Interfacing a DAC with ARM cortex M3 Microcontroller LPC1768

Md. Moyeed Abrar,

Assistant Professor, Khaja Banda Nawaz college of Engineering (E-mail: moyeed.abrar@gmail.com)

Abstract—The ARM cortex M3 is a next generation core that offers system enhancements such as modernized debug features and a high level of support block integration. The ARM cortex M3 based microcontrollers are versatile and has numerous well developed features, thereby finding applications in various embedded applications. High performance, low cost and ease of use are the salient features of the ARM cortex M3 microcontrollers. The ARM cortex M3 microcontroller LPC1768 is a 32 bit microcontroller with advanced features. The state of the art presented in this paper is the interfacing of a Digital to Analog converter (DAC) with the ARM cortex M3 Microcontroller LPC1768. The Analog output waveforms in the form of triangular wave and square wave was displayed on the CRO as a result of this interfacing.

Keywords—Arm cortex M3 microcontrollers, embedded applications, 32 bit microcontroller, interfacing, Digital to Analog converter, analog output waveforms, triangular wave, square wave.

I. INTRODUCTION

The ARM cortex M3 is a general purpose 32 bit microcontroller. This microcontroller has high performance and requires very less power consumption. Apart from this, it offers many new features such as a Thumb 2 instruction set, low interrupt latency, hardware divide, interruptible/ continuable multiple load and store instructions, automatic state save and restore for interrupts, tightly integrated interrupt controller with wake up interrupt controller and multiple core capable of simultaneous accesses. In these buses microcontrollers pipelining techniques are employed so that all parts of processing and memory systems can operate continuously. Typically, while one instruction is being executed, the next instruction (its successor) is being decoded while the third instruction is being fetched from the memory [1].

The Cortex-M3 processor is the central processing unit (CPU) of a micro controller chip. In addition, a number of other components are required for the whole Cortex-M3 processor-based micro controller. After chip manufacturers license the Cortex-M3 processor, they can put the Cortex-M3 processor in their silicon designs, adding memory, peripherals, input/output (I/O), and other features. Cortex-M3 processor-based chips from different manufacturers will have different memory sizes, types, peripherals, and features.

The cortex M3 microcontroller addresses the requirements for the 32 bit embedded market in the following ways

- Greater performance efficiency: allowing more work to be done without increasing the frequency or power requirements.
- Low power consumption: enabling longer battery life, especially critical in portable products including wireless networking applications.
- Enhanced determinism: guaranteeing that critical tasks and interrupts are serviced as quickly as possible in a known number of cycles.
- Improved code density: ensuring that the code fits even in the smallest memory footprints.
- Ease of use: providing easier programming and debugging for the growing number of 8 bit and 16 bit users migrating to 32 bits.
- Lower cost solutions: reducing the 32 bit based microcontroller system costs close to those of legacy 8 bit and 16 bit devices [1], [2], 3].

The rest of the paper is organized in to sections as follows: section II includes the overview of ARM cortex M3 microcontroller LPC1768. Section III focuses on the system design. Results and discussions are reported in section IV. Finally section V summarizes the paper and presents the concluding remark.

II. ARM CORTEX M3 MICROCONTROLLER LPC1768 OVERVIEW

The LPC1768 is an ARM cortex M3 microcontroller used in embedded applications and requires high level of integration and less power consumption. The LPC1768 can operate up to 100 MHz CPU frequency. The peripheral components of the LPC1768 possesses up to 512 kilo bytes of flash memory, up to 64 kilo bytes of data memory, Ethernet medium access control (MAC), a USB interface which can be configured either as host device or OTG, 8 channel general purpose Direct memory access (DMA) controller, 4 Universal asynchronous receiver transmitter (UART's), 2 controller area network (CAN) channels, 2 system service processors (SSP), serial peripheral interface (SPI), 3 I2C interfaces, 2- input plus 2- output I2S interface, 8 channel 12 bit Analog to Digital converter (ADC), 10 bit Digital to Analog converter (DAC), motor control pulse width modulation (PWM), quadrature encoder interface, 4 general purpose timers, 6 output general purpose PWM, ultralow power real time clock (RTC) with separate battery supply, and up to 70 general purpose Input /output (I/O) pins.

IJRECE VOL. 6 ISSUE 4 (OCTOBER- DECEMBER 2018)

The LPC1768 makes use of a multi-layer AHB (Advanced High Performance Bus) matrix for connecting the ARM cortex M3 buses as well as other bus master peripherals in a flexible way which optimizes performance by allowing peripherals which are located on different slave ports of the matrix to be accessed simultaneously by different bus masters [4].

III. SYSTEM DESIGN

A. Technical Specifications of the ALS SDA ARM cortex M3 LPC1768 evaluation board

The following are the salient features of the ARM cortex M3 LPC1768 evaluation board.

