

# LIN Demonstration Using PGA450Q1EVM Firmware Rev 2.1

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## ABSTRACT

This demonstration is intended to illustrate the method of using the internal 8051 MCU firmware of the PGA450-Q1 device to calculate the time of flight ( $t_{of}$ ) using LIN communication to trigger a distance computation. The settings for short distance measurements have been updated from Rev. 2.0 to Rev 2.1 of the firmware. Differences include an optimized threshold algorithm (optimized for the TI setup) and a decreased blanking time for short distance measurements.

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Time of flight ( $t_{of}$ ) is a time estimation of how long the ultrasonic wave transmitted from the transducer takes to travel to the object, and then from the object back to the transducer. Use Equation 1 to calculate the distance between the transducer and object using tof.

Distance (meters) = 
$$\left(\frac{t_{of}}{2}\right) \times C_{Air}$$

where

- $t_{of}$  = time of flight in s
- $C_{Air}$  = 343.1 m/s = speed of sound in air at 20°C and absolute pressure 1 bar •

To calculate the time of flight, use Equation 2.

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$$t_{of}$$
 (s) =  $t_{BLANKING} + \left(Location_{FIFO} \times DOWNSAMPLE \times \frac{1}{f_S}\right)$ 

where

- t<sub>BLANKING</sub> = 16 μs × (BLANKING\_TIME decimal register value)
- Location<sub>FIFO</sub> = single byte location of interest from the 768 bytes available
- DOWNSAMPLE = downsample rate decimal register value
- $f_s = ADC$  sampling frequency, 1 MHz

#### 2 Setup

2

The firmware configures the 8051 with the appropriate settings for long and short distance estimation. These operations are initiated by a LIN transmission from the GUI and LIN master on the PGA450Q1EVM to the on-board PGA450-Q1 slave device.

- Step 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).
- Step 2. Release the micro and send specific LIN transmissions to trigger operations listed in Table 1.

#### **Table 1. LIN Transmit Commands**

LIN TX PID	TX DATA	PURPOSE
11	0x(01)	Long distance from 1 m to 5 m
11	0x(00)	Short distance from 15 cm to 1 m
31	7 bytes [D0:D6]	Program 7 bytes of EEPROM data from addresses 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.

Step 3. Data can also be retrieved back from the device using specific LIN transmissions as listed in Table 2.

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): t <sub>of</sub> = hex2dec(YYYY) × 1e-6 s where • YYYY = 0xMSBLSB (MSB at AddrD3 [TX_DATA0] and LSB at AddrD4 [TX_DATA1]) (3)

### **Table 2. LIN Receive Commands**

(1)

(2)



Step 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 decrease as the FIFO\_DATA location increases as nearer objects produce a stronger echo as compared to objects further away. Figure 1 shows a valid echo compared to the decreasing threshold levels.

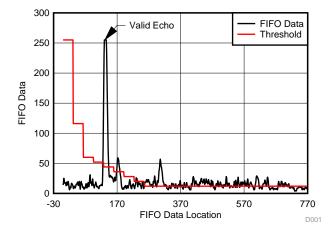


Figure 1. Example of a valid echo logged beyond the threshold

Step 5. For this demonstration to work, ensure that the first 7 bytes of the EEPROM data are programmed with appropriate values to correctly differentiate between valid echoes and noise. 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.



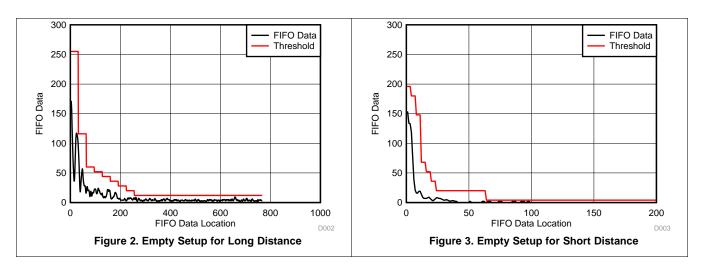
For short distance instruction, FIFO\_CTRL (= 0x07) is set up for Mid-8bit mode with NO ROLLOVER in the firmware. For long distance instruction, FIFO\_CTRL (= 0x06) is configured for LSB mode with NO ROLLOVER in the firmware. The relation between FIFO DATA location and threshold value is as stated listed in Table 3.

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.

