USB Connectivity using MSP430 and TUSB3410

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Agenda

- Why USB connectivity?
- TUSB3410 – MSP430 overview
- USB descriptor customization
- Design and optimization ideas
- Driver customization
- Reference design demo

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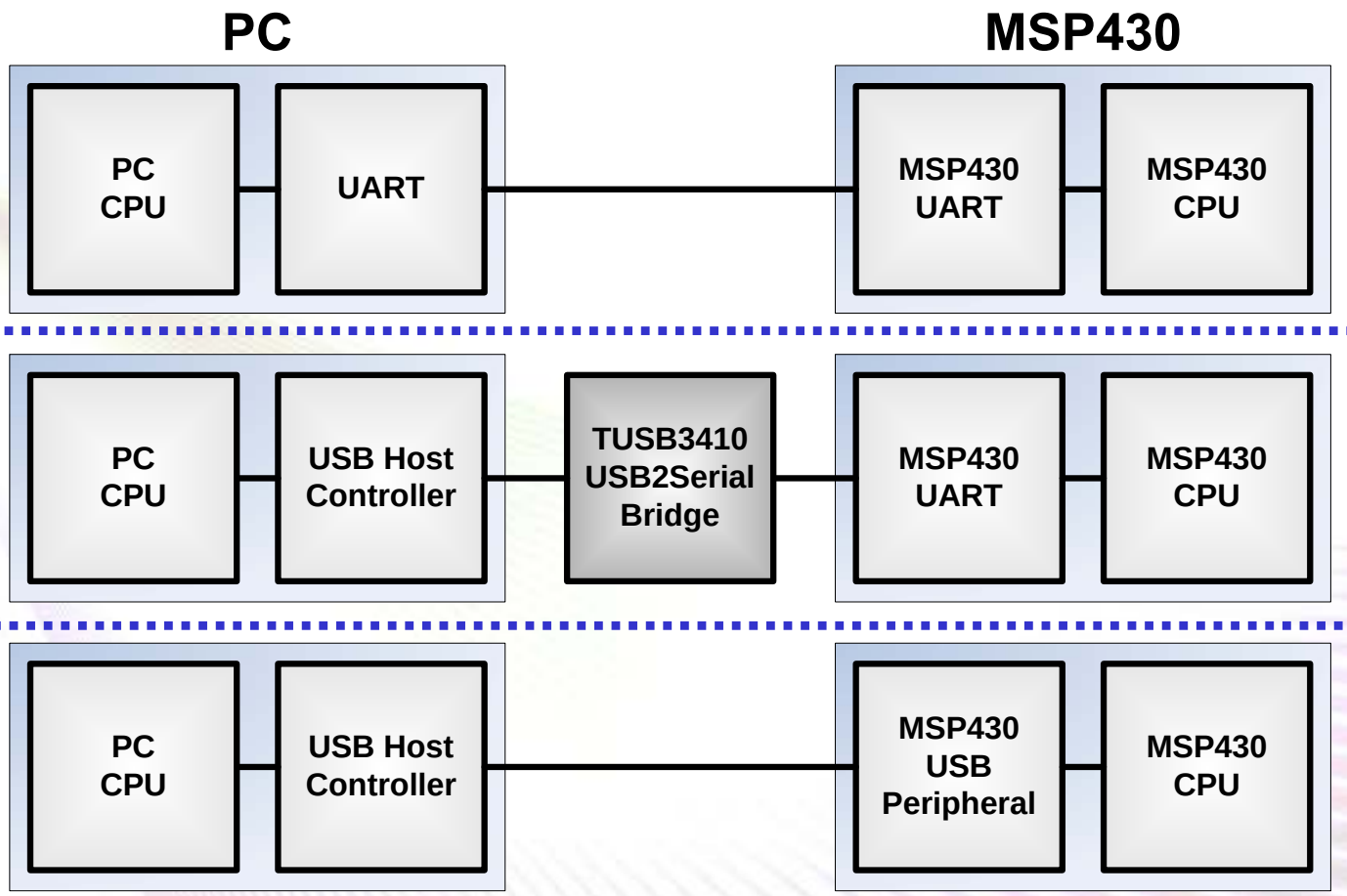
MSP430 PC Connectivity

- Yesterday's RS-232 Link
- Today's USB-UART Link
- Tomorrow's MSP430F5xx USB Link



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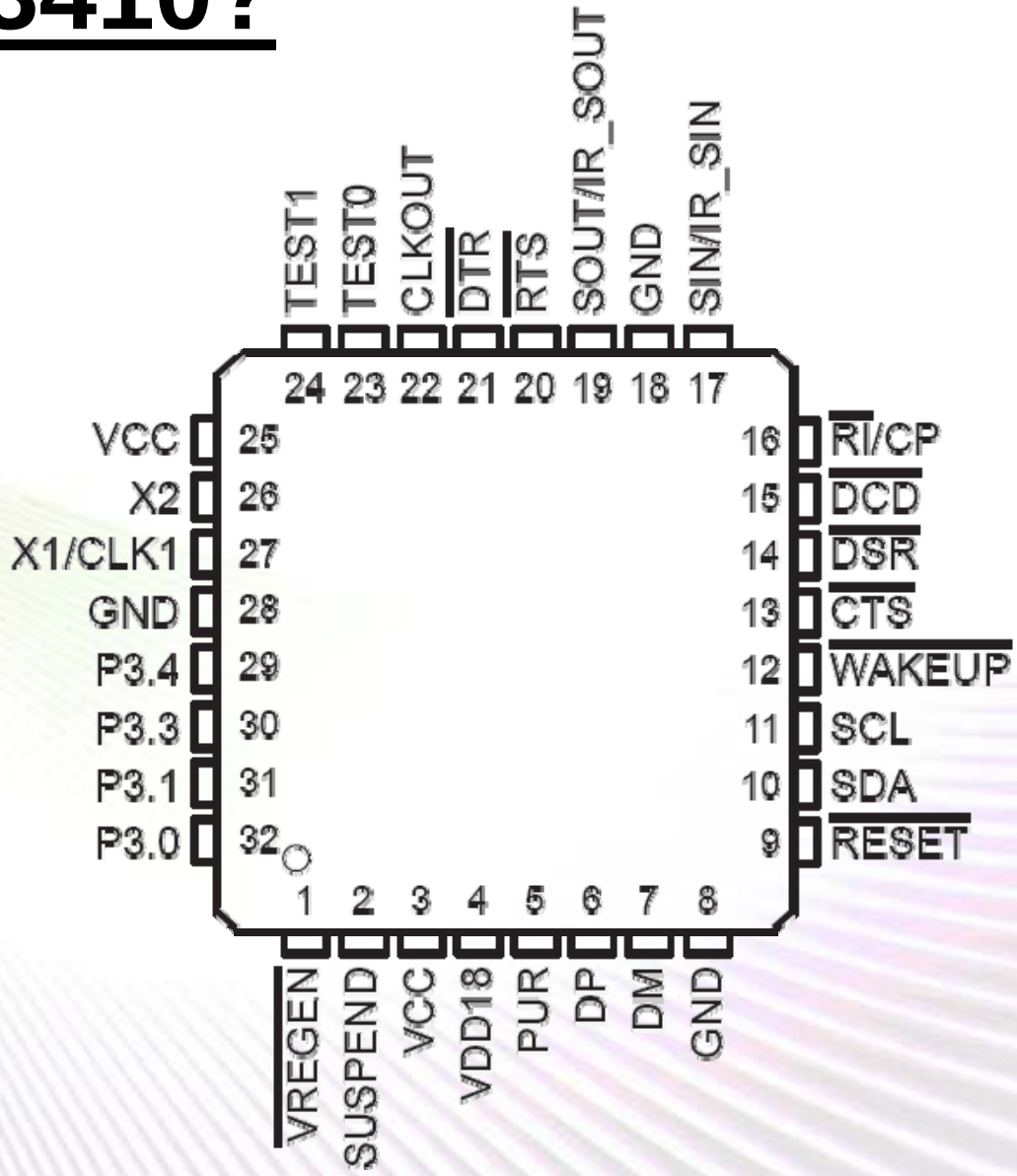
What is the TUSB3410?