- It has 512KB flash memory, 64KB SRAM, In system programming (ISP) and In application programming (IAP) capabilities.
- It possesses Single 3.3 volt power supply (2.4v to 3.6v).
- There are 70 general purpose I/O pins (GPIO) with configurable pull up/ pull down resistors, open drain mode and repeater mode.
- There are 12-bit Analog to Digital converter (ADC) and up to 8 analog channels.
- ➢ 10-bit Digital to Analog converter (DAC) with dedicated conversion timer is also available.
- There are 4 general purpose timers/counters, with a total of eight capture inputs and ten compare outputs.
- > Three enhanced I2C bus interfaces are also available.
- Serial peripheral interface (SPI) controller with synchronous, serial, full duplex communication.
- There are four reduced power modes: sleep mode, deep sleep mode, power down mode and deep power down mode.
- It has a Real time clock (RTC) with a separate power domain.
- > A 12 MHz crystal allows easy communication set up.
- Four external interrupt inputs configurable as edge/level sensitive.
- There is an on board voltage regulator for generating 3.3 volt. Input to this is through the external +5volt DC power supply through a 9 pin DSUB connector.
- The LPC1768 controller is contained in the piggy back module.
- > There is a Reset push button for resetting the controller.
- One RS232 interface circuit with 9 pin DSUB connector.
- > DC motor interface with direction and speed control.
- Stepper motor interface with direction and speed control.

ISSN: 2393-9028 (PRINT) | ISSN: 2348-2281 (ONLINE)

- 16x2 alphanumeric display is available on the board for the purpose of LCD interfacing.
- On chip ADC interface circuit using AD0.5 (P1.31)
- ▶ 8-bit DAC interface is also available.
- ➢ 4x4 key matrix connected to the port lines of the controller.
- For LED indication there is an external interrupt circuit.
- Two digit multiplexed seven segment display interface is also available.
- Interface circuit for on board buzzer, relay and LED indication controlled through push button.
- SPI interface: Two channel ADC IC with POT and Temperature sensor.
- Standard 26 pin FRC connectors to connect to on board interface.

B. System specifications

The system specifications are illustrated in table 1.

TABLE I. SYSTEM SPECIFICATIONS

Sl. No	System specifications
1.	Domain: Microprocessors and Microcontrollers, Embedded systems
2.	Microcontroller used: Arm cortex M3 Microcontroller LPC1768 from NXP founded by Philips.
3.	Microcontroller data capacity: 32bit RISC microcontroller.
4.	Desktop computer: Pentium 4, 1GB RAM , Processor speed 2.5 GHz.
5.	Programming language: Embedded C.
6.	Software: Keil µ vision 4.
7.	Cathode ray oscilloscope (CRO).
8.	Adapter cable, USB cable, connecting probes for CRO.
9.	Port line: P0.4-P0.11
10.	Digital to Analog converter: DAC0800 (16 bit).
11.	In system programming (ISP): flash magic software is used to download the hex files to the flash magic of the controller.
12.	Serial communication: RS 232 cross cable connections required for establishing communication between the evaluation board and a display terminal/ host computer.
13.	Applications: waveform generation such as sine wave square wave and triangular wave and display on CRO.

C. DAC 0800

The term DAC refers to Digital to Analog conversion. Digital to Analog conversion is a process in which the Digital signal is converted into an equivalent Analog signal (voltage). In other words it can be said that, the DAC process involves the translation of Digital information into equivalent Analog information. The DAC allows generating variable analog output [6], [7]. The DAC0800 is a 16 pin IC which is used in the Arm cortex M3 LPC1768 evaluation board to convert the Digital data into Analog signal [9].

D. System set up

The system set up was done in embedded system and Microcontroller lab. Desktop computer, Arm cortex M3 LPC1768 evaluation board and a CRO were used in the system. The adapter cable was plugged in the socket to give the power supply and the adapter pin was connected to the ARM cortex M3 LPC1768 evaluation board. The mandatory hardware connections were done by connecting the USB cable to the USB port of the desktop computer and the other end of the USB cable was connected to the female connector of the RS 232 cable and the male connector of the RS232 cable was connected to the female connector of the ARM cortex M3 LPC1768 evaluation board. The CRO connections were done by connecting the positive probe (red color) at pin 1 of RM3 and negative probe (black color) at pin 2 of RM3 of the ARM cortex M3 LPC1768 evaluation board.

The keil μ vision 4 software was used to write the C program for DAC interfacing to obtain a triangular analog waveform. The keil μ vision 4 software located on the desktop was opened by double clicking it [5]. The project option was clicked and new μ vision project was chosen as shown in figure 1.





Create New project window appeared on the screen. A new and separate folder was created on the desktop and was named as waveforms. A file named TRIANGULAR was saved in the folder as illustrated in figure 2.



Figure 2 Folder creation and file naming A new window named Select Device for Target

A new window named Select Device for Target 'Target1'appeared on the screen. In the search column of this

ISSN: 2393-9028 (PRINT) | ISSN: 2348-2281 (ONLINE)

window nxp was written so as to select the desired microcontroller from this nxp series founded by Philips. The ARM cortex M3 microcontroller LPC1768 was selected and the description of this microcontroller was displayed and ok option was chosen as illustrated in figure 3.