FIFO DA	TA LOCATION	
START	END	THRESHOLD LEVEL
LONG DISTANCE		
0	31	Ignore echo
32	63	EE_DATA_0[7:4] × 8 + 12
64	95	EE_DATA_1[7:4] x 8 + 12
96	127	EE_DATA_2[7:4] × 8 + 12
128	159	EE_DATA_3[7:4] × 8 + 12
160	191	EE_DATA_4[7:4] × 8 + 12
192	223	EE_DATA_5[7:4] × 8 + 12
224	255	EE_DATA_6[7:4] × 8 + 12
256	767	10
SHORT DISTANCE		
0	3	EE_DATA_0[3:0] × 16 + 4
4	7	EE_DATA_1[3:0] × 16 + 4
8	11	EE_DATA_2[3:0] × 16 + 4
12	15	EE_DATA_3[3:0] × 16 + 4
16	19	EE_DATA_4[3:0] × 16 + 4
20	23	EE_DATA_5[3:0] × 16 + 4
24	63	EE_DATA_6[3:0] × 16 + 4
64	767	4

 Table 3. FIFO DATA Location of Threshold Ranges

Step 6. The preferred method of determining the threshold levels is to observe the FIFO DATA for a test set-up with no object (*empty set up*), and then define the appropriate levels. The raw FIFO DATA can be viewed by placing the micro in reset and clicking on the *Read and save FIFO data to file* button (this feature requires MICROSOFT OFFICE 2007 or a later version to be installed). This procedure will need to complete for both long and short distance. Plots for the empty set up on the TI bench are shown in Figure 2 and Figure 3 for reference:





### 3 Procedure

Step 1. Supply power to the EVM and open the GUI.

								INEC DWA		TH	AE: 4:35 PM NUAL					BASE CONVERTE 255
			ERI	ROF	es [		ESET	THIS ATION	•	- Ballin	SV/SV JMP DVM1 DVM2			:		FF 11111111111
SFR EEPROM INTERNAL RAM	EXTE	RNA	LRA	M	OTP		DEV	RAM	FIF	0/8	CHO RAM EVAL MONITOR Evaluat	tion LIN Test M	XL			
ADDRESS	HEX	ь	7 be	5 6	5 64	l b3	3 62	b1	60							
92 (BPF_B1_MSB)	00	0	0	0	0	0	0	0	0		TR	ANSMIT TO	LI	N SL	AVE	(PGA450)
93 (BPF_B1_LSB)	00	0	0	0	0	0	0	0	0							
94 (BPF_A2_MSB)	00	0	Ó	0	0	0	0	Û	0			ter 6 bits Only)	¢ 0			Tx Checksum ENHANCED
95 (BPF_A2_LSB)	00	0	0	0	0	0	0	0	0	E	Manual and an Outer					ENHANCED
96 (BPF_A3_MSB)	00	0	0	0	0	0	0	0	0			a to be Txed Ox	5		÷.	
97 (BPF_A3_LSB)	00	0	0	0	0	0	0	0	0		ON (McroActive)					
A1 (LPF_B1_MSB)	00	0	0	0	0	0	0	0	0		Not	e: 1 byte per row				
A2 (LPF_B1_LSB)	00	0	0	0	0	0	0	0	0	r	OFF (MicroReset)					
A3 (LPF_A2_MSB)	00	0	0	0	0	0	0	0	0	L	(mean reserv				-	TRANSMIT
A4 (LPF_A2_LSB)	00	0	0	0	0	0	0	0	0	L	MICRO ACTIVE				- 10	
A5 (DOWNSAMPLE)	00	0	0	Ð	0	0	0	0	0	L						
A6 (BURST_ONA_MSB)	00	0	0	Ð	0	0	Û	0	0	L						
A7 (BURST_ONA_LSB)	00	0	0	0	0	0	0	0	0	L	DEC	EIVE FROM	U.L.		EAV	
A9 (BURST_OFFA_MSB)	00	0	0	0	0	0	0	0	0	L	10 C C C C C C C C C C C C C C C C C C C			114 2	LAVAI	= (1 GA450)
AA (BURST_OFFA_LSB)	00	0	0	0	0	0	0	0	0	L		mber of data bytes be received	0			Rx Checksum
AB (BURST_ONB_MSB)	00	0	0	0	0	0	0	0	0	L	10 1	be received				ENHANCED
AC (BURST_ONB_LSB)	00	0	0	0	G	0	0	0	Ð	L		Frame PID D	0			
AD (BURST_OFFB_MSB)	00	0	0	0	0	0	0	0	0		(61	ter 6 bits Only)				
	00	0	0	0	0	0	0	0	0		Dat	a received 0	¢		*	(Protocol)
AE (BURST_OFFB_LSB)	00	0	0	0	0	0	0	0	0							Distance
AE (BURST_OFFB_LSB) AF (PULSE_CNTA)			0	0	0	0	0	0	0							
	00	0				0	0	0	0		Not	e: 1 byte per row				
AF (PULSE_CNTA)	-	0	0	0	0				0	1.						
AF (PULSE_CNTA) B1 (PULSE_CNTB)	00	10		0	0	0	0	0	0	112						DECEME
AF (PULSE_CNTA) B1 (PULSE_CNTB) B2 (DEADTIME)	00	0	0				0	0	0	•					-	RECEIVE
AF (PULSE_CNTA) B1 (PULSE_CNTB) B2 (DEADTIME)	00 00 00	0	0	0	0	0		0 A TE SE	0	TE					*	
AF (PULSE_CNTA) B1 (PULSE_CNTB) B2 (DEADTIME) B3 (BURST_MODE)	00 00 00	0 0 EAD	0	D	0	0	WRI	•	ELEC			xas In	S	ΓP	- I IN	

Figure 4. Settings When First Opening GUI

Step 2. Place the micro in reset by clicking OFF (MicroReset) from the ESFR tab.

