CapSense® Proximity Design

1.0

Features

- CapSense® Proximity Sensing
- Pseudo Random Sequence Modulator based LED brightness control
- Software UART interface for viewing CapSense data

General Description

This example is a PSoC Creator starter design. The project demonstrates a CapSense based proximity sensing design to control brightness of a LED. It will help user learn how to design a proximity sensor in their design using a PSoC 4 (4000 family) device and see how an approaching hand controls the intensity of a LED. It will employ the CapSense auto tuning ability, SmartSense®, to tune the proximity sensor of any wire/trace length. The project will also help user understand and design a simple Sleep-scan routine using the proximity sensor where the device will enter a periodic scan mode at a configurable rate and sleep once the sensor scan is complete to save power.

If you are new to CapSense, see PSoC 4 CapSense Design Guide.

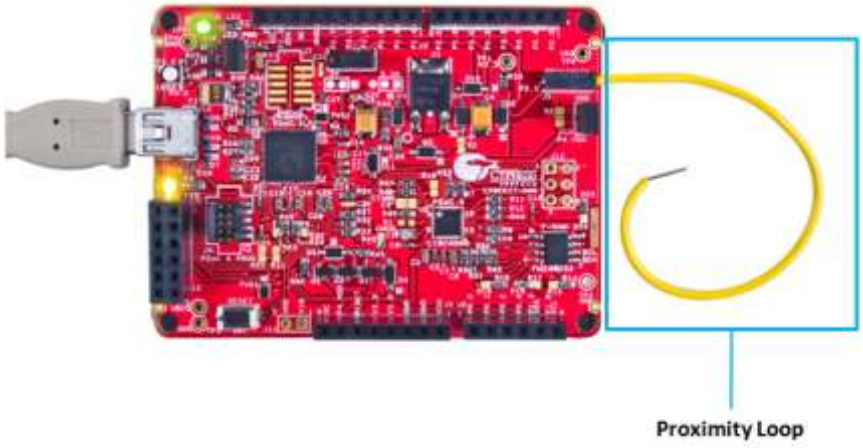
Development Kit Configuration

The following configuration instructions provide a guideline to test this design in CY8CKIT-040. Though the below instructions describe a stepwise procedure to be followed while testing this design with the CY8CKIT-040 (PSoC 4000) Kit. This example, however, can be validated on any other PSoC 4000 development platform. For details, please refer to the Schematic and Pin Mapping section at the end of the document.