10 Window Production Rev Production	C: Wocuments and Settings \Ad	dministratorWesktop1wavefo	rms\TRIANGULAR.uvproj - µVision4		. 8
Image:	File Edit View Project Flash D	vebug Peripherals Tools SVC5	Window Help		
Image:		内内中中一つの	後 連連川 川 🎯	930 Q 0000	8 - 4
extent brokes for Target Target 11 Veries	🔗 🙆 🖾 🥔 🖽 💥 Target	ti 😹 🔊 💩	5. ◆ 劒		
State Larvies for Target Target 1: Unit	roject 💓 🔀				
Window Bit State Window Bit State Unit State Bit State Discretion Bit State	6	Palant Davidse for Toront Tree			
Image: Section of the section of t		CPU Vendor: N0P Device: LPC1768			
Image:		TODGER ARM			
Image: State Control State		Search: NP	Description		
		UPC1789 UPC1789 UPC1789 UPC1789 UPC1785 UPC1785 UPC1786 UPC1786 UPC1786 UPC1787 UPC1787 UPC1787 UPC1776 UPC1777 UPC1777	 Afrid 32 la Cutter et al (decomposi- line System Forgamery (SFF) and EdB FAM, Henre Forgamery (SFF) and EdB FAM, Henre Forgamery (SFF) and EdB FAM, Henre Forgamery (SFF) Edb Forgamer (SFF) and Edb Family (SFF)	der veh still 401, 191 steht son 100 A handen son 100 steht son 100 steht mag Controller, mag Controller, mag Controller, and Controller, der veh forsteht der veh forsteht der veh forsteht der veh forsteht der veh forsteht geförste and reacher 1054 MAX Inter Boder, keht seinen Blattery besturg, keht seinen Blattery besturg, besturg Farer, Norwand derst Control C exclusion Blattery besturg, besturg Farer, Norwand derst Control Blattery Blattery besturg, besturg Farer, Norwand Blattery, besturg Farer, Norwand Blattery,	
а ∰а (1) / (Ца) т Общи и			21 18		
			OK Count 1	9.5	
	DP. (0. 0. 0. 1		Carta		
	NO THE OWNER				
I CAR NUM SON					
I CAPI NUM SCRU					
SALE NOT SUID					COST NUM SCOLO
	A of art MP - 10				

Figure 3 Selection of the ARM cortex M3 microcontroller LPC1768

Another new window named μ vision with two options Yes and No appeared and the option Yes was chosen to add "system LPC17xx.s" as depicted in figure 4.

🖟 C: \Documents and Settings\Administrator\Desktop\waveforms\TRIANGULAR.uvproj - µVision4	B 🗙
Ne Edit View Project Plash Debug Peripherals Tools SVCS Window Help	
□ 22 22 24 24 24 24 24 24 24 24 24 24 24	
③ 岱 逊 @ 磁 및 Target 1 🕑 於 🚵 🕾 🍲 య	
yPhilon	
an vepa	- (9 ×
	1
	2
Control Contro	102 AM

Figure 4 Choosing the Yes option

In the project window target was created as 'Target1'. The + sign of the target was clicked due to which source group 1 was shown below the target as depicted in figure 5.

🖾 C:\Documents and Settings\Administrator\Desktep\waveforms\TRIANGULAR.uvproj - µVision4	
File Edit View Project Flash Debug Peripherals Tools SVCS Window Help	
□◎ 🖉 🕹 🕹 🖄 🖉 ママ ← ⇒ や な な 我 詳 非 圧 版 🐸	
🕑 🖾 🕮 🖗 🔯 🙀 Target 1 🛛 💌 🖧 🏝 🌤 🎰	
Project C 🗶	
In the Incont I	
i Source Group 1	
EP. (30. O.F. 0., T.	
Build Output	9
S	
Simulation	CAP NUM SCR. OV

Figure 5 Creation of source group 1

IJRECE VOL. 6 ISSUE 4 (OCTOBER- DECEMBER 2018)

After the project is created go to file option and select new option to open the editor window as shown in figure 6.



Figure 6 Selection of new file

The program was written in embedded C language for the DAC interfacing to generate a triangular waveform and the program was saved by clicking on the save icon as illustrated in figure 7.



Figure 7 Saving the program

A new window named SaveAs appeared where the file was saved as TRIANGULAR .c. The file extension .c is necessary. This is illustrated in figure 8.

😰 C:\Documents and Settings\Administrator\Desktop\waveforms\TRIANGULAR.uvproj	- µ¥ision4 📃 🗗 🗙
File Edit View Project Flash Debug Peripherals Tools SVCS Window Help	
🗋 😂 🛃 🖇 🖓 🥙 🤍 🗢 🐂 🖗 🖓 🖉 🖉 🖉) 🛛 🗟 🥐 🔍 o O 🔗 🏨 🔟 🔹
😒 🖾 🕼 🔅 🙀 Target 1 🔤 🔊 🛔 🕾 🔶 🎰	
Project C X Text1*	▼ ×
#include <lpc17xx.h></lpc17xx.h>	
B Car Source Group 1	
Save As	2 🗵
Save in: 🗀 waveforms	• + 🗈 🖆 🗊 •
a startup_LPC170c.s	
LPO TRIANGLAR	.4 to PO.11 as GPIO
Documents TRIANGULAR.build_log	
Desktop	
My Documents	
1	
39	
Ny Computer	
My Network File name: TBIANGULAB d	- Save
Places Save as https://	Cancel
sare as the part of (1)	
P. (0. ()r. 0.T. ()//End of main()	
build Curput	(9 ×
	A
	M
	Simulation LIS2 C11 CAPI NUM SCRU OVEL RJ
🛃 start 🔣 C:(Documents and Se 🖆 triangle_were 💽 triangular - Not	apad 😰 🖞 🍕 1:05 AM

Figure 8 Naming the file as TRIANGULAR.c.