							SCON			TIN			_ 🔝 📝	BASE CONVERTE 255
			ER	ROR	3		ESET PLIC			L.L.L.			: 🕜 🗄	FF 111111111111
SFR EEPROM INTERNAL RAM	EXTE	RNA	L RA	M	OTP	• ].	DEVI	RAM	FU	O/E	MONITOR Evaluation LIN Test I	MUX		
ADDRESS	HEX	b7	7 Ы	b!	5 b4	4 b.	3 b2	b1	60	•				
92 (BPF_B1_MSB)	80	0	0	0	0	0	0	0	0		TRANSMIT T	OL	IN SLAVE	(PGA450)
93 (BPF_81_LSB)	00	0	0	0	0	0	0	0	0		The second s			and the second s
94 (BPF_A2_MSB)	00	0	0	0	0	0	0	0	0		(Enter 6 bits Only)	<b>0x</b> 0		Tx Checksum ENHANCED
95 (BPF_A2_LSB)	00	Ð	0	0	Û	0	0	0	0	Đ	State	-		ENHANCED
96 (BPF_A3_MSB)	00	0	0	0	0	0	0	0	0		Uata to be fixed	Ox	~	
97 (BPF_A3_LSB)	00	0	0	0	0	0	0	0	0		6			
A1 (LPF_B1_MSB)	00	0	0	0	0.	0	0	0	0		Note: 1 byte per row			
A2 (LPF_B1_LSB)	00	0	0	0	0	0	0	0	0	Г	5 C			
A3 (LPF_A2_MSB)	00	Ð	0	0	0	0	0	0	0		MIN.		-	TRANSMIT
A4 (LPF_A2_LSB)	00	0	0	0	0	0	0	0	0	1	ISET		10	
A5 (DOWNSAMPLE)	00	0	0	0	0	0	0	0	0	1				
A6 (BURST_ONA_MSB)	00	0	0	0	0	0	0	0	0					
A7 (BURST_ONA_LSB)	00	0	0	0	0	0	0	0	0	1	RECEIVE FRO	1.1.4	IN CLAN	
A9 (BURST_OFFA_MSB)	00	0	0	0	0	0	0	0	0		RECEIVE FRO		LIN SLAVI	E (FGA450)
AA (BURST_OFFA_LSB)	00	0	0	0	0	0	0	0	0		Number of data byte	s 0		Rx Checksam
AB (BURST_ONB_MSB)	00	0	0	0	0	0	0	0	0		to be receiied			ENHANCED
AC (BURST_ONB_LSB)	00	0	0	0	0	0	0	0	0	1	Rx Frame PID	Ox 0		
AD (BURST_OFFB_MSB)	00	0	0	0	0	0	0	0	0		(Enter 6 bits Only)			
AE (BURST_OFFB_LSB)	00	0	0	0	0	0	0	0	0	1	Data received	0x		1 mar 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
AF (PULSE CNTA)	00	0	0	0	0	0	0	0	0					Distance
B1 (PULSE_CNTB)	00	0	0	0	0	0	0	0	0					
B2 (DEADTIME)	00	9	0	0	0	0	0	0	0		Note: 1 byte per row			
83 (BURST_MODE)	00	0	0	0	0	0	0	0	0					orerage
	'nn	In	10	10		0	•	0	•				*	RECEIVE
	B	EAD	SEL	ECT	ED	10	WRI	TE SI	ELEC	TED				
ERO GRID DESELECT GRID		-									🠌 Texas In			

Figure 5. Placing Microcontroller in Reset State Under ESFR Tab



Procedure

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Step 3. Check status of OTP by clicking *Check OTP Status* from the OTP tab. Verify the response reads *PROGRAMMED to jump to DEVRAM* or *EMPTY*). If the response reads *PROGRAMMED*, replace the PGA450-Q1 device on the EVM with a new unit.

	ERRORS	DISCONNECT USB HARDWARE	TIME: 4:37 PM MANUAL				BASE CONVERT
	Ennons	RESET THIS APPLICATION	DVM1 DVM2		1		FF 11111111111111
FR   EEPROM   INTERNAL RAM   EXTE			IFO/ECHO RAM   EVAL MONITOR	Evaluation UN Test MUZ		VE (	PGA450)
SELECT DEVICE PROG	SHAM OTP IN SOL	DERED (MAIN) DE	WICE •	Tx Frame PID 0x (Enter 6 bits Only)	0		Tx Checksum
ADDRESS	DATA	ſ	Check OTP Status	Data to be Txed Ox		*	ENHANCED
Load .HEX File into	GUI	F	PROGRAMMED to jump to DEVRAM	Note: 1 byte per row			TRANSMIT
<ul> <li>Program OTP Memory from</li> <li>Verify OTP Programming</li> </ul>	n HEX File			RECEIVE FROM		AVE	20170471/2/16
	n HEX File			Number of data bytes to be received	0	AVE	20170471/2/16
	n HEX File			Number of data bytes	0	AVE	Rx Checksum
	n HEX File			Number of data bytes to be received Bx Frame PID	0	AVE	Rx Checksum
	n, HEX File			Number of data bytes to be received Rx Frame PID (Enter 6 bits Only) 0x	0	AVE	Rx Checksum ENHANCED Distance
	n HEX File			Number of data bytes to be received Pix Frame PID (br (Enter 6 bits Only) Data received (br	0	AVE	Rx Checksum ENHANCED
Verfy OTP Programming	n HEX File			Number of data bytes to be received Pix Frame PID (Entre 5 bits Cety) Data received Ox Note: 1 byte per row	0		Rx Checksum ENHANCED Distance RECEIVE
Verfy OTP Programming		WRITE SELE		Number of data bytes to be received Pix Frame PID (br (Enter 6 bits Only) Data received (br	0		Rx Checksum ENHANCED Distance RECEIVE

