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PGA 450

EVM Demonstration using PGA 450 Firmware Rev 2.1

Objective:

This demonstration is to illustrate the method of using 8051 firmware to determine the time of flight (TOF) using LIN communication to trigger a distance computation and to retrieve the time information back.

Changes from Rev 2.0:

The settings for short distance measurements are updated in Rev 2.1 of the firmware. Differences include an optimized threshold algorithm (optimized for the TI setup) and less blanking time for short distance measurements.

Introduction:

TOF is the estimation of the time from the ultrasonic wave burst from the transducer to the object and then from the object back to the transducer. This time is an indicator of the distance of the object from the transducer.

Distance = TOF / 2 * Speed of sound in air (Typically 340 meters / sec at room temperature)

The firmware sets up the device with the appropriate settings for long and short distance estimation. These operations are initiated by a LIN transmission via the GUI and LIN master on the EVM to PGA450 which is the slave device.

The idea is to:

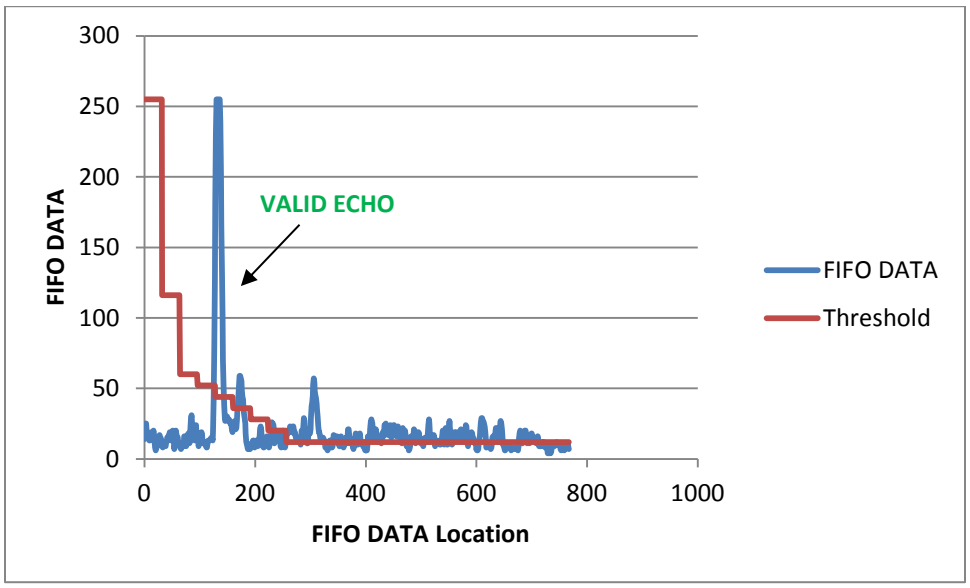
1. Hold the micro in reset and load the firmware into the DEVRAM (OTP programmed to JUMP to DEVRAM so that micro executes instructions from the DEVRAM)
2. Then release the micro and send specific LIN transmissions to trigger operations listed below:

LIN PID	Data	Purpose
11	0x(01)	Long distance from 1m to 5m
11	0x(00)	Short distance from 15cm to 1m
31	7 bytes <d0:d6>	Program 7 bytes of EEPROM data from 0x0400 to 0x0406. These 7 bytes are used to determine the threshold levels during echo detection. The upper nibble of each byte is used for long distance measurement, while the lower nibble is used for short distance measurement.

3. Data can also be retrieved back from the device using specific LIN transmissions, stated below:

LIN PID	Bytes to be received	Purpose
21	2	LIN communication check – Data 0x1234 will be received
22	2	Time of flight data – Data 0xYYYY will be received Data = FFFF implies no object, Data = 0000 implies no burst Time of flight can be determined by converting data into decimal and then multiplying by 1e-6 (Timer resolution) TOF = hex2dec(YYYY) * 1e-6 sec. Distance = TOF/2 * 340 meters

4. Echo data is stored in an external RAM of 768 bytes (FIFO_DATA from 0 to 767). A valid echo is determined by comparing the FIFO_DATA with the threshold level corresponding to the FIFO_DATA location. The threshold levels typically reduce as the FIFO_DATA location increases as nearer objects produce a stronger echo than the ones further away. An illustration is shown below:



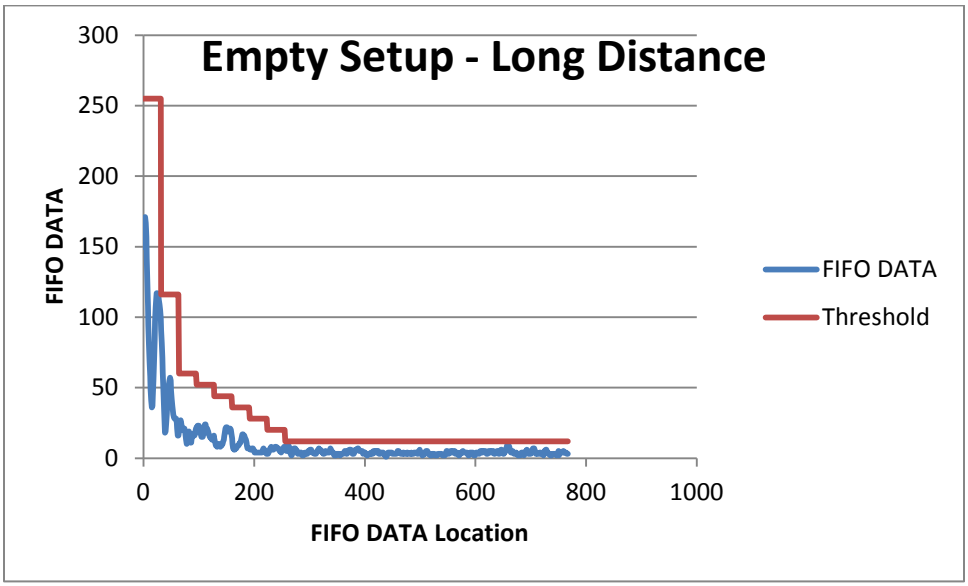
5. For this demonstration to work, it is imperative to ensure that the first 7 bytes of the EEPROM data is programmed with appropriate values to ensure that the echo determination is correct. Thresholds levels for long distance range can be set up independent to the threshold levels for the short distance range. The upper nibble of EE_DATA<0:6> controls the threshold levels for the long distance instruction, while the lower nibble of EE_DATA<0:6> controls the threshold levels for the short distance instruction.
   For long distance instruction, FIFO_CTRL (= 0x06) is set up for LSB mode with NO ROLLOVER in the firmware. The relation between FIFO DATA location and threshold value is as stated below:

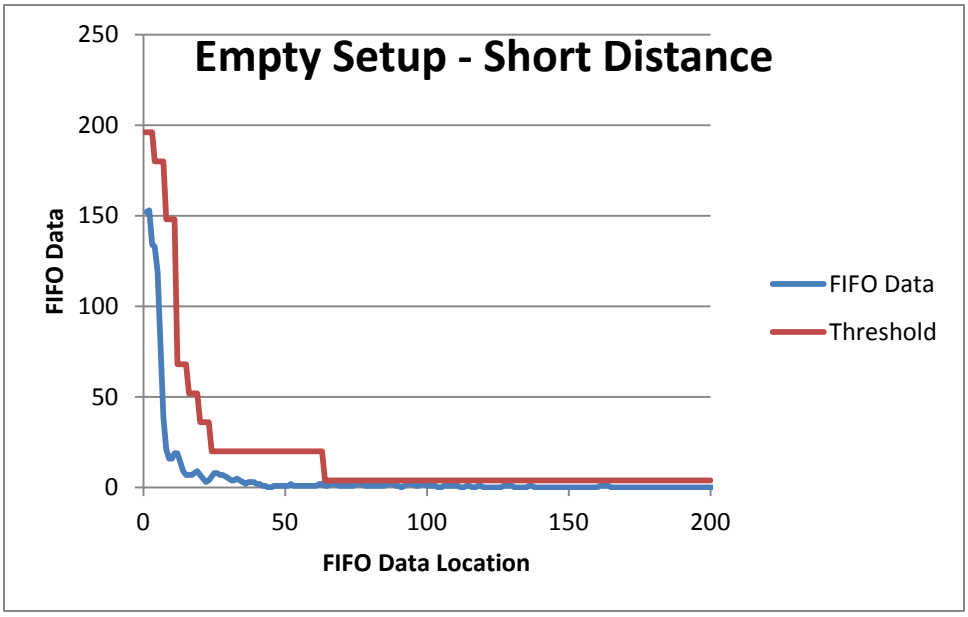
FIFO DATA location		Threshold level for long distance
Start	End	
0	31	Ignore echo
32	63	EE_DATA_0<7:4> X 8 + 12
64	95	EE_DATA_1<7:4> X 8 + 12
96	127	EE_DATA_2<7:4> X 8 + 12
128	159	EE_DATA_3<7:4> X 8 + 12
160	191	EE_DATA_4<7:4> X 8 + 12
192	223	EE_DATA_5<7:4> X 8 + 12
224	255	EE_DATA_6<7:4> X 8 + 12
256	767	10