- USB-to-serial bridge
- USB 2.0 full speed
- 50 Baud to 921.6 kBaud
- Self and bus-powered applications
- 8052 CPU, ROM, 16KB RAM
- Can run custom firmware
- UART + handshake pins
- Four GPIO pins
- 12MHz, V_{CC} - 3.0 to 3.6V
- 32-pin LQFP



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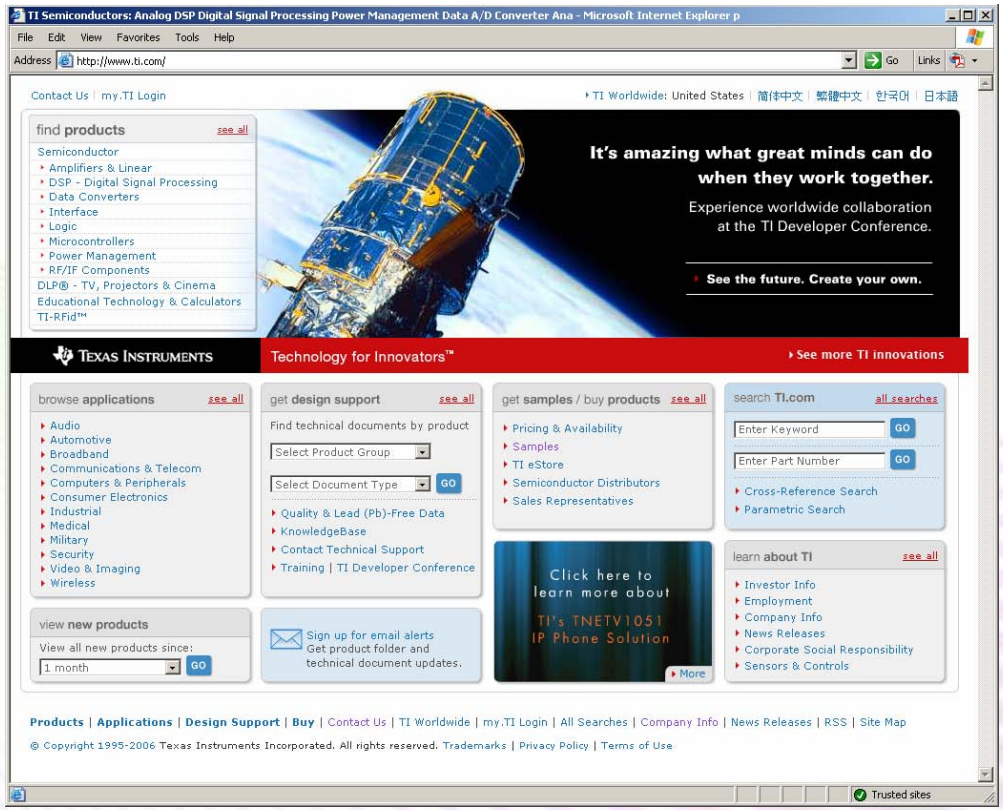
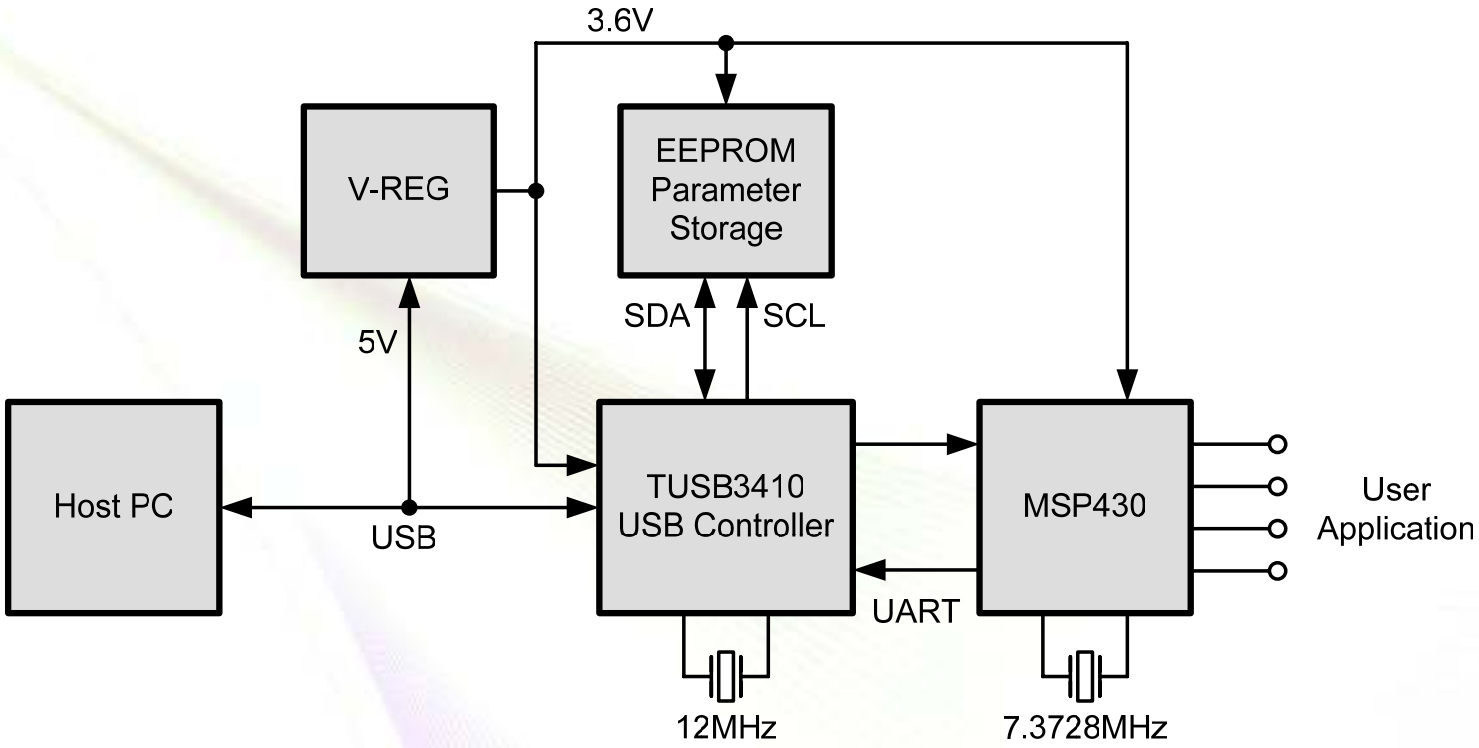
TUSB3410 Support

- **TUSB3410 product folder on www.ti.com**
- **Data sheet / errata sheet**
- **Device samples**
- **Drivers**
- **Application notes**
  - MSP430 USB Connectivity using TUSB3410
  - VIDs / PIDs / Firmware design decisions
  - EEPROM header generation utility
  - EEPROM burner utility
- **Evaluation modules**
  - UART Applications
  - General Purpose Applications



MSP430 USB Connectivity Solution



- **Used in production MSP-FET430UIF**
- **Max. UART link speed: 921,600 Bit/s**
- **App note: “MSP430 USB Connectivity using TUSB3410” (SLAA276)**

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USB Solution Usage

- PC-to-MSP430 access through virtual COM port (VCP)
- Full-duplex communication
- Use from PC like any other COM
- MSP430 UART settings must match the VCP config (baud rate etc.)
- Data is exchanged using standard Windows API calls and MSP430 UART accesses
- Transparent underlying USB transfers
- Includes PC and MSP430 software, drivers, Gerbers

- Hassle-free solution

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Basic MSP430 Firmware Example

```
// Code Example: fet140_uart01_0115k.c
// Runs on all MSP430F13x, F14x, F15x, F16x family members
#include  <msp430x16x.h>

void main(void)
{ volatile unsigned int i;

  WDTCTL = WDTPW + WDTHOLD;     // Stop WDT
  P3SEL |= 0x30;                // P3.4,5 = USART0 TXD/RXD
  BCSCTL1 |= XTS;               // ACLK= LFXT1= HF XTAL

  do
  {
    IFG1 &= ~OFIFG;             // Clear OSCFault flag
    for (i = 0xFF; i > 0; i--);// Time for flag to set
  }
  while (IFG1 & OFIFG);         // OSCFault flag still set?

 BCSCTL2 |= SELM_3;             // MCLK = LFXT1 (safe)
 ...
```

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Basic MSP430 Firmware Example

```
  ...
  ME1 |= UTXE0 + URXE0;           // Enable USART0 TXD/RXD
  UCTL0 |= CHAR;                  // 8-bit character
  UTCTL0 |= SSEL0;                // UCLK= ACLK
  UBR00 = 0x45;                   // 8MHz 115200
  UBR10 = 0x00;                   // 8MHz 115200
  UMCTL0 = 0x00;                  // 8MHz 115200 modulation
  UCTL0 &= ~SWRST;                // Release USART module
  IE1 |= URXIE0;                  // Enable USART0 RX int

  _BIS_SR(LPM0_bits + GIE);       // Enter LPM0 w/ interrupt

#pragma vector=UART0RX_VECTOR
__interrupt void usart0_rx (void)
{
  while (!(IFG1 & UTXIFG0));      // USART0 TX buffer ready?
  TXBUF0 = RXBUF0;                // RXBUF0 to TXBUF0
}
```

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HW Design Considerations

- Use the reference design for guidance
- Check TUSB3410 silicon errata
- USB transient suppressor for increased robustness (TI Part # SN75240)
- Bus-only powered application could use LDO (TPS377301: 250mA max, 8MSOP)
- Combined bus/battery powered applications: broad range of TI power and battery management products are available
- Check Power Management Selection Guide (SLVT145)