Figure 6. Checking OTP Status Under OTP Tab

Step 4. Load the program into the DEVRAM by clicking Load .HEX File into GUI from the DEVRAM tab. If the OTP status was PROGRAMMED to JUMP to DEVRAM in the previous step, then checking the PROGRAM OTP Memory Also box is not required (as shown in Figure 7). If the OTP status was EMPTY, then this box must be checked and 8 V must be supplied on the VPROG OTP pin. A provision on the EVM provides 8 V to the VPROG\_OTP pin through jumper settings.

PGA450 Customer EVM GUI 1.40.0		
ERRORS DISCONNECT TIME: 4.33 PN USB HARDWARE RESET THIS RESET THIS PAPLICATION DVM1	· · · · · · · · · · · · · · · · · · ·	BASE CONVERTER 255 FF 1111111111111111
ESFR EEPROM INTERNAL RAM EXTERNAL RAM OTP DEVRAM FIFO/ECHO RAM EVAL MONITOR  ADDRESS DATA Cx  Load .HEX File into GUI Program OTP Memory Also Program DEVRAM from HEX File Verly DEVRAM from HEX File DEVRAM Verification Successful	Evaluation UN Test MUX TRANSMIT TO LIN SLAVE Tr Frame PID (Eriter 6 bits Only) Data to be Txed Qx Note: 1 byte per row RECEIVE FROM LIN SLAVE Number of data bytes Received Rx Frame PID (Eriter 6 bits Only) Qx Note: 1 byte per row Note: 1 byte per row	(PGA450) Tx Onecksam ENHANCED • TRANSMIT
		RECEIVE
ZERO GRID DESELECT GRID READ SELECTED WRITE SELECTED	Texas Instrum	IENTS
STATUS: Loaded.	IEAAS INSTRUM	IEN IS

Figure 7. Loading .HEX File if OTP is Programmed to Jump to DEVRAM



Step 5. Release the micro out of reset by clicking ON (MicroActive) from the ESFR tab.

