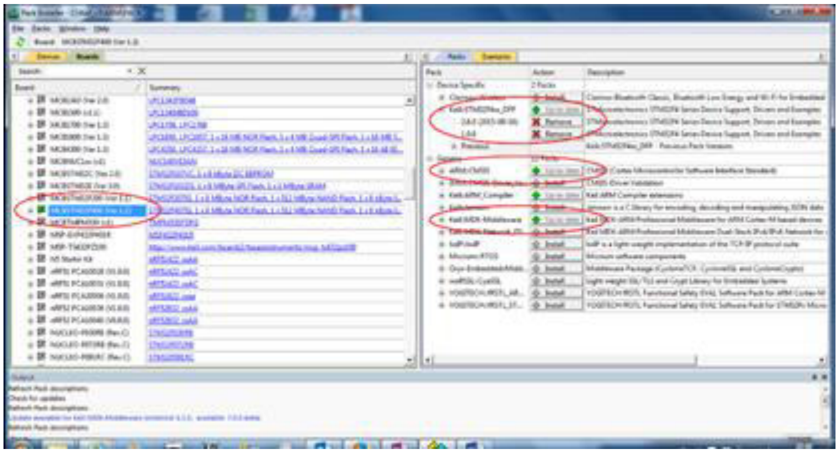
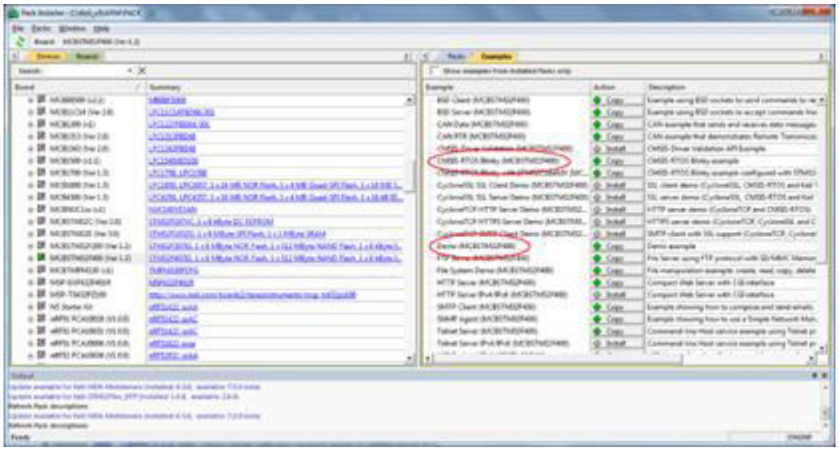
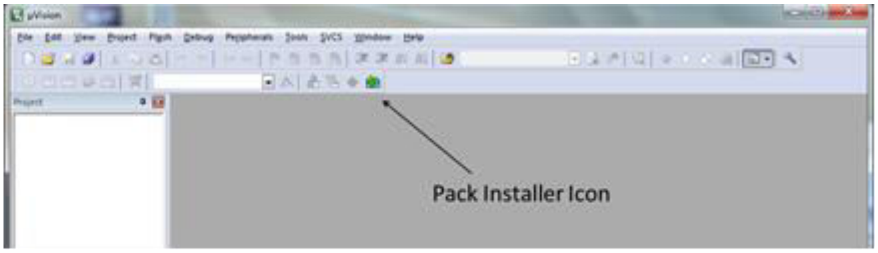
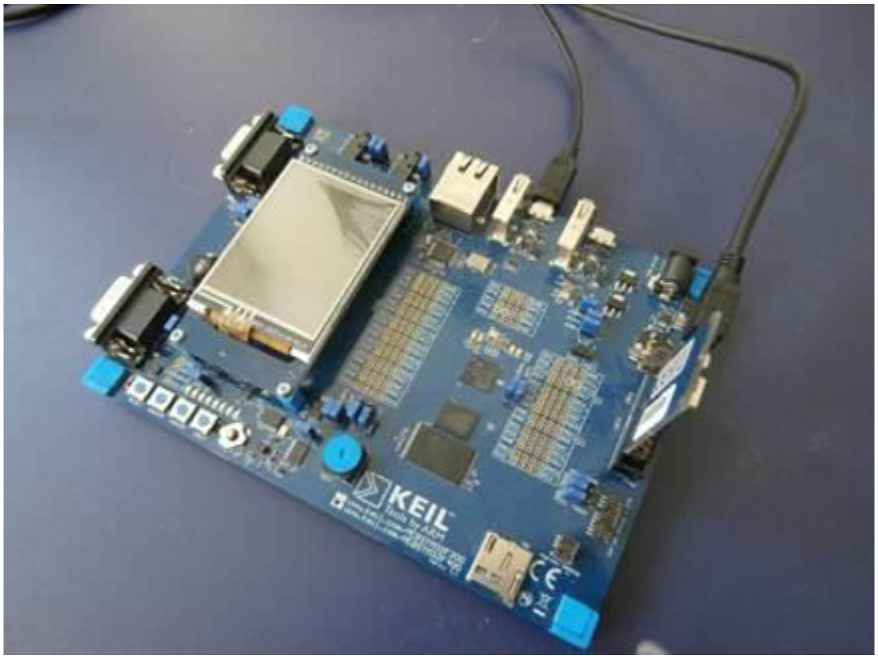
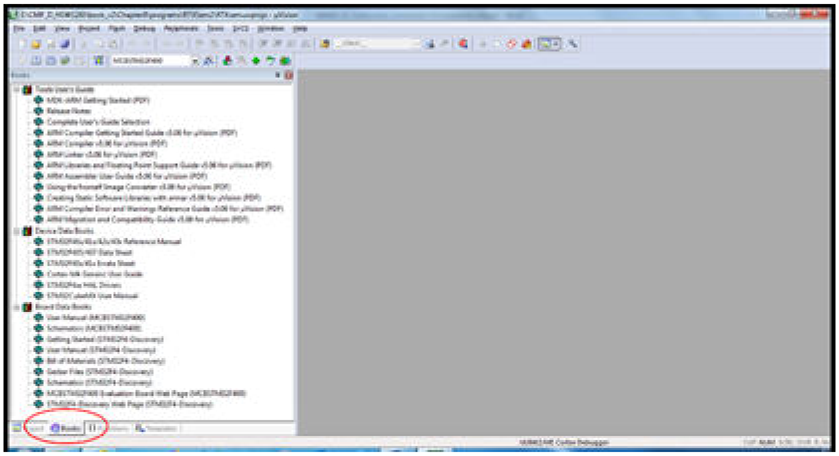
Chapter 1: A Practical Introduction to ARM® CORTEX®






µVision
File Edit View Project Flash Debug Peripherals Tools SVCS Window Help
Project
Pack Installer Icon

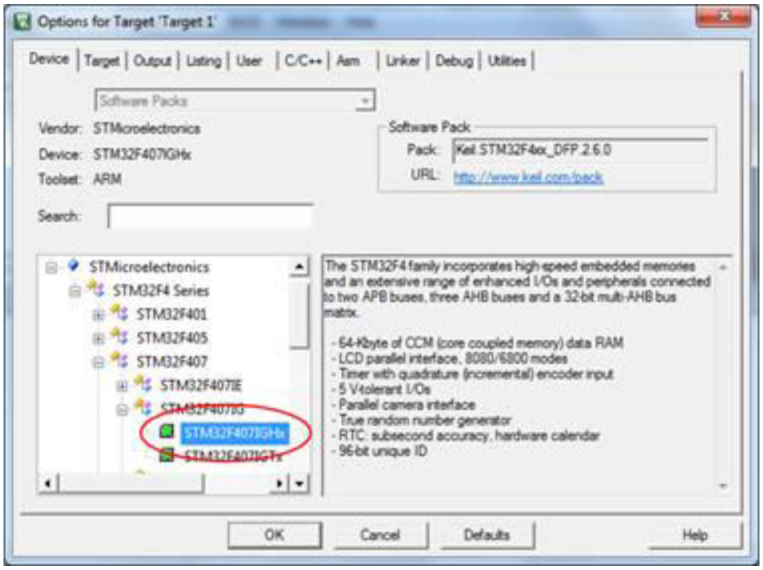




Books

- Tools User's Guide
  - MDK-ARM Getting Started (PDF)
  - Release Notes
  - Complete User's Guide Selection
  - ARM Compiler Getting Started Guide v5.06 for µVision (PDF)
  - ARM Compiler v5.06 for µVision (PDF)
  - ARM Linker v5.06 for µVision (PDF)
  - ARM Libraries and Floating Point Support Guide v5.06 for µVision (PDF)
  - ARM Assembler User Guide v5.06 for µVision (PDF)
  - Using the fromelf Image Converter v5.06 for µVision (PDF)
  - Creating Static Software Libraries with armar v5.06 for µVision (PDF)
  - ARM Compiler Error and Warnings Reference Guide v5.06 for µVision (PDF)
  - ARM Migration and Compatibility Guide v5.06 for µVision (PDF)
- Device Data Books
  - STM32F40x/41x/42x/43x Reference Manual
  - STM32F405/407 Data Sheet
  - STM32F40x/41x Errata Sheet
  - Cortex-M4 Generic User Guide
  - STM32F4xx HAL Drivers
  - STM32CubeMX User Manual
- Board Data Books
  - User Manual (MCBSTM32F400)
  - Schematics (MCBSTM32F400)
  - Getting Started (STM32F4-Discovery)
  - User Manual (STM32F4-Discovery)
  - Bill of Materials (STM32F4-Discovery)
  - Gerber Files (STM32F4-Discovery)
  - Schematics (STM32F4-Discovery)
  - MCBSTM32F400 Evaluation Board Web Page (MCBSTM32F400)
  - STM32F4-Discovery Web Page (STM32F4-Discovery)

File Edit View Project Flash Debug Peripherals Tools SVCS Window Help
MCBSTM32F400
Project | Books | Functions | Templates
ULINK2/ME Cortex Debugger



Options for Target 'Target 1'

Software Packs

Vendor: STMicroelectronics
Device: STM32F407IGHx
Toolset: ARM
Search:

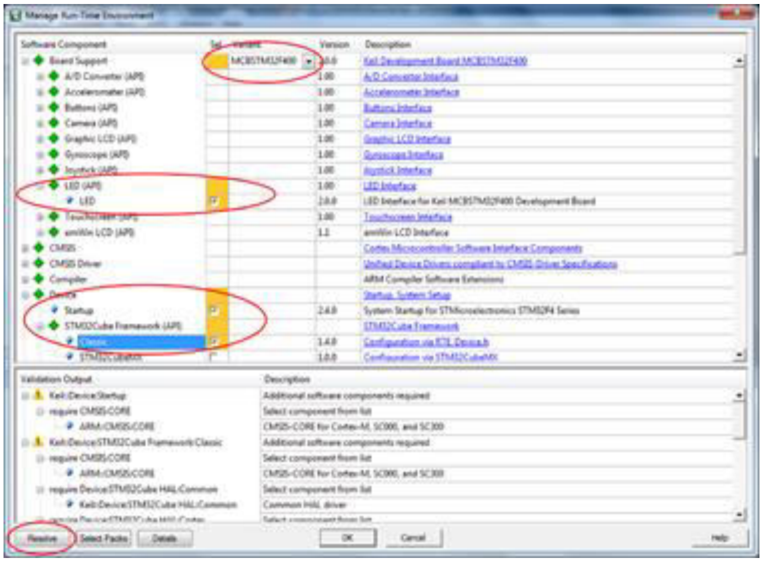
Software Pack
Pack: Keil.STM32F4xx_DFP.2.6.0
URL: http://www.keil.com/pack

- STMicroelectronics
  - STM32F4 Series
    - STM32F401
    - STM32F405
    - STM32F407
      - STM32F407IE
      - STM32F407IG
        - STM32F407IGHx
        - STM32F407IGTx

The STM32F4 family incorporates high-speed embedded memories and an extensive range of enhanced I/Os and peripherals connected to two APB buses, three AHB buses and a 32-bit multi-AHB bus matrix.

- 64-Kbyte of CCM (core coupled memory) data RAM
- LCD parallel interface, 8080/6800 modes
- Timer with quadrature (incremental) encoder input
- 5 V-tolerant I/Os
- Parallel camera interface
- True random number generator
- RTC: subsecond accuracy, hardware calendar
- 96-bit unique ID

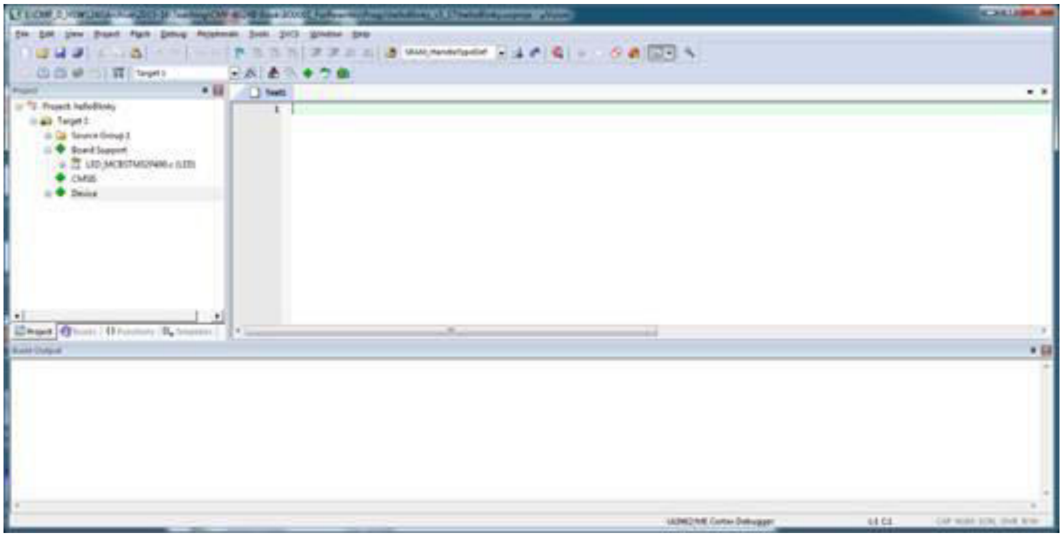
Device | Target | Output | Listing | User | C/C++ | Asm | Linker | Debug | Utilities
OK
Cancel
Defaults
Help

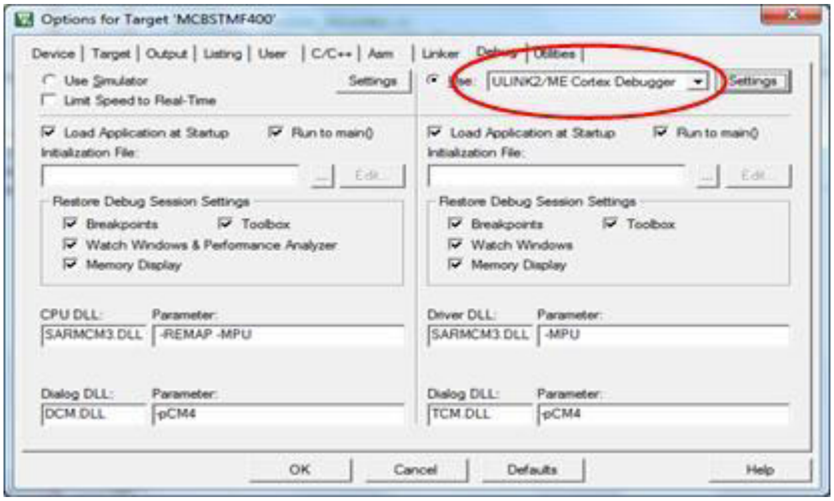


Manage Run-Time Environment

Software Component	Sel.	Variant	Version	Description
Board Support		MCBSTM32F400	2.0.0	Keil Development Board MCBSTM32F400
A/D Converter (API)			1.00	A/D Converter Interface
Accelerometer (API)			1.00	Accelerometer Interface
Buttons (API)			1.00	Buttons Interface
Camera (API)			1.00	Camera Interface
Graphic LCD (API)			1.00	Graphic LCD Interface
Gyroscope (API)			1.00	Gyroscope Interface
Joystick (API)			1.00	Joystick Interface
LED (API)			1.00	LED Interface
LED	☑		2.0.0	LED Interface for Keil MCBSTM32F400 Development Board
Touchscreen (API)			1.00	Touchscreen Interface
emWin LCD (API)			1.1	emWin LCD Interface
CMSIS				Cortex Microcontroller Software Interface Components
CMSIS Driver				Unified Device Drivers compliant to CMSIS-Driver Specifications
Compiler				ARM Compiler Software Extensions
Device				Startup, System Setup
Startup	☑		2.4.0	System Startup for STMicroelectronics STM32F4 Series
STM32Cube Framework (API)				STM32Cube Framework
Classic	☑		1.4.0	Configuration via RTE_Device.h
STM32CubeMX	□		1.0.0	Configuration via STM32CubeMX

Validation Output	Description
Keil::Device:Startup	Additional software components required
require CMSIS:CORE	Select component from list
ARM::CMSIS:CORE	CMSIS-CORE for Cortex-M, SC000, and SC300
Keil::Device:STM32Cube Framework:Classic	Additional software components required
require CMSIS:CORE	Select component from list
ARM::CMSIS:CORE	CMSIS-CORE for Cortex-M, SC000, and SC300
require Device:STM32Cube HAL:Common	Select component from list
Keil::Device:STM32Cube HAL:Common	Common HAL driver
require Device:STM32Cube HAL:Cortex	Select component from list





Options for Target 'MCBSTMF400'

Device | Target | Output | Listing | User | C/C++ | Asm | Linker | Debug | Utilities

○ Use Simulator — Settings
□ Limit Speed to Real-Time
● Use: ULINK2/ME Cortex Debugger — Settings

☑ Load Application at Startup ☑ Run to main()
Initialization File:

Restore Debug Session Settings
☑ Breakpoints ☑ Toolbox
☑ Watch Windows & Performance Analyzer
☑ Memory Display

