

XC800 Family

AP08114

DALI Control Device using XC836

Application Note

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Microcontrollers

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Overview

1 Overview

Digital Addressable Lighting Interface (DALI) is a communication protocol for lighting control in buildings. The interface was first described in Annex E, IEC60929 standard for fluorescent lamp ballast. Subsequently, it was updated to the new standard IEC-62386, to include other lighting devices, such as LED, HID, and so on. The complete standard for control interface of electronic control gears was published in June 2009. The standard for lighting control devices is scheduled to be published in 2012.

DALI requires only a pair of wires to form the bus for communication to all devices on a single DALI network. Each piece of operating equipment with a DALI interface can be communicated with, over DALI, individually. Using a bidirectional data exchange, a DALI controller can query and set the status of each connected lighting device. As a standalone system, DALI can be operated with a maximum of 64 devices. Alternatively, DALI can be used as a subsystem via DALI gateways for connection to building management systems.



Figure 1 DALI system types



Overview



Figure 2 Block Diagram for DALI Control Device and Control Gear

An example solution for a DALI control device¹⁾ has been created using the Infineon XC836 Easy Kit. This solution makes use of the available touch pads and 7 segment display on the XC836 Easy Kit to send user commands and display the responses received from the connected DALI control gear. The solution also allows the user to send DALI commands automatically after a defined time period.

This document describes how the DALI control device software has been constructed and demonstrates the supported software functions.

The following items are required for use with this application note:

- 1 set of XC822 Easy Kit including DALI Control Gear Software Stack (AP08102), and,
- 1 set of XC836 Easy Kit.

¹⁾ IEC-62386 Part 300 for Control Devices is scheduled to be published in 2012. This application example is targeted at providing a method for the user to send out DALI commands frames.



Hardware Setup

2 Hardware Setup

This section describes the hardware setup required for this example application. The control device, which makes use of the XC836 Easy kit, has 12 built-in touch pads used for user command entries, and 4x 7-segment displays that are used to detail the commands and responses.

Details on the DALI control gear software and setup can be found in AP08102 DALI Control Gear Software Stack.

Figure 3, **Figure 4** and **Figure 5** show respectively the hardware overview, the physical connections between the control device and control gear, and the board modification required.





Hardware Setup



Figure 4 DALI Control Device connection to a DALI Control Gear







3 DALI Control Device Software

This section describes the program operational flow and the software structure used for developing this example solution. In terms of usage, the software is partitioned into 2 distinct operation phases; Phase 1: Command Entry and Phase 2: Command Execution. This operation is presented in Figure 6.



Figure 6 Main Program Flow



For code implementation, we have divided the software into two main layers:

- DALI protocol layer
 - Supports the translation of user commands into the desired DALI format to be sent through the DALI bus.
- Application code layer
 - Provides the user commands through the touch pads and 7-segment displays on the XC836 Easy Kit board.

The following XC83x device modules are required for the implementation:

- Real-Time Clock (RTC)
- Timer 0
- Timer 2
- LED and Touch Sense Control Unit (LEDTSCU)
- LEDTS ROM library.

Note: The configuration settings are done via Infineon's Technologies' free tool DAvE, which will generate the skeleton code based on the configurations set. The screen shots that follow are taken from DAvE.

3.1 DALI Protocol Layer

In the control device, the DALI protocol layer provides the translation of user commands into the desired DALI format to be sent and received through the DALI bus. For our example, the DALI bus chosen is P2.7 (Rxd) and P0.7 (Txd).

3.1.1 Timer 0

Timer 0 module is used to send DALI command frames. Mode 1: 16 bit timer is selected for this purpose (see Figure 7).