			50	208			CONN	ECT VARE	TH	ME: 4:38 PM NUAL 3V/5V JMP				BASE CONVERTE
			La vi					SET THIS		DVM1 DVM2		Î 🕜		FF 111111111111
FR EEPROM   INTERNAL RAM	EXTE	RNA	L RA	м	OTP	D	EVR	M	FO/E	ECHO RAM   EVAL MONITOR	Evaluation UN Test MUX	1		
ADDRESS	HEX	b	7 Ьб	6	5 b4	b3	b2	b1 bi	-					
92 (BPF_B1_MSB)	80	0	0	0	0	0	0	0 0			TRANSMIT TO	LIN SLA	AVE	(PGA450)
93 (BPF_B1_LS8)	00	0	0	0	0	0	0	0 0			Table to the second second second second			and a second second second
94 (BPF_A2_MSB)	00	0	0	0	0	0	0	0 0		Soldered Device:	Tx Frame PID 0x (Enter 6 bits Only)	0		Tx Checksum
95 (BPF_A2_LS8)	00	0	0	0	0	0	0 1	0 0	E	Microcontroller State				ENHANCED
96 (BPF_A3_MSB)	00	0	0	0	0	0	0	0 0			Data to be Txed Ox			
97 (BPF_A3_LSB)	00	0	0	0	0	0	0	0 0		ON (McroActive)	dependence of the second second second			
A1 (LPF_B1_MSB)	00	0	0	0	0	0	0	0 0			Note: 1 byte per row			
A2 (LPF_B1_LSB)	00	0	0	0	0	0	0	0 0	T	OFF (MicroReset)				
A3 (LPF_A2_MSB)	00	0	0	0	0	0	0	0 0	1	(Michonosen)				TRANSMIT
A4 (LPF_A2_LSB)	00	0	0	0	0	0	0	0 0	1	MICRO ACTIVE			12	
A5 (DOWNSAMPLE)	00	0	0	0	0	0	0	0 0						
A6 (BURST ONA MSB)	00	0	0	0	0	0	0	0 0	1					
	00	0		1.5										
A7 (BURST_ONA_LSB)		0	0	0	0	0	0	0 1			DECENT FROM	LUM CI	A1/F	
A7 (BURST_ONA_LSB) A9 (BURST_OFFA_MSB)	00	0	0 0	0	1.00		0				RECEIVE FROM	I LIN SL	AVE	E (PGA450)
A9 (BURST_OFFA_MSB)	00	C		1000	0	0		0 0			Number of data bytes	I LIN SL	AVE	STATISTICS IS
A9 (BURST_OFFA_MSB) AA (BURST_OFFA_LSB)		0	0	0	0	0	0	0 0			and the second state of the second state of		AVE	Rx Checksum
A9 (BURST_OFFA_MSB)	00	0	0	0	0 0 0	0 0 0	0	0 0 0 0 0 0			Number of data bytes to be received Bx Frame PID	0	AVE	Rx Checksum
A9 (BURST_OFFA_MSB) AA (BURST_OFFA_LSB) AB (BURST_ONB_MSB)	00	0 0 0	0 0 0	0 0 0	0 0 0 0 0	0 0 0	0				Number of data bytes to be received	0	AVE	Rx Checksum
A9 (BURST_OFFA_MSB) AA (BURST_OFFA_LSB) AB (BURST_ONB_MSB) AC (BURST_ONB_LSB)	00 00 00	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0 0 0	0 0 0 0	0				Number of data bytes to be received Bx Frame PID	0	AVE	Rx Checksum ENHANCED
A9 (BURST_OFFA_MSB) AA (BURST_OFFA_LSB) AB (BURST_ONB_MSB) AC (BURST_ONB_LSB) AD (BURST_OFFB_MSB)	00 00 00 00	0 0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0 0 0	0 0 0 0 0	0	0 0 0 0 0 0 0 0 0 0 0 0			Number of data bytes to be received Rx Frame PID (Enter 6 bits Only)	0	AVE	Rx Checksum
A9 (BURST_OFFA_MSB) AA (BURST_OFFA_LSB) AB (BURST_ONB_MSB) AC (BURST_ONB_LSB) AD (BURST_OFFB_MSB) AE (BURST_OFFB_LSB)	00 00 00 00 00	0 0 0 0 0 0	0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0		0 0 0 0 0 0 0 0 0 0 0 0 0 0			Number of data bytes to be received Rx Frame PID (Enter 6 bits Only)	0	AVE	Rx Checksum ENHANCED
A9 (BURST_OFFA_MSB) AA (BURST_OFFA_LSB) A8 (BURST_ONE_MSB) AC (BURST_ONE_LSB) AC (BURST_OFFB_MSB) AE (BURST_OFFB_LSB) AF (PULSE_CNTA)	00 00 00 00 00 00		0 0 0 0 0 0 0	0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0				Number of data bytes to be received Rx Frame PID (Enter 6 bits Only)	0	AVE	Rx Checksum ENHANCED
A9 (BURST_OFFA_MSB) A4 (BURST_OFFA_LSB) A8 (BURST_ONB_MSB) AC (BURST_ONB_LSB) A0 (BURST_OFFB_MSB) A6 (BURST_OFFB_MSB) A6 (BURST_OFFB_LSB) A7 (PULSE_CNTB) B1 (PULSE_CNTB)	00 00 00 00 00 00 00		0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0					Number of data bytes to be received Rx Frame PID ( (Enter 6 bits Only) Data received ()x	0	AVE	Rx Checksum ENHANCED Distance
A9 (BURST_OFFA_USB) AA (BURST_OFFA_USB) AB (BURST_ONB_MSB) AC (BURST_ONB_LSB) AC (BURST_OFFB_USB) AE (BURST_OFFB_USB) AF (PULSE_CNTA) B1 (PULSE_CNTB) B2 (DEADTIME)	00 00 00 00 00 00 00 00 00		0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0		0 0 0 0 0 0 0 0 0 0					Number of data bytes to be received Rx Frame PID ( (Enter 6 bits Only) Data received ()x	0	AVE	Rx Checksum ENHANCED
A9 (BURST_OFFA_MSB) AA (BURST_OFFA_LSB) AB (BURST_ONB_MSB) AC (BURST_ONB_LSB) AC (BURST_OFFB_MSB) AE (BURST_OFFB_LSB) AF (PULSE_CNTA) B1 (PULSE_CNTB) B2 (DEADTIME)	00 00 00 00 00 00 00 00 00 00		0 0 0 0 0 0 0 0 0 0 0 0 0 0			000000000000000000000000000000000000000			CTEG		Number of data bytes to be received Rx Frame PID ( (Enter 6 bits Only) Data received ()x	0	*	Par Checkaum ENHANCED Distance RECEIVE

Figure 8. Placing the Microcontroller to the Active State After Loading .HEX File

Step 6. Send a LIN transmission by clicking the RECEIVE button with a PID = 21 and the number of bytes to be received = 2. As shown in Figure 9, 0x1234 should be received, verifying that the LIN communication is working.