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USB Vendor ID / Product ID

- Used for association of USB hardware with drivers
- Required by USB−IF and Microsoft WHQL certification
- Vendor must have unique VID
- Vendor must use unique PID for each product / model
- OEMs can’t use silicon vendor’s VID / PIDs
- Must be stored within the USB device hardware (needed upon connect)
- More info: www.usb.org

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VID / PID Considerations

- Vendor requests VID from USB-IF
- PID is vendor-specific
- VID & PID are 16-bit values
- TUSB3410 default VID: 0x0451 (TI's VID)
- TUSB3410 default PID: 0x3410
- External EEPROM required to store custom VID / PID
- Must match to host values stored in INF files
- See "USB/Serial Applications Using TUSB3410/ 5052 and the VCP Software" (SLLA170)

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EEPROM Header Generation

- **Use TI USB I2C Header Generator Utility (SLLC251)**
- **Input: EEPROM config file (*.CFG)**
- **Output: Binary image (*.BIN)**
- **CFG file must include:**
  - Vendor specific VID / PIDs
  - Standard USB descriptor blocks as per example
- **Can include:**
  - Unique serial number
  - Custom TUSB3410 firmware (Impacts EEPROM size!)
- **Examples are included**

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EEPROM Programming Options

- Dedicated EEPROM programmer
- Through USB using TI's EEPROM burner utility (SLLC259)
- Via MSP430 at production time
- Via MSP430 at application run-time (as shown in the MSP430-TUSB3410 Reference Design)

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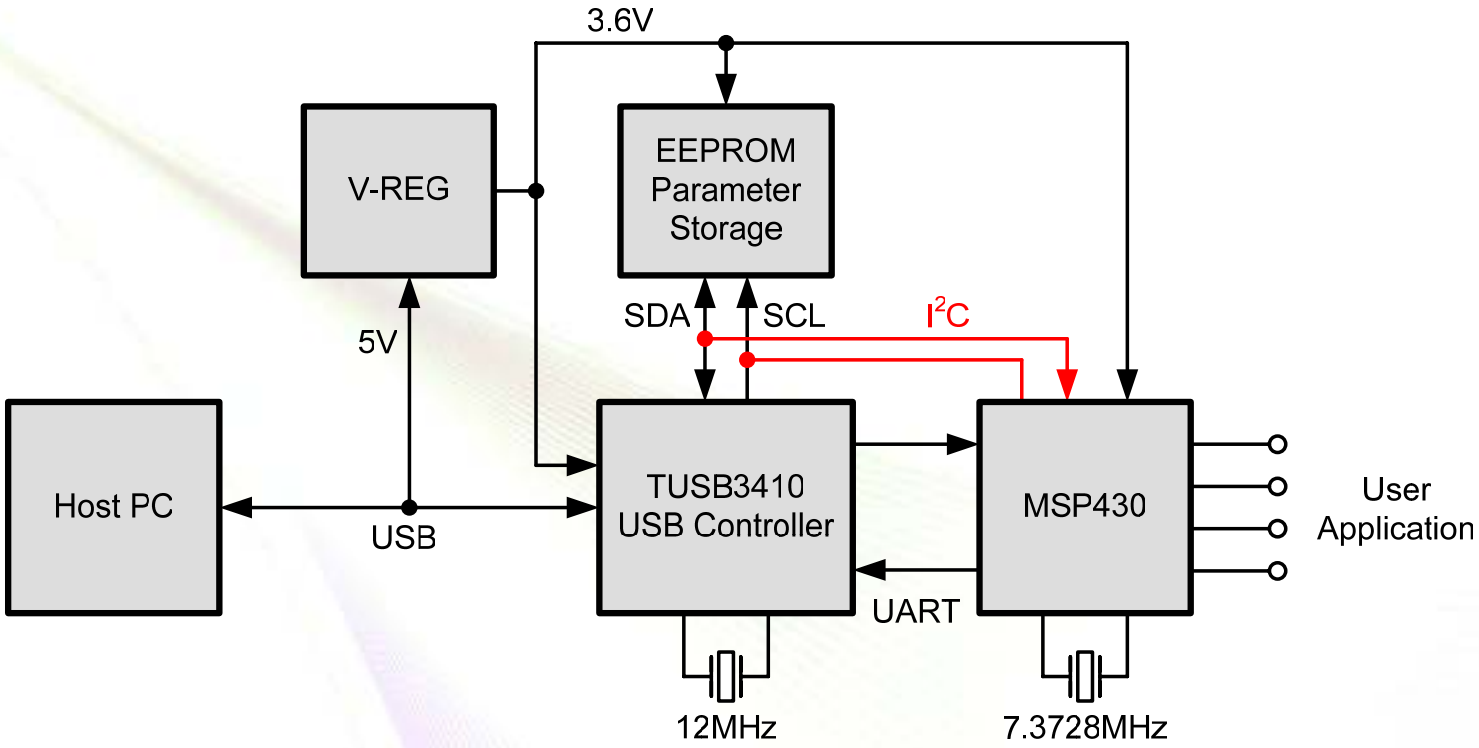
Adding EEPROM Update Capability



- **I²C signals connected to any MSP430 pins**
- **Blank EEPROM can be programmed by MSP430**
- **Eliminates need for EEPROM programmer**

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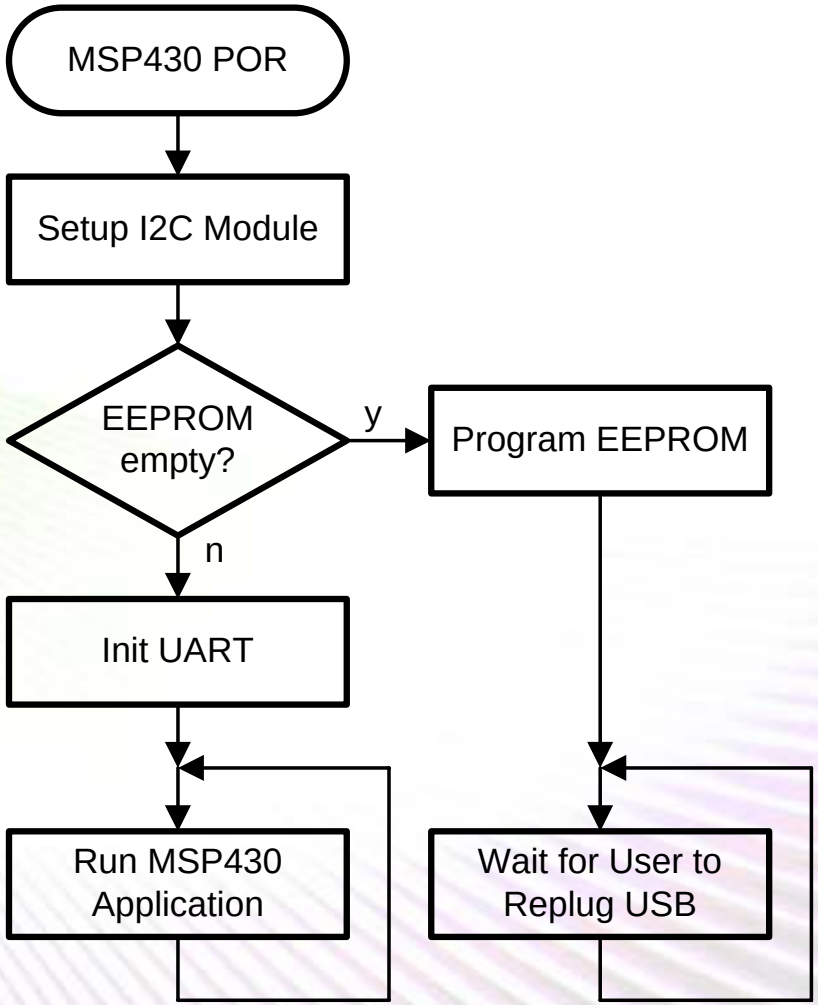
Blank EEPROM Programming Flow

- **Include EEPROM image in MSP430 firmware**
- **For robustness verify EEPROM contents & program if mismatch**
- **Uses ~150 Bytes of MSP430 Flash for USB VID, PID, serial number, and ID strings**
- **Note that TUSB3410 accesses EEPROM after power-on!**