	T O i
- Timer Mode (TMUD, TUM)	- Timer Uptions
Mode 0: 8-bit timer (TH0) with a divide-by-32 prescaler (TL0)	Enable counter operation on Pin None
Mode 1: 16-bit timer (TH0/TL0)	Enable Gating Control: T0 is enabled only while EXINT0 pin [None] is high (GATE0)
Mode 2: 8-bit timer (TL0) with 8-bit auto-reload (TH0)	☑ Turn on timer (TR0)
Mode 3: 8-bit timer (TL0) and second 8-bit timer (TH0)	
Timer Registers	Interrupt Control
Lower byte of 16-bit timer (TL0) 0x78	Enable interrupt of timer (ET0)
Higher byte of 16-bit timer (TH0) 0xEC	
Timer overflow [µs] (TF0) 416 667	

Figure 7 Timer 0 DAvE Configurations



3.1.2 Timer 2

Timer 2 module is selected for reception of DALI command frames. The 16 bit timer function capture mode is selected. Timer 2 is started on a falling edge on T2EX input. (See Figure 8 to Figure 9)

<u>9</u> • • •	
fodule Clock Timer 2 T2EX Interrupts Functions	Parameters Notes
Prescaler Options	Timer / Counter Register
Enable Prescaler (PREN)	Timer register (T2H,T2L) 0x0000
Prescaler (PRE) fPCLK	Reload register (RC2H,RC2L) 0x0000
Timer / Counter Select (C_T2)	Timer overflow [usec] 2730.667
 16-bit timer function 	
C 16-bit counter function	Timer resolution [usec]
T2 Input Select	
T2 Input Pin Selection None	EXF2 Output Pin Selection
Capture / Reload Select (CP_RL2)	EXF2 Output Pin Selection None
Automatic reload when timer 2 overflows	Interrupt Control
 16-bit capture mode (normal timer/counter) 	Enable Timer 2 interrupt (ET2)
Start / Stop Control	Enable Overflow interrupt
Start timer 2 after initialization (TR2)	Enable External interrupt

Figure 8 Timer 2 DAvE Configurations

Interrupts Functions Paran	neters Notes
Timer2 External Trigger Input	Timer 2 External Enable Control
Timer2 External Trigger Input Select T2EX_6(P2.7)	Capture or reload when a positive/negative transition occurs on pin T2EX (EXEN2)
Timer2 External Start Enable	Up / Down Counter
Enable external start (T2RHEN)	Enable timer 2 as an up/down counter depending on pin T2EX (DCEN)
External Start Edge Select (T2REGS)	Edge Select in Capture/Reload mode (EDGESEL)
Select falling edge at Pin T2EX	Select falling edge at Pin T2EX
C Select rising edge at Pin T2EX	 Select rising edge at Pin T2EX

Figure 9 T2EX DAve Configurations



3.2 Application Protocol Layer

The application layer provides the user interface control through the touch pads for user commands, displaying the returned responses on the 7-segment displays. By making use of the real-time clock, the application allows DALI commands to be sent after a user defined time period.

3.2.1 Real-Time Clock (RTC)

The RTC module is used to support sending DALI commands after a user defined time period. For this purpose, "Mode 1: Periodic wake-up mode with 75KHz oscillator clock" is selected for the RTC.

Interrupt on compare counter match (ECRTC) is enabled, where a timer match of 1's is selected. This is used as a time base for tracking the user requested period for sending the DALI commands. The user can also configure the time base towards minute, hour or day timer matches (see Figure 10).

General Interrupts Functions Parameters Notes	
┌─ Mode Selection (RTM)	Clock / Prescaler
Mode 0 : Time keeping mode with 32.768KHz	RTCCLK Input Frequency [kHz] 75.000
Crystal clock	Prescaler (9-Bit) Available
 Mode 1 : Periodic wake-up mode with 75KHz oscillator clock 	Time Base [ms] 6.827
	Vear Type (RTYR)
 Mode 2: Time keeping mode with 1Hz externa clock via RTCCLK pin (P3.1) 	Normal (365 days) C Leap (366 days)
Mode 2 : Timer mode with outernal clock via	Timer Match / Compare Registers
RTCCLK pin (P3.1)	Required Timer Match [s] 1.000
- Counter Clock Registers	Real Timer Match [ms] 996.693
CNT0 0x00 CNT1 0x00	RTCCR0 0x92 RTCCR1 0x00
CNT2 0x00 CNT3 0x00	RTCCR2 0x00 RTCCR3 0x00
CNT4,5 n.a.	RTCCR4,5 n.a.
Interrupt Control	Start / Stop Control
Enable compare interrupt (ECRTC)	
Enable interrupt at every second (ESBTC)	Start RTC clock after initialization (RTCC)