1. Use J1 on the CY8CKIT-040 to select 5.0 V.

2. Plug the Proximity wire loop into J5 on the base board and create a loop as shown in figure.

Figure 1. Proximity demo using CY8CKIT-040 Setup

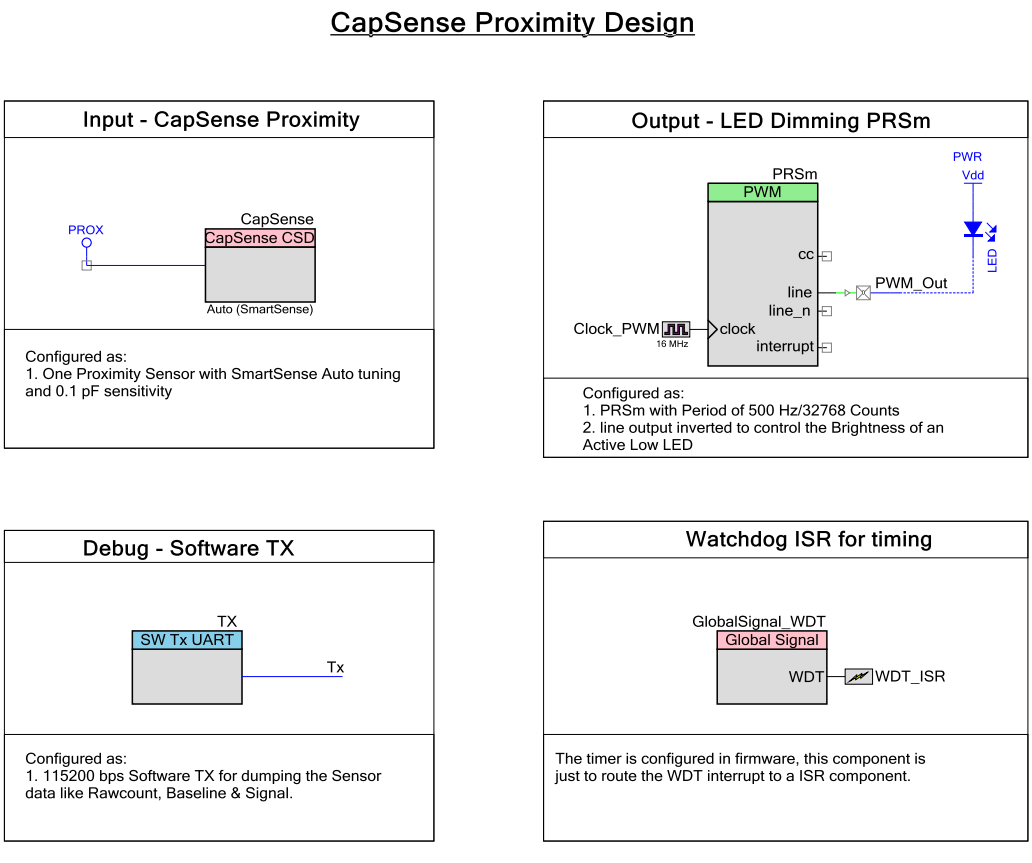


3. Make sure Jumper J14 and J13 are present.
4. Plug the USB cable into J10.
5. Build the project in creator and program the device.
6. Now move your hand towards the loop and notice the Red LED on the board starts turning ON and its brightness will increase as the hand approaches the loop.

Project Configuration

This example project uses CapSense component for proximity, TCPWM for LED brightness and SW Tx UART component for data logging over PC. Figure shows the Top Design schematic of this project.

Figure 2. Topdesign Schematic of the Design



Component Configuration:

CapSense:

CapSense Component is configured in SmartSense Auto tuning mode with one proximity sensor for the design with the parameters shown in Table 1.

Table 1. CapSense Component Parameters

Parameter	Tab present	Value	Rationale
Tuning Method	General	Auto(SmartSense)	To automatically adjust sensitivity for different system environments
Threshold Mode		Automatic	To enable run-time threshold calculation for 5:1 SNR
Raw data noise filter		First Order IIR 1/4	Filter out noise/unwanted spikes in raw count. This setting can be tweaked based on requirement.
Immunity level		Low	Based on system needs can be set to high/low. Defaults to 'Low'.
ProximitySensor0	Widgets Config	-	Need to add a Proximity sensor by clicking on 'Proximity Sensors' and then clicking 'Add Proximity sensor'. The only parameter that is available to modify in this tab is debounce. This can be set/adjusted based on system requirement
Analog switch divider source	Advanced	PRS-12b	For reduced EMI emission and enhanced EMC immunity.
Sensor Auto reset		Disabled	Not required in the design. Can be added if required by the application.
Low Baseline Reset		5	System dependent number. Can be configured as per the user needs
Inactive sensor Connection		Ground	To make the proximity loop doesn't pick up any charge when not scanned
Shield		Disabled	Not used in the design
Guard sensor		Disabled	Not used in the design
Cmod precharge		By Vref	Vref is enough for precharging here, as there is only one sensor, Cmod voltage will not drop too low for a fast GPIO precharge
Sensitivity	Scan Order	1	To obtain the maximum possible sensitivity using SmartSense. The parameter controls the scan time, so for a lower number of sensitivity setting, scan rate will be higher. The parameter can be tweaked depending on the response rate and desired proximity range needed.

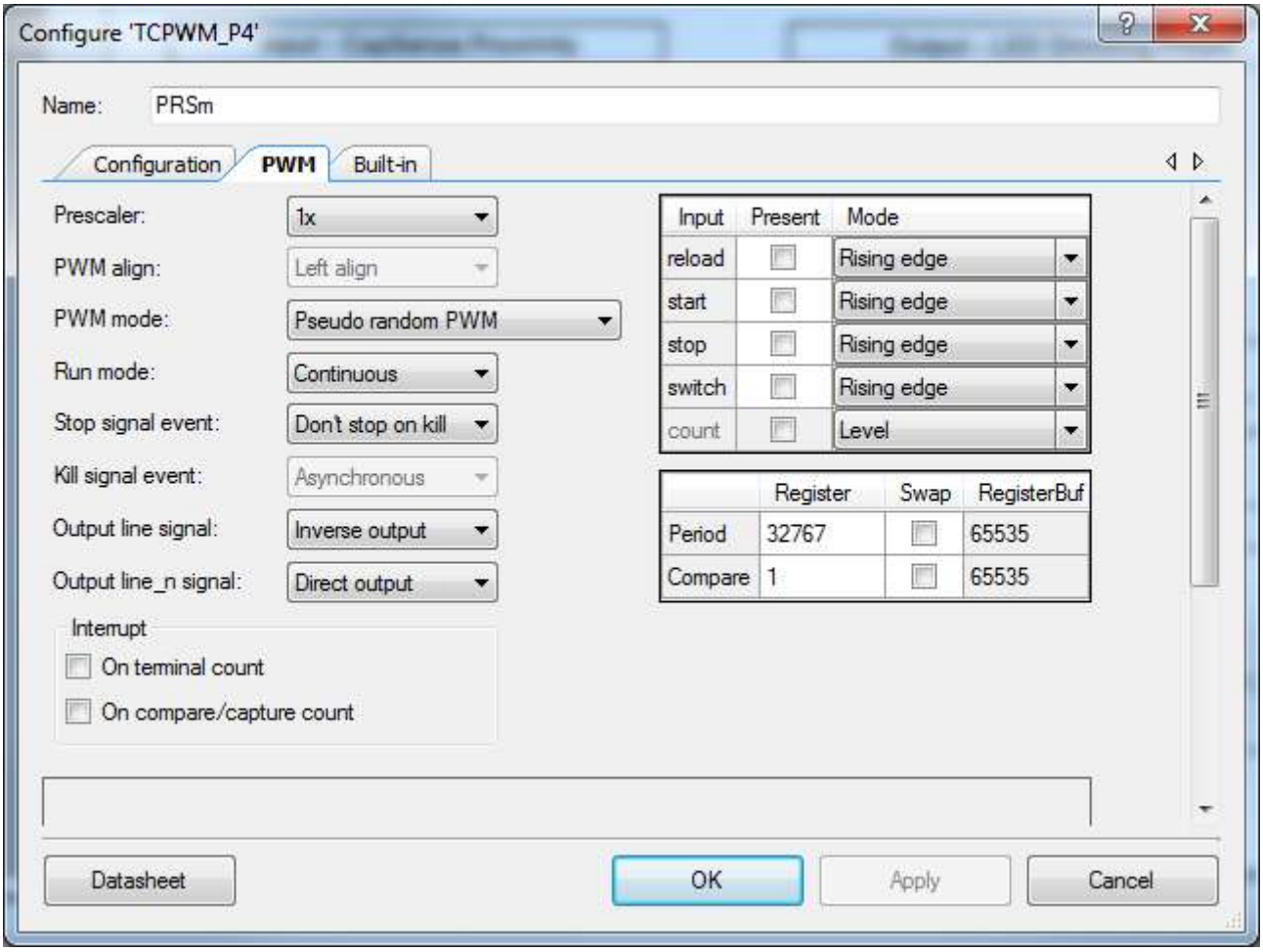
Tune helper	Tune helper	No tuner used	No tuner used