ISSN: 2393-9028 (PRINT) | ISSN: 2348-2281 (ONLINE)

Color syntax highlighting was enabled after the file TRIANGULAR.c was saved. The source group 1 located below the Target 1 in the project window was right clicked and the option Add existing files to group 'Source group 1' was selected to add the .c source file to the group as shown in figure 9.

C:Wocuments	and SettingsWdministrat	or\Desktop\waveforn	ms\TRIANGULAR.uvproj - µ¥ision4		- 🕫 🗙
File Edit View	Project Flash Debug Peri	pherals Tools SVCS	Window Help		
🗋 🖬 🖬 🖉	\$ in 😰 🤊 (*)	> P & B &	医课课 ///////////////////////////////////	🛛 🗟 🌾 🔍 🔍 🖉 🔛	4
I I I I I I I I I I I I I I I I I I I	🔅 🙀 Target 1	🛛 🕺 🖉	5 🗢 飽		
Project		AR.c			• ×
E Target 1	22 #1no	clude <lpc17xx.h< td=""><td>></td><td></td><td>^</td></lpc17xx.h<>	>		^
	K Options for Group 'Source	Group 1' Alt-	+F7		
	Add New Item to Group 'S	Source Group 1°	p=0x00000000;		
	Add Existing Files to G	roup 'Source Group 1'			
	Add Group		- OxFF0000FF ;	// Configure P0.4 to P0.11 as GPIO	
	Remove Group 'Source Gr	oup 1' and its Files	OXCOODOFFO ; OXFFFFFOOF;		
	 Hanage Project Mellett. 		-		
	Open File Open List Eile				
	Open Map File		; 1++)		
	Open Build Log				
	Rebuild all target files		< 4;		
	🔝 Build target		F7 OPIN = temp;		
	Translate File		1		
	Stop build		0,1)		
	Show Include File Depende	encies	A.		
	47	LPC_GPIOD	->FIOPIN = temp;		
	48 49 },	//End of while(1)		
EP. (38. () F.	0.T. 50)//1	End of main()			~
Build Output					e x
					^
<					×
Add Existing Files to a	urrent Project Group		Simulation	L:52 C:1 G	AP NUM SCRU OVR R
🛃 start	C:\Documents and Se	C triangle_wave	🐻 triangular - Notepad		1:05 AM

Figure 9 Adding the existing files to group source group 1.

A new window appeared with the name Add files to group 'Source Group 1' where the file TRIANGULAR.c was selected and then the Add and close option was clicked one after the other as depicted in figure 10.

C: Wocuments and Se	ttings\Administrator\Desktop	waveforms\TRIANGUL/	R.uvproj - µVision4			
File Edit View Project	Flash Debug Peripherals To	ols SVCS Window Help				
🗋 💕 🖬 🕔 🐰 🛛	a 🚨 🤊 (*) 🔶 р	自自良 课课//	1/12 🖉	۵ 🐢 🖻 🗹) O 🔗 🍓 🔳 🔹	
I 🖾 🕮 🖉 🚟 🔰	🖡 Target 1 🛛 💌	K 🛔 🗟 🔶 🏨				
Project 🕑 🔀	TRIANGULAR.c					•
E Target 1	22 #include <l< td=""><td>PC17xx.H></td><td></td><td></td><td></td><td></td></l<>	PC17xx.H>				
# Source Group 1	24 Add Files to G	roup 'Source Group 1'		2 🛛		
	25 26 Leek in 23 m	waterms				
	27	PEGINS				
	28 E TRIAVGULAR 29				0.11 as GPIO	
	30					
	31					
	33					
	35					
	36					
	38					
	39					
	41					
	43					
	44 File name:	RIANGULAR.d		Add		
	46 Files of type:	Source file (*.c)		Close		
	47					
	49			1		
🖬 P. 🚷 8. () F. 0., T.	< SU)//End OF m	u ()				Σ
uid Output						9
						>
			Simulation		LISZ CIL CAP NUM	SCRL OVR
🛃 start 🔰 🔞 🕬	Documents and Se ն triang	e_wave 🛛 🔂 tria	ngular - Notepad		8 1 1	1:06 AM

Figure 10 Choosing the file TRIANGULAR.c

The same window Add files to group 'Source Group 1' appeared once again. Here the startup file folder was clicked and in it the NXP was chosen then LPC17xx folder was opened and finally system_LPC17xx was selected as shown in figures 11, 12 and 13 respectively.