		[					SCON	VECT WARE		IME: 4:38 PM IANUAL Tavisyump			7	BASE CONVERTE 255
			ERP	ERRORS		RESET T APPLICA				DVM1 DVM2	4 4	?		FF 1111111111111
SFR EEPROM INTERNAL RAM	EXTE	RNA	L RA	м	OTP		DEVR	AM F	IFO,	ECHO RAM EVAL MONITOR Evaluation LIN Test MU	<			
ADDRESS	HEX	b7	66	b	5 b4	63	b2	61 bi	0					
92 (8PF_81_MS8)	00	0	0	0	0	0	0	0 0		TRANSMIT TO	LIN	SLA	VE	(PGA450)
93 (BPF_B1_LSB)	00	0	0	0	0	0	0	0 0		Part Sector Sector (1997)				E more moundaire
94 (BPF_A2_MSB)	00	0	0	0	0	0	0	0 0		Soldered Device: (Enter 6 bits Only)	0			Tx Checksum
95 (BPF_A2_LSB)	00	0	0	0	0	0	0	0 0		E Mcrocontroller State				ENHANCED
96 (BPF_A3_MSB)	00	0	0	0	0	0	0	0 0		Data to be Txed Ox			1	
97 (BPF_A3_LSB)	00	0	8	0	0	0	0	0 0		ON (McroActive)				
A1 (LPF_B1_MSB)	00	0	0	0	0	0	0	0 0	σ.	Note: 1 byte per row				
A2 (LPF_B1_LSB)	00	0	0	0	0	0	0	0 0	1	OFF (McroReset)				
A3 (LPF_A2_MSB)	00	0	0	0	0	0	0	0 0	8	(INCOLICES)				TRANSMIT
A4 (LPF_A2_LSB)	00	0	0	D	0	0	0	0 0		MICRO ACTIVE			521	
A5 (DOWNSAMPLE)	00	0	0	0	0	0	0	0 0						
A6 (BURST_ONA_MSB)	00	0	0	0	0	0	0	0 0						
A7 (BURST_ONA_LSB)	00	0	0	0	0	0	0	0 0		RECEIVE FROM				
A9 (BURST_OFFA_MSB)	00	0	0	0	0	0	0	0 0		NEGEVE PROM	1 611	I SLA	IVL	. (1 0/1450)
IL PUPET OFFICE LOD	00	0	Ũ	0	0	0	0	0 0		Number of data bytes to be received	2			Rx Checksum
AA (BURST_OFFA_LSB)	in all	0	0	0	0	0	0	0 0		to be received				ENHANCED
AA (BURST_OFFA_LSB) AB (BURST_ONB_MSB)	00	0	190	14.						1 (ALC MALE NO 10 ALC				
	00	0	0	0	0	0	0	0 0		Rx Frame PID Ox	21			
AB (BURST_ONB_MSB)		1000			0	0		0 0		Rx Frame PID 0x (Enter 6 bits Only)	21			
AB (BURST_ONB_MSB) AC (BURST_ONB_LSB)	00	0	0	0		- 25	0	S - S -			12		14	
AB (BURST_ONB_MSB) AC (BURST_ONB_LSB) AD (BURST_OFFB_MSB)	00	0	0	0	0	0	0	0 0		(Enter 6 bits Only)			-	Distance
AB (BURST_ONB_MSB) AC (BURST_ONB_LSB) AD (BURST_OFFB_MSB) AE (BURST_OFFB_LSB)	00 00 00	0 0	0 0 0	0 0 0	0	0	0 0 0	0 0		(Enter 6 bits Only)	12		4	Distance 0.80 m
AB (BURST_ONB_MSB) AC (BURST_ONB_LSB) AD (BURST_OFFB_MSB) AE (BURST_OFFB_LSB) AF (PULSE_CNTA)	00 00 00 00	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0	0 0	0 0 0 0	0 0 0 0 0 0		(Enter 6 bits Only)	12		4	
AB (BURST_ONB_MSB) AC (BURST_ONB_LSB) AD (BURST_OFFB_MSB) AE (BURST_OFFB_LSB) AF (PULSE_CNTA) B1 (PULSE_CNTB)	00 00 00 00 00	0 0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0	0 0 0 0	0 0 0 0 0 0 0 0		(Enter 6 bits Only) <sup>ox</sup> Data received Ox	12		14	0.80 m
AB (BURST_ONB_MSB) AC (BURST_ONB_LSB) AD (BURST_OFF8_MSB) AE (BURST_OFF8_LSB) AF (PULSE_CNTA) B1 (PULSE_CNTB) B2 (DEADTIME)	00 00 00 00 00 00	0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0	0 0 0 0 0 0 0 0 0 0		(Enter 6 bits Only) <sup>ox</sup> Data received Ox	12		*	
AB (BURST_ONB_MSB) AC (BURST_ONB_LSB) AD (BURST_OFF8_MSB) AE (BURST_OFF8_LSB) AF (PULSE_CNTA) B1 (PULSE_CNTB) B2 (DEADTIME)	00 00 00 00 00 00 00	0 0 0 0 0		0 0 0 0 0 0 0 0	000000000000000000000000000000000000000	0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0	CTE	(Enter 6 bits Only) <sup>the</sup> Data received Ox Note: 1 byte per row	12 34			0.80 m
AB (BURST_ONB_MSB) AC (BURST_ONB_LSB) AD (BURST_OFFB_MSB) AE (BURST_OFFB_LSB) AF (PULSE_CNTA) B1 (PULSE_CNTA) B2 (DEADTME) B3 (BURST_MODE)	00 00 00 00 00 00 00	0 0 0 0 0 0		0 0 0 0 0 0 0	000000000000000000000000000000000000000	0 0 0 0 0 0	0 0 0 0 0 0			(Enter 6 bits Only) <sup>44</sup> Data received <u>0</u> x Note: 1 byte per row	12 34	BI	÷	0.80 m