PWM (TCPWM mode)

TCPWM component is used for controlling the brightness of the LED. The CapSense Proximity sensor's signal output is used for deducing the LED brightness. The parameters for TCPWM component are as in Figure **3**. The TCPWM block is configured as a PWM and in Pseudo Random Sequence modulator (PRSm) mode with a resolution of 15-bit (fixed by TCPWM block architecture). This 15-bit resolution of the PRSm along with a 16 MHz input clock generates a period of 500 Hz (PRS repeat period). The output line is inverted to drive the Active Low LED. A period of 32768 is set in the component to generate proper period macro for the 15-bit PRSm. Though the output of PRSm has a variable frequency with a max frequency of 8 MHz (16 MHZ/2), the repeat rate of PRSm is considered as the period in this context.

Note: The Compare value should be minimum '1', '0' will leave the LED ON.

Figure 3. TCPWM component configuration - PWM tab

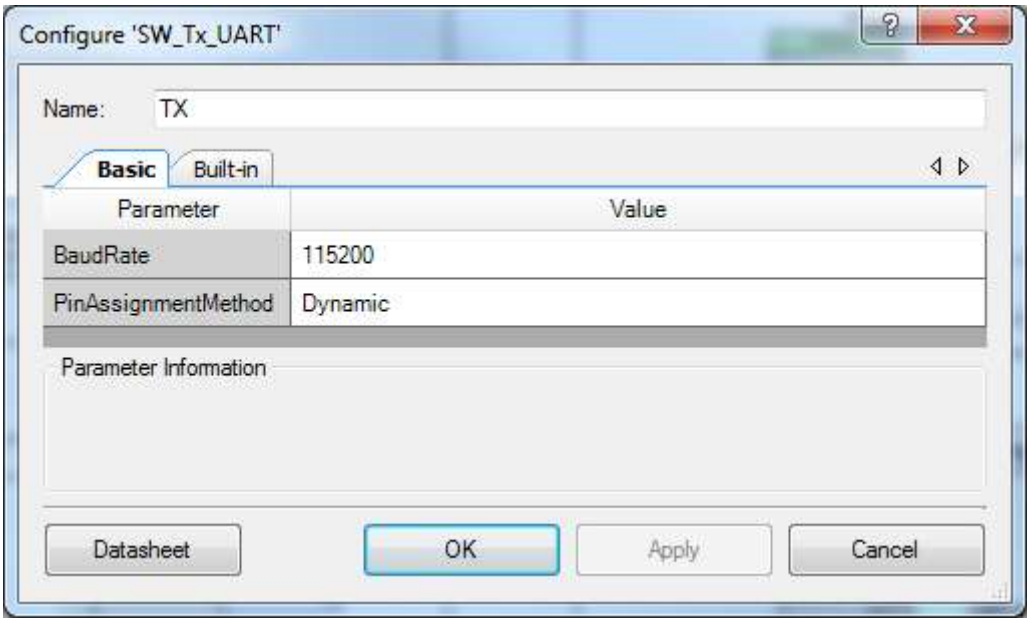


TX (SW Tx UART)

The software transmit Tx is used to send out proximity sensor related data for debugging. The configuration for the component is as in Figure **4**. The SW TX can be sent over to PC using either a RS232 connector (with a translator in between) or through USB-UART bridge available

in CY8CKIT-040 PSoC 5 LP UART Bridge or CY3240 bridge configured as UART bridge as documented in AN2397. The TX pin selected in firmware through TX_PORT and TX_PIN macros defined in 'main.h' file

Figure 4. Software UART Tx Component parameters



PWM_Out (Digital Output Pin)

For driving the PWM output to the LED. It is a standard Strong drive output pin.