IJRECE VOL. 6 ISSUE 4 (OCTOBER- DECEMBER 2018)

Add Files to	o Group 'Source Group 1'	×
Look in: 🗲) ARM 💽 🔶 🖆 🖽 -	
ARMCC BIN Boards CMSIS CMSIS Device Examples Flash HIp INC NULInk RL RV31 Segger	SFD Signum Sitabs Startup Strink Size: 11.0 MB ULI Folders: Actel, ADI, AMS, ARM, Atmel, Cypress, EnergyMicro, Files: Retarget.c, SVC.c, SWI.s	
File name:	Add]
Files of type:	C Source file (*.c)	

Figure 11 clicking startup folder

Add Files to	Group 'Se	ource Grou	p 1'					1	
Look in: 🔎	NXP				 •	(È 💣	•	
EM77x EM77x EM78x LPC11Axx LPC11Axx LPC11Exx LPC11xxL LPC11xxL LPC11xxL LPC13xx LPC13xx LPC13xx LPC15xx LPC15xx	,	LPC18xx LPC43xx LPC112x LPC112x LPC177x LPC313x LPC407x	_8x _8x_177x_8x	_					
Size: Files File name: Files of type:	33.0 KB : startup_LP C Source f	C17xx.s, systi ile (°.c)	m_LPC17xx.c		 	·		Add Close	

Figure 12 Opening the folder LPC17xx

Add Files to	Group 'Source Group 1'				? 🔀
Look in: 🛅	LPC17xx	•	🔶 🔁) 💣 🎟	•
system_LP(:17xx				
File name:	system_LPC17xx			A	dd
Files of type:	C Source file (".c) C Source file (".c) Asm Source file (".s"; ".src; ".a")		•	Cle	ose
}	ubject me Looj Liberay file ("Jkt", "t, "t, "c) C++ Source file ("c, pp) Image file (".")				

Figure 13 Selecting system_LPC17xx

The next important task was to compile the files. For this purpose build icon was clicked as shown in figure 14.

ISSN: 2393-9028 (PRINT) | ISSN: 2348-2281 (ONLINE)



Figure 14 Choosing the build icon for compilation

After this step, the build output window was checked where the message TRIANGULAR.axf 0 Error(s), 0 warning(s) was displayed which ensured that the program was without errors. This is illustrated in figure 15.

File Edit View Project Flash Debug Peripherals To	als SVCS Window Help	
🗎 😂 🖬 🏈 🕺 🕰 🙇 🥙 🗠 🔶 🥐	魯 毘 敬 課 課 准 版 🦉 🛛 💌 🗟 🐢 🔍 鱼 🔿 🍂 🔤	• •
🥩 🗓 🕮 🧼 🗮 🙀 Target 1 🛛 💌	▲ 書 ◆ 約	
Project CX TRIANGULAR.c		•
Target 1 22 #include <1	PC17xx.H>	
Source Group 1 23		
25 (
26 unsigned	long int temp=0x00000000;	
27 unsigned	int 1=0;	
28		
29 LPC_PINCO	<pre>#->PINSELO &= 0xFF0000FF ; // Configure P0.4 to P0.11 as GPIO</pre>	
30 LPC_GPICO	->FIODIR = Ox00000FF0 ;	
31 LPC_GPIOC	->FIOMASK = OXFFFFFOOF;	
32		
34 (
35 //out	put 0 to FE	
36 for	[1=0;1!=0xFF;1++]	
37 (
38 t	emp=1;	
39 t	emp = temp << 4;	
40 1	<pre>// C_GPIOO->FIOPIN = temp;</pre>	
41 1		
12 //	Sucput PF to 1	
44 ((1-0477) 11-0, 1)	
45	emp=1:	
16 1	emp = temp << 1j	
47 1	PC_GPIO0->FIOPIN = temp;	
40)	-	
49)//End of	while(1)	
50)//End of m	ain()	
uld Output		, s
linking		
Program Size: Code=1456 RO-data=236 RW-d	Ata=4 ZI-data=612	
U LEFOF(8), U WAENS	1910) -	
	Simulation LIS2 C:1 0	AP NUM SCRU OVE
Start C:\Documents and Se	e_wave 🚯 triangular - Notepad 😰 🖞	1:09 AP

Figure 15 Getting the error free program with 0 errors and 0 warnings

In the project window Target 1 option was right clicked and then options for Target 'Target 1' was chosen as shown in figure 16