CPU DLL: SARMCM3.DLL Parameter: -REMAP -MPU

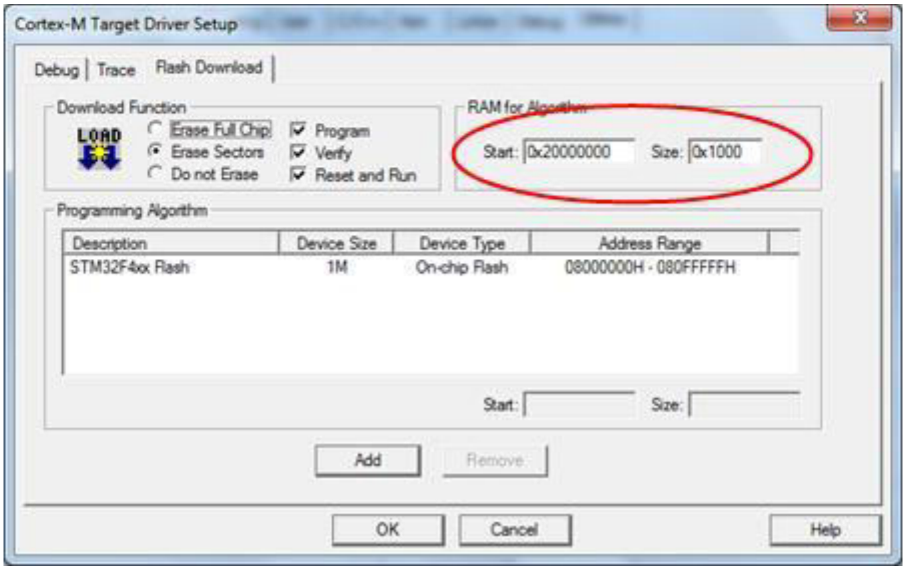
Dialog DLL: DCM.DLL Parameter: -pCM4

☑ Load Application at Startup ☑ Run to main()
Initialization File:

Restore Debug Session Settings
☑ Breakpoints ☑ Toolbox
☑ Watch Windows
☑ Memory Display

Driver DLL: SARMCM3.DLL Parameter: -MPU

Dialog DLL: TCM.DLL Parameter: -pCM4



Cortex-M Target Driver Setup

Debug | Trace | Flash Download

Download Function

○ Erase Full Chip ☑ Program

● Erase Sectors ☑ Verify

○ Do not Erase ☑ Reset and Run

RAM for Algorithm

Start: 0x20000000 Size: 0x1000

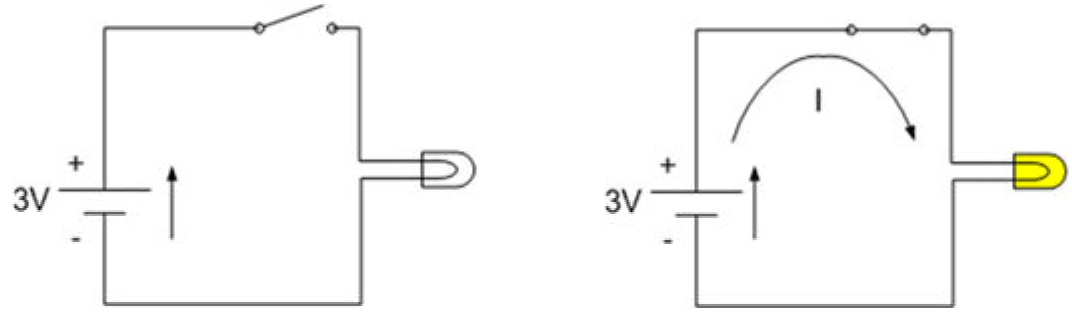
Programming Algorithm

Description	Device Size	Device Type	Address Range
STM32F4xx Flash	1M	On-chip Flash	08000000H - 080FFFFFH

Start: Size:

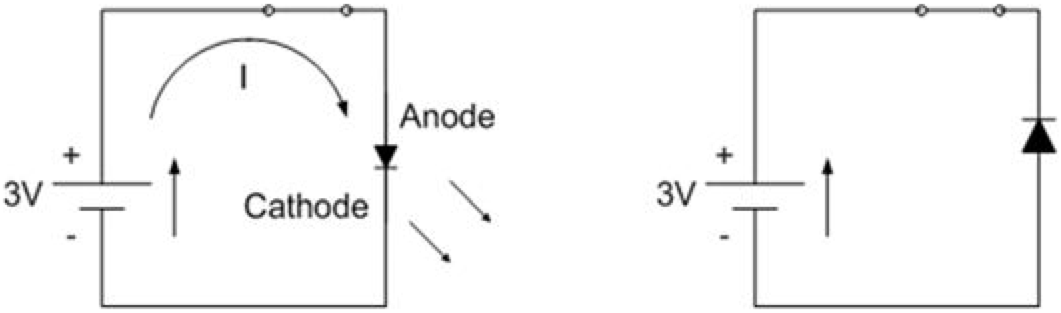
Add Remove

OK Cancel Help

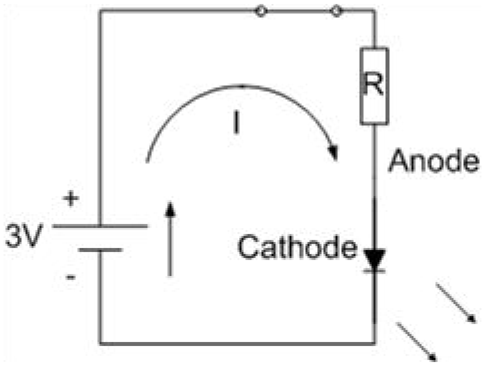


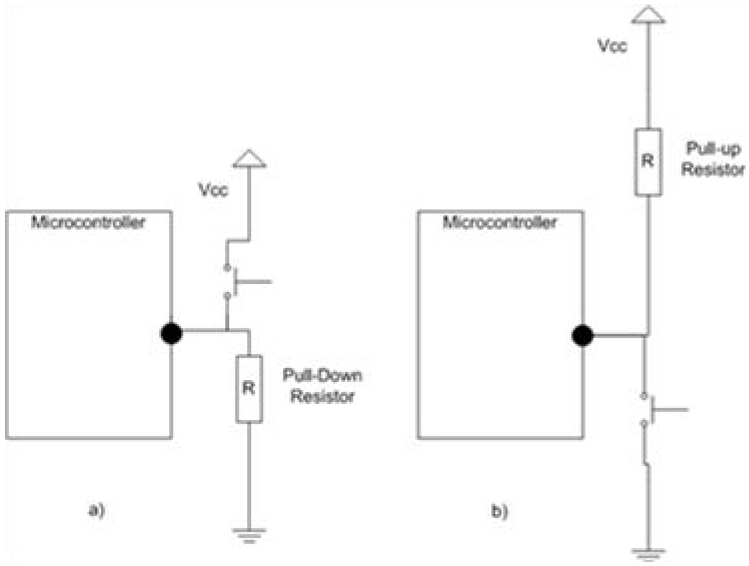
a) b)

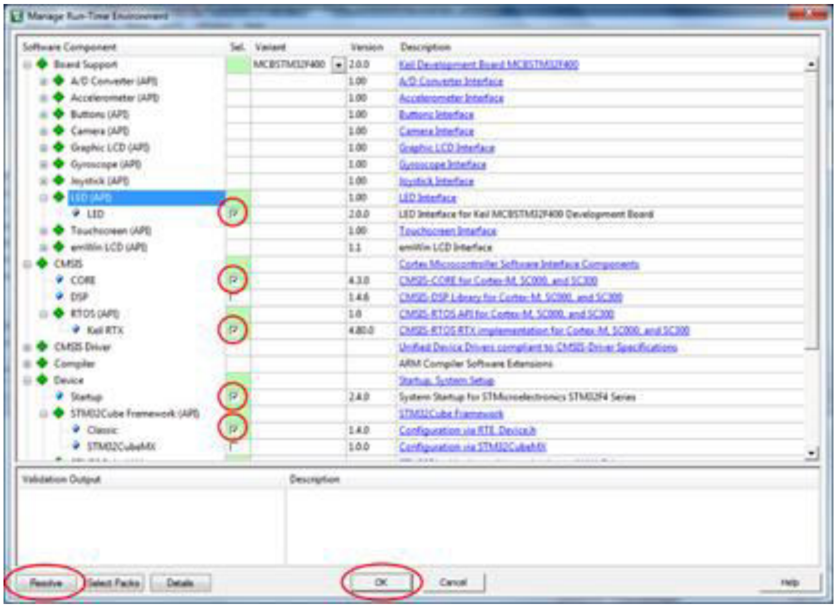
$$I = \frac{V}{R}$$



a) b)


R
I
Anode
+
3V
-
Cathode


Vcc
Pull-up
Resistor
R
Microcontroller
Vcc
Microcontroller
R
Pull-Down
Resistor
a)
b)



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Joystick (API)			1.00	Joystick Interface
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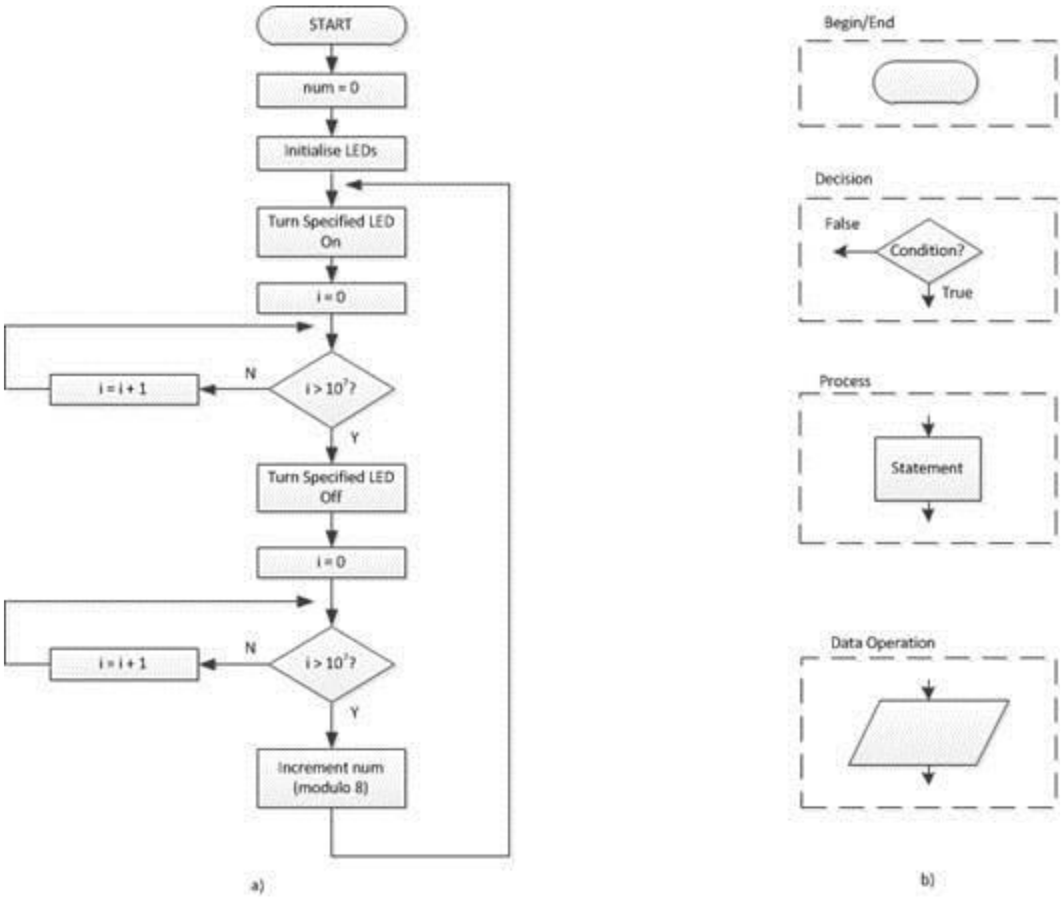
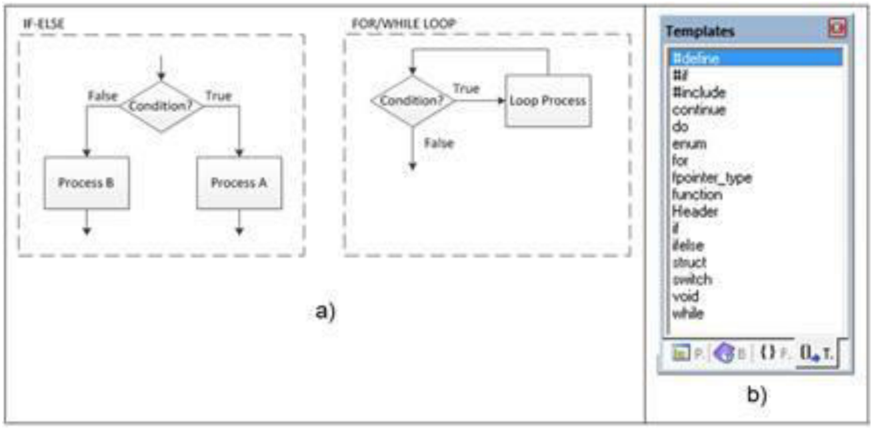
emWin LCD (API)			1.1	emWin LCD Interface
CMSIS				Cortex Microcontroller Software Interface Components
CORE	☑		4.3.0	CMSIS-CORE for Cortex-M, SC000, and SC300
DSP	□		1.4.6	CMSIS-DSP Library for Cortex-M, SC000, and SC300
RTOS (API)			1.0	CMSIS-RTOS API for Cortex-M, SC000, and SC300
Keil RTX	☑		4.80.0	CMSIS-RTOS RTX implementation for Cortex-M, SC000, and SC300
CMSIS Driver				Unified Device Drivers compliant to CMSIS-Driver Specifications
Compiler				ARM Compiler Software Extensions
Device				Startup, System Setup
Startup	☑		2.4.0	System Startup for STMicroelectronics STM32F4 Series
STM32Cube Framework (API)				STM32Cube Framework
Classic	☑		1.4.0	Configuration via RTE_Device.h
STM32CubeMX	□		1.0.0	Configuration via STM32CubeMX

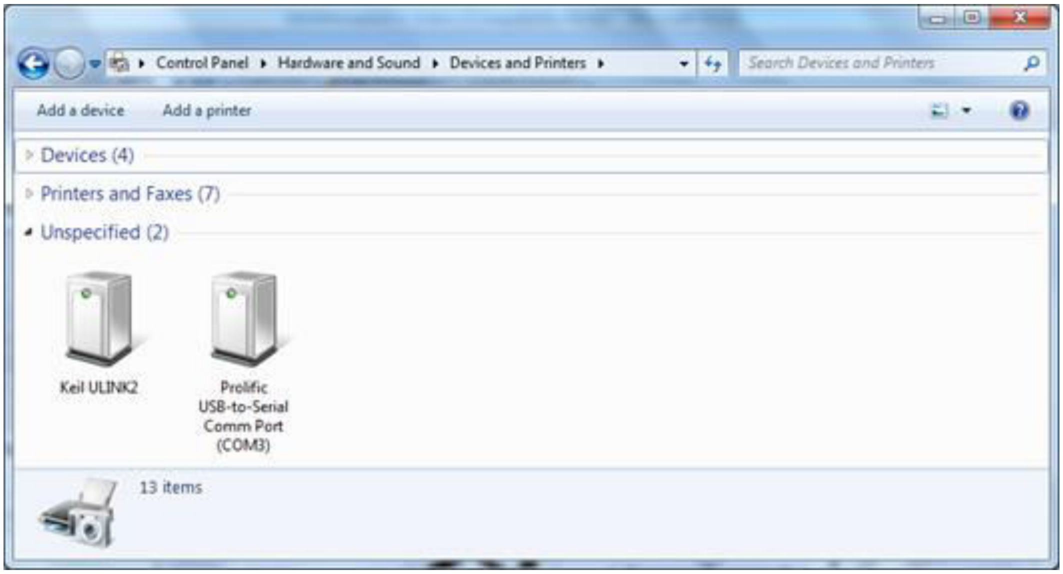
Validation Output

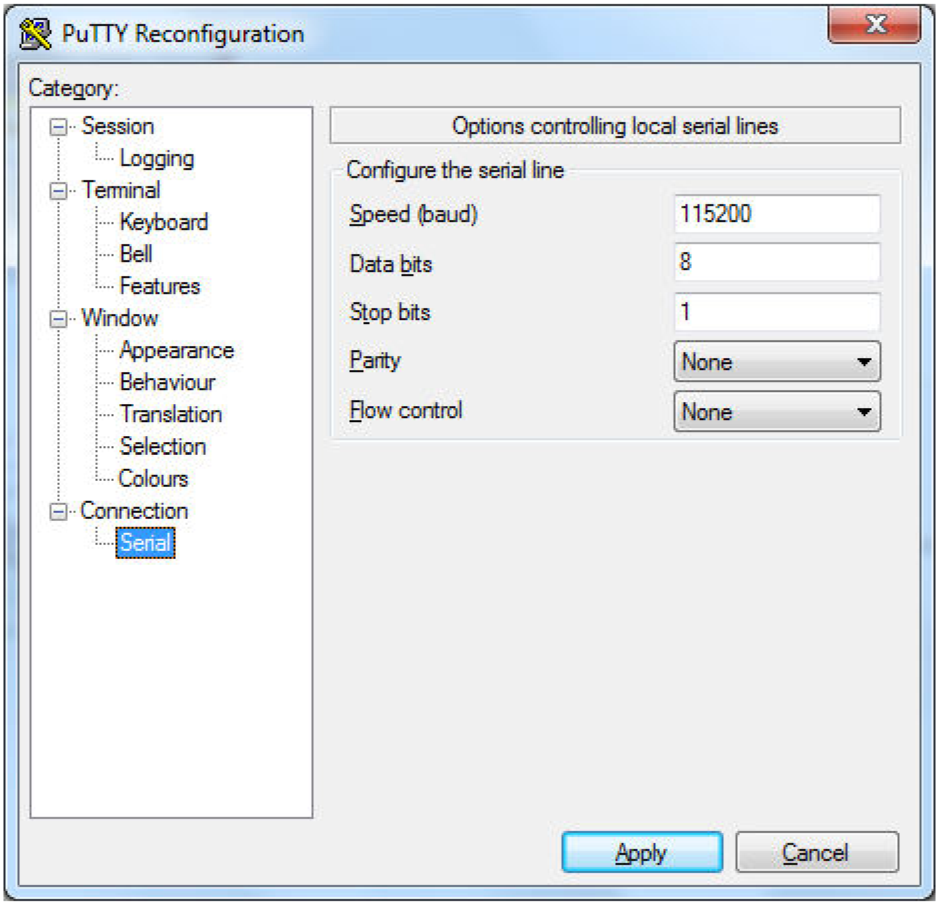
Description

$$\text{System Clock} = \frac{HSI \times N}{M \times P} = \frac{25 \times 336}{25 \times 2} = 168\ \text{MHz.}$$


START
num = 0
Initialise LEDs
Turn Specified LED On
i = 0
N
i = i + 1
i > 10^7?
Y
Turn Specified LED Off
i = 0
N
i = i + 1
i > 10^7?
Y
Increment num (modulo 8)
a)
Begin/End
Decision
False
Condition?
True
Process
Statement
Data Operation
b)