Clock_PWM (Clock)

It provides the clock that drives the PWM block. The clock is configured to be the max possible/allowed (16 MHz), so that repeat rate of the PRSm is as high as possible for reduced LED flickers.

Project Description

A capacitive proximity sensor controlling the brightness of a LED is implemented in the project. The project configures the sensor as a CapSense proximity widget with SmartSense auto tuning. The firmware flow is presented in Figure **5**. The CapSense/Input initialization part tunes the CapSense system parameters using SmartSense. The output initialization part configures the PWM and the software UART Tx output. The infinite loop code is divided into two phases – Input process and Output process.

The input process phase scans the proximity sensor, processes the sensor signal, such as applying filter, calculating baseline and filtered signal. The output processing phase is also split into two phases – data calculation and data output sub-phases. In the data calculation sub-phase, the proximity signal is compared against a minimum and maximum threshold defined for an approaching hand. The LED brightness is then calculated based on the sensor's signal value relative to the thresholds. Minimum threshold generates the lowest LED brightness and maximum limit generates the highest LED brightness.

The data output phase, updates the PWM compare value with the calculated brightness. The

system data such as sensor raw data, baseline, signal and calculated LED brightness are sent over UART Tx line. The device monitors the activity on the proximity sensor and if there is no activity i.e. if the hand is out of range of the proximity, then the device enters a Sleep-scan mode. The time for which the device checks for a no activity on the sensor before entering Sleep-scan mode is set to one second and is configurable in the project (ENTER_SLEEP_COUNTS macro in main.h). In the Sleep-scan mode, the device wakes up every 100 ms and checks for any activity on the proximity sensor. This wakeup rate is configurable by modifying the 'WATCHDOG_TIMER_COUNT' macro in the 'main.h' file.

Note: By default debug is disabled and UART TX line is enabled on SWD IO line (P3[0]) in the project. If debug is desired, then the Debug Select parameter should be set to SWD (serial wire debug) value as shown in Figure 6. If debug is enabled, TX should be disabled (by commenting out TX_ENABLE macro in 'main.h') or routed to another pin (by modifying TX_PORT and TX_PIN macros).

The periodic interrupts from WDT may complicate debugging of project due to frequent jumps of the instruction pointer into the interrupt handler. To make debugging more comfortable, interrupts can be disabled by using option "Disable global interrupts" from menu "Debug".