										2
ie Edit Vi	aw Project	Flash Debug	Peripherals	Tools SVCS	i Window	Help				
🗋 💕 🖬	4 X Da	🔁 🤊 C ^u	(4 4)	P 2. 2.	热律	津ルル	2		💌 🗟 🌮 🔍 👄 🔿 🔗 🏨 📰 📲	
۵ 🕮 🕸	@ Eij 🙀	Target 1		1 🔊	3 * :	60				
oject	<u> (* ×</u>		GULAR.c							
			filmer Trades	of the section.	WS .				k.	
۰ 🗀 🖻	Options for T	arget Target 1'						Alt+F7		
	Add New Iter	n to Group								
	Add Existing I	Files to Group								
	Add Group									
	Remove Item								// Configure PO.4 to PO.11 as GPIO	
	Manage Proje	ct Items								
	Open File									
	Open List File									
	Open C:\Do	cuments and S	ettings\Adm	inistrator\l	Desktop\v	vaveforms\T	RIANGULA	R.map		
	Open Build Lo	0								
(11)	Rebuild all tae	ont files								
(3)	Build target							F7		
	Translate File									
623	Stop build									
~	Show Include	File Dependencie	4							
_				cemp-xr					1	
		46		LPC GPI	temp <<	4; PIN = tem	.,			
		48)							
		49)//End of	of while	(1)					
]P. 🚷. I	0 F. 0, T.	< 30)	//End OI	Bain()						>
ld Output										e
nking										
cogram Si	ze: Code=	1456 R0-dat	a=236 RU-	-data=4	ZI-data	=612				
TRIANGO	LAF. BXL.	- O AFFOR(8	i), U wars	ning(s).						
dia wa havaal	ontione						Circu	lation	1/92 Cr4 CAD M	M SCRI OVP
and carged	000.010		-		1	-	SING			- 1.00 AM
start	C:/D	ocuments and Se	0.0			Co changuar	- Nocepad		U 7	

Figure 16 Selecting options for Target Target 1

IJRECE VOL. 6 ISSUE 4 (OCTOBER- DECEMBER 2018)

A new window named options for Target 'Target 1' appeared where the output option was clicked and then create hex file option was enabled as shown in figure 17.

File Edit View Project I	flash Debug Peripherals Tools SVCS Window Help	
i 🗈 💕 🖬 🕔 🕺 🖏	🙇 🤊 🔍 🔶 👰 奈 高 吉 淳 淳 川 川 🦉 🖉 🖉 🔶 🔗 🖉	🤉 🊓 🖬 🗣 🔦
🕲 🕮 🕮 🖉 🞇	Target 1 😪 🎊 📥 🕾 🚸	
Project 🕑 🔀	TRIANGULAR.c	▼ ×
🖂 🔜 Target 1	S Options for Target 'Target 1'	~
In - Source Group 1	Denie Trees Dittel Line 1 Ctru Line 1 Dates Dates 100001	
	Device rage _ Cotox Losing Use C/C++ Asim Linker Debug Debug Debug	
	Select Folder for Objects Name of Executable: TRIANGULAR	
	G. Conde Eventable: 178(4)/018-48	as OPIO
	Create Batch File	
	Crasta MEX Ela	
	₹ Brown Information	
	C Crante Library ATRIANGULAR IN	
	OK Cencel Default: Help	
🖻 Р. 🚷 0. () г. О. т.		<u>></u>
Build Output		,⊖ ×
linking	486 DO 400-036 DV 400-04 27 400-0413	<u>^</u>
".\TRIANGULAR.axf"	- O Error(s), O Warning(s).	
<u>(4)</u>		2
	Smuletion L:52 C	2:1 CAP NUM SCRU OVR R
🧃 start 🔣 🔣 cijo	ocuments and Se 🖆 triangle_wave 🔂 triangular - Notepad	😫 🗘 🍕 1:10 AM

Fig 17 Enabling create hex file option

in the same window the linker option was cliked and then the option use memory layout from target dialog was enabled as shown in figure 18

😨 C: Documents and SettingsVAdministrator VDesktop/waveforms\TRIANGULAR. uvproj - µVision4 📃 🗃	×
File Edit View Project Filish Debug Peripherals Tools SVCS Window Help	
😵 🛄 🕮 🥪 🤐 🙀 Target 1 🛛 💌 🔊 📥 🕾 🔶 🎰	
Project. C 🗷 📄 TRIANGULAR.c 👻	×
Edit Terrett Cyclemen for Terreget 'Terreget 1 Cyclemen for Terreget 1 Cyclemen fo	~
Don't Search Standard Unavies Report hight fall Conditions as Errors disable Warnings:	
Sealine Fin	
Livie concentration and the second se	
DK Carcel Defaults Help	~
here we have a second sec	
11nking Program Sizen Coder1455 BO-data=236 BH-data=4 21-data=612 ••• YFILMBULAB.art* - 0 Error(s), D Warning(s).	< 1
💕 start 🔰 😨 Cl/Documents and Se 🎽 triangle_meme 💿 triangular - Notepad 😨 🕄 🎄 110 A	1

Figure 18 Enabling the option use memory layout from target dialog.

Lastly to come out of this window ok option was clicked. Finally rebuild icon was clicked in order to rebuild the target files as depicted in figure 19.