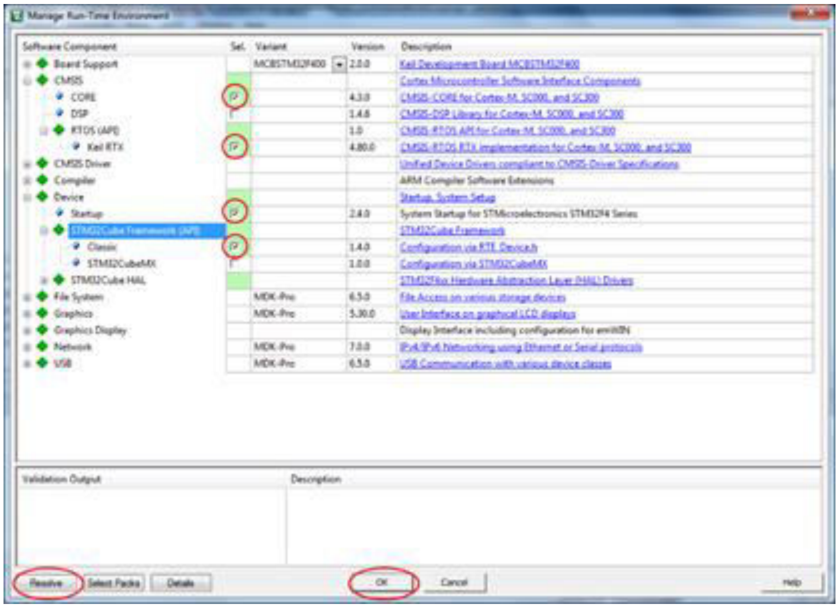

IF-ELSE
False
Condition?
True
Process B
Process A
FOR/WHILE LOOP
Condition?
True
Loop Process
False
a)
Templates
#define
#if
#include
continue
do
enum
for
fpointer_type
function
Header
if
ifelse
struct
switch
void
while
P.
B
{} F.
T.
b)


Control Panel ▸ Hardware and Sound ▸ Devices and Printers ▸
Search Devices and Printers
Add a device
Add a printer
Devices (4)
Printers and Faxes (7)
Unspecified (2)
Keil ULINK2
Prolific USB-to-Serial Comm Port (COM3)
13 items



Configure the serial line

Speed (baud)	115200
Data bits	8
Stop bits	1
Parity	None
Flow control	None



Software Component	Sel.	Variant	Version	Description
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RTOS (API)			1.0	CMSIS-RTOS API for Cortex-M, SC000, and SC300
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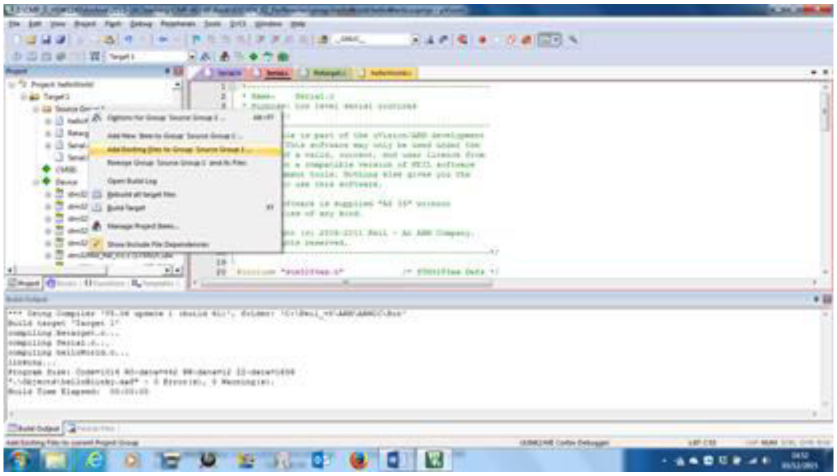
Classic	☑		1.4.0	Configuration via RTE_Device.h
STM32CubeMX	□		1.0.0	Configuration via STM32CubeMX
STM32Cube HAL				STM32F4xx Hardware Abstraction Layer (HAL) Drivers
File System		MDK-Pro	6.5.0	File Access on various storage devices
Graphics		MDK-Pro	5.30.0	User Interface on graphical LCD displays
Graphics Display				Display Interface including configuration for emWIN
Network		MDK-Pro	7.0.0	IPv4/IPv6 Networking using Ethernet or Serial protocols
USB		MDK-Pro	6.5.0	USB Communication with various device classes

Validation Output	Description

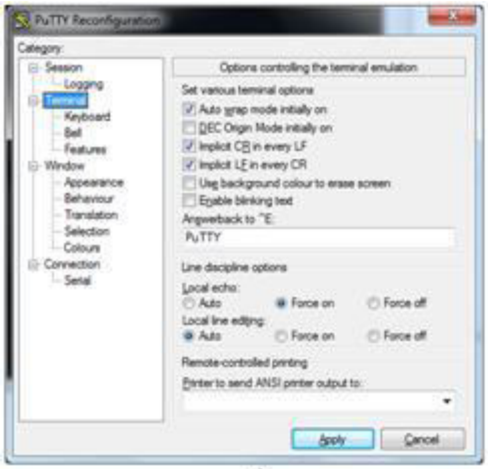
Resolve
Select Packs
Details
OK
Cancel
Help



Project
Project: helloWorld
Target 1
Source Group 1
CMSIS
Device
Serial.c
Retarget.c
helloWorld.c
Options for Group 'Source Group 1'...
Add New Item to Group 'Source Group 1'...
Add Existing Files to Group 'Source Group 1'...
Remove Group 'Source Group 1' and its Files
Open Build Log
Rebuild all target files
Build Target
Manage Project Items...
Show Include File Dependencies
Build Output
Add Existing Files to current Project Group
ULINK2/ME Cortex Debugger

```
 * Name:    Serial.c
 * Purpose: Low level serial routines
```

```
*** Using Compiler 'V5.06 update 1 (build 61)', folder: 'C:\Keil_v5\ARM\ARMCC\Bin'
Build target 'Target 1'
compiling Retarget.c...
compiling Serial.c...
compiling HelloWorld.c...
linking...
Program Size: Code=1316 RO-data=442 RW-data=12 ZI-data=1656
".\Objects\helloBlinky.axf" - 0 Error(s), 0 Warning(s).
Build Time Elapsed:  00:00:05
```



Options controlling the terminal emulation

Set various terminal options

☑ Auto wrap mode initially on
□ DEC Origin Mode initially on
☑ Implicit CR in every LF
☑ Implicit LF in every CR
□ Use background colour to erase screen
□ Enable blinking text

Answerback to ^E:
PuTTY

Line discipline options

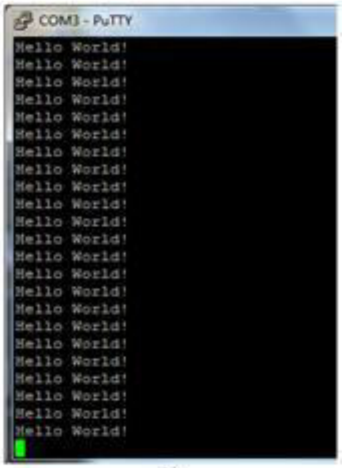
Local echo:
○ Auto ● Force on ○ Force off

Local line editing:
● Auto ○ Force on ○ Force off

Remote-controlled printing

Printer to send ANSI printer output to:

a)

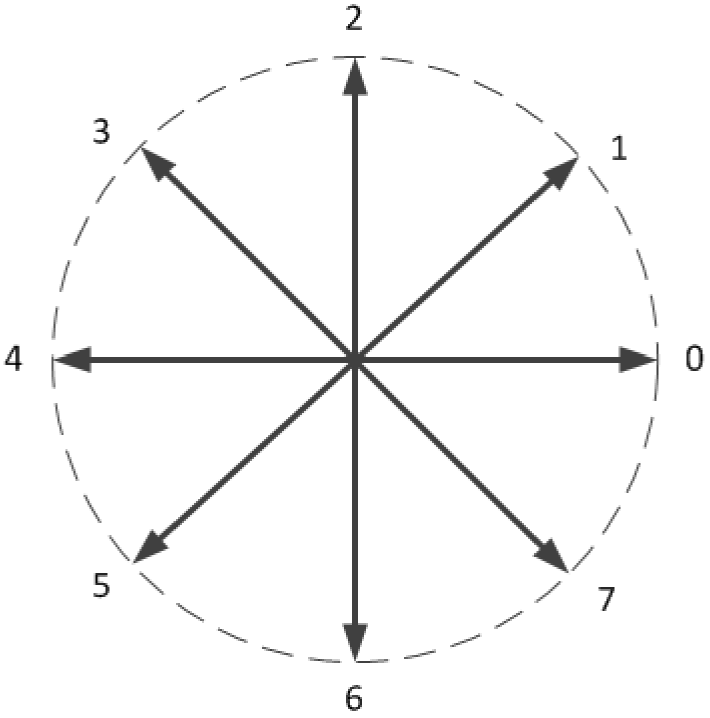


```
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
```

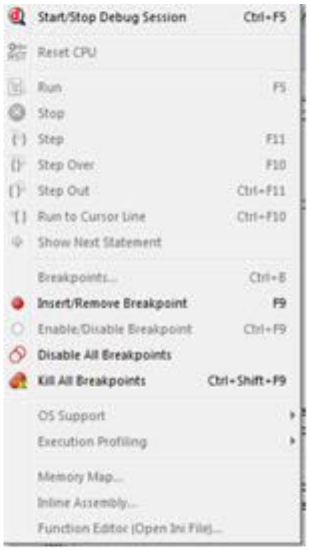
b)

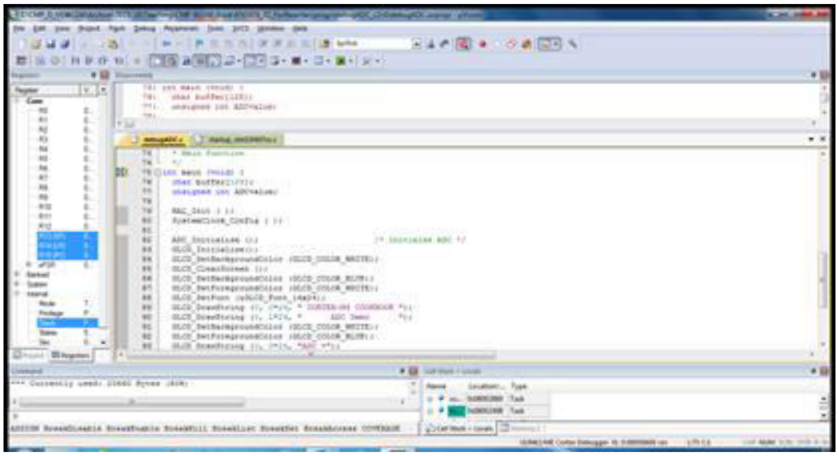
$$\text{Tx/Rx baud} = \frac{f_{clk}}{8\left(2 \times \text{OVERS}\right) \times \text{USARTDIV}}$$

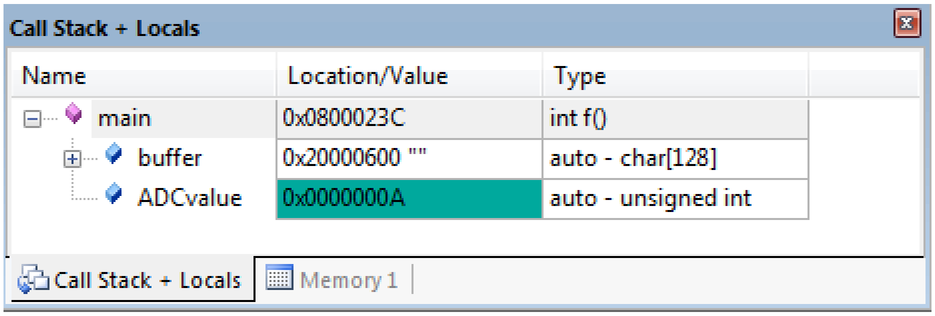
$$\text{USARTDIV} = \frac{42 \times 10^6}{16 \times 115200} = 22.78 = 22\frac{12}{16}$$



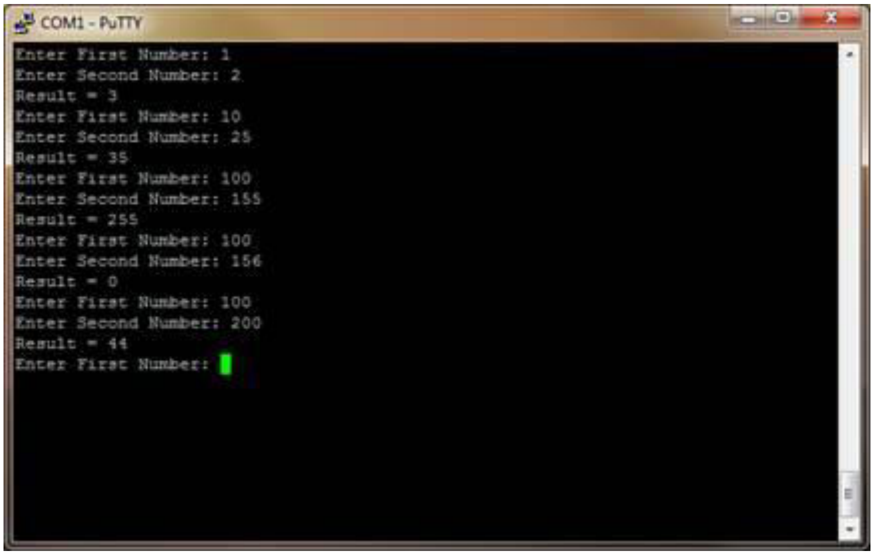
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
0x0000																	0
0x01E0						■	■	■	■								1
0x03F0					■	■	■	■	■	■							2
0x0738				■	■	■			■	■	■						3
0x0618				■	■					■	■						4
0x0618				■	■					■	■						5
0x0330					■	■			■	■							6
0x01F0					■	■	■	■	■								7
0x00F0					■	■	■	■									8
0x00F8				■	■	■	■	■									9
0x319C			■	■	■			■	■				■	■			10
0x330E		■	■	■					■	■			■	■			11
0x1E06		■	■							■	■	■	■				12
0x1C06		■	■								■	■	■				13
0x1C06		■	■								■	■	■				14
0x3F06		■	■						■	■	■	■	■	■			15
0x730C			■	■					■	■			■	■	■		16
0x21F0					■	■	■	■	■					■			17
0x0000																	18
0x0000																	19
0x0000																	20
0x0000																	21
0x0000																	22
0x0000																	23


Start/Stop Debug Session Ctrl+F5
Reset CPU
Run F5
Stop
Step F11
Step Over F10
Step Out Ctrl+F11
Run to Cursor Line Ctrl+F10
Show Next Statement
Breakpoints... Ctrl+B
Insert/Remove Breakpoint F9
Enable/Disable Breakpoint Ctrl+F9
Disable All Breakpoints
Kill All Breakpoints Ctrl+Shift+F9
OS Support
Execution Profiling
Memory Map...
Inline Assembly...
Function Editor (Open Ini File)...

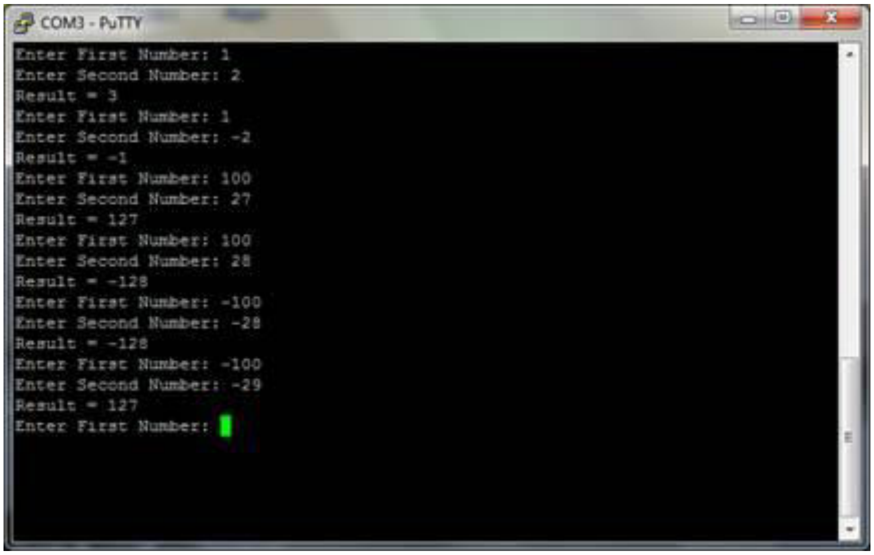




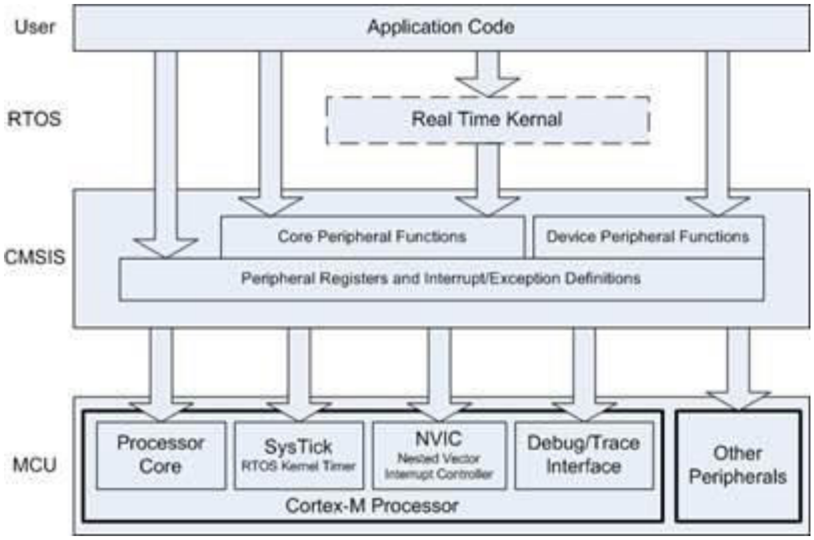
Name	Location/Value	Type
main	0x0800023C	int f()
buffer	0x20000600 ""	auto - char[128]
ADCvalue	0x0000000A	auto - unsigned int