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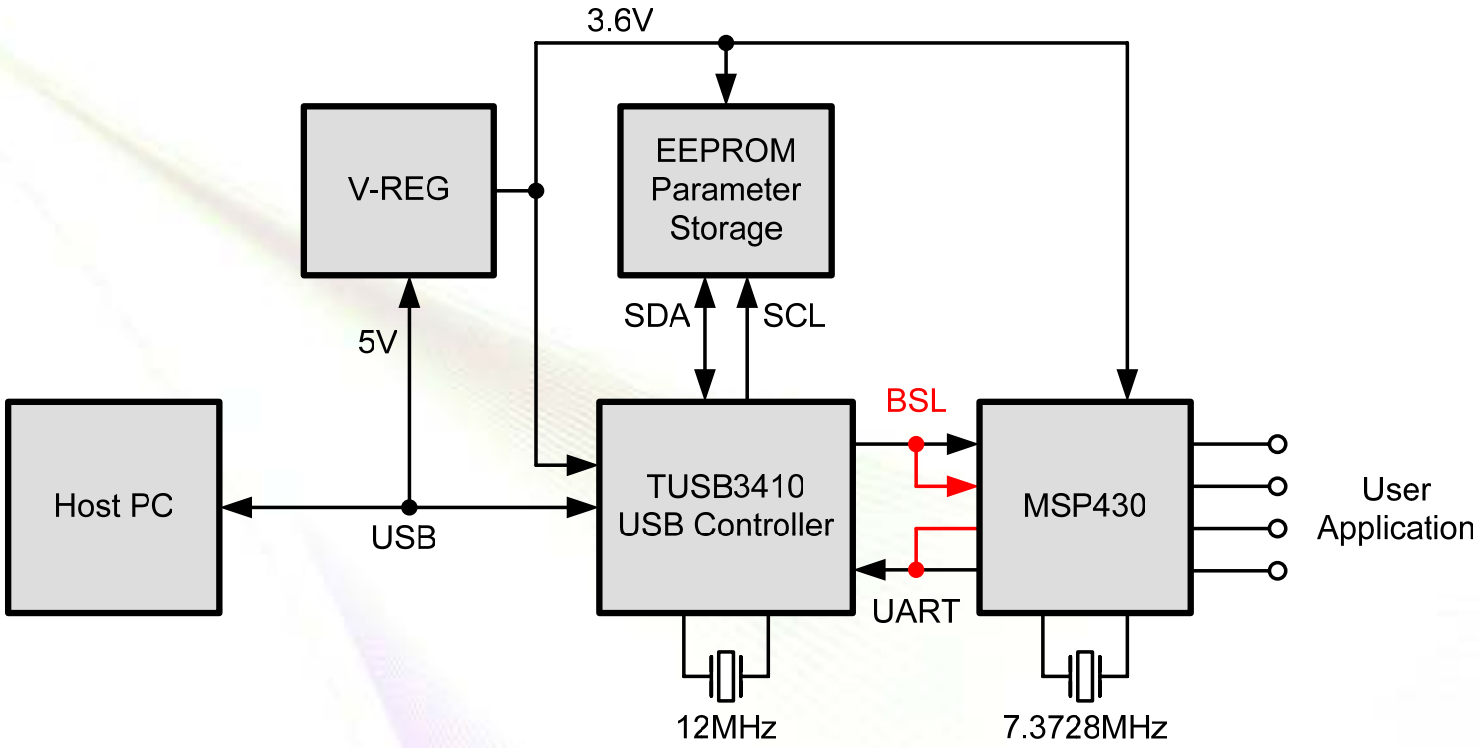
Adding BSL Capability



- **UART signals in parallel with BSL pins**
- **Connections to RESET and TCK needed (not shown) to invoke BSL**
- **Blank MSP430 can be programmed through USB**

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BSL-Through-USB Flow

- Generate MSP430-TXT output file
- Connect USB application to PC
- Use standard TI TUSB3410 VCP drivers
- Open Windows device manager to identify COM port
- Use PC software from app note “Application of MSP430 bootstrap loader” (SLAA096)
  Note: ***Minor code modification required***
- Run PC application to download code
- Done!

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BSL PC-Software Modifications

- RST and TCK signals are inverted
- Two changes to file bslcomm.c needed:

```
void SetRSTpin(BOOL level)
{
  comDCB.fDtrControl =
    level ? DTR_CONTROL_ENABLE : DTR_CONTROL_DISABLE;
    level ? DTR_CONTROL_DISABLE : DTR_CONTROL_ENABLE;
  SetCommState(hComPort, &comDCB);
}
void SetTESTpin(BOOL level)
{
  comDCB.fRtsControl =
    level ? RTS_CONTROL_ENABLE : RTS_CONTROL_DISABLE;
    level ? RTS_CONTROL_DISABLE : RTS_CONTROL_ENABLE;
  SetCommState(hComPort, &comDCB);
}
```

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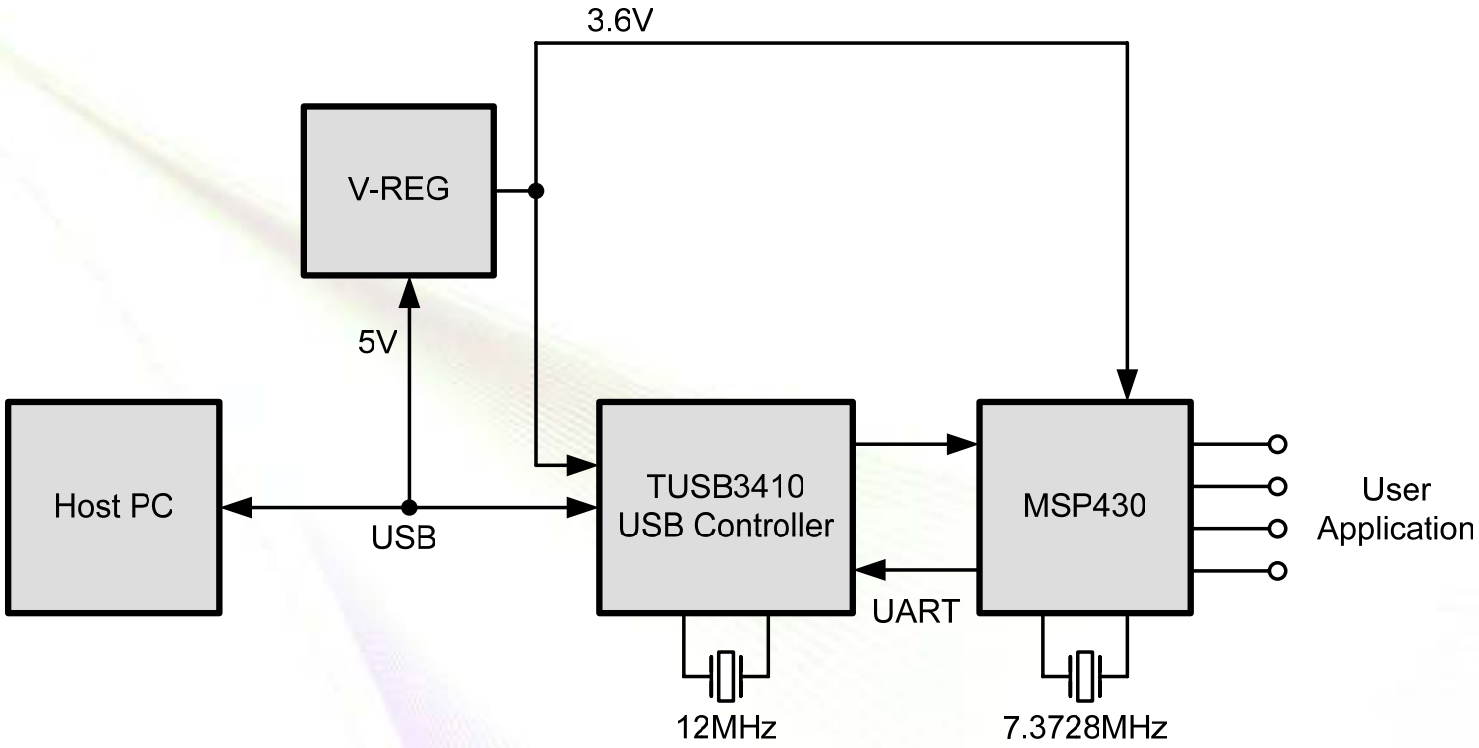
Lower Cost Option: No EEPROM



- External EEPROM can be omitted to save costs
- Application will report as “TUSB3410 Device”
- Works with as-is TI VCP drivers
- Solution can’t be USB certified