C: Documents and Settings Administrator/Desktop/waveforms/TRIANGULAR.uvproj - pVision4		🗠 🔀
File Edit View Project Flash Dabug Paripherals Tools SVCS Window Help		
🗋 😂 🛃 🖇 🖏 😋 😁 (+ ->) 🥐 啓 啓 啓 部 郎 版 🧐	👟 🍋 🚷 🗢 🍳 🖉 🖉 🕷 🔜 🗧	
🕸 🕮 📖 🧼 🛗 🙀 Target 1 🛛 💌 🍂 🧥 🔶 📾		
Project B Rebuild TRIANGULAR.c		▼ ×
Terret I 22 Minclude <lpc17xx.h></lpc17xx.h>		~
Gource Group 1 23		
24 105 Mein ()		
26 unsigned long int temp=0x0000000000		
27 unsigned int 1=0;		
20		
29 LPC FINCEN->FINELD 4= OXPFODOFF ;	// Configure P0.4 to P0.11 as GPIO	
31 LPC GPIOD->FIOMABE = OXFFFFFOOF;		
32		
33 While (1)		-
35 //OUEDUE O EO FE		
36 for (1=0;1!=0xFF;1++)		
37 (
30 temp=1;		
40 LPC GPIOL FIN = term		
41)		
42 // output FF to 1		
43 for (1=0xPF) 1:=0/1)		
45 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5		
46 temp = temp << 42		
47 LPC_GPIO0->FIOPIN = temp;		
40)//Fed of shile(1)		
50)//End of main()		~
		2
Build Output		e × 🕑
linking		~
Program Size: Code=1456 RO-data=226 RV-data=4 ZI-data=612		_
		~
International Processing Street	LUC CAL LOUGH	
Transferrenza and the		1111.01

Figure 19 Choosing the Rebuild icon to build target files.

ISSN: 2393-9028 (PRINT) | ISSN: 2348-2281 (ONLINE)

This created the hex file with 0 Error(s) and 0 warning(s) as displayed in the build output window. This is shown in figure 20.

C:Wocuments and S	Things va dministrator wesktop wavererms i Klarkovi, ak. uvproj - µvision4	- 10
e Edit View Project	Flash Debug Peripherals Tools SVCS Window Help	
a 🐸 🖬 🥵 🖉 🤅		
	Target 1 📉 🔊 🐁 🗣 🌚	
ed 🖉 🏾	TRIANGUEAR.c	
Target 1	22 #include <lpc17xx.h></lpc17xx.h>	
. Searce aroup a	24 int main ()	
	25 (
	26 unsigned long int temp=0x00000000;	
	27 unsigned int 1=0; 28	
	29 LPC PINCON->PINSELO 4= 0xFF0000FF ; // Configure P0.4 to P0.11 as GPI0	
	30 LPC_GPIO0->FIODIR = 0x00000FF0 ;	
	31 LPC_GPIO0->FIOMASK = OXFFFFFOOF;	
	33 while(1)	
	34 (
	35 //output 0 to FE	
	36 ECF(1=0)1!=0XFF(1++)	
	38 temp=1;	
	39 temp = temp << 4;	
	40 LPC_GPIO0->FIOPIN = temp;	
	42 // output FF to 1	
	43 for (i=0xFF; i!=0;i)	
	44 (
	45 temp=1;	
	47 LPC GPIOD-FIOPIN = temp;	
	48 >	
	49)//End of while(1)	
P. 🦚 18 F. 0. T.	SU)//End of main()	
Other		
gram Size: Code	1456 DO-datat206 DV-datat4 71-datat610	
mELF: creating	her file	
TRIANGULAR.axf"	- O Error(s), O Warning(s).	
	Simulation LtS2 Ct1 CAP NUM	
start 🕅	Don ments and Se 😰 briangle wave 👘 triangular - Notepad	1.13

Fig 20 Creation of Hex file.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

The analog output waveform in the form of Triangular wave was observed on the CRO by connecting the positive probe at pin-1 of RM3 with respect to the ground pin-2 RM2 by connecting the negative probe on the ARM cortex M3 LPC1768 evaluation board. In order to obtain this final output flash magic software was used to download the hex files to the controller. The flash magic software located on the desktop was double clicked and five steps were carried out sequentially to get the required output.

STEP 1: COMMUNICATION

In this step the following selections were made

- Device: LPC1768
- Com port: COM5 (as the USB cable is connected to this port).
- ➢ Baud rate: 19200
- ➢ Interface : None (ISP)
- Solution (MHz): 12

STEP 2: ERASE

In this step, the option erase blocks used by the hex file was enabled by selecting it.

STEP 3: HEX FILE

In step 3, browse option was clicked to download the hex files. In the proposed system the hex file named TRIANGULAR.hex was located in a folder named WAVEFORMS on the desktop.

STEP 4: OPTIONS

The option verify after programming was enabled in this step by selecting this particular option.

STEP 5: START

In step 5, start option was clicked so as to download the hex file to the controller on the Arm cortex M3 LPC1768 evaluation board.

IJRECE VOL. 6 ISSUE 4 (OCTOBER-DECEMBER 2018)

The steps 1 to 5 are illustrated by the photographic view as shown in figure 21

1)						
🏶 Flash Magic - NON PRODUCTION USE ONLY						
File ISP Options Tools Help						
🛅 🗔 🔍 🗃 🐗 🖌 🎩 🔉 😻 國 🌚 😂						
Step 1 - Communications Step 2 - Erase						
Select Device	LPC1768	Erase block 0 (0x000000-0x000FFF)				
COM Port:	СОМ 5 🗸 🗸 🗸	Erase block 1 (UxU01000-0x001FFF) = Erase block 2 (0x002000-0x002FFF)				
Baud Rate:	19200 💌	Erase block 3 (0x003000-0x003FFF) Erase block 4 (0x004000-0x004FFF)				
Interface:	None (ISP) 🛛 👻	Erase block 5 (0x005000-0x005FFF)				
Oscillator (MHz):	12	Erase all Flash+Lode Hd Prot Erase blocks used by Hex File				
Step 3 - Hex File Hex File: C:\Documents and Settings\Administrator\Desktop\waveforms\TR] Browse Modified: Friday, April 15, 2005, 1:12:06 AM						
Step 4 - Options Step 5 - Start!						
Verify after programming Fill unused Flash Gen block checksums Execute						
Technical on-line articles about 8051 and XA programming						
www.esacademy.com/fag/docs						
Finished 1						

Figure 21 Performing 5 flash magic software steps

As step 5 was completed, a triangular output waveform was obtained on the CRO as illustrated by the photographic view as shown in figure 22. The complete system setup for triangular output waveform is depicted in figure 23.