For short distance instruction, FIFO_CTRL (= 0x07) is set up for MSB-1 mode with NO ROLLOVER in the firmware. The relation between FIFO DATA location and threshold value is as stated below:

FIFO DATA location		Threshold level for short distance
Start	End	
0	3	EE_DATA_0<3:0> X 16 + 4
4	7	EE_DATA_1<3:0> X 16 + 4
8	11	EE_DATA_2<3:0> X 16 + 4
12	15	EE_DATA_3<3:0> X 16 + 4
16	19	EE_DATA_4<3:0> X 16 + 4
20	23	EE_DATA_5<3:0> X 16 + 4
24	63	EE_DATA_6<3:0> X 16 + 4
64	767	4

6. The preferred method of determining the threshold levels is to look at the FIFO DATA for a set up with no object (“empty set up”) and then determine the appropriate levels. The raw FIFO DATA can be viewed by putting the micro in reset and clicking on the “Read and save FIFO data to file” button (Note: This feature will require MICROSOFT OFFICE 2007 or a later version installed). This procedure will need to done for both long and short distance. Plots for the empty set up on the TI bench is shown below for reference:





As a reference, the EE_DATA<0:6> was programmed with 0x(DC), 0x(6B), 0x(59), 0x(44), 0x(33), 0x(22) and 0x(11) for measurements on the TI set up.

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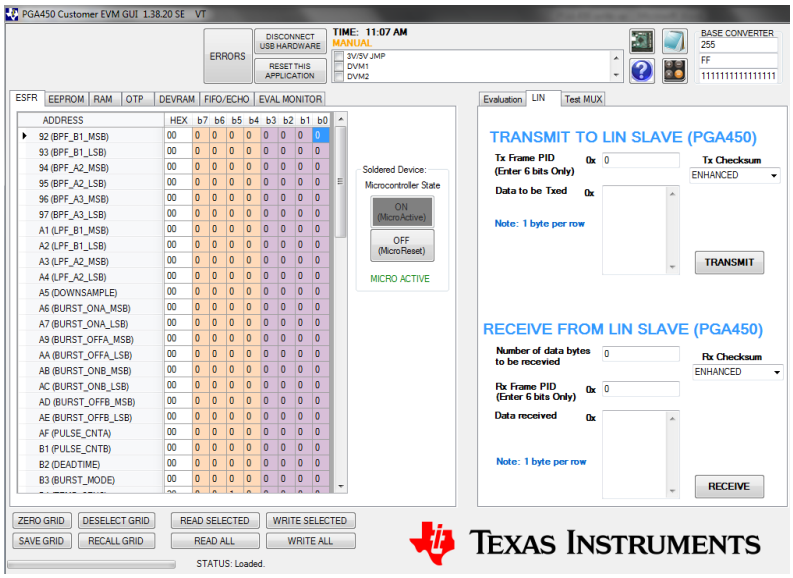
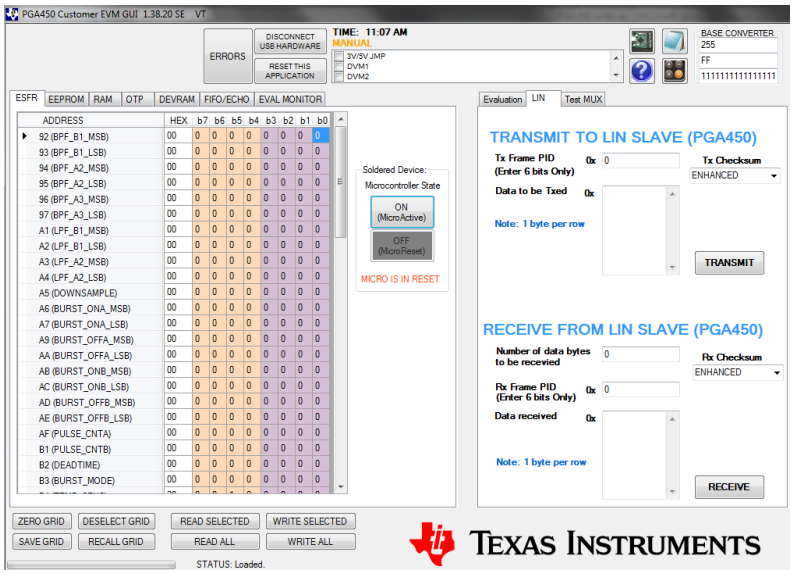
Procedure with GUI screenshots:

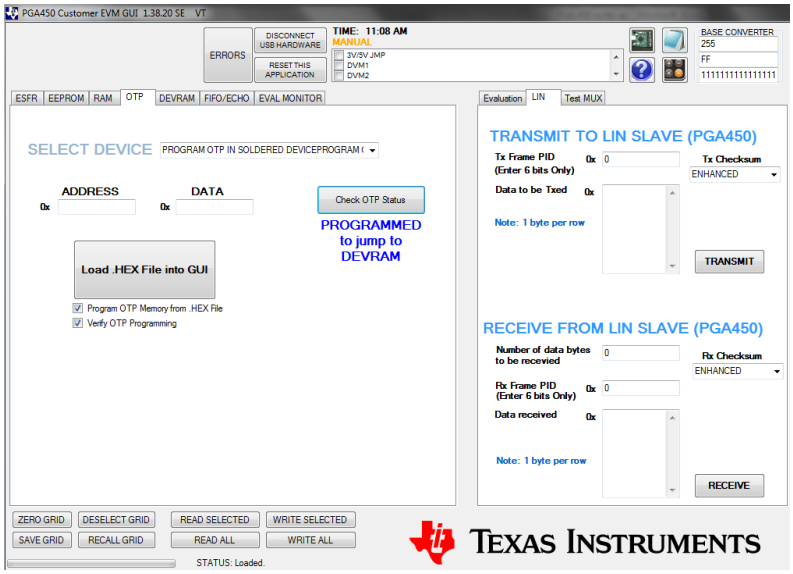
1. Power up the device and open GUI.



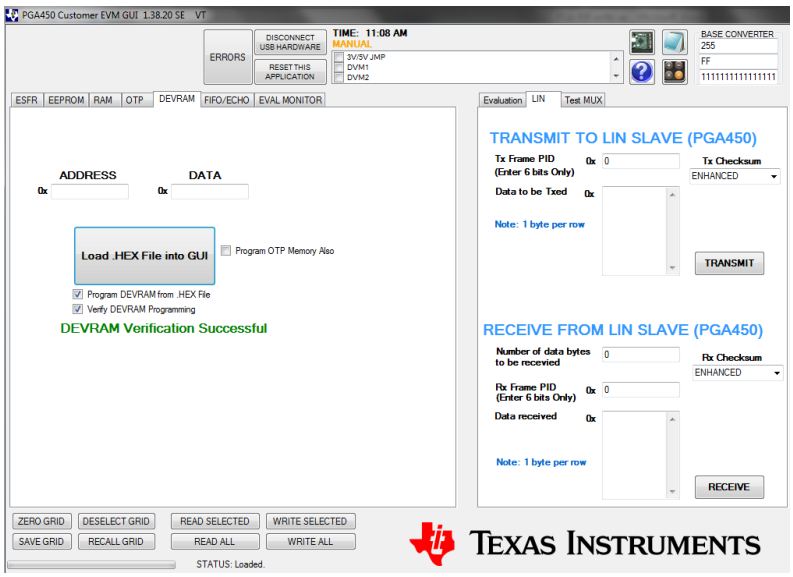
2. Put the micro in reset.