Figure 5. Firmware flowchart

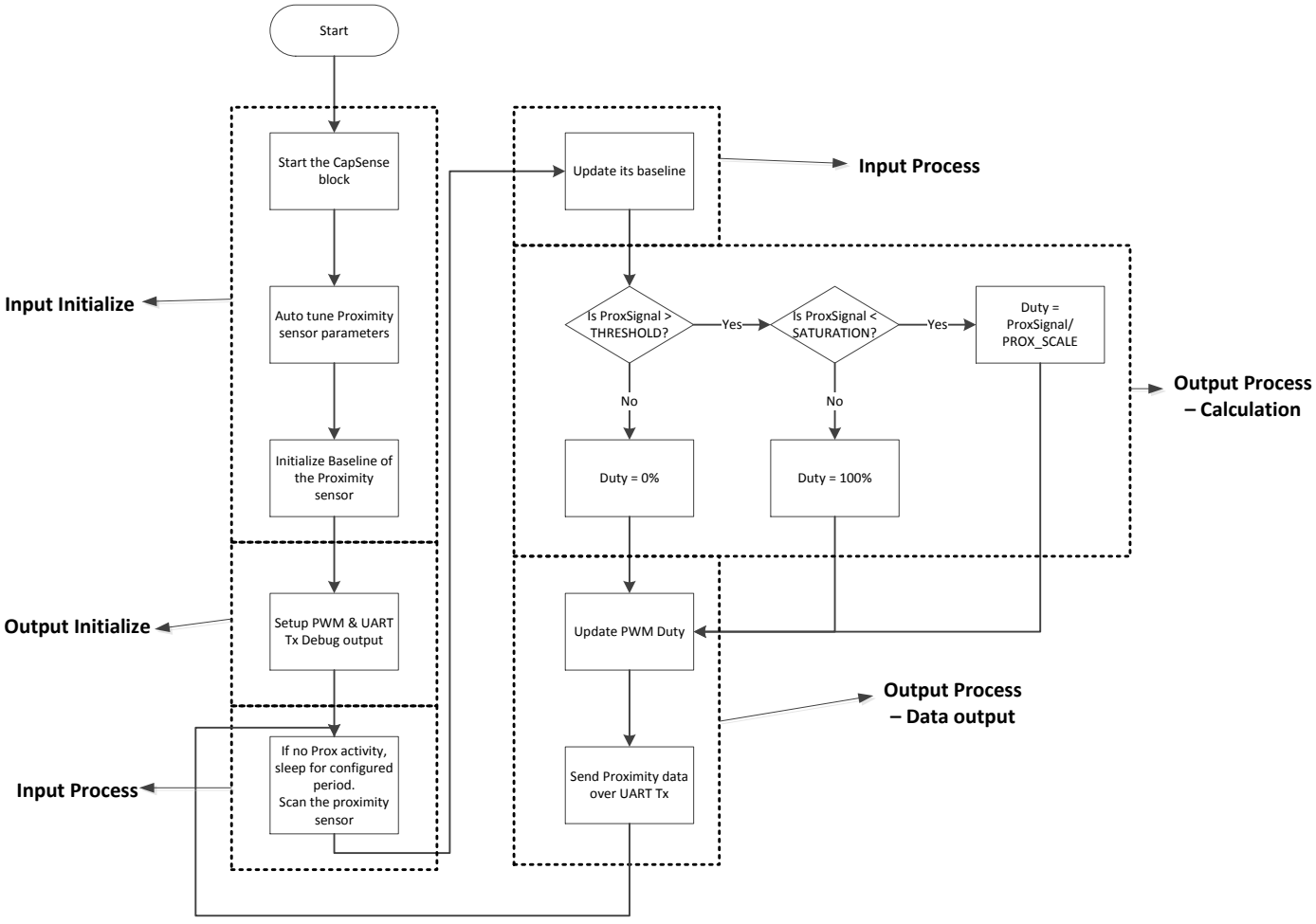
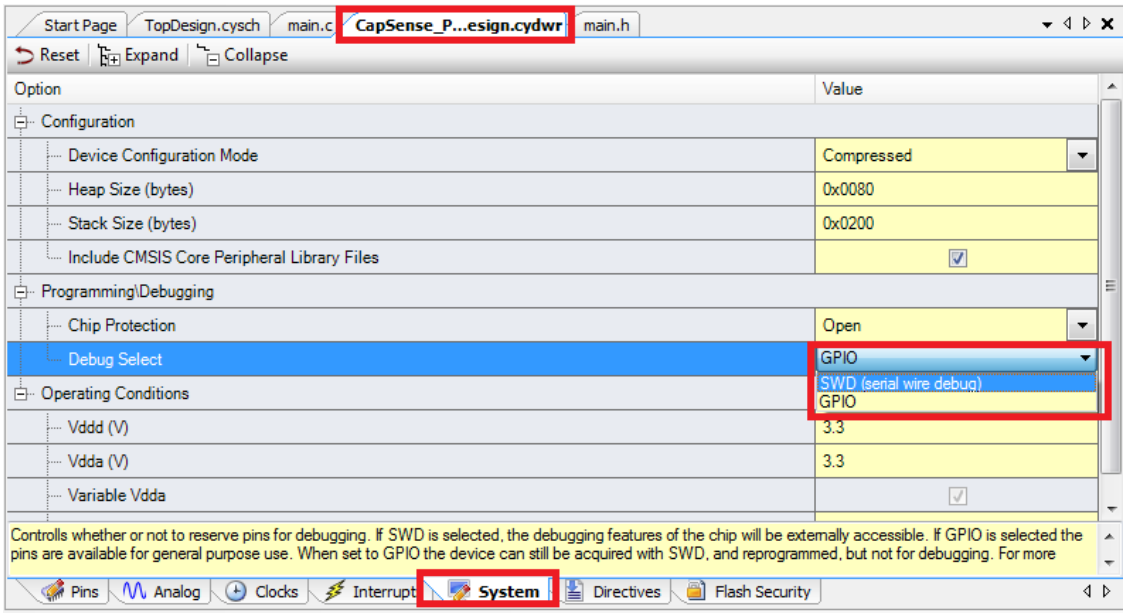


Figure 6. Enabling Debug in the project



Debug Interface (UART)

For viewing the debug data transmitted over UART Tx line, Bridge Control Panel software is used. One UART packet size is 13 bytes which includes 8 bytes of data, 2 bytes of header and 3 bytes of footer. The two byte header precedes the data bytes and in the design it is 0x0D and 0x0A. The three byte footer follows the data bytes and in this design consists of 0x00, 0xFF and 0xFF. The data itself consists of proximity sensor raw counts (RC), baseline (BL) and signal (SIG) along with the calculated PWM duty (DUTY). The UART Tx data packet structure is as shown below –

