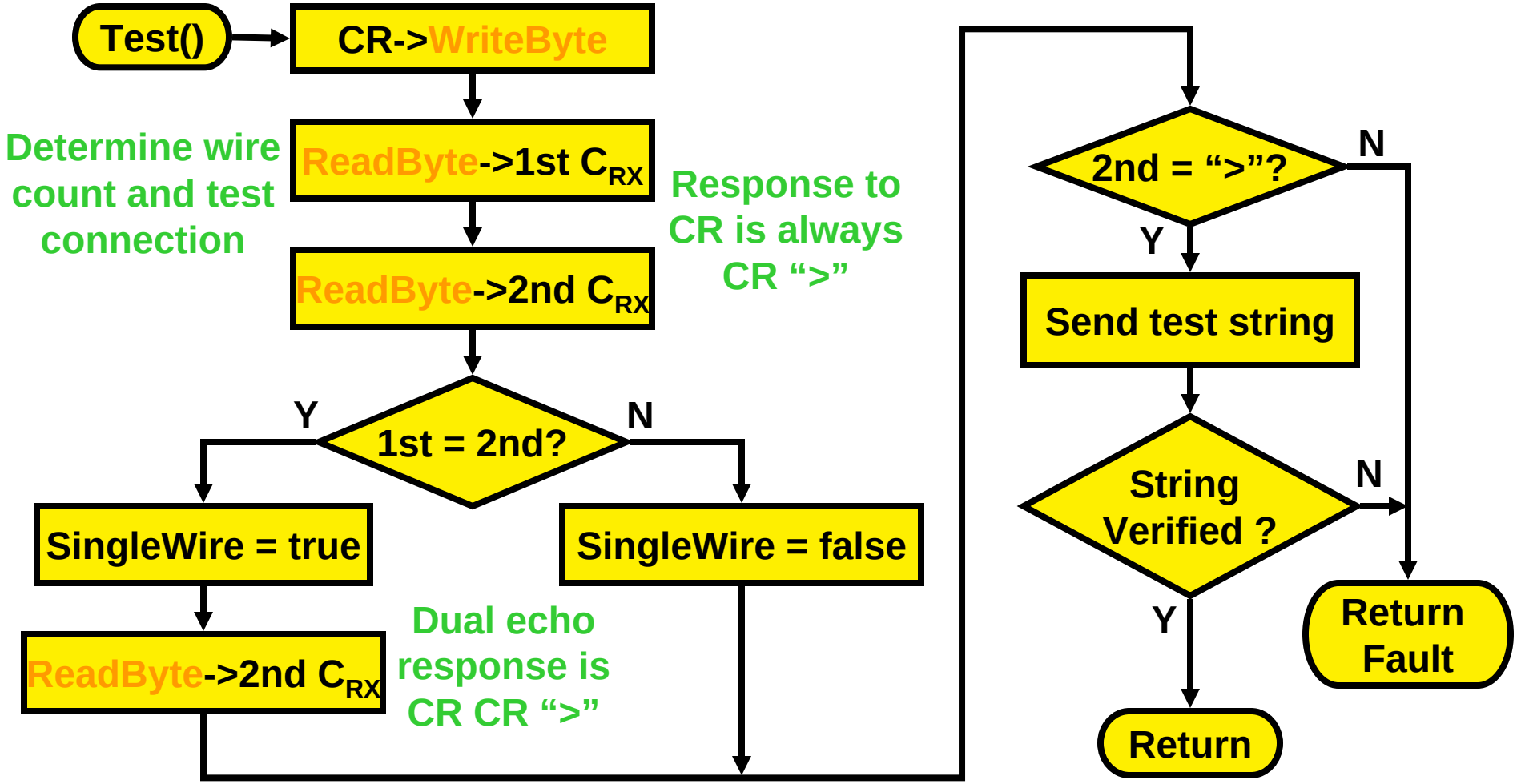
Wait required to allow Autocal to finish and setup for receive