Figure 10 RTC DAvE Configurations

3.2.2 LED and Touch Sense Control Unit (LEDTSCU) and LEDTS ROM Library

This module is used for the user command entry and 7-segment displays for this application.

For the LEDTSCU module pin control:

- P0.0-P0.4 are selected as touch sense pins
- P0.0-P0.6 are selected for LED line pins
- P1.0-P1.4 are selected for LED column pins

The LEDTS ROM library is enabled (see **Figure 12**). The brightness of the LEDs can be adjusted by setting the COMPARE parameter under the LED box. For the touch sense, fixed trip point and oscillation window are selected for all 5 touch pads. Error detection is also enabled to have a long touch/press function for the application.



Note: The touch pad sensitivity may vary for different touch-sense application. Calibration may be required for different touch sense applications. Please refer to Application Note AP08100: Configuration for Capacitive Touch-Sensing Application, for further calibration and methodology details.

Image: Second Secon		×
Module Clock Pin Control General ROM Library Interru	pts Functions Parameters	s Notes
Operating Mode (LD_EN, TS_EN)	LED Column Enable	5 Columns 💌
 LED and Touch Sense 		
Touch Sense Pins TSIN0 (P0.0) COLA None	LED Line Pins	LED Column Pins
TSIN1 (P0.1)	LINE1 (P0.1)	COLO P1.0 💌
TSIN2 (P0.2)	LINE2 (P0.2)	COL1 P1.1 💌
🔽 TSIN3 (P0.3)	🔽 LINE3 (P0.3)	COL2 P1.2 💌
✓ TSIN4 (P0.4)	🔽 LINE4 (P0.4)	COL3 P1.3 💌
🗖 TSIN5 (P0.5)	🔽 LINE5 (P0.5)	COL4 P1.4 💌
TSIN6 (P0.6)	IINE6 (P0.6)	COL5 None 🔽
TSIN7 (P0.7)	🗖 LINE7 (P0.7)	COL6 None 🔽

Figure 11 LEDTSCU DAvE Configurations for Pin Control

ろ • ◎ • ◎		
Module Clock Pin Control Ge	neral ROM Library Interru	pts Functions Parameters Notes
LED/TS Counter clock		Time Slice Compare Shadow Register (COMPARE)
Clock Source (CLKSEL)	FPCLK (48.00 MHz)	Compare Value 0xFF
Prescaler (CLK_PS)	FPCLK / 47	Required Duty Cycle [%] 100.00
Clock [MHz]	1.021	Real Duty Cycle [%] 100.00
Time Slice Duration [us]	250.667	Interrupt Control
	1.504	Enable Time-Slice interrupt (ITS_EN)
l ime Frame Duration [ms]	J1.504	Enable Time-Frame interrupt (ITF_EN)
LED Column Active Level (C	OLLEV)	H/W Control Pad Turn Enable
 Active level is low 	C Active level is High	Number of Pad Turns [1 Pad]
TS Pad Turn Control (PADT)	6W)	TS COLA Pin Pull-up selection (EPULL)
O By Hardware	By Software	Internal pull-up C External pull-up
TS Output Low level Extension	on (TSOEXT)	TS Counter Control
Extended by 1 FPCLK		Enable TS counter saturation (TSCTRSAT)
TS Output Low level Extension Extended by 1 FPCLK	on (TSOEXT)	TS Counter Control