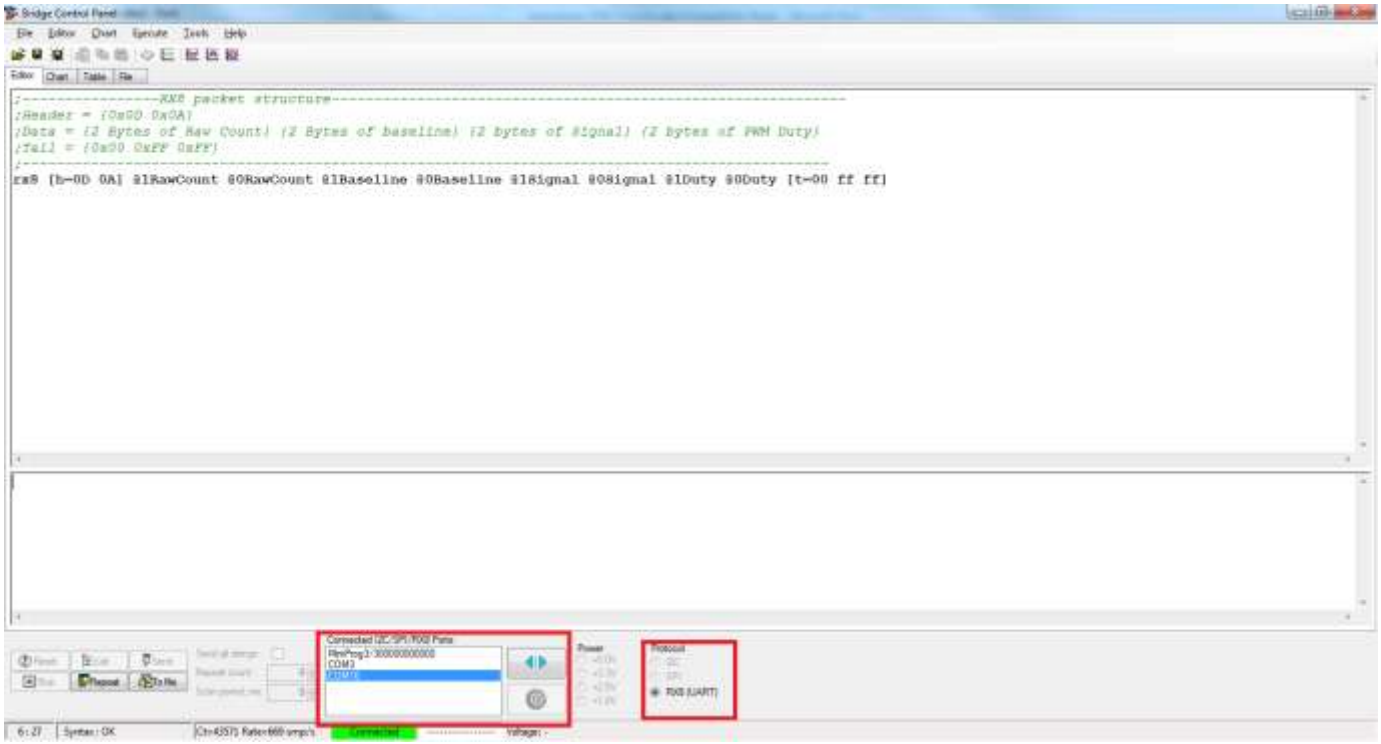
Table 2. UART Tx Packet Structure

Header		***Data***				
BYTE 0	**BYTE 1**	**BYTE 2**	**BYTE 3**	**BYTE 4**	**BYTE 5**	**BYTE 6**
0x0D	0x0A	RC_MSB	RC_LSB	BL_MSB	BL_LSB	SIG_MSB
Data		***Footer***				
BYTE 7	**BYTE 8**	**BYTE 9**	**BYTE 10**	**BYTE 11**	**BYTE 12**	
SIG_LSB	DUTY_MSB	DUTY_LSB	0x00	0xFF	0xFF	

Follow the below steps to setup Bridge Control Panel (BCP) for viewing the data with CY8CKIT-040's USB-UART bridge,

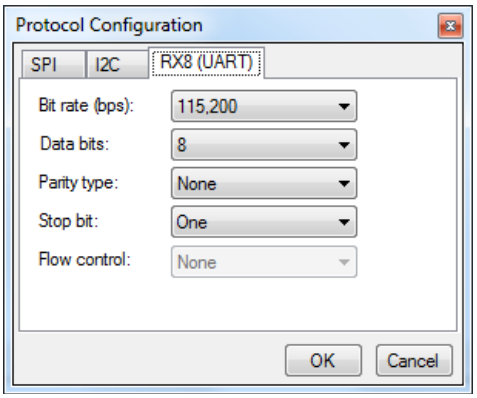
1. Open Bridge control Panel software available under 'All programs -> Cypress -> Bridge Control Panel 1.10.0 -> Bridge Control Panel 1.10.0
2. Route the Tx pin of the device to any available Rx which can connect to the PC Com port. CY3240 (refer AN2397) or KitProg in CY8CKIT-040 can be used for this purpose. In CY8CKIT-040, Pin 3[0] (Tx line) is directly connected to RX line (P12[6]) of PSoC 5LP bridge (Zero Ohm R57 in the board needs to be populated) .
3. In the Bridge Control Panel software, click on the COM port to which you have connected the data. In our case, it is KitProg's COM (can be found in Device manager).
4. Select RX8 as protocol, as shown in Figure **7**