SendBreak()

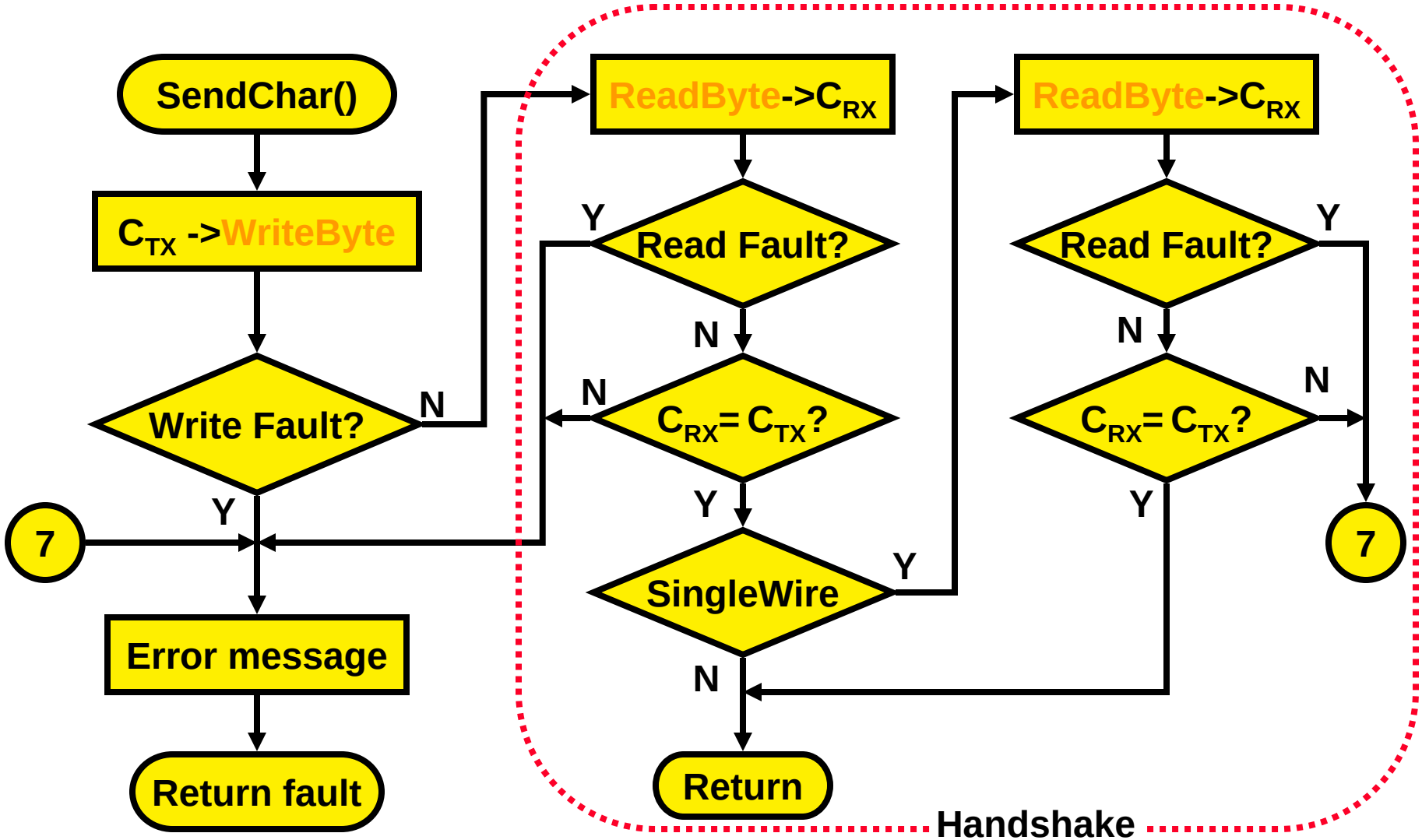


Break time must