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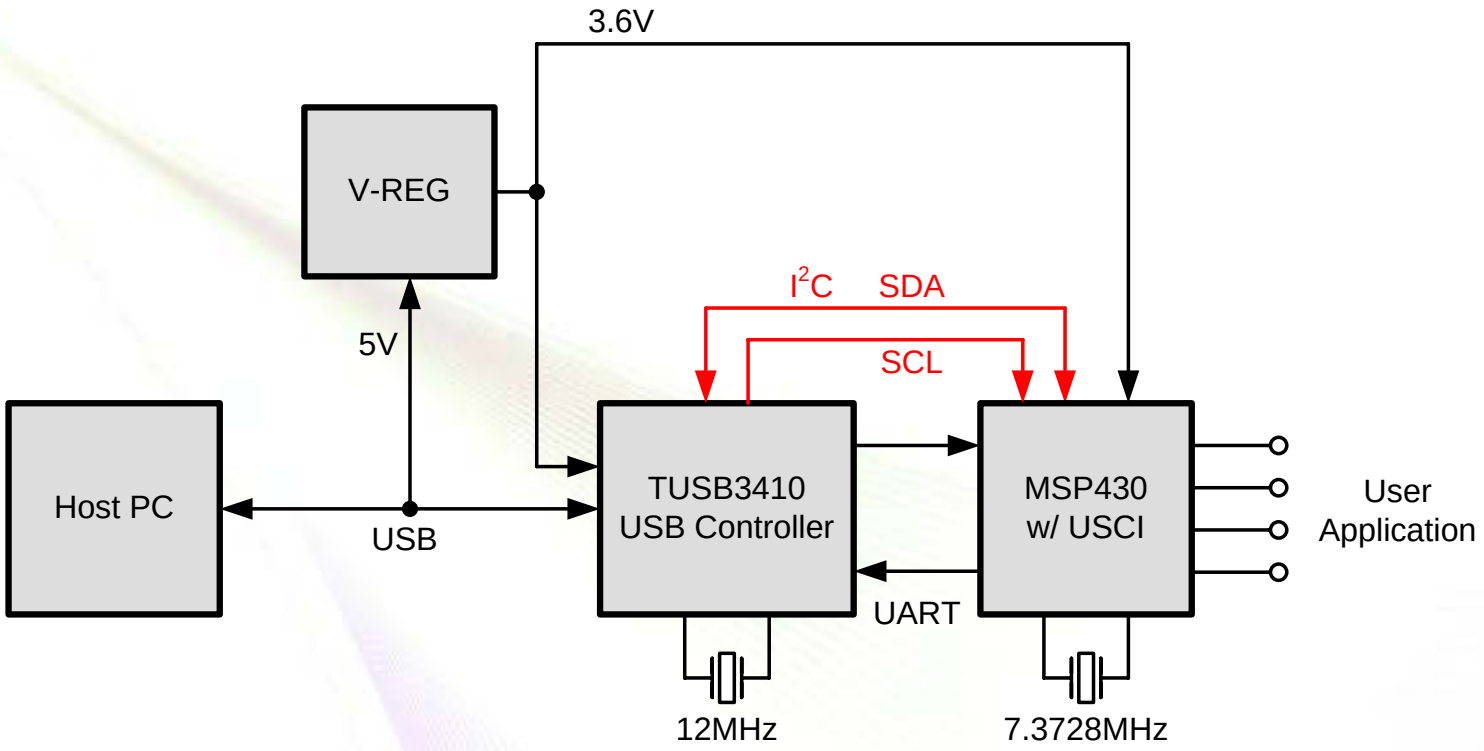
Lower Cost Option: ‘430 = EEPROM



- **EEPROM is emulated by MSP430 USCI I²C module**
- **Full flexibility for USB configuration**
- **Requires 2xx device, or 4xx device with USCI/DMA**

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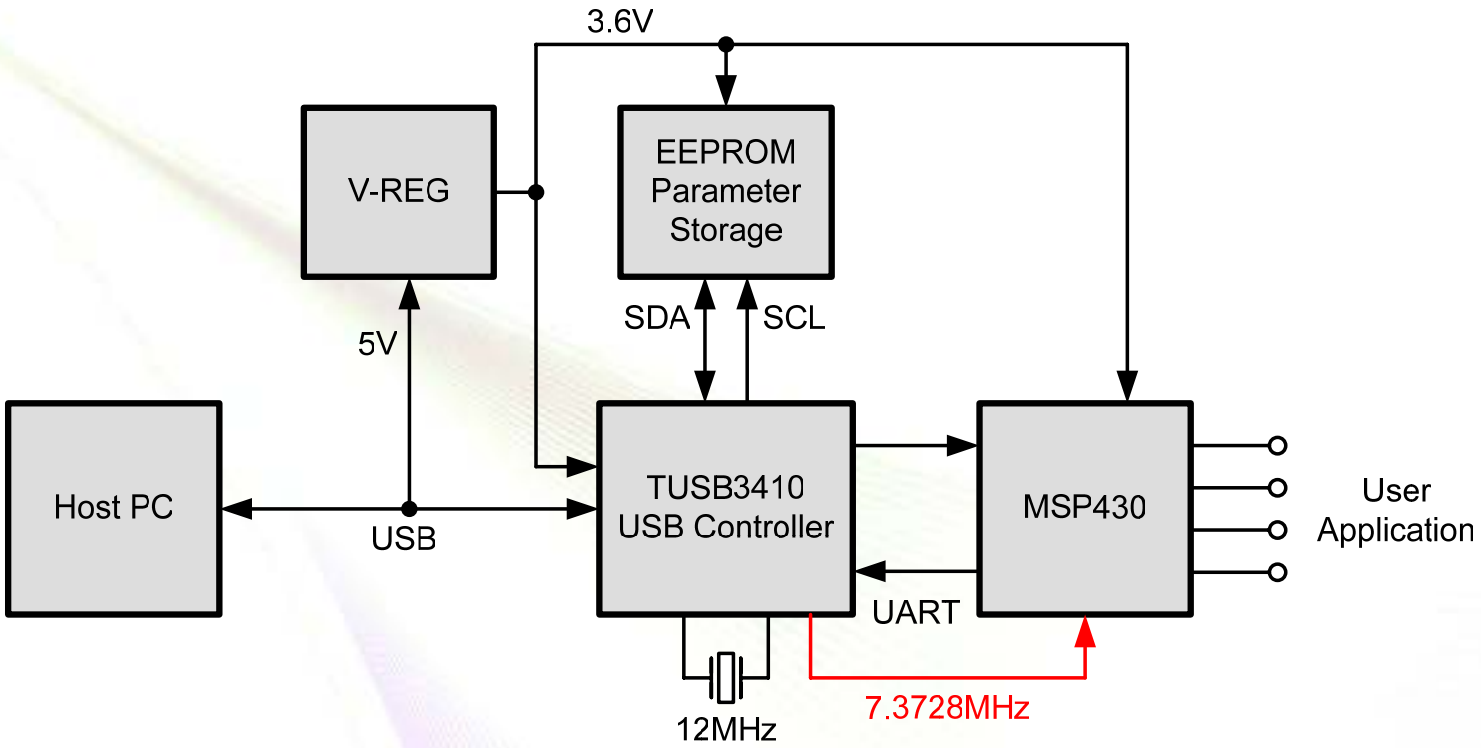
Lower Cost Option: No ‘430 XTAL



- **TUSB3410 can output UART baud clock or fixed 3.556MHz on CLKOUT**
- **Use CLKOUT to drive MSP430 XIN (in HS mode)**
- **OR: Use 2xx device with calibrated DCO**

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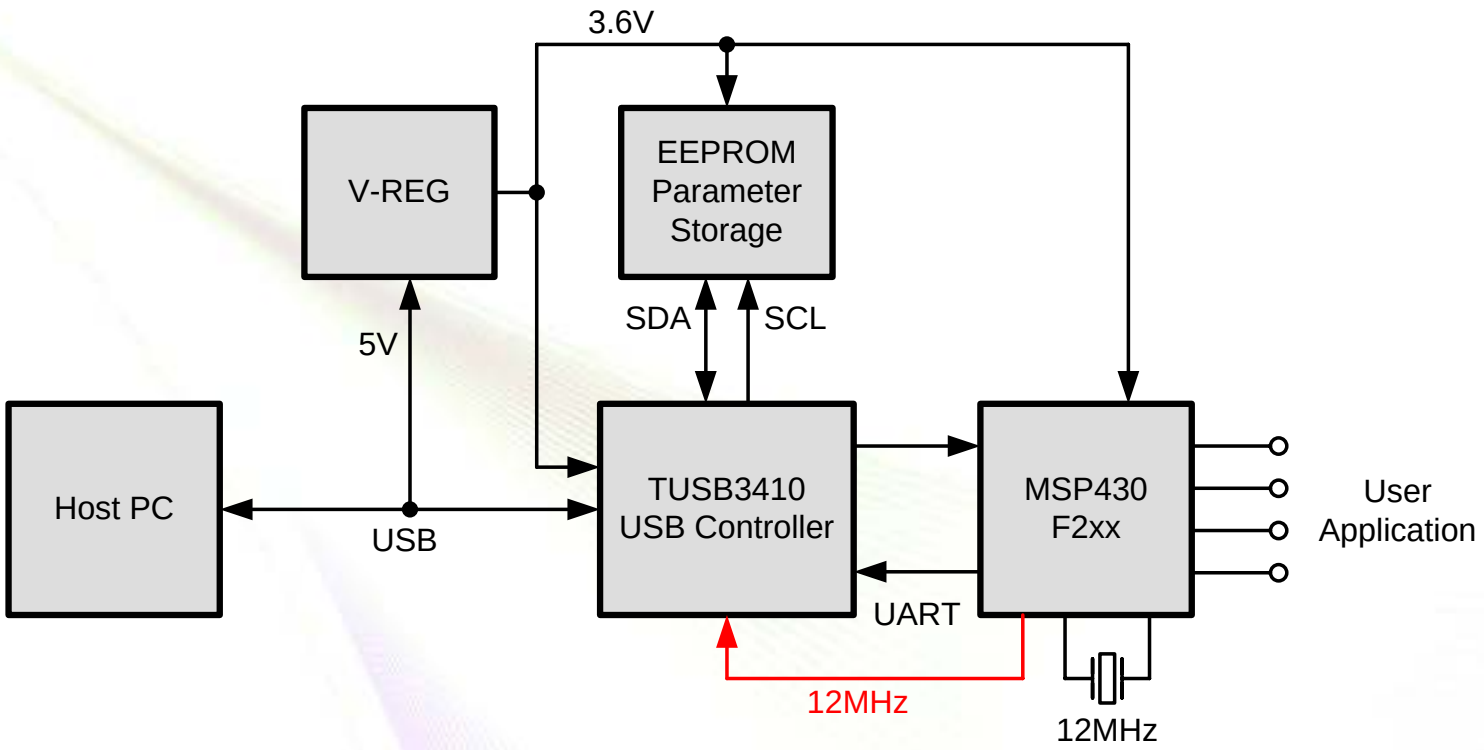
Lower Cost Option: No ‘3410 XTAL