Figure 9. LIN Receive Command Verifying Communication



Procedure

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- Step 7. Send a LIN transmission by clicking the *TRANSMIT* button with a PID = 11 and the *Data to* be *Txed* = 0x01 which triggers a long distance measurement.
- Step 8. Next, send a LIN transmission by clicking the RECEIVE button with PID = 22 and bytes to be received = 2. The time of flight in micro seconds in the format of 0xYYYY and distance in meters is provided.

					ROF				INEC DWAI		TI	ME: 4:39 PM					BASE CONVERT
				En	nur			ESET PLIC	THIS	e.	J. L.J.	DVM1 DVM2		-	0		FF 11111111111
SFR	EEPROM   INTERNAL RAM	EXTE	RNA	LR	M	OTF		DEVI	RAM	FIF	0/8	ECHO RAM EVAL MONITOR	Evaluation LIN Test MUD	¢.			
	ADDRESS	HEX	b	7 bi	5 b	5 b4	4 b.	3 b2	b1	60		5					
	92 (BPF_B1_MSB)	00	0	0	0	0	0	0	0	0	17	1	TRANSMIT TO	LIN	I SLA	VE	(PGA450)
	93 (BPF_B1_LSB)	00	0	0	0	0	0	0	0	0			Carlo and a contract of the second				A REAL PROPERTY AND A REAL
	94 (BPF_A2_MSB)	00	0	0	0	0	0	0	0	0	U	Soldered Device:	(Enter 6 bits Only)	11			Tx Checksum
	95 (BPF_A2_LSB)	00	0	0	0	0	0	0	0	0	8	Microcontroller State					ENHANCED
	96 (BPF_A3_MSB)	00	0	0	0	0	0	0	0	0			Data to be Txed Ox	01		~	
	97 (BPF_A3_LSB)	00	0	0	0	0	0	0	0	0		ON (McroActive)	International Advancement of the Article				
	A1 (LPF_B1_MSB)	00	0	0	0	0	0	0	0	0			Note: 1 byte per row				
	A2 (LPF_B1_LSB)	00	0	0	0	0	0	0	0	0	r	OFF (MicroReset)					
	A3 (LPF_A2_MSB)	00	0	0	0	0	0	0	0	0	Ľ	(warrowsen)					TRANSMIT
	A4 (LPF_A2_LSB)	00	0	0	0	0	0	0	0	0	ł.	MICRO ACTIVE				12	
	A5 (DOWNSAMPLE)	00	0	0	0	0	0	0	0	0	E.						
	A6 (BURST_ONA_MSB)	00	0	0	0	0	0	0	0	0	Ŀ						
	A7 (BURST_ONA_LSB)	00	0	0	0	0	0	0	0	0	Ŀ		RECEIVE FROM		N CI	A1/E	
	A9 (BURST_OFFA_MSB)	00	0	0	0	0	0	0	0	0	Ŀ		and the second of the second second	1 11	N SL	AVE	= (FGA450)
	AA (BURST_OFFA_LSB)	00	0	0	0	0	0	0	0	0	Ŀ		Number of data bytes to be received	2			Rx Checksum
	AB (BURST_ONB_MSB)	00	0	0	0	0	0	0	0	0	Ŀ		to be received				ENHANCED
	AC (BURST_ONB_LSB)	00	0	0	0	0	0	0	0	0	Ŀ		Rx Frame PID Ox	22		1	
	AD (BURST_OFFB_MSB)	00	0	0	0	0	0	0	0	0			(Enter 6 bits Only)	-777-)			
	AE (BURST_OFFB_LSB)	00	0	0	0	0	0	0	0	0			Data received Ox	15		*	
	AF (PULSE_CNTA)	00	0	0	0	0	0	0	0	0				50			Distance 0.94 m
	B1 (PULSE_CNTB)	00	0	0	0	0	0	0	0	0							0.94 m
	82 (DEADTIME)	00	9	0	0	0	0	0	0	0			Note: 1 byte per row				
	B3 (BURST_MODE)	00	0	0	0	0	0	0	0	0	1						RECEIVE
		nn.	In	0	0	0	0	0	0	•		1					RECEIVE
	GRID	R	EAD	SEL	FCT	ED	1 C	WRI	TE SE	LEC	TE						
ERC	( www.www.dowe.	1.00		- and			9.6				J and		<b>T</b> I				
	and I Carrow and I	1		14.00			1.10										THE TOTAL
	GRID RECALL GRID		RE	AD /	ALL			٧	/RITI	E AL	ι.		TEXAS IN	51	RI	JM	IENTS