exceed 1 character time

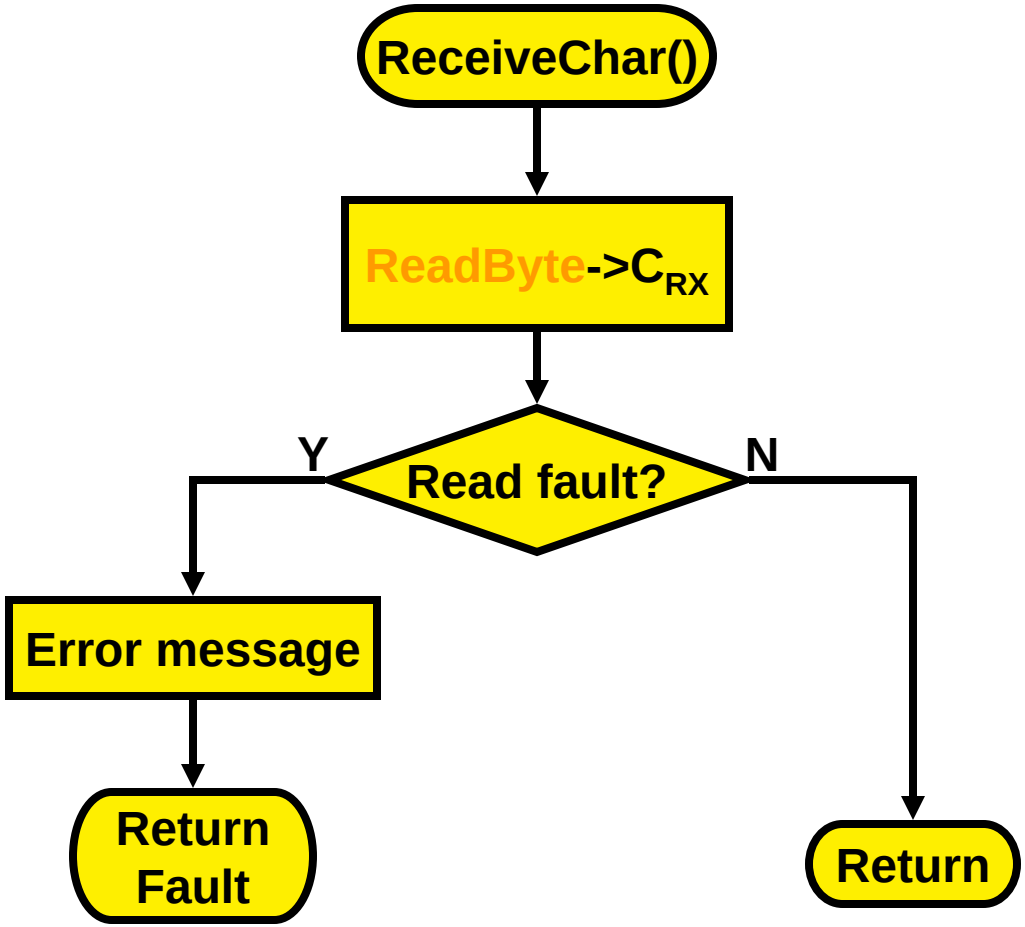
Test()