- **Attach 12MHz XTAL to MSP430**
- **Use ACLK or SMCLK output to drive TUSB3410 XIN**
- **Note: Clock signal must be voltage divided!**

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Additional Design Ideas

- Transfer data in blocks rather than byte-by-byte
- Use MSP430 DMA for efficient high-speed UART
- Connect MSP430 GPIO to TUSB3410 RESET to generate unplug – replug event
- Use TUSB3410 H/W handshake signals CTS or DSR to control data flow to MSP430
- USB bus can supply up to 500mA @ 5V on request (standard is 100mA)
- Power-down TUSB3410 to conserve power
- Use EEPROM as extra MSP430 storage

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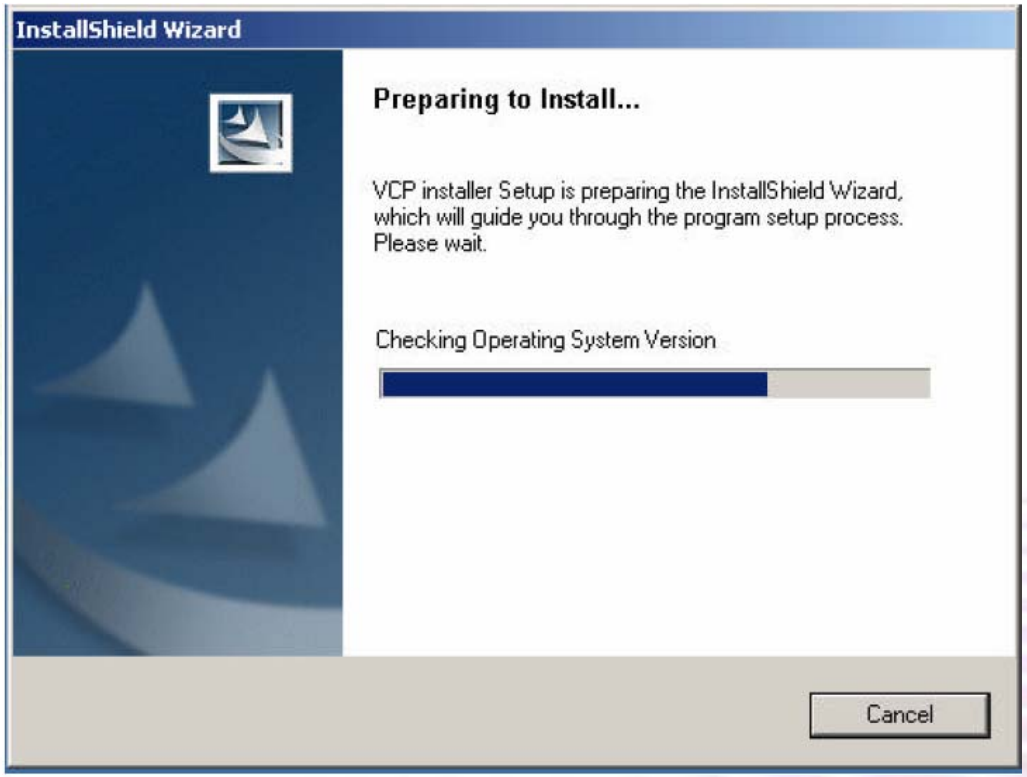
Host Driver Overview

- **Extensive Windows VCP driver package**
- **Includes installer**
- **For use with Windows 98, 2000, and XP**
- **WHQL certified**
- **TI part # TUSBWINVCP**
- **3rd party drivers for Linux and MacOS X available**



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WinXP Driver Customization

- **Must-do when using custom VID / PID**
- **For two drivers, there are two INF files to modify**
- **Look for “Vendor replace …”**
- **umpusbXP.inf**
  - New HWID string, e.g. “VID_0451_BEEF_com”
  - New VID / PID, e.g. ”TI3410.Uni,USB\VID_0451&PID_BEEF”
  - New descriptor string, e.g. “MSP430-TUSB3410 Ref Design”
- **UmpComXP.inf**
  - New references, e.g. “umpport\VID_0451_BEEF_com”
  - New descriptor string “MSP430-TUSB3410 Ref Design - Serial Port”
- **Driver SYS and INF files ready for use**
- **Done!**

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WinXP Driver Installer

- Created with InstallShield
- For automated HW installation
- Makes HW and drivers known to system
- Use custom INF files as discussed
- One additional customization step
- Open installer file “system\devices.txt”
- Insert VID / PID were indicated
- Now simply distribute TI’s InstallShield package
- Done!

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WinXP Driver Installation

- **Connect USB hardware**
- **HW wizard will popup**
- **When installer was used, simply push “Next >” until everything is done**
- **Otherwise, select “Install from a list or specific location”**
- **Two devices get installed:**
  - Multi-port serial adapter (UMP)
  - Virtual serial COM port

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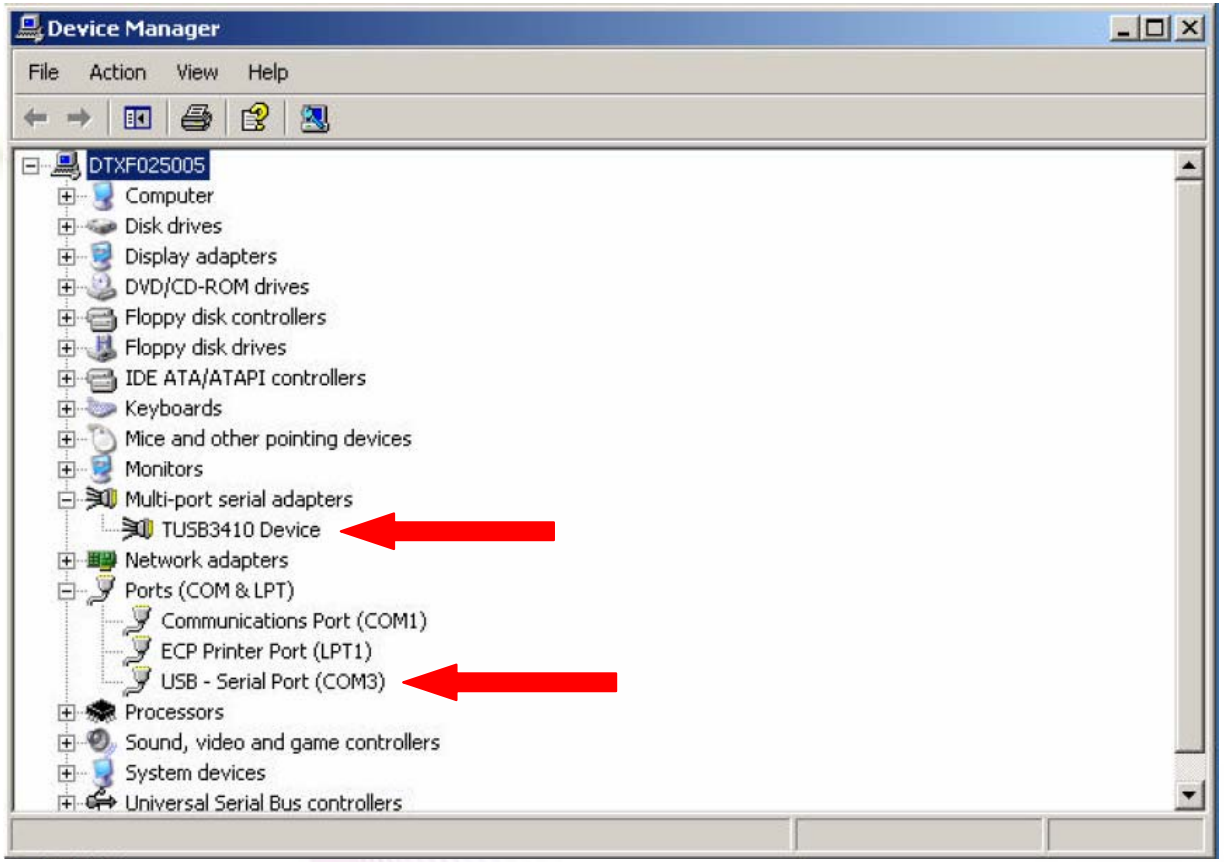
WinXP Driver Installation