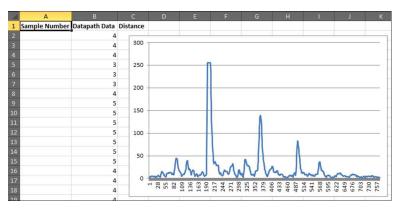
Figure 10. LIN Transmission Example of a Long Distance Measurement

Step 9. If the EEPROM must be programed for echo threshold comparison, send a LIN transmission by clicking the *TRANSMIT* button with a PID = 31 and the *Data to be Txed* with the seven data bytes. This command programs EEPROM locations 0x0400 to 0x0406 with the transmitted data.

		ERRORS	DISCONNECT USB HARDWARE	TIME: 4:39 PM MANUAL	🔝 💽	BASE CONVERTER
		ERROR	APPLICATION	DVM1 DVM2	: 🕜 🗄	FF 1111111111111
ESFR EEPROM INTERNAL R	MEXTER	NAL RAM	OTP DEVRAM FI	O/ECHO RAM EVAL MONITOR Evalua	stion LIN Test MUX	
ADDRESS	HEX	b7 b6 b5	5 b4 b3 b2 b1 b0			
92 (BPF_B1_MSB)	00	0 0 0	0 0 0 0 0	TE	RANSMIT TO LIN SLAVE	E (PGA450)
93 (BPF_81_LS8)	00	0 0 0	0 0 0 0 0			and an and a second
94 (BPF_A2_MSB)	00	0 0 0	0 0 0 0 0		Frame PID Dx 31 ster 6 bits Only)	Tx Checksum ENHANCED
95 (BPF_A2_LSB)	00	0 0 0	0 0 0 0 0	E Managementer Darte		ENHANCED
96 (BPF_A3_MSB)	00	0 0 0	0 0 0 0 0		la to be ixed Ox dc -	
97 (BPF_A3_LSB)	00	0 0 0	0 0 0 0	ON (MicroActive)	59	
A1 (LPF_B1_MSB)	00	0 0 0	0 0 0 0	No	33	
A2 (LPF_B1_LSB)	00	0 0 0	0 0 0 0	OFF (McroReset)	22	
A3 (LPF_A2_MSB)	00	0 0 0	0 0 0 0 0	( VIII VIII VIII VIII VIII VIII VIII VI	11	TRANSMIT
A4 (LPF_A2_LSB)	00	0 0 0	0 0 0 0	MICRO ACTIVE		
A5 (DOWNSAMPLE)	00	0 0 0	0 0 0 0 0	The second s		
A6 (BURST_ONA_MSB)	00	0 0 0	0 0 0 0 0			
A7 (BURST_ONA_LSB)	00	0 0 0	0 0 0 0 0	DE	CEIVE FROM LIN SLAV	
A9 (BURST_OFFA_MSB)	00	0 0 0	0 0 0 0 0	Contraction of the second		L (1 04450)
AA (BURST_OFFA_LSB)	00	0 0 0	0 0 0 0 0	N	mber of data bytes 2 be received	Rx Checksum
AB (BURST_ONB_MSB)	00	0 0 0	0 0 0 0 0	10	De Foueried	ENHANCED
AC (BURST_ONB_LSB)	00	0 0 0	0 0 0 0 0		Frame PID Ox 22	
AD (BURST_OFFB_MSB)	00	0 0 0	0 0 0 0 0	(6	nter 6 bits Only)	
AE (BURST_OFFB_LSB)	00	0 0 0	0 0 0 0 0	Da	ta received Ox 15	Distance
AF (PULSE_CNTA)	00	0 0 0	0 0 0 0 0		50	0.94 m
B1 (PULSE_CNTB)	00	0 0 0	0 0 0 0	E. C.		- U. U. H.
	00	0 0 0	0 0 0 0 0	No	ste: 1 byte per row	
B2 (DEADTIME)		0 0 0	0 0 0 0 0			RECEIVE
B3 (BURST_MODE)	0.0	0 0 0	0 0 0 0			THE REAL PROPERTY OF
B3 (BURST_MODE)		AD SELECTE	ED WRITE SELEC		xas Instrum	

Figure 11. LIN Transmit to Program EEPROM-Based Thresholds

- Step 10. To retrieve the echo data, put the micro in reset and click on the *Read and Save FIFO data to File* button from the FIFO/ECHO tab which opens an Excel® file with the data.
- NOTE: Microsoft® Office 2007 or newer version is needed.



This is example snippet showcases results from a different experiment, but was exported using the same GUI.

Figure 12. Example Snippet of FIFO Data Exported to Excel Spreadsheet



**Revision History** 

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# **Revision History**

Cł	hanges from Original (#IMPLIED) to A Revision	Page
•	Changed the units for time of flight (t <sub>of</sub> )	2

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

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