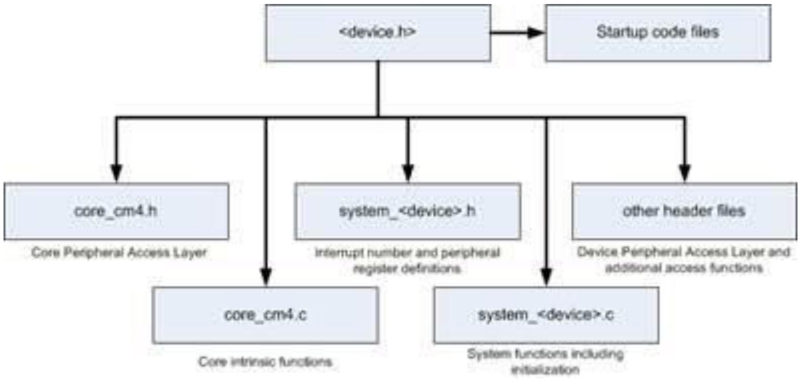


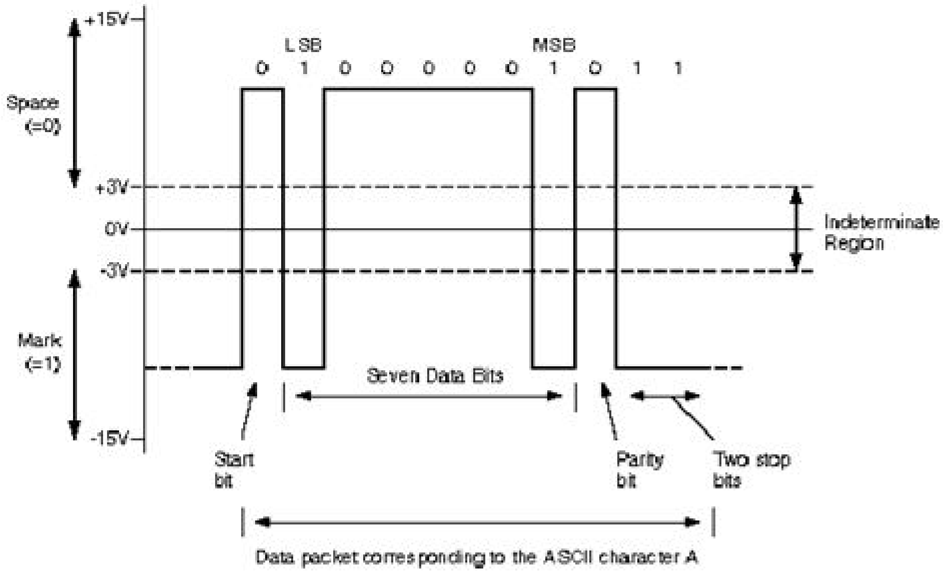
```
Enter First Number: 1
Enter Second Number: 2
Result = 3
Enter First Number: 10
Enter Second Number: 25
Result = 35
Enter First Number: 100
Enter Second Number: 155
Result = 255
Enter First Number: 100
Enter Second Number: 156
Result = 0
Enter First Number: 100
Enter Second Number: 200
Result = 44
Enter First Number:
```



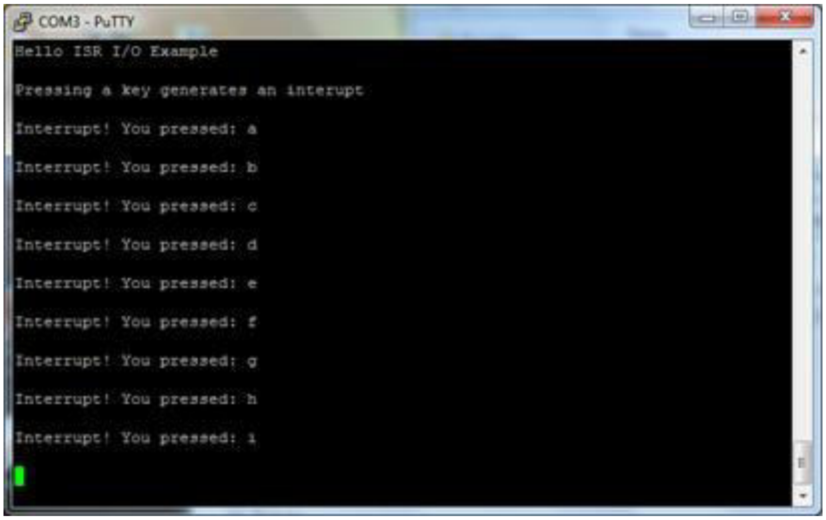
```
Enter First Number: 1
Enter Second Number: 2
Result = 3
Enter First Number: 1
Enter Second Number: -2
Result = -1
Enter First Number: 100
Enter Second Number: 27
Result = 127
Enter First Number: 100
Enter Second Number: 28
Result = -128
Enter First Number: -100
Enter Second Number: -28
Result = -128
Enter First Number: -100
Enter Second Number: -29
Result = 127
Enter First Number:
```


User
Application Code
RTOS
Real Time Kernal
CMSIS
Core Peripheral Functions
Device Peripheral Functions
Peripheral Registers and Interrupt/Exception Definitions
MCU
Processor Core
SysTick
RTOS Kernel Timer
NVIC
Nested Vector Interrupt Controller
Debug/Trace Interface
Other Peripherals
Cortex-M Processor

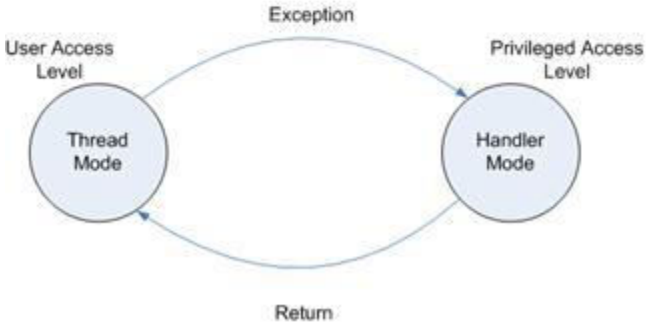

<device.h>
Startup code files
core_cm4.h
Core Peripheral Access Layer
system_<device>.h
Interrupt number and peripheral register definitions
other header files
Device Peripheral Access Layer and additional access functions
core_cm4.c
Core intrinsic functions
system_<device>.c
System functions including initialization

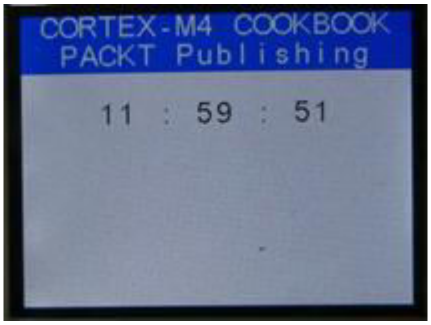


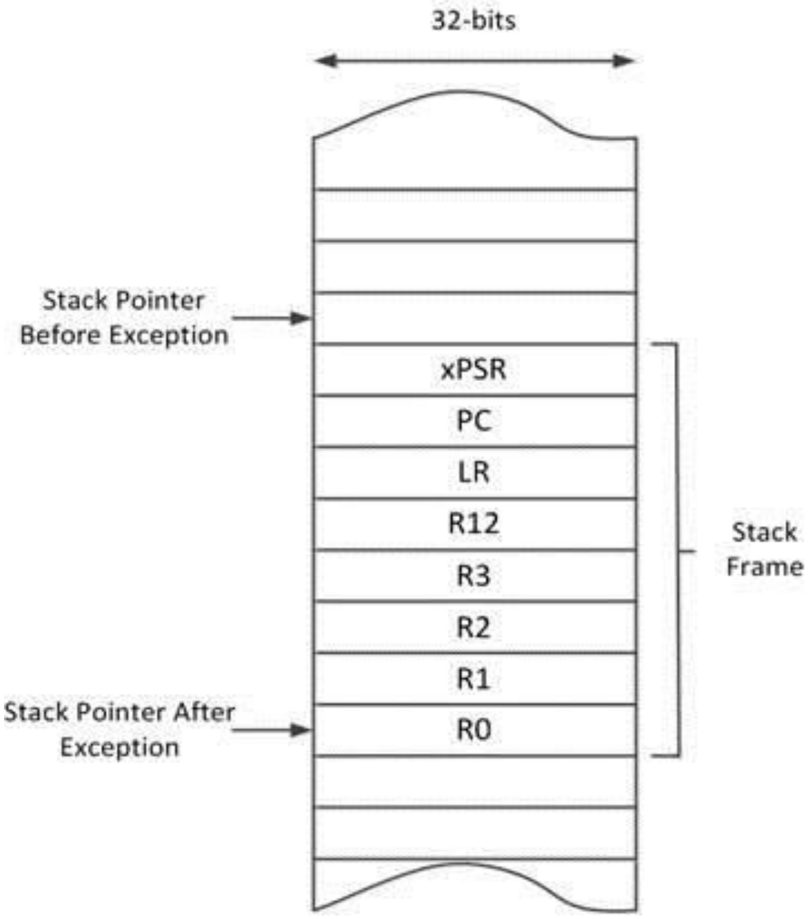
$$\text{Tx/Rx baud}=\frac{f_{clk}}{8\left(2\times\text{OVERS}\right)\times\text{USARTDIV}}$$

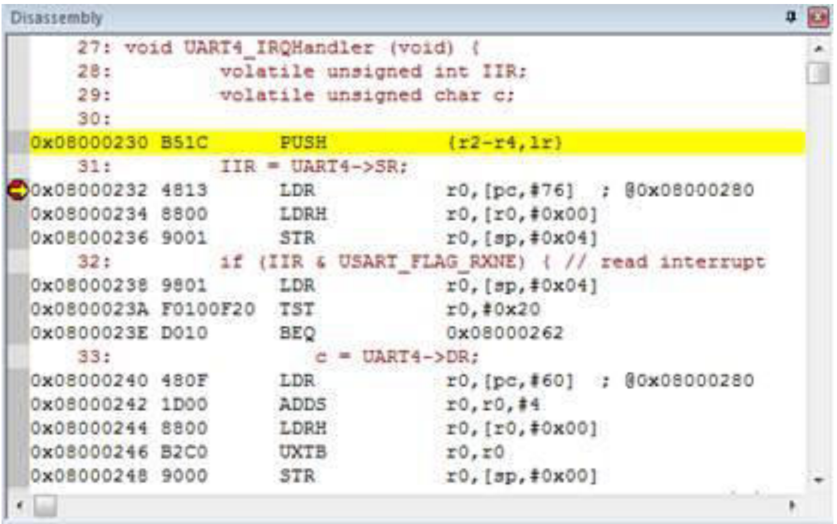


```
Hello ISR I/O Example

Pressing a key generates an interupt

Interrupt! You pressed: a

Interrupt! You pressed: b

Interrupt! You pressed: c

Interrupt! You pressed: d

Interrupt! You pressed: e

Interrupt! You pressed: f

Interrupt! You pressed: g

Interrupt! You pressed: h

Interrupt! You pressed: i
```

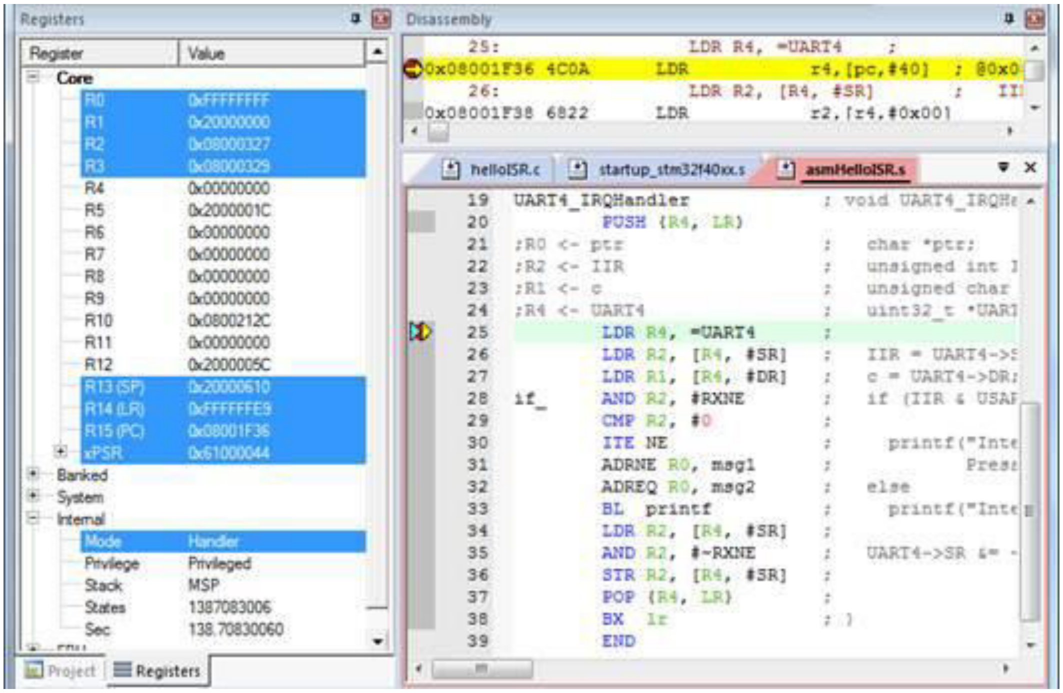





32-bits
Stack Pointer Before Exception
xPSR
PC
LR
R12
R3
R2
R1
R0
Stack Frame
Stack Pointer After Exception



```
    27: void UART4_IRQHandler (void) {
    28:         volatile unsigned int IIR;
    29:         volatile unsigned char c;
    30:
0x08000230 B51C      PUSH          {r2-r4,lr}
    31:         IIR = UART4->SR;
0x08000232 4813      LDR           r0,[pc,#76]  ; @0x08000280
0x08000234 8800      LDRH          r0,[r0,#0x00]
0x08000236 9001      STR           r0,[sp,#0x04]
    32:         if (IIR & USART_FLAG_RXNE) { // read interrupt
0x08000238 9801      LDR           r0,[sp,#0x04]
0x0800023A F0100F20  TST           r0,#0x20
0x0800023E D010      BEQ           0x08000262
    33:                 c = UART4->DR;
0x08000240 480F      LDR           r0,[pc,#60]  ; @0x08000280
0x08000242 1D00      ADDS          r0,r0,#4
0x08000244 8800      LDRH          r0,[r0,#0x00]
0x08000246 B2C0      UXTB          r0,r0
0x08000248 9000      STR           r0,[sp,#0x00]
```

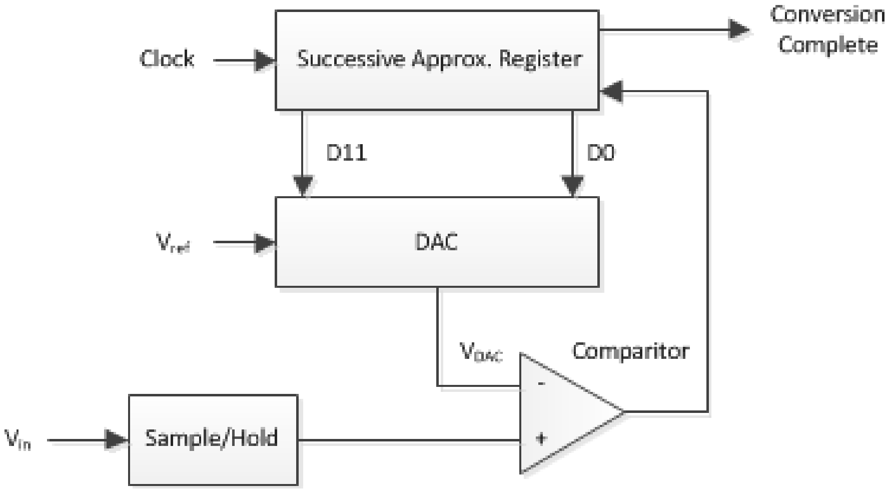


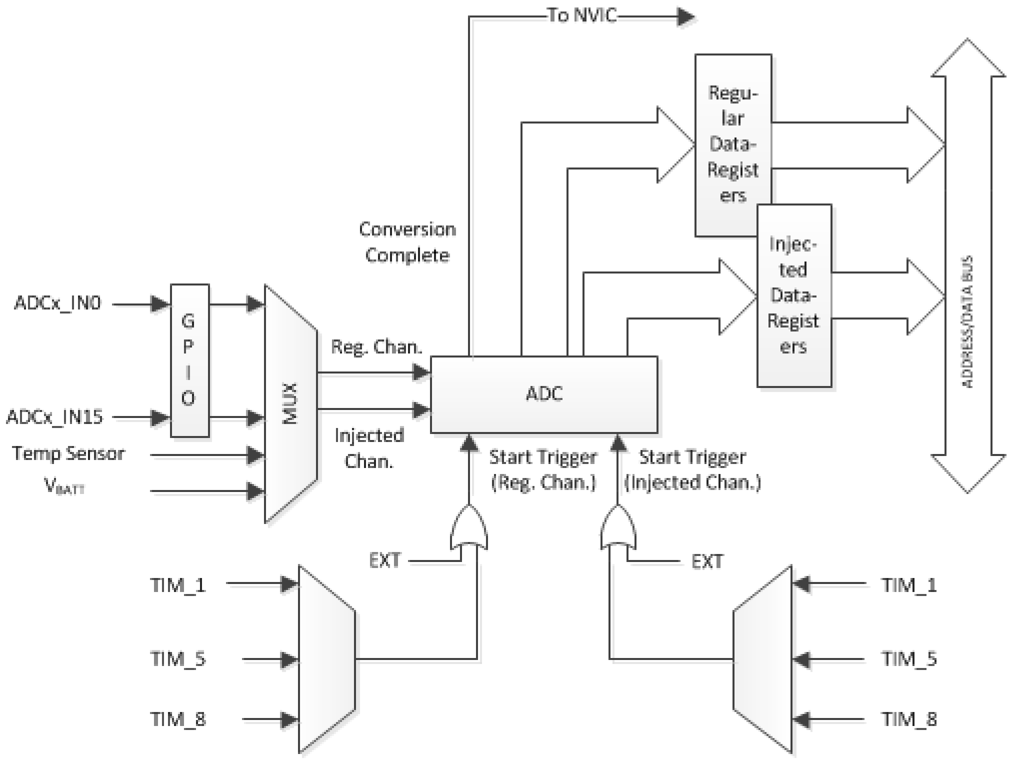
Register	Value
Core	
R0	0xFFFFFFFF
R1	0x20000000
R2	0x08000327
R3	0x08000329
R4	0x00000000
R5	0x2000001C
R6	0x00000000
R7	0x00000000
R8	0x00000000
R9	0x00000000
R10	0x0800212C
R11	0x00000000
R12	0x2000005C
R13 (SP)	0x20000610
R14 (LR)	0xFFFFFFE9
R15 (PC)	0x08001F36
xPSR	0x61000044
Banked	
System	
Internal	
Mode	Handler
Privilege	Privileged
Stack	MSP
States	1387083006
Sec	138.70830060