- **Windows device manager after driver install**
- **Two drivers were added**
- **Here: access through COM3**

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Detecting The Right VCP How-To

- Better: Auto-detect VCP using the Windows SetupAPI
- Enumerate all Windows COM port class devices (GUID_CLASS_COMPORT)
- Read HW IDs and friendly names from registry
- Look for a HW ID of “umpport\VID_0451_BEEF_com”
- Friendly name string includes COMnn
- Parse string and extract COM port
- See app note MSP430 USB Connectivity using TUSB3410 (SLAA276) for example code

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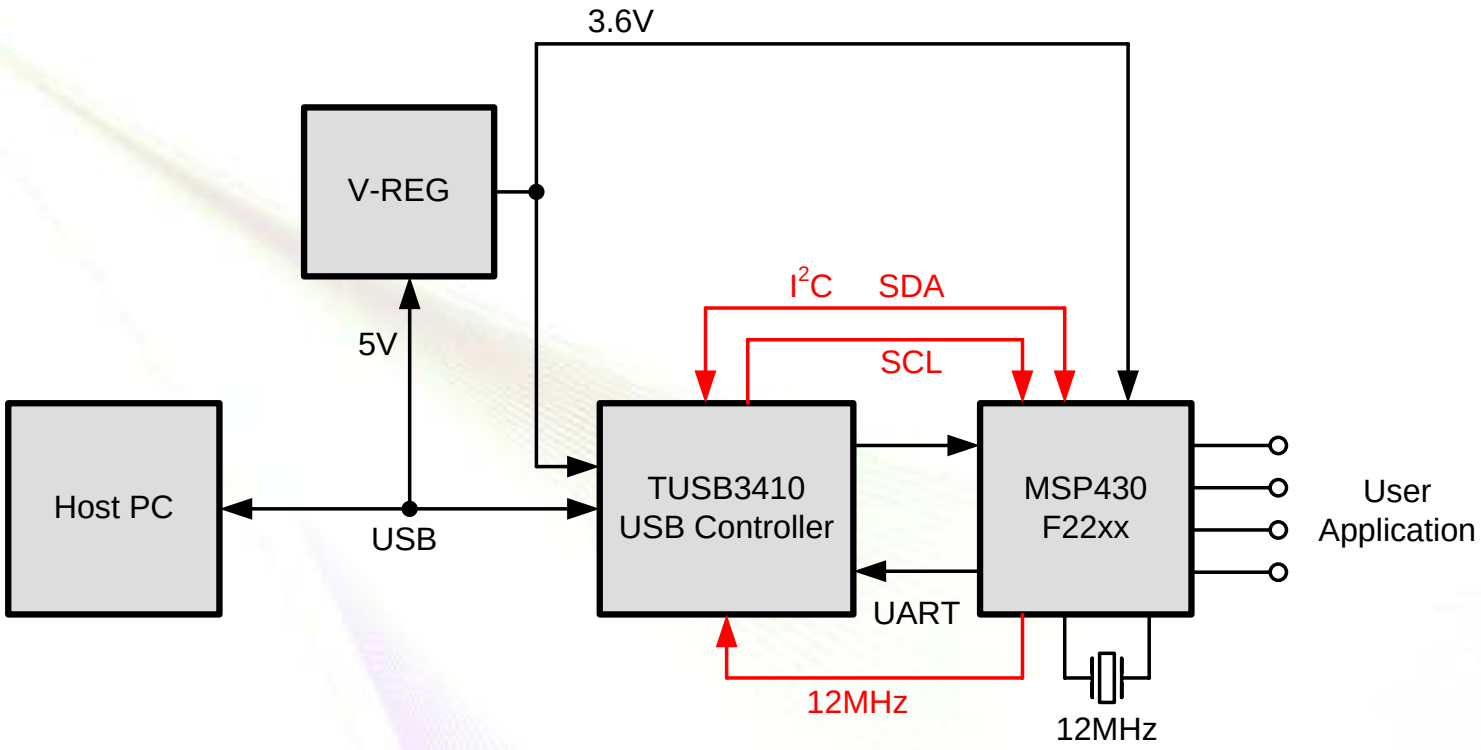
Demo: MSP430 USB Ref Design



- Uses MSP430F2274
- MSP430 supplies clock to TUSB3410
- MSP430 emulates USB configuration EEPROM
- *Short BOM!*

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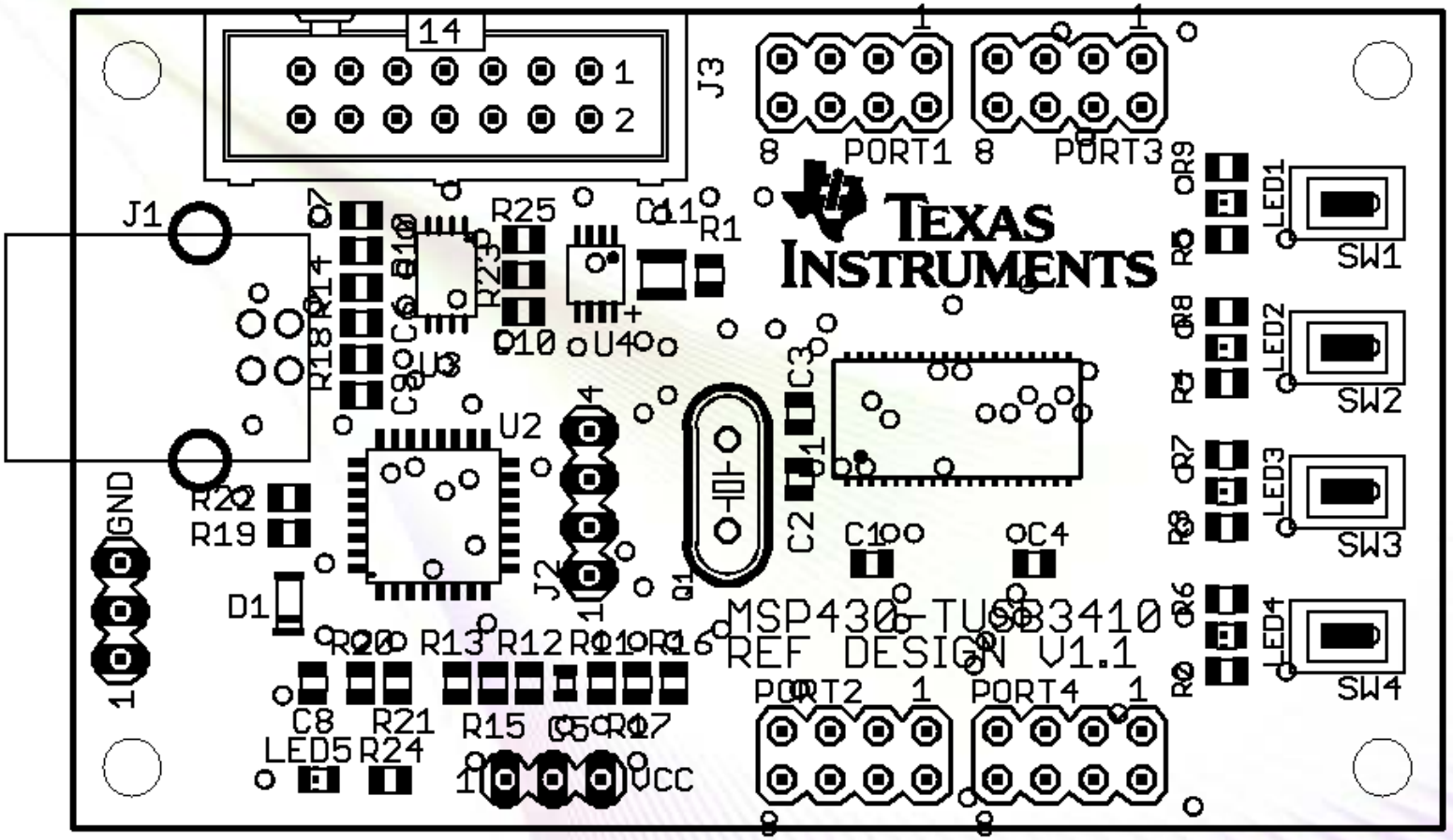
Demo: MSP430 USB Ref Design