Figure 12 LEDTSCU DAvE Configurations for General Control



🎽 🍈] • 💡							
Module Cloci	k Pin Cont	trol General	ROM Library	Int	errupts Func	tions Parame	ters Notes	
– ROM Libra	rv Selection) —			TOUCH SEN	ISE		
	.,				No. of touch	pad 5 💌	No. of samp to accumula	le Ox03
Support fo	r ROM Libra	ary Enabl	ed 💌		Low-pass filt gain	er 8 💌	Valid pad co (Short count	ount 60.16 ms
						Error detection	Long pad to (Error count)	uch 1.02 s
LED					Trip Point	Fixed 💌	Oscillation Window	Fixed
		BRIGH	TNESS				OSCILLATIO	
COLUMN	LDLINE	Duty Cycle %	COMPARE		PAD	OFFSET	TIME (us)	COMPARE
COLA	0xFF	n.a.	n.a.		FIXED	0x60	124.84	0x80
COLO	0x3F	49.80	0x7F		TSINO	n.a.	n.a.	n.a.
COL1	0x3F	49.80	0x7F		TSIN1	n.a.	n.a.	n.a.
COL2	0x3E	49.80	0x7E		TSIN2	n.a.	n.a.	n.a.
	10.101 10v3E	49.80	IOv7E		TSIN3	n.a.	n.a.	n.a.
		49.00	0.75		TSIN4	n.a.	n.a.	n.a.
		43.00			TSIN5	n.a.	n.a.	n.a.
	In.a.	In.a.	In.a.		TSIN6	In.a.	In.a.	In.a.
LULB	n.a.	n.a.	n.a.		I I SIN7	jn.a.	In.a.	In.a.

Figure 13 LEDTS ROM Library DAvE Configuration



4 Getting Started

This section provides an overview on the program flow and how the user can use this application. Information on the software package contents and customization details are also included.

4.1 Supported Commands

This section describes the commands supported and their operation with this application example.

This application example is designed for the XC836 Easy kit, which has 12 built-in touch pads used for user command entry, and 4x 7-segment displays used to display the entered commands and returned responses. Table 1 shows the supported command category list used with this application.

Table 1 Commands Category List

Touch Pad Inputs	Category Description
0XXX	DALI Commands
1XXX	Address Configurations
2XXX	Data Transfers
3XXX	Timed Commands
4XXX to 9XXX	Not supported; reserved for future use

4.2 DALI Commands

Table 2 and Table 3 show the supported DALI commands and recommended command sequence, together with the expected response to be observed.

Table 2	Category DALI Command	ł
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Touch Pad Inputs					
D1	D2/D3/D4	Description of DALI commands supported			
0	XXX	 DALI Commands are sent where XXX represents the DALI command numbers. Supported DALI commands are the following. Indirect Arc Power Commands: 000 to 008, 016 to 031 Configuration Commands: 032 to 033, 042 to 047, 064 to 128 Query Commands: 144 to 157, 160 to 165, 176 to 197 All other commands not supported 			

Table 3 Command Sequence for DALI commands

Step	Description of Activity	Display on 7 Segment
1	User enters command through touch pad.	'0XXX', where XXX is entered DALI command
2	User enters '#' to execute command.	-
3A	If this is a Query Command, response is sent to 7 segment display.	'AXXX', where XXX is the returned response from Control Gear.
3B	Else this command does not require a response. The command will be displayed to 7 segment display.	'CXXX', where XXX is entered DALI command
4	User enters '*' to exit to command entry screen.	'_'XXX, where XXX is blank.



4.3 Address Configuration Commands

This configures the address of the subsequent DALI commands. **Table 4** and **Table 5** show the supported address configuration, the recommended command sequence and the expected response to be observed.

Touch Pad Inputs		
D1	D2/D3/D4	Description of address configuration supported
1	1XX	Group Address where XX represents 00 to 15; otherwise broadcast address assumed.
	2XX	Short Address where XX represents 00 to 63; otherwise broadcast address assumed.
	0XX, 3XX to 9XX	Broadcast Address assumed.