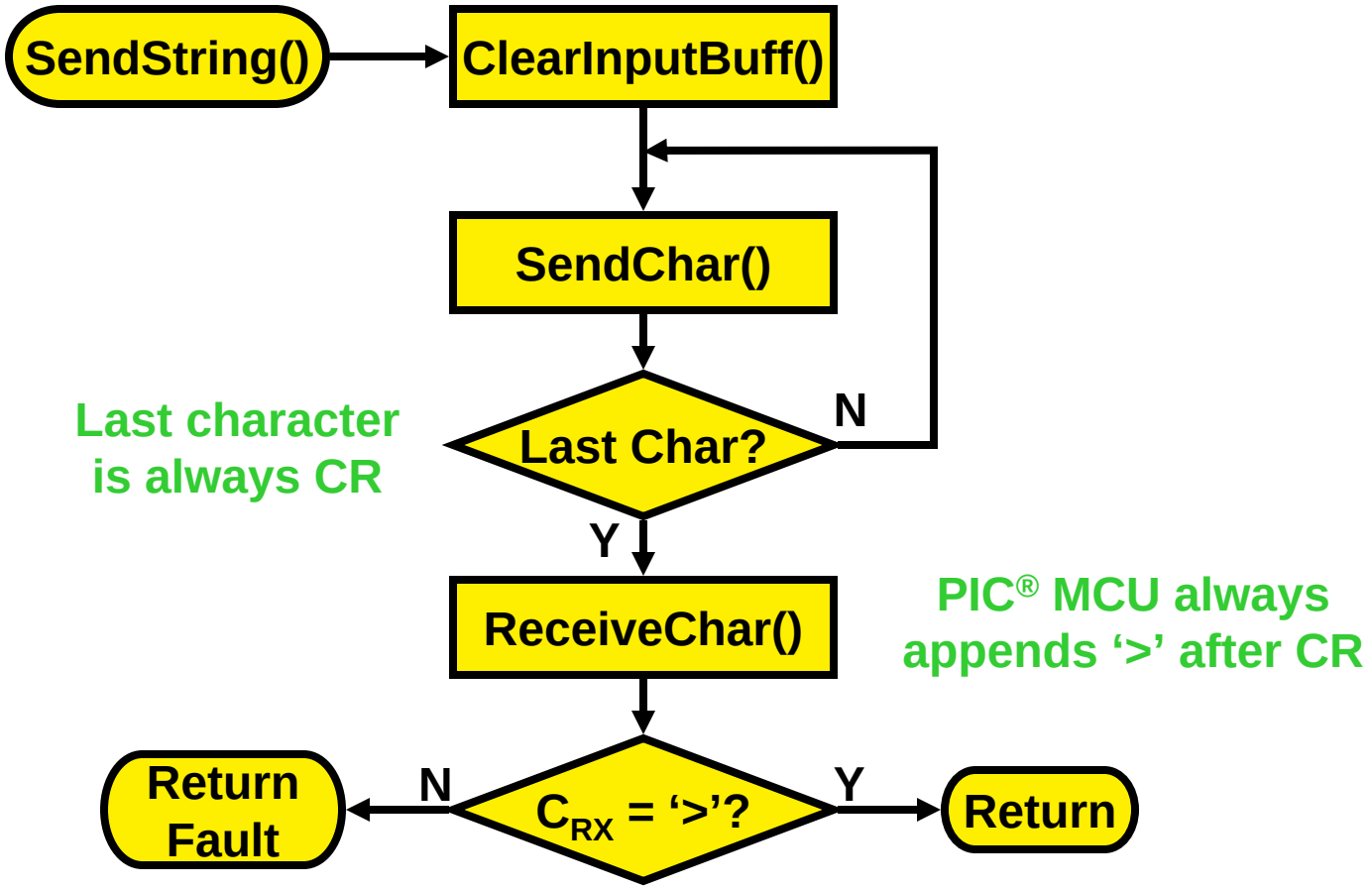
SendChar()



ReceiveChar()