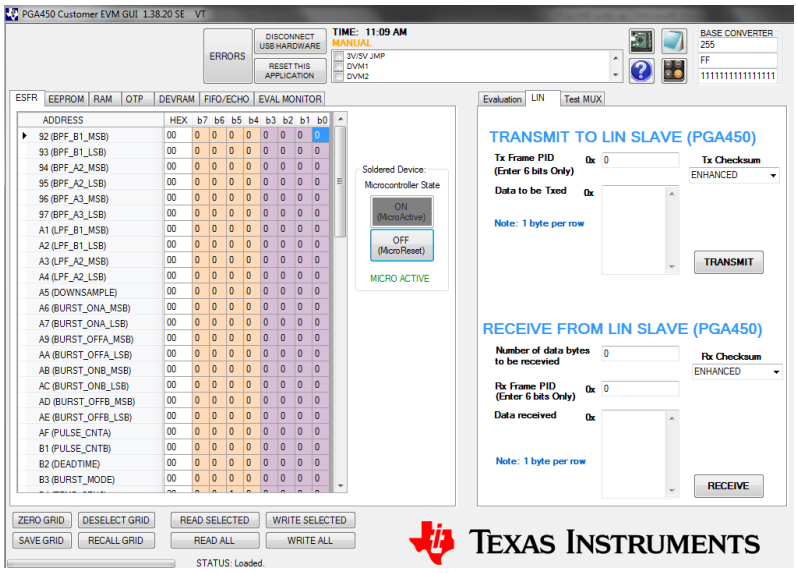
3. Check status of OTP (Make sure it says “PROGRAMMED to jump to DEVRAM” or “EMPTY”). If it says just “PROGRAMMED”, replace the PGA450 unit on the EVM with a new one.



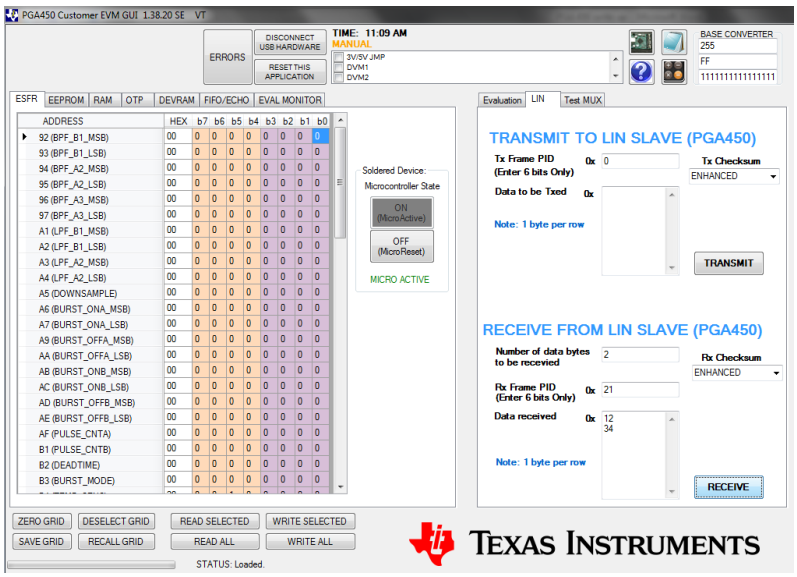
4. Load program into the DEVRAM. If the OTP status was PROGRAMMED to JUMP to DEVRAM in the previous step, you don’t need to have the “PROGRAM OTP Memory Also” box checked (As shown below). If the OTP status was EMPTY, then you need to have this box checked and supply 8V on VPROG OTP pin (There is a provision on the EVM to provide 8V to the VPROG_OTP pin through jumper settings).