- **Entire solution, including software, hardware design and Gerber files available as app note *today!***

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Demo: USB Ref Design Overview

- **Initial condition:**
  - MSP430 is already programmed with firmware
  - Firmware includes the EEPROM emulation image (VID, PID, …)
- **Board gets connected to PC and starts operating**
- **MSP430 starts outputting the 12-MHz clock, and releases the TUSB3410 reset signal**
- **The stored EEPROM image is read out and processed by the TUSB3410**
- **Board reports as “MSP430-TUSB3410 Ref Design”**
- **Customized TUSB3410 driver opens virtual COM port**
- **PC demo application can be started**
- **Press SW1..SW4 on the MSP430, keys 1..4 on the PC**

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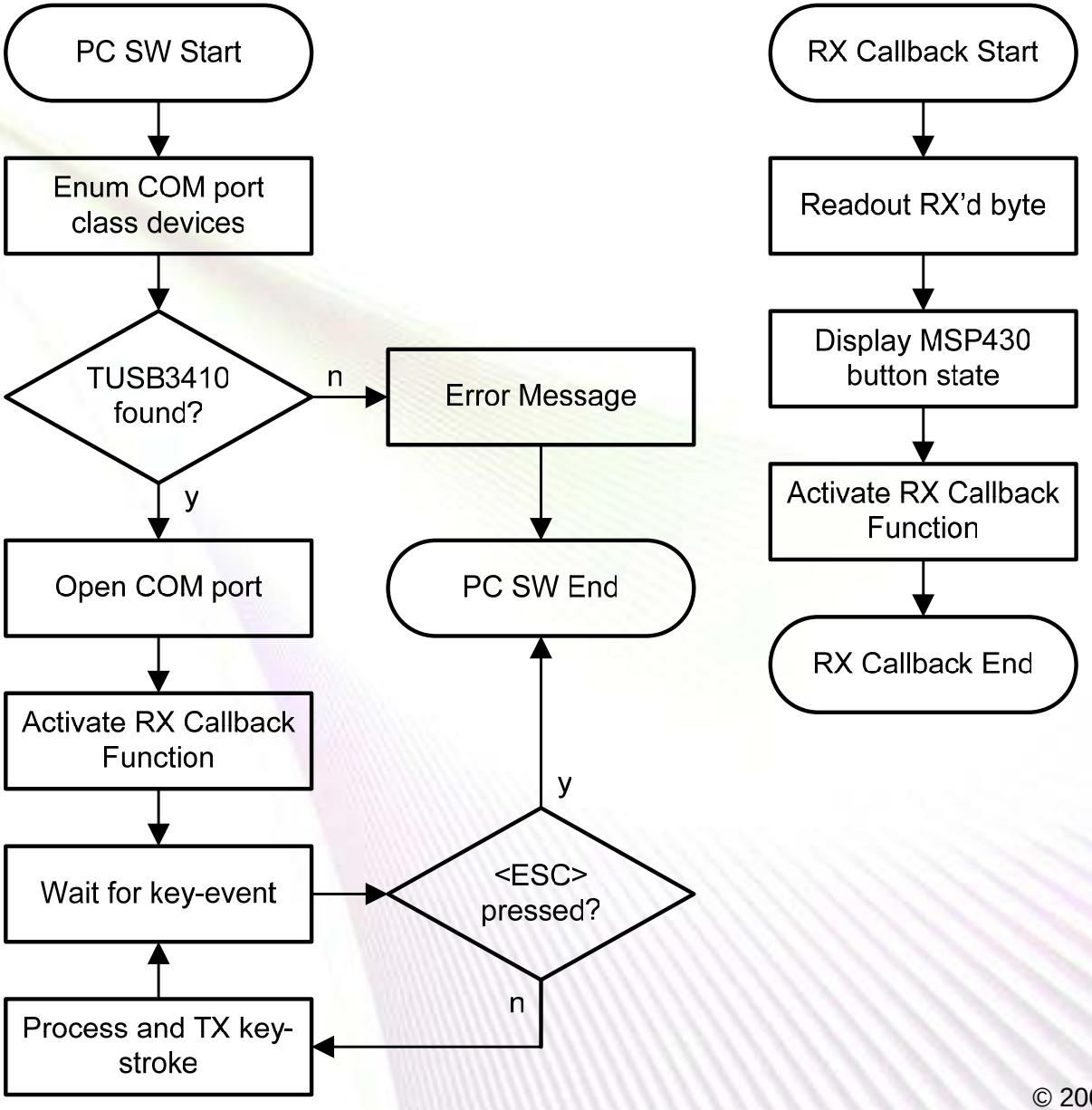
Demo: PC Software Flow



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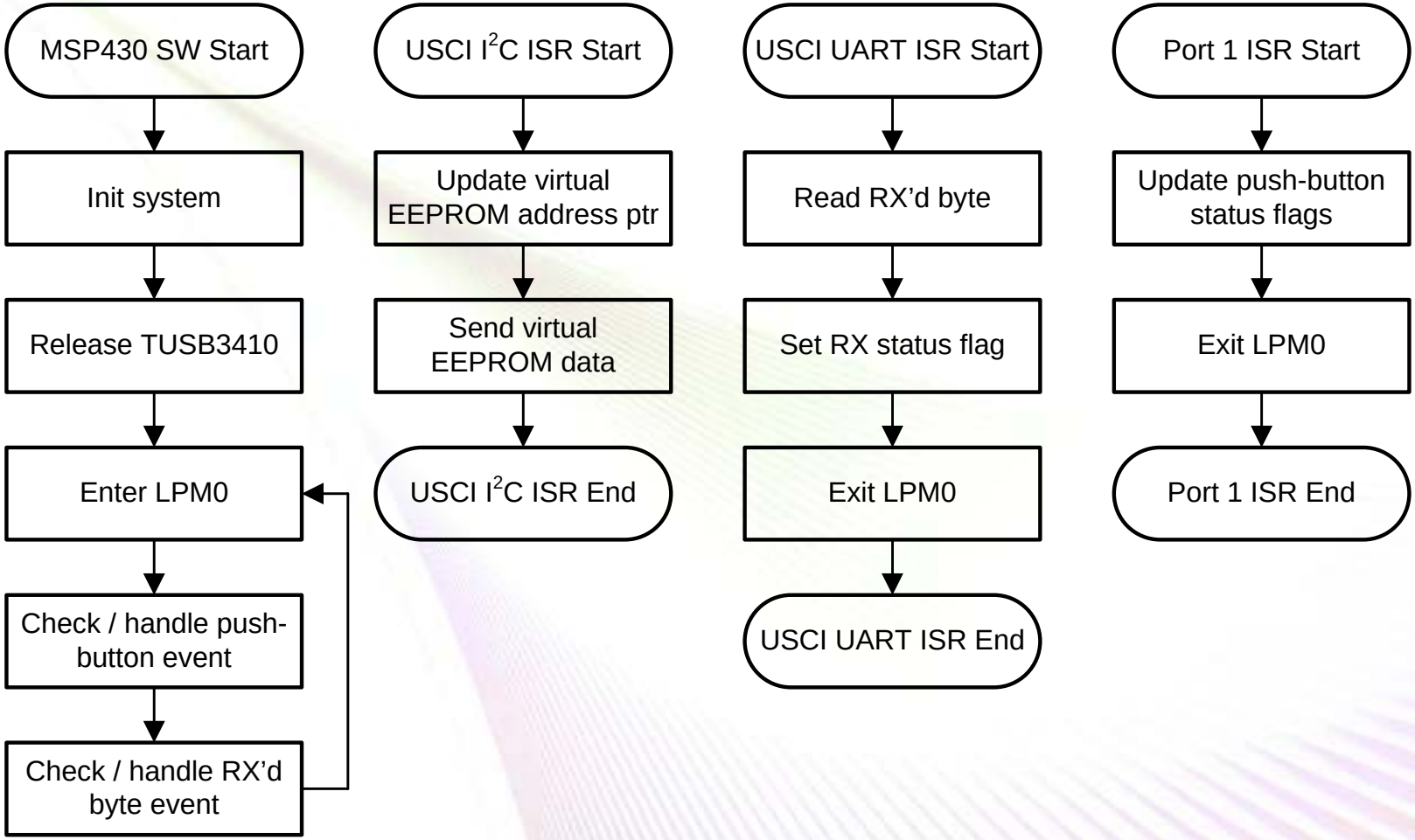
Demo: MSP430 Software Flow



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Summary

- TUSB3410 makes your design USB compatible today
- Transfer speeds of up to ~1Mbit/s
- Extensive apps collateral available from TI
- Designed as turnkey solution
- MSP430F5xx with integrated USB in late 2007

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