Table 4 Category Address Configuration

Table 5 Command Sequence for Address Configuration commands

Step	Description of Activity	Display on 7 Segment
1	User enters command through touch pad.	'1XXX', where XXX represents
		Group/Short/Broadcast address.
2	User enters '#' to execute command.	-
3	Response is sent to 7 segment display.	'AXXX', where XXX is the address entered by user
4	User enters '*' to exit to command entry screen.	'_'XXX, where XXX is blank.

4.4 Data Transfer Commands

Table 6 and Table 7 show the format where the data transfer is supported, the recommended command sequence and the expected response to be observed.

Touch Pad Inputs		
D1	D2/D3/D4	Description of data transfer supported
2	XXX	Transfer of user specified content to Data Transfer Register (DTR) where XXX represent 000 to 255. If a value greater than 255 is entered, 255 will be sent to the DTR.
		 Configuration commands that require the use of DTR are: Arc power parameter settings: 042 to 47, 64 to 79 System parameter settings: 128

Table 6 Category Data Transfer

Table 7 Command Sequence for Data Transfer commands

Step	Description of Activity	Display on 7 Segment
1	User enters command through touch pad.	'2XXX', where XXX represents the user data entered.
2	User enters '#' to execute command.	-
3	Response is sent to 7 segment display.	'dXXX', where XXX is the data entered by user.
4	User enters '*' to exit to command entry screen.	'_'XXX, where XXX is blank.



4.5 Timed Commands

Table 8 shows the format where the timed commands are supported. The user is required to select the commands to be executed after a defined time period. Up to a maximum of eight pre-defined commands are supported. Once the options are entered, the user can start the timer and the commands will be executed when the correct time is reached.

Table 9 shows the recommended command sequence and the expected response to be observed. The time-base for the timer can be configured (see **Chapter 3.2.1**). The default-time base is 1 second.

Touch Pad Inputs		ıts	
D1	D2	D3/D4	Description
3	0 to 7	XX	D2: User defined commands from 0 to 7. D3/D4: time duration where XX is from 00 to 99. The current supported time-base is 1 second.
	8	XX	Enables the clock function for automated command sending. This will start the execution of timed commands selected by the user.
	9	XX	Reset the user selection and disables the clock function for automated command sending.

Table 8Category Timed Command

Table 9 Command Sequence for Timed commands

Step	Description of Activity	Display on 7 Segment
1	User enters command through touch pad.	'3XXX', where XXX represents the user defined command and timing selected.
2	User enters '#' to execute command.	-
3	Response is sent to 7 segment display.	'CXXX', where XXX is the command and timing entered by user.
4	User enters '*' to exit to command entry screen.	'_'XXX, where XXX is blank.

4.5.1 Customising Automated Commands

DALI functions are assigned to the touch pads via a user configuration file (config.h). **Table 10** shows the supported DALI commands and **Table 11** gives the customisation possibility for the timed command functions.

Table 10	Supported DALI commands
----------	-------------------------

Supported Commands	Description
DALI_OFF	Turns light off
DALI_DIM_UP	Set lighting level up by 1 level
DALI_DIM_DOWN	Set lighting level down by 1 level
DALI_STEP_UP	Fades lighting level up for 200ms
DALI_STEP_DOWN	Fades lighting level down for 200ms
DALI_RECALL_MIN	Sets connected lighting device level to minimum level
DALI_RECALL_MAX	Sets connected lighting device level to maximum supported level
DALI_STEP_DOWN_OFF	Set lighting level down by 1 level. If already at minimum, turn lights off.



Supported Commands	Description	
DALI_ON_AND_STEP_UP	Turns on connected lighting device. If already on, set the arc power level up one level.	
DALI_GOTO_SCENE_XX	This is a Scene Selection commands. Choosing this enables device for user configured Scene XX, where XX represents 00 to 15.	