Figure 7. Bridge Control Panel - COM Port and Protocol Selection



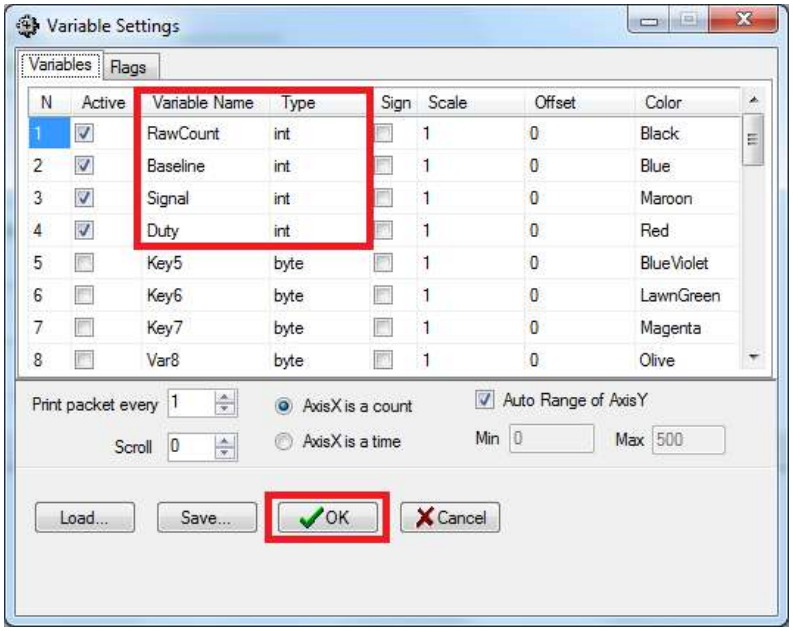
5. Click on ‘Tools -> Protocol Configuration’ or Press ‘F7’ and configure the RX8 protocol parameters as shown below.

Figure 8. RX8 Protocol Configuration



6. Click on ‘Chart -> Variable Settings’ and Set the variable names and types as shown in Figure **9** and then press ‘OK’

Figure 9. Bridge Control Panel - Variable settings



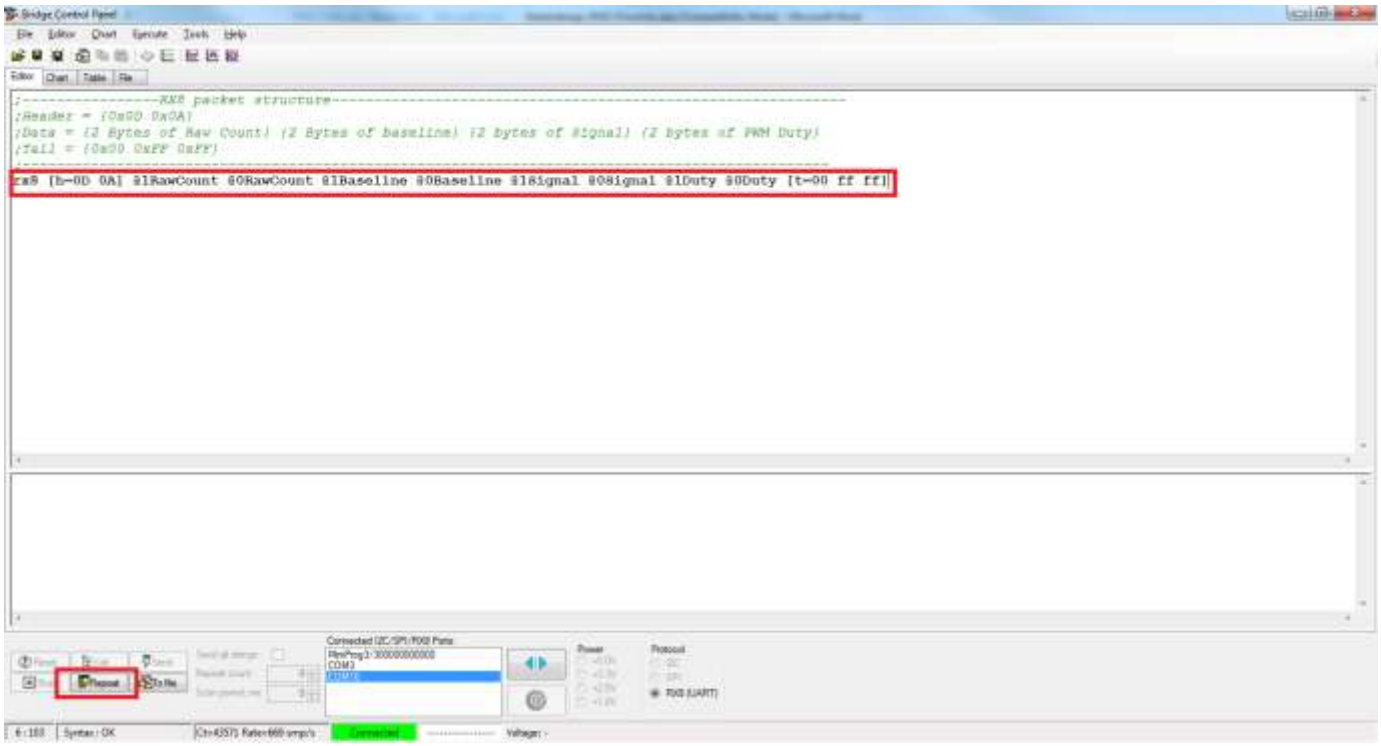
7. Go to editor and Type or copy the command as shown below