Figure 22 Getting the triangular output waveform.



ISSN: 2393-9028 (PRINT) | ISSN: 2348-2281 (Online)

Figure 24 Photographic view of triangular output waveform set up

Following the same procedure, the experiment was performed to get a square wave. The complete interfacing and the square wave output are illustrated by the photographic view as shown in figure 24 and 25.



Figure 24 photographic view of square output waveform



Figure 25 Getting the square output waveform.

V. CONCLUSION

In this paper the interfacing of a DAC with the ARM cortex M3 microcontroller LPC1768 was presented. The hardware and software features of Digital to Analog conversion with Analog output waveforms are presented using the ARM cortex M3 microcontroller LPC1768 Two experiments were performed with respect to the DAC interfacing. The first experiment output was a triangular waveform and the second experiment output was a square waveform. The complete interfacing system was comprised of ALS-SDA ARM cortex M3-06 evaluation board, desktop computer, and a CRO. The interfacing was carried out very smoothly by making proper hardware connections. Keil μ vision 4 and flash magic

IJRECE VOL. 6 ISSUE 4 (OCTOBER-DECEMBER 2018)

software's were used in this interfacing. The entire system was very simple, stable, reliable and easy to implement and use.

ACKNOWLEDGMENT

First of all I would like to thank Almighty Allah by the grace of whom I reached the stage of completion of this work. This avenue has been a turning point in my career to mold me into a thorough and dynamic Professional. My sincere thanks to the Management of the esteemed institution Khaja Banda Nawaz college of Engineering for their inspiration and support.

REFERENCES

- [1] Joseph Yiu, The Definitive Guide to the ARM cortex-M3, second edition, Elsevier: USA Texas instruments incorporated, 2010, pp 1-9.
- [2] Andrew N Sloss, Dominic Symes, Chris Wright, ARM System Developer"s guide Designing and optimizing system software. USA: Morgan Kaufman publications, 2004.
- [3] Trevor Martin, The Insider's Guide to the Philips ARM7 –based Microcontrollers, February 2005, pp.124-126.
- [4] Datasheet LPC1769/68/67/66/65/64/63 32-bit ARM cortex M3 microcontroller, NXP semiconductors, 4 May 2018 pp. 1-3.
- [5] A manual on Keil tools by ARM: Getting started Creating applications with μ-vision pp. 55-85, 1997-2009 <u>www.keil.com</u>
- [6] S Bhasker Reddy, K Malakondaiah, S. Raja Ratnam, Interfacing Digital to Analog converters with a Microcontroller, physics Education, October-December 1997, pp.233-244.
- [7] P.S.S Sushama, C. Nagaraja, K. Nagabhushan Raju, K. Malakondaiah, "Digital to Analog Conversion using ARM Processor", International journal of Scientific & Engineering Research, vol.3, issue 10, October 2012, pp.1-4.
- [8] Douglas Sommerville, Embedded Systems Interfacing for Engineers using the free scale HCS08 Microcontroller II: Digital and Analog Hardware Interfacing 2009, pp. 139.
- [9] Md. Moyeed Abrar, "Implementation of a Ramp Output Waveform Generator using DAC 0800", International Journal of Latest Engineering and Management Research (IJLEMR), vol. 03, issue 02, February 2018, pp. 19-25.
- [10] Aruna Kommu, Naveen Kumar Uttarkar, raghavendra Rao Kanchi, "Design and development of sensor based mini projects

ISSN: 2393-9028 (PRINT) | ISSN: 2348-2281 (ONLINE)

for embedded system laboratory using ARM cortex-M3 (LPC1768)", International conference on Information Communication and Embedded Systems (ICICES) Chennai India 2014.



Md. Moyeed Abrar is working as Assistant Professor in the department of Computer science and engineering of Khaja Banda Nawaz college of Engineering, Kalaburagi Karnataka since 2014. He has done his B.E in Electrical and Electronics from P.D.A college of Engineering affiliated to Visvesvaraya Technological University, Belagavi Karnataka. He has completed his M.Tech in Digital Electronics from Appa Institute of Engineering and Technology affiliated to Visvesvaraya Technological University, Belagavi, Karnataka. He has excellent technical skills and is a versatile and dynamic professional. He has also published several papers in various reputed International Journals. His research areas of interest are Power and Energy systems, Digital circuits and logic design, Microprocessors and Microcontrollers, Power electronics, control systems, Electrical machine design and IOT.