Table 10Supported DALI commands

Table 11	Customising the Timed commands
----------	--------------------------------

DALI Commands	Description	
Customising the Timed Command list	In the file: config.H, the timed command to be executed can be configured by the user at compile time. A list of supported DALI commands can be referenced from Table 10 .	
	 To support timed command: #define USR_CMDX <dali command=""> where DALI commands can be referenced from Table 10.</dali> 	
	 To disable timed command: #define USR_CMDX <notsupported></notsupported> 	
	Default command selection for file: config.H	
	#define USR_CMD0 DALI_OFF	
	#define USR_CMD1 DALI_ON_AND_STEP_UP	
	#define USR_CMD2 DALI_STEP_UP	
	#define USR_CMD3 DALI_DIM_UP	
	#define USR_CMD4 DALI_RECALL_MAX	
	#define USR_CMD5 DALI_DIM_DOWN	
	#define USR_CMD6 DALI_RECALL_MIN	
	#define USR_CMD7 NOTSUPPORTED	

4.6 Software Package

The file description for the software package is documented in Table 12 and Table 13.

Table 12	Source files	description
	000100 11100	400011011

Filename	Description	
Dali_master.dav	DAvE project	
Dali_master.uvproj	Uvision project	
MAIN.c	Performs main program initialisation	
IO.c	Performs GPIO module initialisation	
RTC.c	Performs RTC module initialisation	
T01.c	Performs Timer 0 module initialisation for application control functions inclusive of DALI frame transmission activities.	
T2.c	Performs Timer 2 module initialisation for DALI command interpreter functions inclusive of DALI frame reception activities.	
START_XC.A51	Start up code for XC8xx device. This is part of the C51 Compiler package.	
LTS.c	Performs LED and Touch-Sense Controller module initialisation	
BOOTROM_ADDR.A51	Library address for bootrom user routines	
SHARED_INT.c	Shared interrupts; LEDTS and RTC interrupt handling sections;	



Connecting to a DALI network

Table 13 Header files description		
Filename	Description	
MAIN.h	SFR Header file for XC836 Microcontroller	
IO.h	GPIO function prototypes and macros	
RTC.h	RTC prototypes and macros	
T01.h	Timer 01 function prototypes and macros	
T2.h	Timer 2 function prototypes and macros	
LTS.h	LED and Touch-Sense Controller function prototypes and macros	
SHARED_INT.h	Shared interrupt function prototypes and macros	
config.h	Definitions of DALI commands and timed command assignments	

5 Connecting to a DALI network

An Infineon DALI PHY¹⁾ board can be used to support evaluation within a typical DALI network. The DALI PHY board can be used by attaching it onto either the header rows of the XC822 or XC836 Easy Kit.

Figure 14 shows the DALI PHY board and the connections required. Figure 15 shows the connections between the DALI Control Device (using the XC836 Easy Kit) and DALI Control Gear (using XC822 Easy kit) for a DALI network.



Figure 14 DALI PHY Board

¹⁾ Schematics and Bill of Materials, for the DALI PHY board can be found in AP08104: Guide to using DALI LightNet tool, Section 4 Connecting to a DALI network.



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Summary



Figure 15 DALI Control Device and Control Gear with DALI PHY board connected

6 Summary

Infineon microcontrollers provides a great deal of flexibility for the creation of a wide variety of robust applications for the users. This application note demonstrates the ease of creating a DALI control device, using the touch sense module and real-time clock module in the XC836. With the given instructions, the user can customise this solution to their application with ease. Together with a DALI PHY board, this application is ready for use in any DALI network.

7 References

- IEC 62386 Digital addressable lighting interface; Part 101: General requirements System (Edition 1.0, 2009-06)
- [2] IEC 62386 Digital addressable lighting interface; Part 102: General requirements Control gear (Edition 1.0, 2009-06)
- [3] AP08102 DALI Control Gear Software Stack
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- [6] XC836 User Manual 1.0
- [7] Hardware Manual Easy Kit XC836-TSSOP28 board V1.0

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