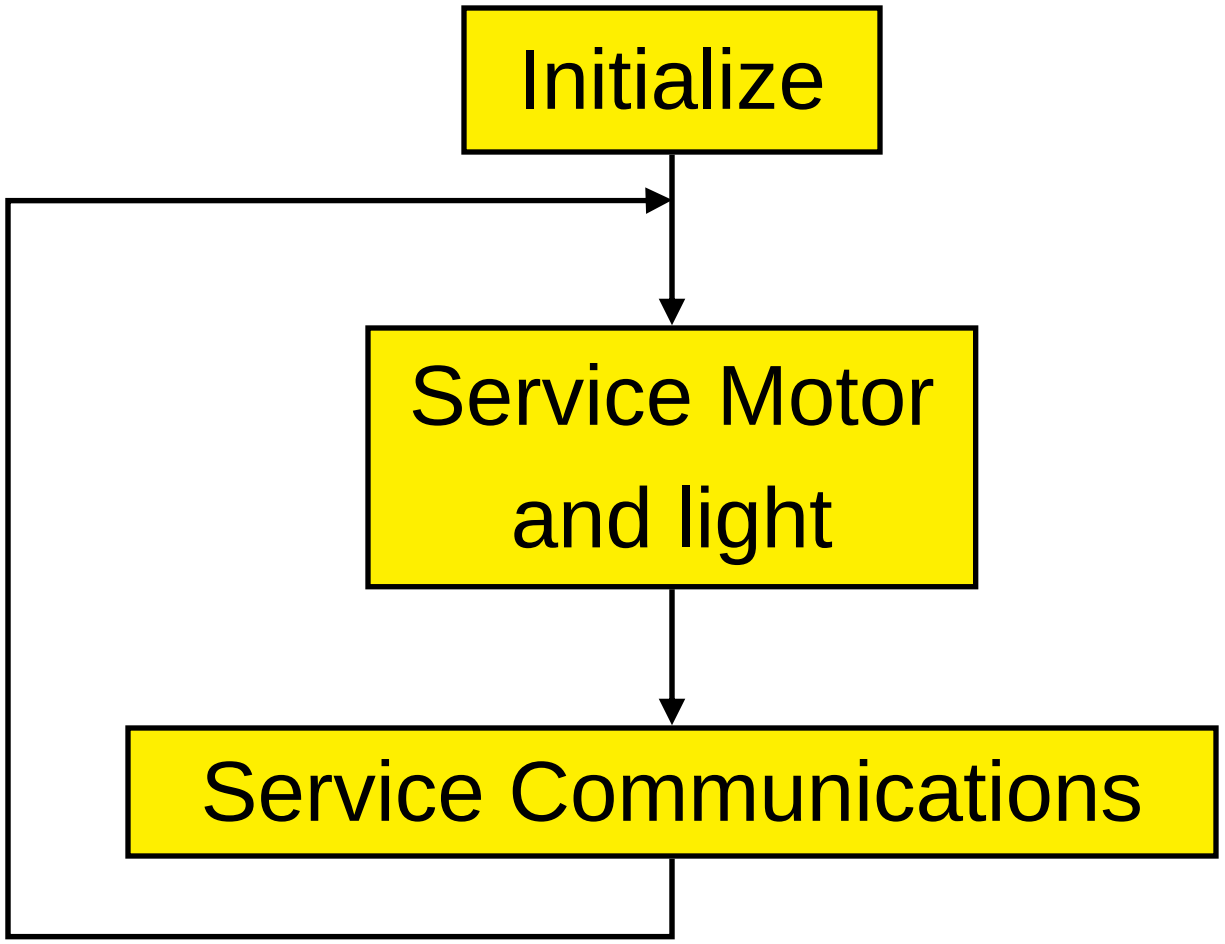


SendString()