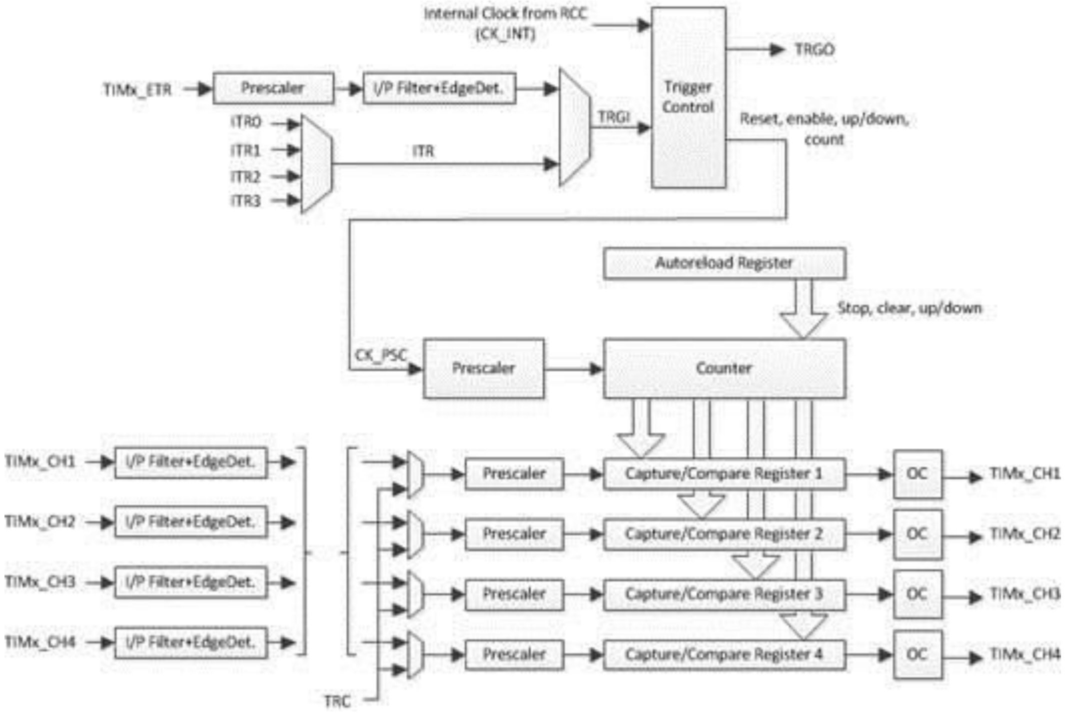
```
    25:                 LDR R4, =UART4      ;
0x08001F36 4C0A      LDR           r4,[pc,#40]   ; @0x0
    26:                 LDR R2, [R4, #SR]   ;     II
0x08001F38 6822      LDR           r2,[r4,#0x00]
```

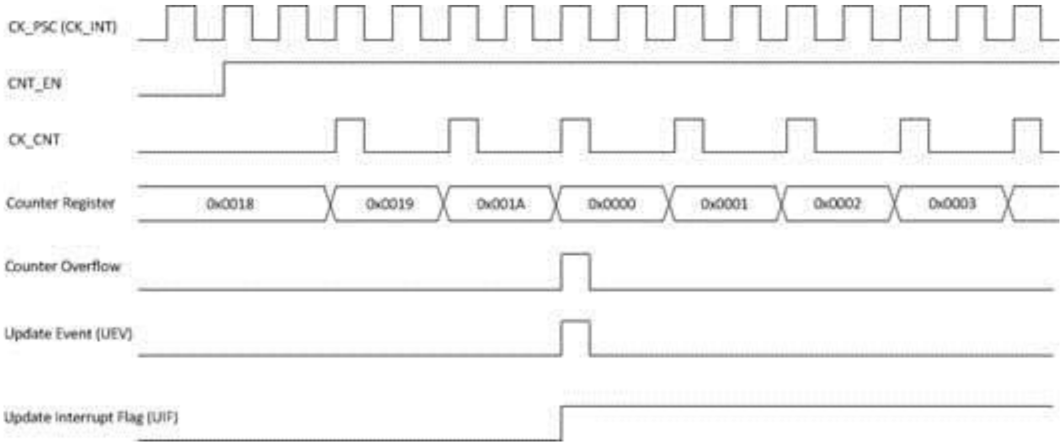
```
UART4_IRQHandler                      ; void UART4_IRQH
            PUSH {R4, LR)
;R0 <- ptr                            ;   char *ptr;
;R2 <- IIR                            ;   unsigned int I
;R1 <- c                              ;   unsigned char
;R4 <- UART4                          ;   uint32_t *UART
            LDR R4, =UART4            ;
            LDR R2, [R4, #SR]         ;   IIR = UART4->S
            LDR R1, [R4, #DR]         ;   c = UART4->DR;
if_         AND R2, #RXNE             ;   if (IIR & USAR
            CMP R2, #0                ;
            ITE NE                    ;     printf("Inte
            ADRNE R0, msg1            ;             Press
            ADREQ R0, msg2            ;   else
            BL  printf                ;     printf("Inte
            LDR R2, [R4, #SR]         ;
            AND R2, #~RXNE            ;   UART4->SR &= ~
            STR R2, [R4, #SR]         ;
            POP {R4, LR}              ;
            BX  lr                    ; }
            END
```

Chapter 5: Data Conversion



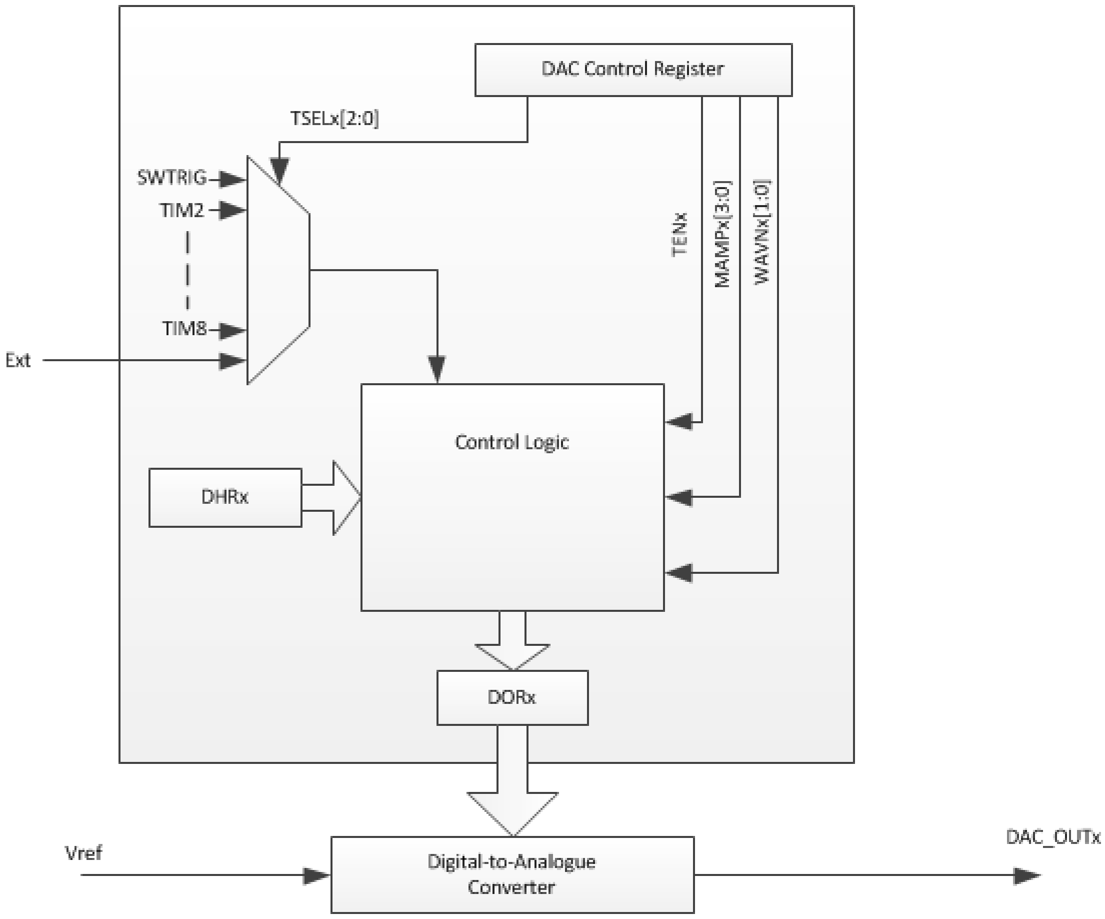


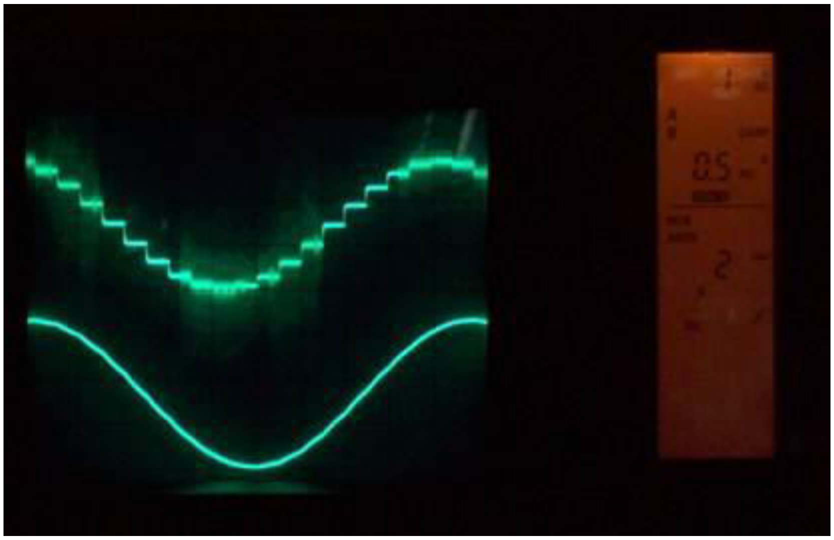

Internal Clock from RCC (CK_INT)
TRGO
TIMx_ETR
Prescaler
I/P Filter+EdgeDet.
Trigger Control
TRGI
Reset, enable, up/down, count
ITR0
ITR1
ITR2
ITR3
ITR
Autoreload Register
Stop, clear, up/down
CK_PSC
Prescaler
Counter
TIMx_CH1
TIMx_CH2
TIMx_CH3
TIMx_CH4
I/P Filter+EdgeDet.
I/P Filter+EdgeDet.
I/P Filter+EdgeDet.
I/P Filter+EdgeDet.
Prescaler
Prescaler
Prescaler
Prescaler
Capture/Compare Register 1
Capture/Compare Register 2
Capture/Compare Register 3
Capture/Compare Register 4
OC
OC
OC
OC
TIMx_CH1
TIMx_CH2
TIMx_CH3
TIMx_CH4
TRC

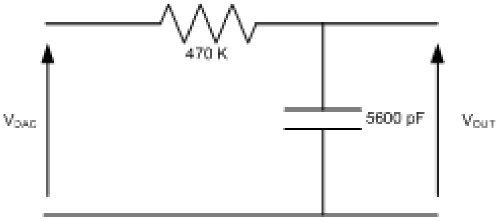

CK_PSC (CK_INT)
CNT_EN
CK_CNT
Counter Register
0x0018
0x0019
0x001A
0x0000
0x0001
0x0002
0x0003
Counter Overflow
Update Event (UEV)
Update Interrupt Flag (UIF)

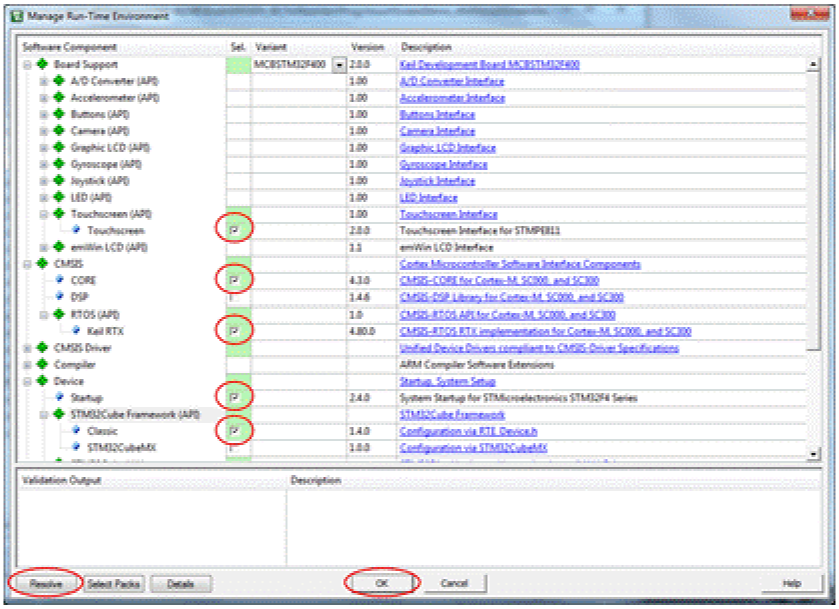
$$0.1\times\frac{\mathrm{SYSCLK}}{2}$$

$$\mathrm{CK\_CNT} = f_{\mathrm{CK\_PSC}}/\mathrm{PSC}[15:0] + 1$$



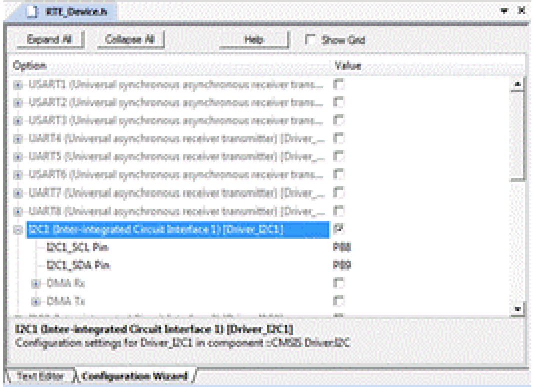

0.5
2


470 K
V_{DAC}
5600 pF
V_{OUT}



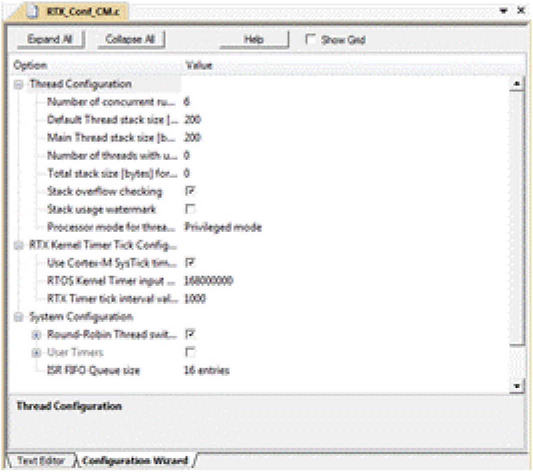
Software Component	Sel.	Variant	Version	Description
Board Support		MCBSTM32F400	2.0.0	Keil Development Board MCBSTM32F400
A/D Converter (API)			1.00	A/D Converter Interface
Accelerometer (API)			1.00	Accelerometer Interface
Buttons (API)			1.00	Buttons Interface
Camera (API)			1.00	Camera Interface
Graphic LCD (API)			1.00	Graphic LCD Interface
Gyroscope (API)			1.00	Gyroscope Interface
Joystick (API)			1.00	Joystick Interface
LED (API)			1.00	LED Interface
Touchscreen (API)			1.00	Touchscreen Interface
Touchscreen	☑		2.0.0	Touchscreen Interface for STMPE811
emWin LCD (API)			1.1	emWin LCD Interface
CMSIS				Cortex Microcontroller Software Interface Components
CORE	☑		4.3.0	CMSIS-CORE for Cortex-M, SC000, and SC300
DSP	□		1.4.6	CMSIS-DSP Library for Cortex-M, SC000, and SC300
RTOS (API)			1.0	CMSIS-RTOS API for Cortex-M, SC000, and SC300
Keil RTX	☑		4.80.0	CMSIS-RTOS RTX implementation for Cortex-M, SC000, and SC300
CMSIS Driver				Unified Device Drivers compliant to CMSIS-Driver Specifications
Compiler				ARM Compiler Software Extensions
Device				Startup, System Setup
Startup	☑		2.4.0	System Startup for STMicroelectronics STM32F4 Series
STM32Cube Framework (API)				STM32Cube Framework
Classic	☑		1.4.0	Configuration via RTE_Device.h
STM32CubeMX	□		1.0.0	Configuration via STM32CubeMX

Validation Output	Description



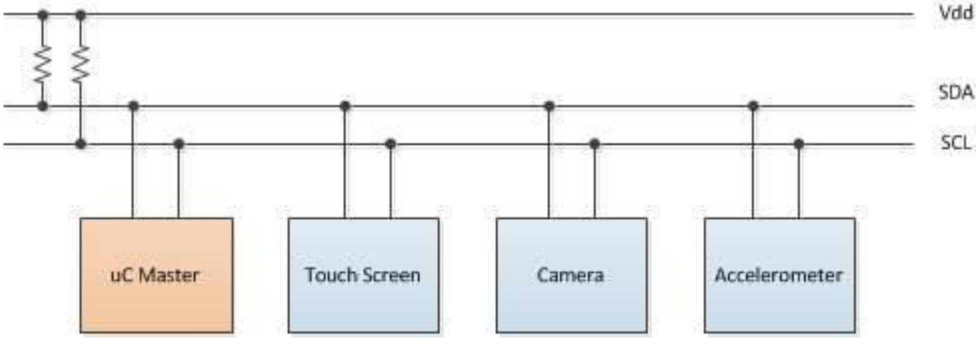
Option	Value
USART1 (Universal synchronous asynchronous receiver trans...	□
USART2 (Universal synchronous asynchronous receiver trans...	□
USART3 (Universal synchronous asynchronous receiver trans...	□
UART4 (Universal asynchronous receiver transmitter) [Driver_...	□
UART5 (Universal asynchronous receiver transmitter) [Driver_...	□
USART6 (Universal synchronous asynchronous receiver trans...	□
UART7 (Universal asynchronous receiver transmitter) [Driver_...	□
UART8 (Universal asynchronous receiver transmitter) [Driver_...	□
I2C1 (Inter-integrated Circuit Interface 1) [Driver_I2C1]	☑
I2C1_SCL Pin	PB8
I2C1_SDA Pin	PB9
DMA Rx	□
DMA Tx	□