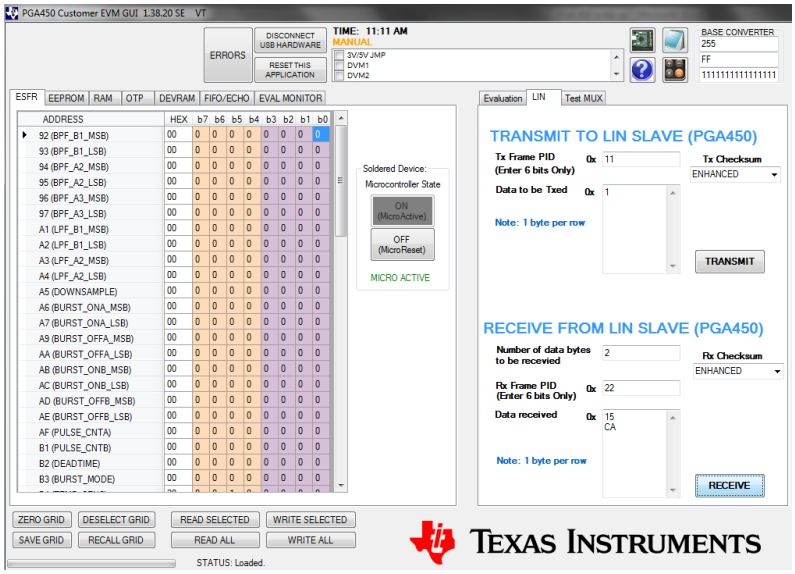
5. Release the micro out of reset.



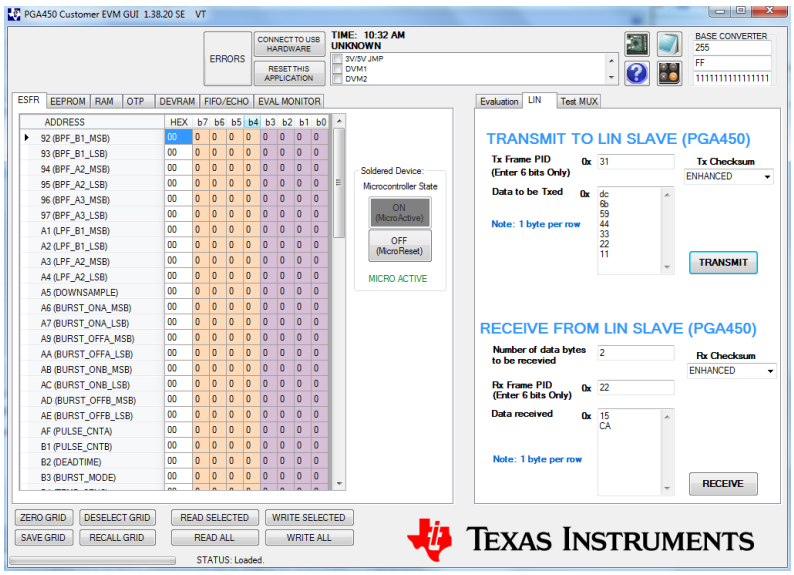
6. Send a LIN transmission by clicking the RECEIVE button with a PID = 21, bytes to be received = 2. You should receive 0x(1234) as shown below that verifies the LIN communication.



7. Send a LIN transmission by clicking the TRANSMIT button with a PID = 11 with data = 0x(01) as shown below. This will trigger a “long distance” measurement. Next, send a LIN transmission by clicking the RECEIVE button with PID = 22 and bytes to be received = 2. You will receive the time of flight in u sec as 0xYYYY as shown below.



8. If you want to program the EEPROM used for echo threshold comparison, send a LIN transmission by clicking the TRANSMIT button with a PID = 31 with 7 data bytes as shown below. This will program the EEPROM locations 0x0400 to 0x0406 with the transmitted data.



9. To retrieve the echo data, put the micro in reset and click on the “Read and Save FIFO data to File” button as shown below. This will open an EXCEL file with the data. Note: MICROSOFT OFFICE 2007 or newer version needed.