Command:

rx8 [h=0D 0A] @1RawCount @0RawCount @1Baseline @0Baseline @1Signal @0Signal @1Duty @0Duty [t=00 ff ff]

8. Click ‘Repeat’ as shown below to start receiving the packets (make sure you have powered the device and programmed with the project’s firmware and the Tx is connected to Rx line of the COM and the COM port is selected in BCP)

Figure 10. Bridge Control panel - Protocol execution



9. You should start receiving data, Click on ‘Chart’ tab to view the graph.

Expected Results

Following table provides the expected behavior for a wire loop of approximately 5 cm diameter

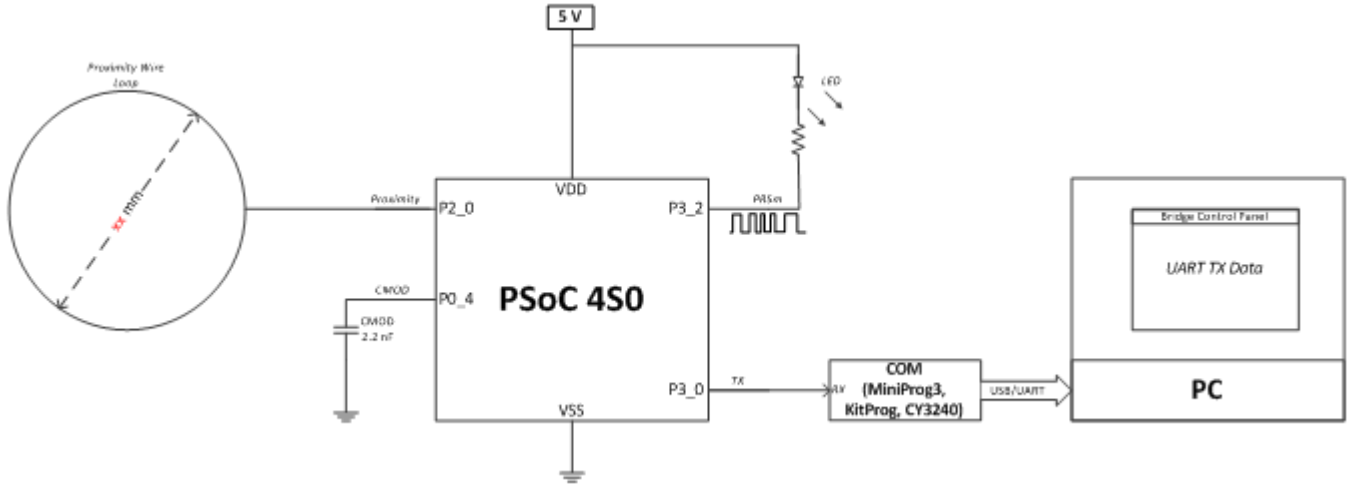
Table 3. Expected Results

Hand Distance(in cm)	Signal observed in BCP GUI	LED state
5-6	40-50	Just turns ON with lowest brightness
1	250	LED with full brightness

Schematic and Pin Mapping

Schematic:

Figure 11. Schematic of the Project



Pin mapping table:

Table 4. Pin Mapping and Alternate pin options

Function	Pin	Alternate Pins
Proximity Sensor	P2[0]	Any CapSense supported GPIO. Refer datasheet for the supported GPIOs
Modulator Capacitor	P0[4]	Fixed to P0[4]
LED	P3[2]	P1[1]. Alternately P1[6] can be used as well for an inverted output.
UART Tx	P3[0]	Any available GPIO.

Cypress Semiconductor
198 Champion Court
San Jose, CA 95134-1709

Phone : 408-943-2600
Fax : 408-943-4730
Website : www.cypress.com