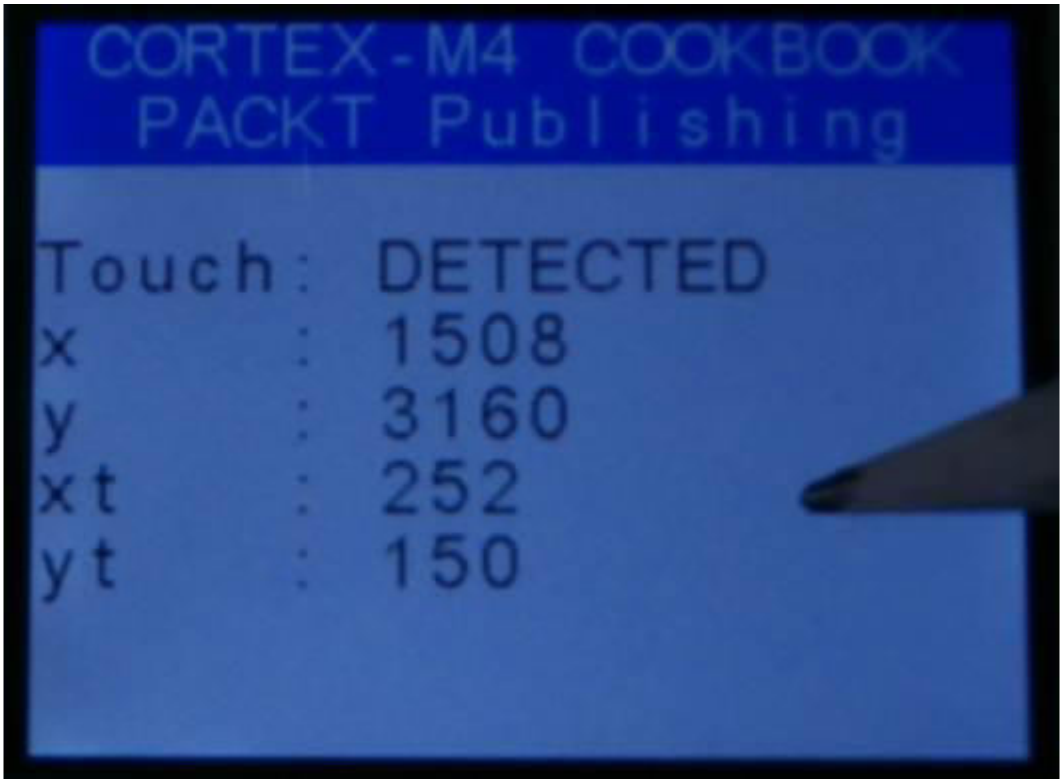
I2C1 (Inter-integrated Circuit Interface 1) [Driver_I2C1]
Configuration settings for Driver_I2C1 in component ::CMSIS Driver:I2C



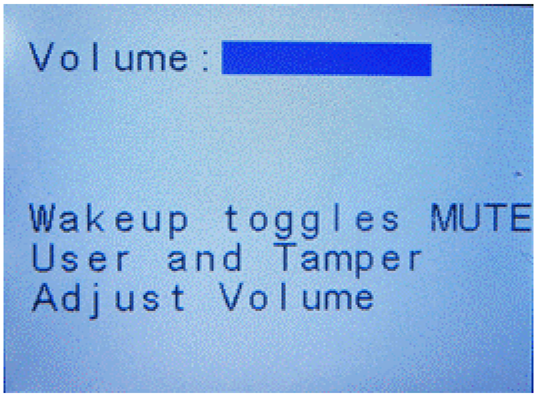
Option	Value
⊟ Thread Configuration	
Number of concurrent ru...	6
Default Thread stack size [...	200
Main Thread stack size [b...	200
Number of threads with u...	0
Total stack size [bytes] for...	0
Stack overflow checking	☑
Stack usage watermark	□
Processor mode for threa...	Privileged mode
⊟ RTX Kernel Timer Tick Config...	
Use Cortex-M SysTick tim...	☑
RTOS Kernel Timer input ...	168000000
RTX Timer tick interval val...	1000
⊟ System Configuration	
⊞ Round-Robin Thread swit...	☑
⊞ User Timers	□
ISR FIFO Queue size	16 entries

Thread Configuration

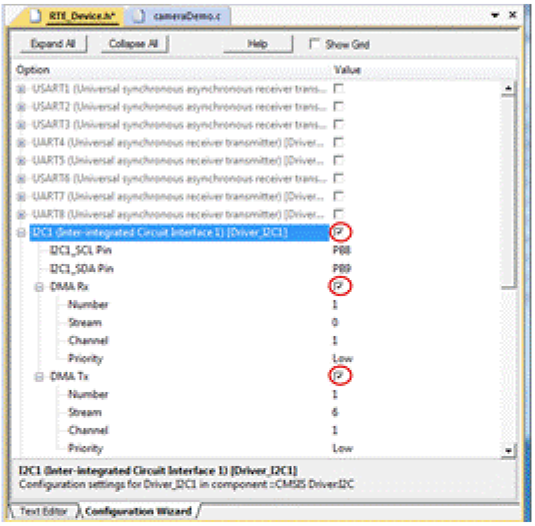




```
CORTEX-M4 COOKBOOK
PACKT Publishing

Touch : DETECTED
x     : 1508
y     : 3160
xt    : 252
yt    : 150
```

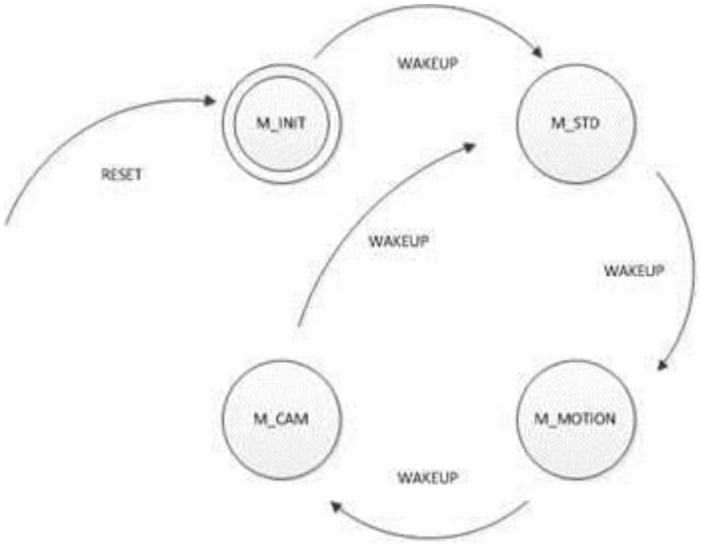


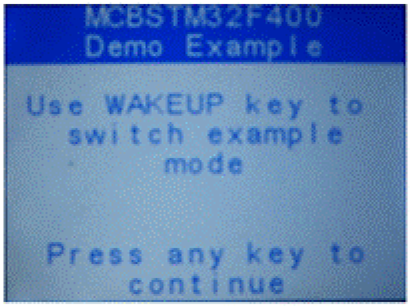
```
Volume:


Wakeup toggles MUTE
User and Tamper
Adjust Volume
```

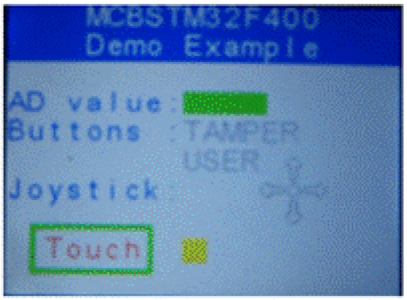


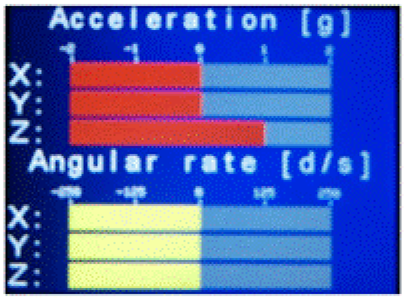
Option	Value
⊞ USART1 (Universal synchronous asynchronous receiver trans...	□
⊞ USART2 (Universal synchronous asynchronous receiver trans...	□
⊞ USART3 (Universal synchronous asynchronous receiver trans...	□
⊞ UART4 (Universal asynchronous receiver transmitter) [Driver...	□
⊞ UART5 (Universal asynchronous receiver transmitter) [Driver...	□
⊞ USART6 (Universal synchronous asynchronous receiver trans...	□
⊞ UART7 (Universal asynchronous receiver transmitter) [Driver...	□
⊞ UART8 (Universal asynchronous receiver transmitter) [Driver...	□
⊟ I2C1 (Inter-integrated Circuit Interface 1) [Driver_I2C1]	☑
I2C1_SCL Pin	PB8
I2C1_SDA Pin	PB9
⊟ DMA Rx	☑
Number	1
Stream	0
Channel	1
Priority	Low
⊟ DMA Tx	☑
Number	1
Stream	6
Channel	1
Priority	Low

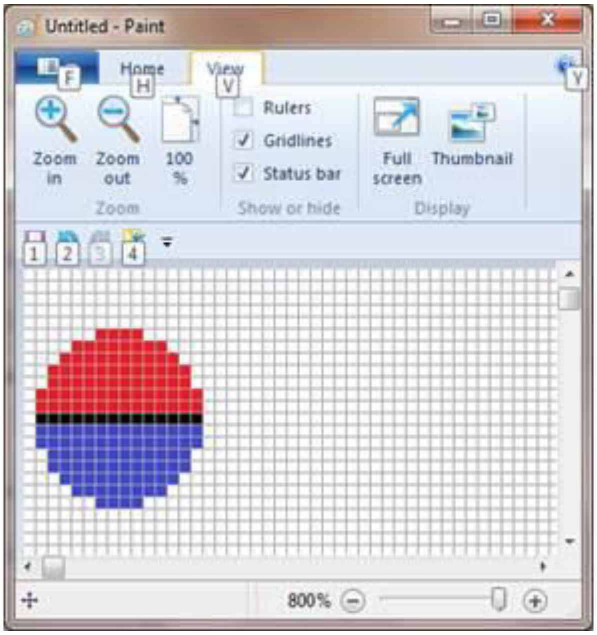
I2C1 (Inter-integrated Circuit Interface 1) [Driver_I2C1]
Configuration settings for Driver_I2C1 in component ::CMSIS Driver:I2C

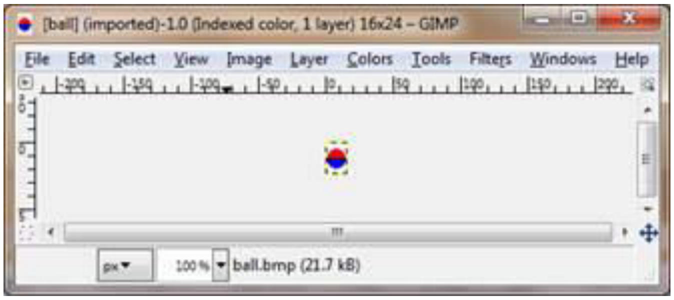



MCBSTM32F400
Demo Example
Use WAKEUP key to switch example mode
Press any key to continue


MCBSTM32F400
Demo Example
AD value:
Buttons :TAMPER
USER
Joystick:
Touch

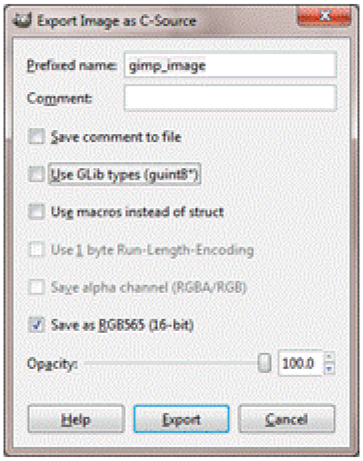

Acceleration [g]
-2
-1
0
1
2
X:
Y:
Z:
Angular rate [d/s]
-250
-125
0
125
250
X:
Y:
Z:


Untitled - Paint
F
Home
H
View
V
Y
Zoom in
Zoom out
100 %
Zoom
Rulers
Gridlines
Status bar
Show or hide
Full screen
Thumbnail
Display
1
2
3
4
800%



[ball] (imported)-1.0 (Indexed color, 1 layer) 16x24 – GIMP

ball.bmp (21.7 kB)



Export Image as C-Source

Prefixed name: gimp_image

Comment:

□ Save comment to file

□ Use GLib types (guint8*)

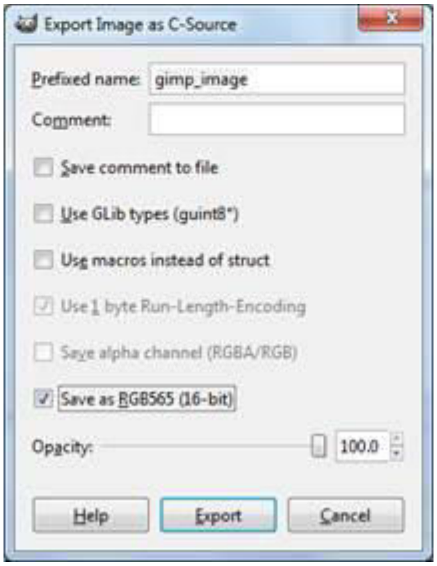
□ Use macros instead of struct

□ Use 1 byte Run-Length-Encoding

□ Save alpha channel (RGBA/RGB)

☑ Save as RGB565 (16-bit)

Opacity: 100.0



Export Image as C-Source

Prefixed name: gimp_image

Comment:

□ Save comment to file

□ Use GLib types (guint8*)

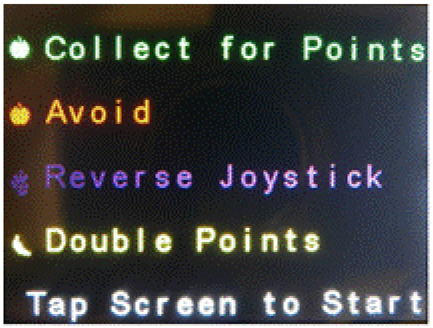
□ Use macros instead of struct

☑ Use 1 byte Run-Length-Encoding

□ Save alpha channel (RGBA/RGB)

☑ Save as RGB565 (16-bit)