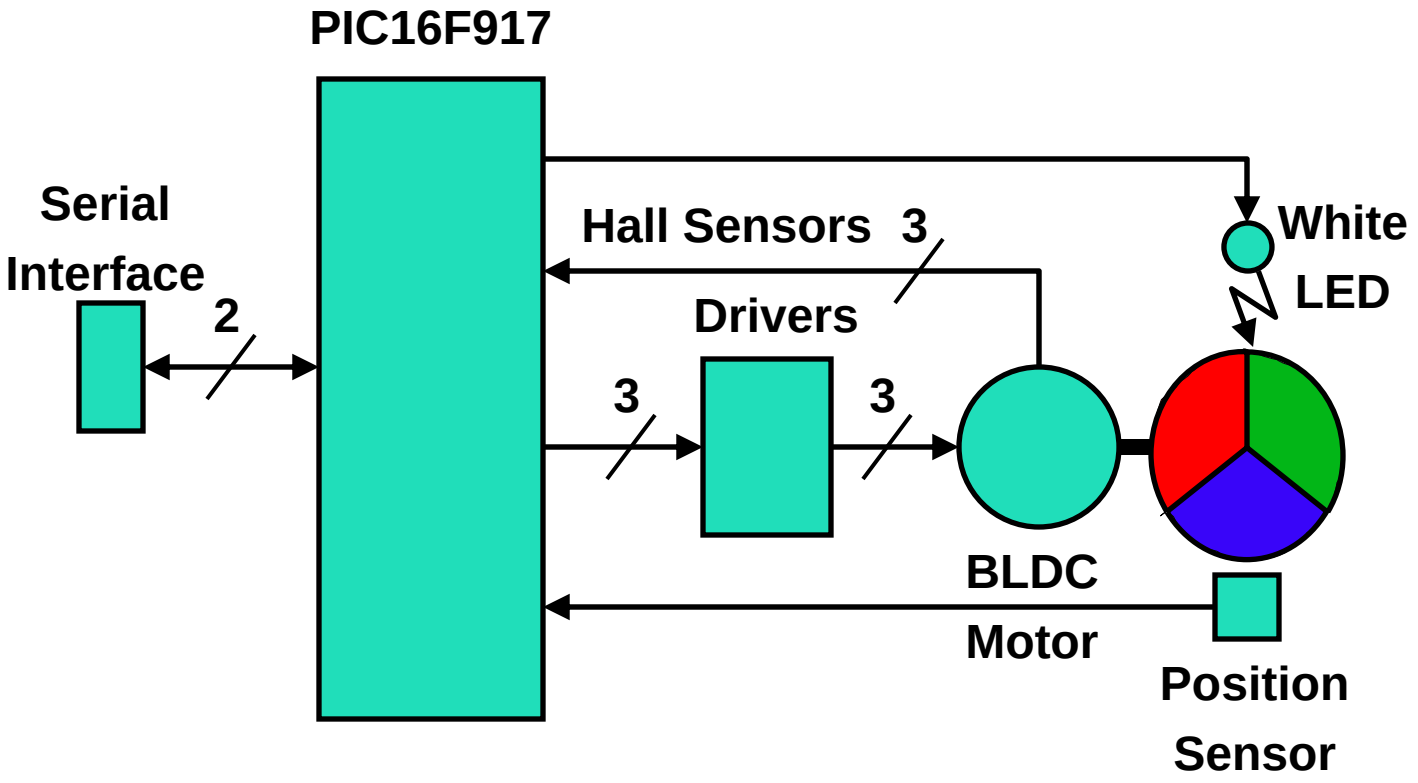


Communication Application Demo

Demo Flowchart



Demo Block Diagram



Summary

- **Elements of communications solution**
  - Hardware: RS-232 to TTL interface
  - Firmware: Polled or interrupt driven UART buffers and command decoder
  - Software: .NET functions for VB and C#
- **Build firmware and software in layers**
- **Read and write SFR and GPR space with minimum universal interface**

Dev Tools used in this class

Color Wheel Demo

- PICDEM™ Mechatronics Demo board (DM163029)
- Standard 9-Pin subminiature D cable
- Hurst brushless motor (DMB0224C10002)
- Keyspan USB to 4 Port Serial adapter (USA-49WLC)

References

- AN712 - Autobaud for the PIC16C5X devices
- AN774 - Asynchronous communications with the PICmicro® USART
- EDN (August 22, 2002) – “Use a PIC® for automatic baud-rate detection”
- DM163029 – PICDEM™ Mechatronics Demo board
- C# For Dummies (ISBN:978-0-7645-9704-3)
- http://msdn.microsoft.com/vstudio/express/

Thanks for Attending

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