Opacity: 100.0



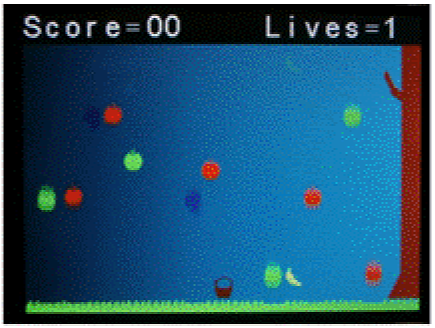
● Collect for Points

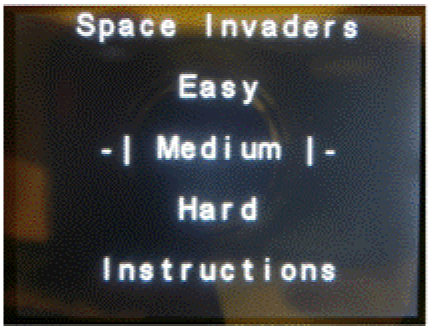
● Avoid

Reverse Joystick

Double Points

Tap Screen to Start





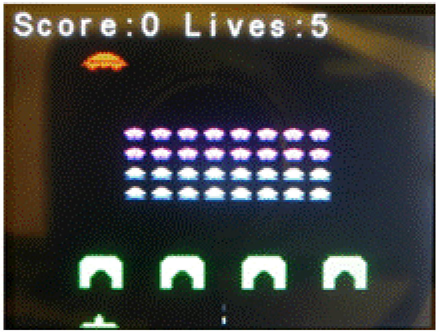
Space Invaders

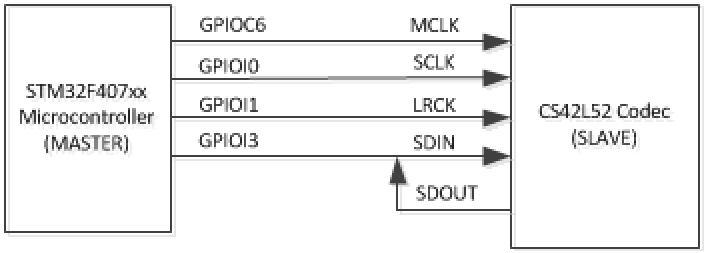
Easy

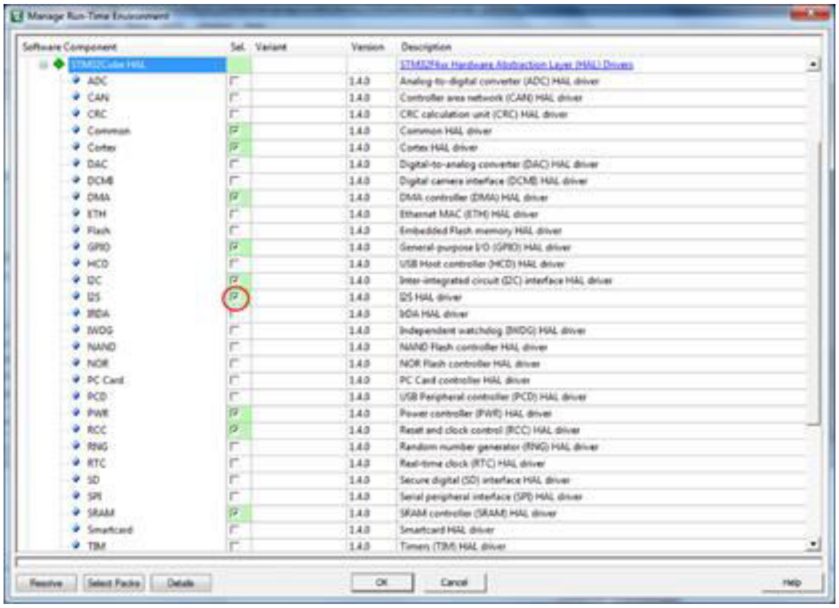
-| Medium |-

Hard

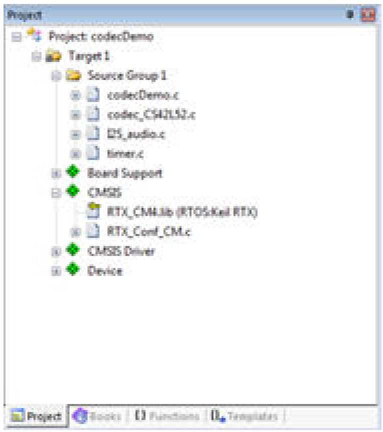
Instructions



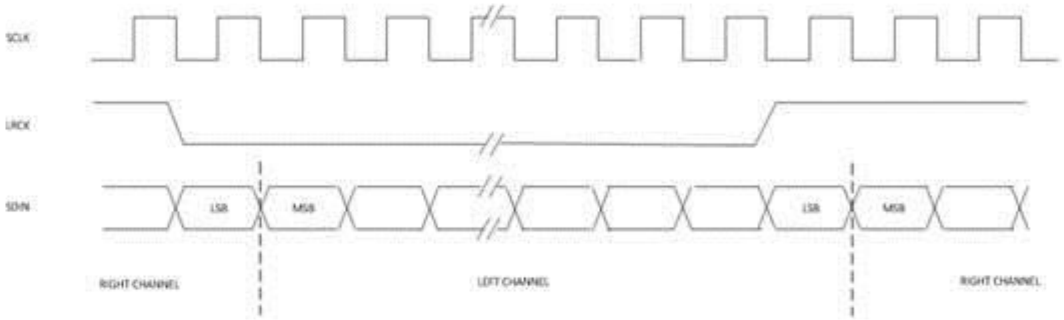


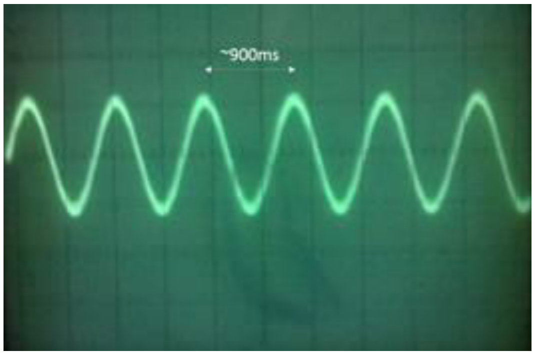

Manage Run-Time Environment

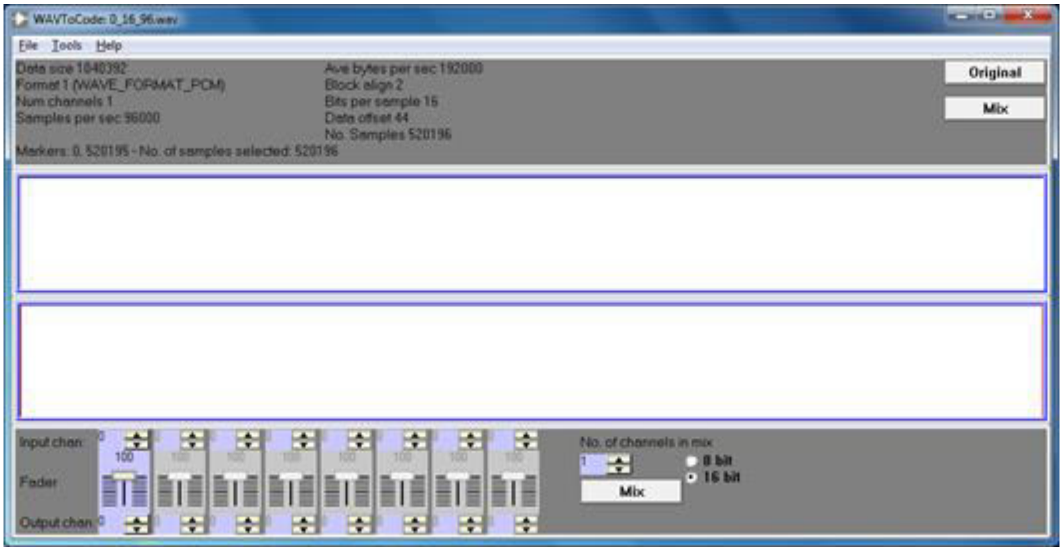
Software Component	Sel.	Variant	Version	Description
STM32Cube HAL				STM32F4xx Hardware Abstraction Layer (HAL) Drivers
ADC	□		1.4.0	Analog-to-digital converter (ADC) HAL driver
CAN	□		1.4.0	Controller area network (CAN) HAL driver
CRC	□		1.4.0	CRC calculation unit (CRC) HAL driver
Common	☑		1.4.0	Common HAL driver
Cortex	☑		1.4.0	Cortex HAL driver
DAC	□		1.4.0	Digital-to-analog converter (DAC) HAL driver
DCMI	□		1.4.0	Digital camera interface (DCMI) HAL driver
DMA	☑		1.4.0	DMA controller (DMA) HAL driver
ETH	□		1.4.0	Ethernet MAC (ETH) HAL driver
Flash	□		1.4.0	Embedded Flash memory HAL driver
GPIO	☑		1.4.0	General-purpose I/O (GPIO) HAL driver
HCD	□		1.4.0	USB Host controller (HCD) HAL driver
I2C	☑		1.4.0	Inter-integrated circuit (I2C) interface HAL driver
I2S	☑		1.4.0	I2S HAL driver
IRDA	□		1.4.0	IrDA HAL driver
IWDG	□		1.4.0	Independent watchdog (IWDG) HAL driver
NAND	□		1.4.0	NAND Flash controller HAL driver
NOR	□		1.4.0	NOR Flash controller HAL driver
PC Card	□		1.4.0	PC Card controller HAL driver
PCD	□		1.4.0	USB Peripheral controller (PCD) HAL driver
PWR	☑		1.4.0	Power controller (PWR) HAL driver
RCC	☑		1.4.0	Reset and clock control (RCC) HAL driver
RNG	□		1.4.0	Random number generator (RNG) HAL driver
RTC	□		1.4.0	Real-time clock (RTC) HAL driver
SD	□		1.4.0	Secure digital (SD) interface HAL driver
SPI	□		1.4.0	Serial peripheral interface (SPI) HAL driver
SRAM	☑		1.4.0	SRAM controller (SRAM) HAL driver
Smartcard	□		1.4.0	Smartcard HAL driver
TIM	□		1.4.0	Timers (TIM) HAL driver


Project

```
Project: codecDemo
  Target 1
    Source Group 1
      codecDemo.c
      codec_CS42L52.c
      I2S_audio.c
      timer.c
    Board Support
    CMSIS
      RTX_CM4.lib (RTOS:Keil RTX)
      RTX_Conf_CM.c
    CMSIS Driver
    Device
```

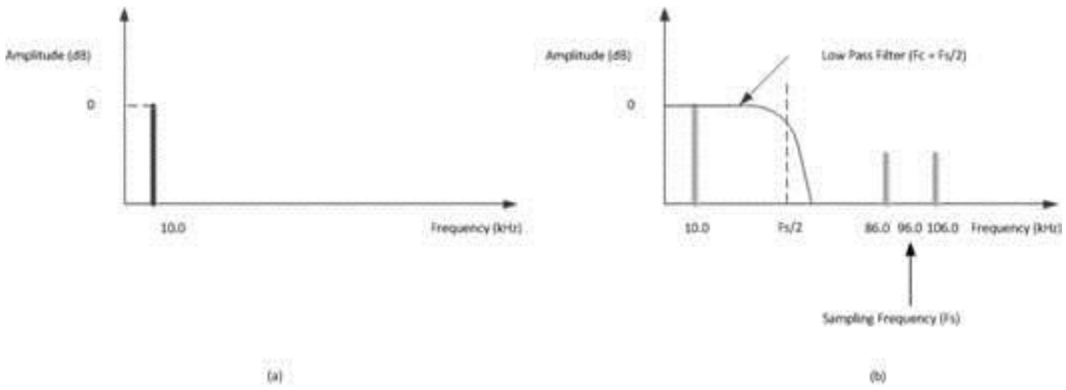


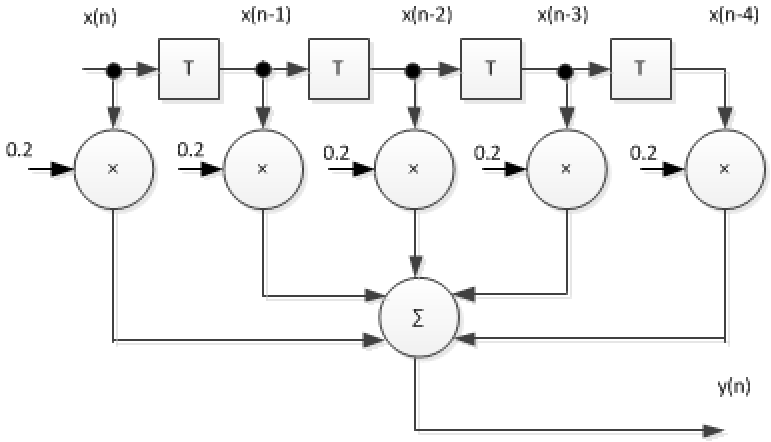




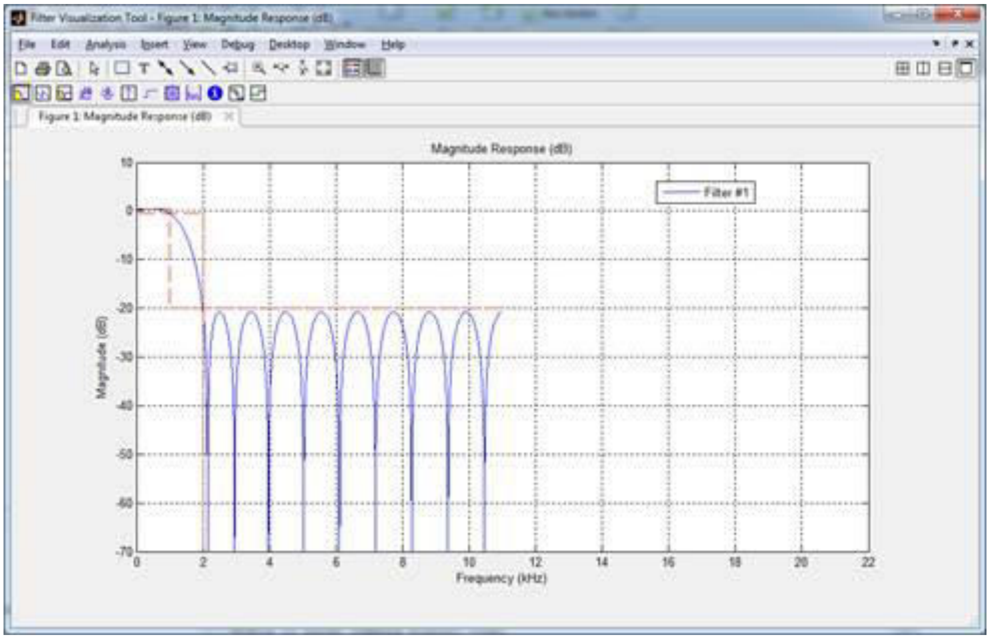
Data size 1040392
Format 1 (WAVE_FORMAT_PCM)
Num channels 1
Samples per sec 96000
Ave bytes per sec 192000
Block align 2
Bits per sample 16
Data offset 44
No. Samples 520196
Markers: 0, 520195 - No. of samples selected: 520196

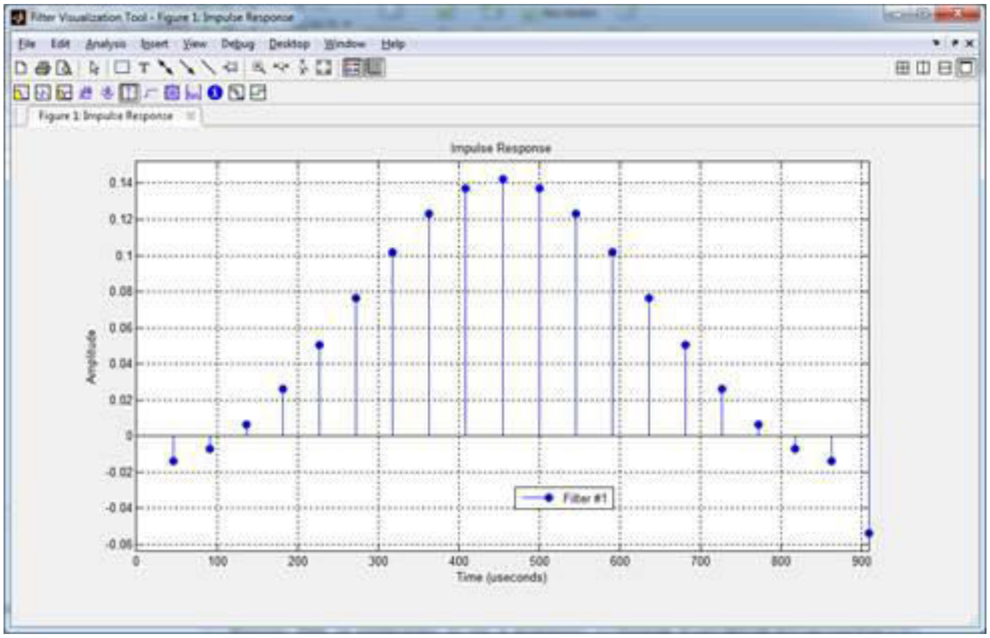
No. of channels in mix: 1
○ 8 bit
● 16 bit

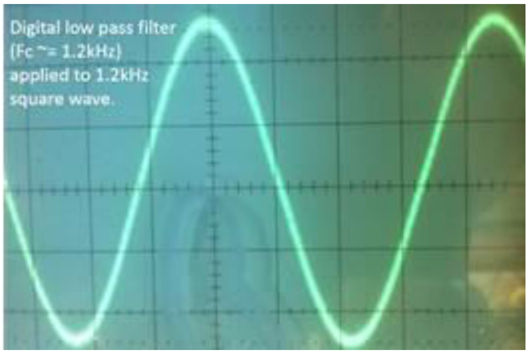


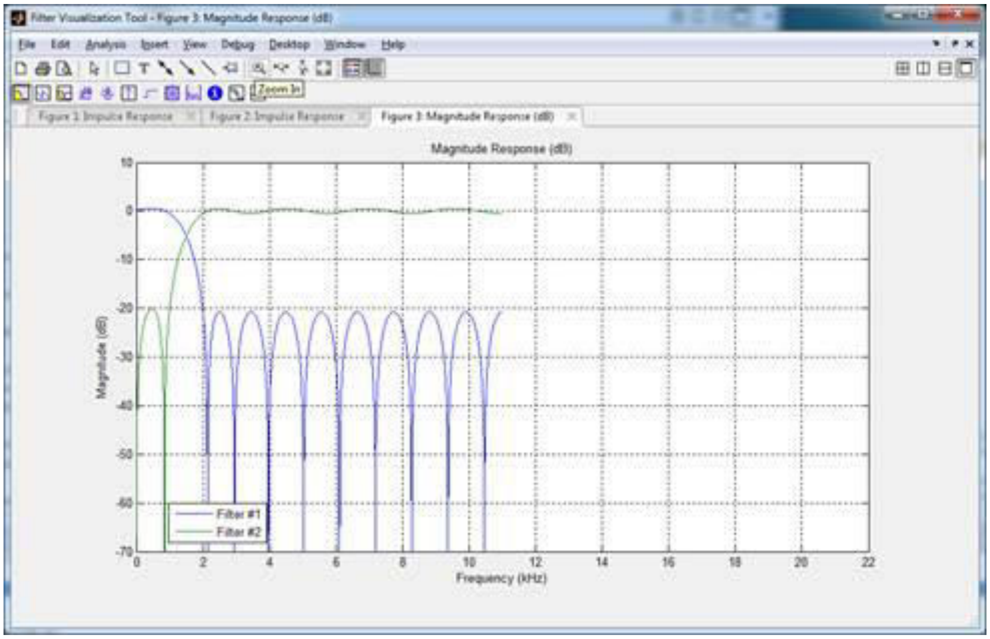


$$y(n) = \sum_{k=0}^{n} x(n)h(n-k)$$

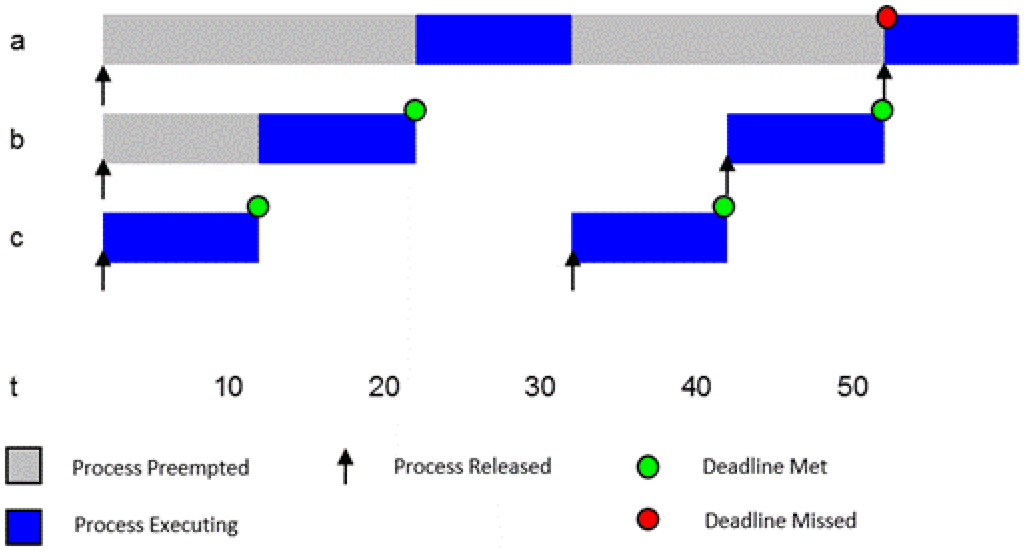

Filter Visualization Tool - Figure 1: Magnitude Response (dB)
File Edit Analysis Insert View Debug Desktop Window Help
Figure 1: Magnitude Response (dB)
Magnitude Response (dB)
Filter #1
Magnitude (dB)
10
0
-10
-20
-30
-40
-50
-60
-70
0
2
4
6
8
10
12
14
16
18
20
22
Frequency (kHz)

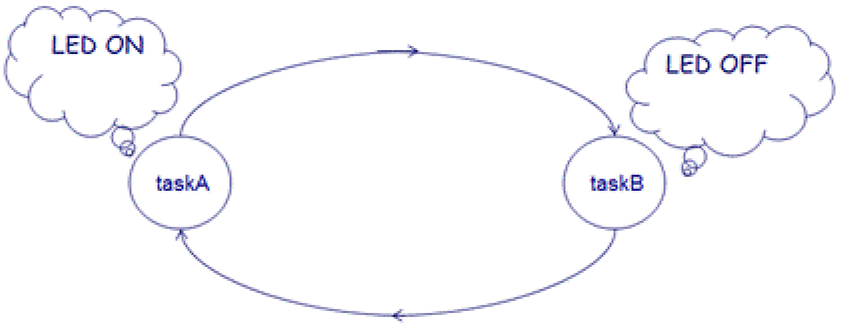

Filter Visualization Tool - Figure 1: Impulse Response
File Edit Analysis Insert View Debug Desktop Window Help
Figure 1: Impulse Response
Impulse Response
Filter #1
Amplitude
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
0
100
200
300
400
500
600
700
800
900
Time (useconds)

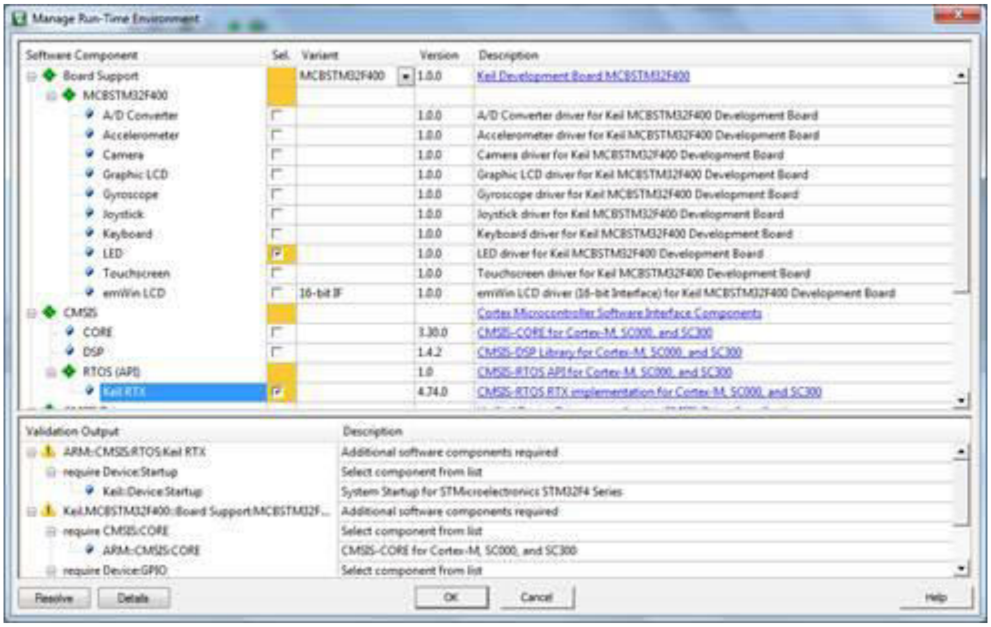

Digital low pass filter
(Fc ~= 1.2kHz)
applied to 1.2kHz
square wave.


Filter Visualization Tool - Figure 3: Magnitude Response (dB)
File
Edit
Analysis
Insert
View
Debug
Desktop
Window
Help
Zoom In
Figure 1: Impulse Response
Figure 2: Impulse Response
Figure 3: Magnitude Response (dB)
Magnitude Response (dB)
10
0
-10
-20
-30
-40
-50
-60
-70
Magnitude (dB)
0
2
4
6
8
10
12
14
16
18
20
22
Frequency (kHz)
Filter #1
Filter #2

Chapter 8: Real-Time Embedded Systems

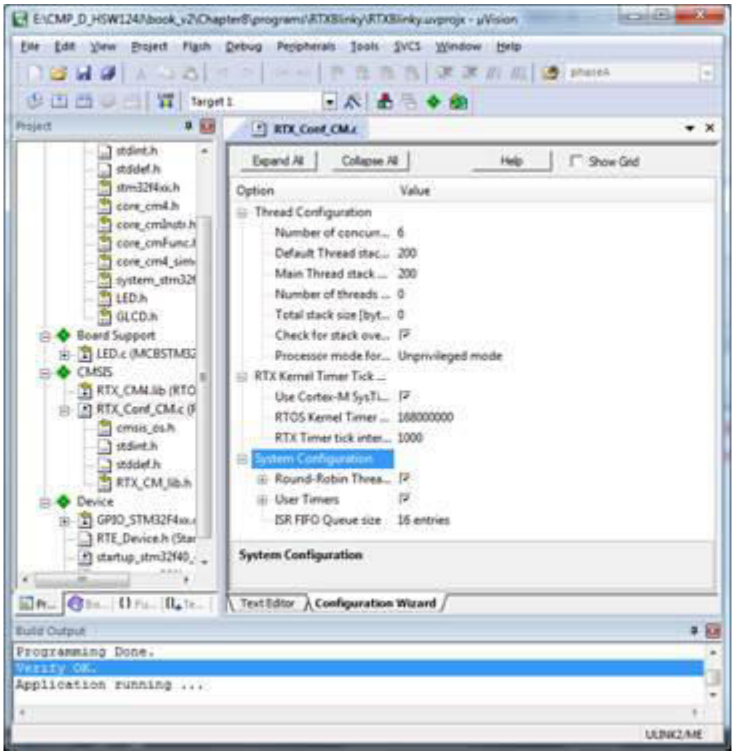






Software Component	Sel.	Variant	Version	Description
Board Support		MCBSTM32F400	1.0.0	Keil Development Board MCBSTM32F400
MCBSTM32F400				
A/D Converter	□		1.0.0	A/D Converter driver for Keil MCBSTM32F400 Development Board
Accelerometer	□		1.0.0	Accelerometer driver for Keil MCBSTM32F400 Development Board
Camera	□		1.0.0	Camera driver for Keil MCBSTM32F400 Development Board
Graphic LCD	□		1.0.0	Graphic LCD driver for Keil MCBSTM32F400 Development Board
Gyroscope	□		1.0.0	Gyroscope driver for Keil MCBSTM32F400 Development Board
Joystick	□		1.0.0	Joystick driver for Keil MCBSTM32F400 Development Board
Keyboard	□		1.0.0	Keyboard driver for Keil MCBSTM32F400 Development Board
LED	☑		1.0.0	LED driver for Keil MCBSTM32F400 Development Board
Touchscreen	□		1.0.0	Touchscreen driver for Keil MCBSTM32F400 Development Board
emWin LCD	□	16-bit IF	1.0.0	emWin LCD driver (16-bit Interface) for Keil MCBSTM32F400 Development Board
CMSIS				Cortex Microcontroller Software Interface Components
CORE	□		3.30.0	CMSIS-CORE for Cortex-M, SC000, and SC300
DSP	□		1.4.2	CMSIS-DSP Library for Cortex-M, SC000, and SC300
RTOS (API)			1.0	CMSIS-RTOS API for Cortex-M, SC000, and SC300
Keil RTX	☑		4.74.0	CMSIS-RTOS RTX implementation for Cortex-M, SC000, and SC300

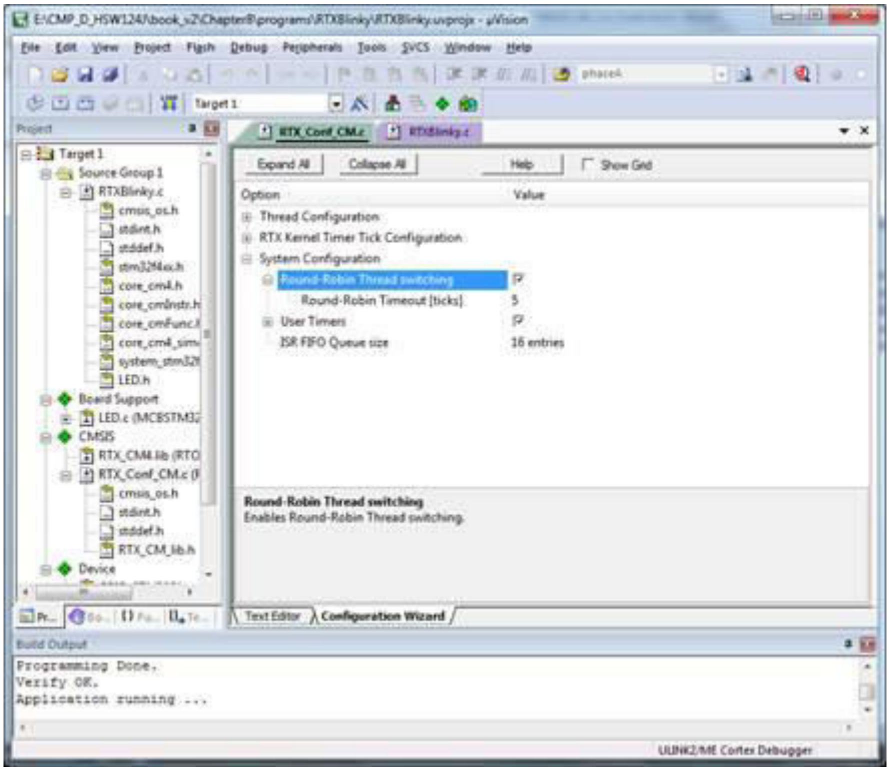
Validation Output	Description
ARM:CMSIS:RTOS:Keil RTX	Additional software components required
require Device:Startup	Select component from list
Keil:Device:Startup	System Startup for STMicroelectronics STM32F4 Series
Keil:MCBSTM32F400:Board Support:MCBSTM32F...	Additional software components required
require CMSIS:CORE	Select component from list
ARM:CMSIS:CORE	CMSIS-CORE for Cortex-M, SC000, and SC300
require Device:GPIO	Select component from list



Option	Value
Thread Configuration	
Number of concurr...	6
Default Thread stac...	200
Main Thread stack ...	200
Number of threads ...	0
Total stack size [byt...	0
Check for stack ove...	☑
Processor mode for...	Unprivileged mode
RTX Kernel Timer Tick ...	
Use Cortex-M SysTi...	☑
RTOS Kernel Timer ...	168000000
RTX Timer tick inter...	1000
System Configuration	
Round-Robin Threa...	☑
User Timers	☑
ISR FIFO Queue size	16 entries

System Configuration

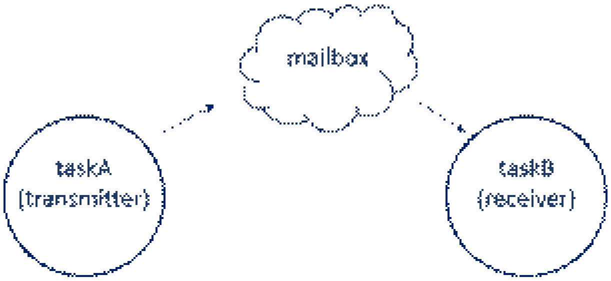
```
Programming Done.
Verify OK.
Application running ...
```

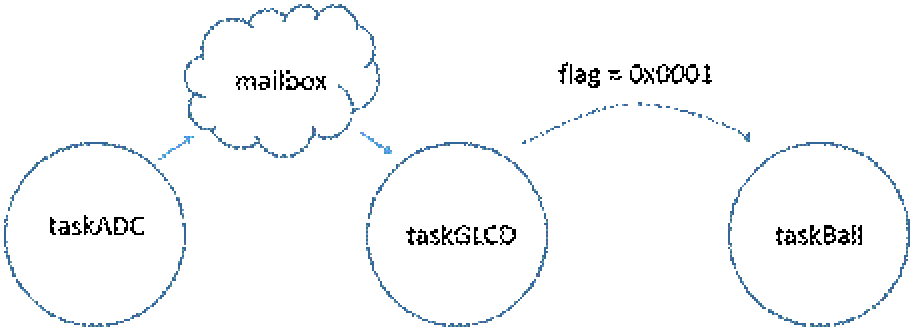


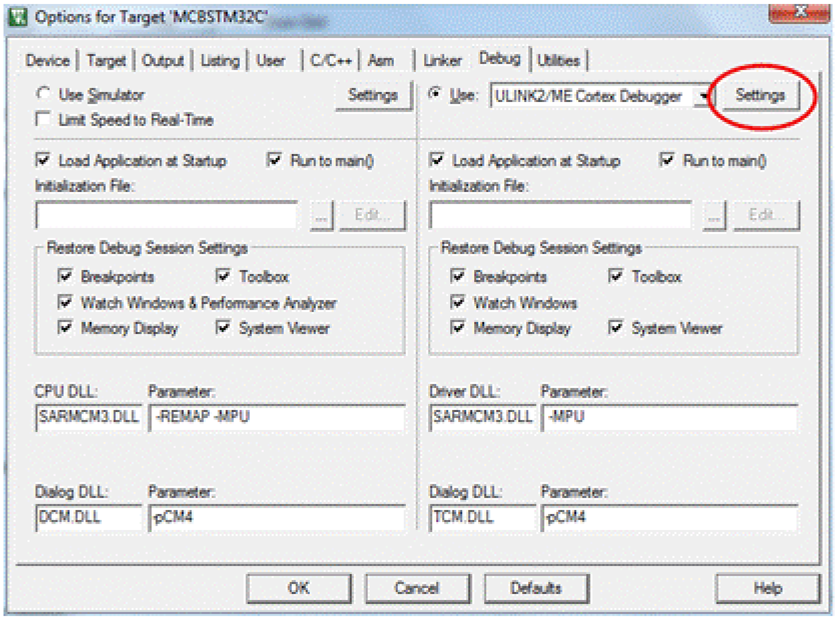
Option	Value
Thread Configuration	
RTX Kernel Timer Tick Configuration	
System Configuration	
Round-Robin Thread switching	☑
Round-Robin Timeout [ticks]	5
User Timers	☑
ISR FIFO Queue size	16 entries

Round-Robin Thread switching
Enables Round-Robin Thread switching.

```
Programming Done.
Verify OK.
Application running ...
```







Options for Target 'MCBSTM32C'

○ Use Simulator
□ Limit Speed to Real-Time

☑ Load Application at Startup ☑ Run to main()

Initialization File:

Restore Debug Session Settings

☑ Breakpoints ☑ Toolbox

☑ Watch Windows & Performance Analyzer

☑ Memory Display ☑ System Viewer

CPU DLL: SARMCM3.DLL Parameter: -REMAP -MPU

Dialog DLL: DCM.DLL Parameter: -pCM4

● Use: ULINK2/ME Cortex Debugger

☑ Load Application at Startup ☑ Run to main()

Initialization File:

Restore Debug Session Settings

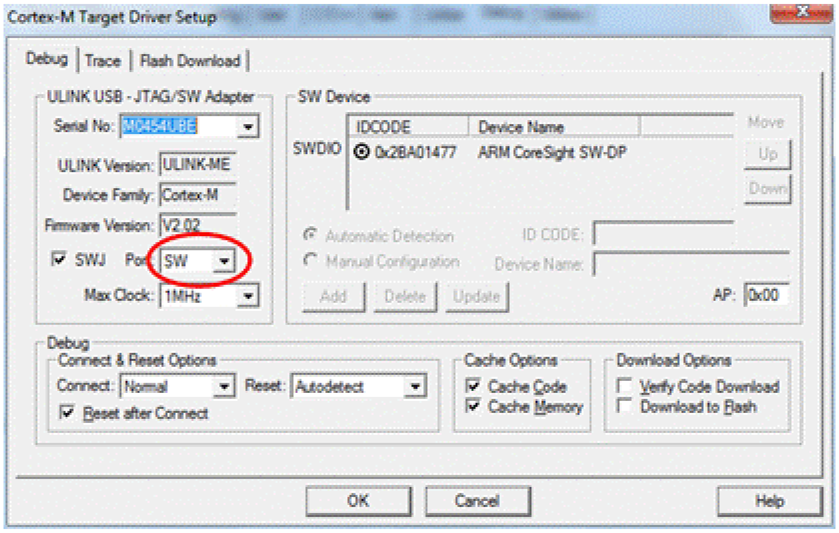
☑ Breakpoints ☑ Toolbox

☑ Watch Windows

☑ Memory Display ☑ System Viewer

Driver DLL: SARMCM3.DLL Parameter: -MPU

Dialog DLL: TCM.DLL Parameter: -pCM4



Cortex-M Target Driver Setup

ULINK USB - JTAG/SW Adapter

Serial No: M0454UBE

ULINK Version: ULINK-ME

Device Family: Cortex-M

Firmware Version: V2.02

☑ SWJ Port: SW

Max Clock: 1MHz

SW Device

	IDCODE	Device Name
SWDIO	● 0x2BA01477	ARM CoreSight SW-DP

● Automatic Detection ID CODE:

○ Manual Configuration Device Name:

AP: 0x00

Debug

Connect & Reset Options

Connect: Normal Reset: Autodetect

☑ Reset after Connect

Cache Options

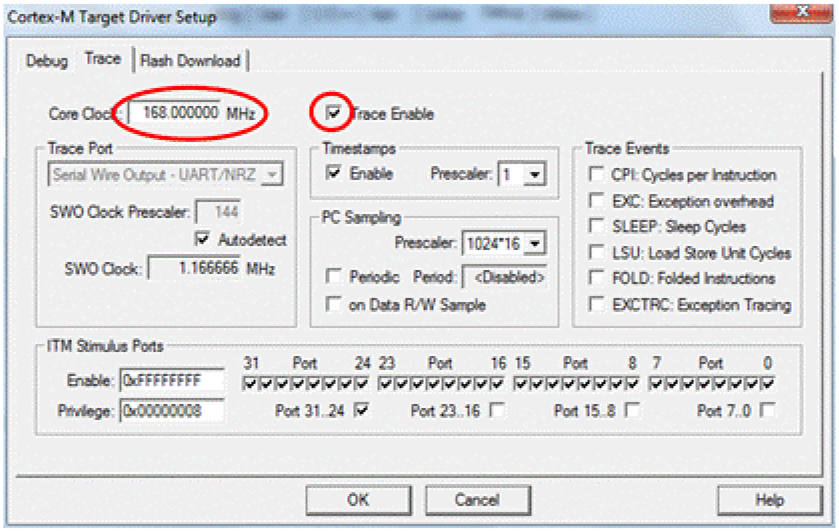
☑ Cache Code

☑ Cache Memory

Download Options

□ Verify Code Download

□ Download to Flash



Core Clock: 168.000000 MHz

☑ Trace Enable

Trace Port

Serial Wire Output - UART/NRZ

SWO Clock Prescaler: 144

☑ Autodetect

SWO Clock: 1.166666 MHz

Timestamps

☑ Enable Prescaler: 1

PC Sampling

Prescaler: 1024*16

☐ Periodic Period: <Disabled>

☐ on Data R/W Sample

Trace Events

☐ CPI: Cycles per Instruction

☐ EXC: Exception overhead

☐ SLEEP: Sleep Cycles

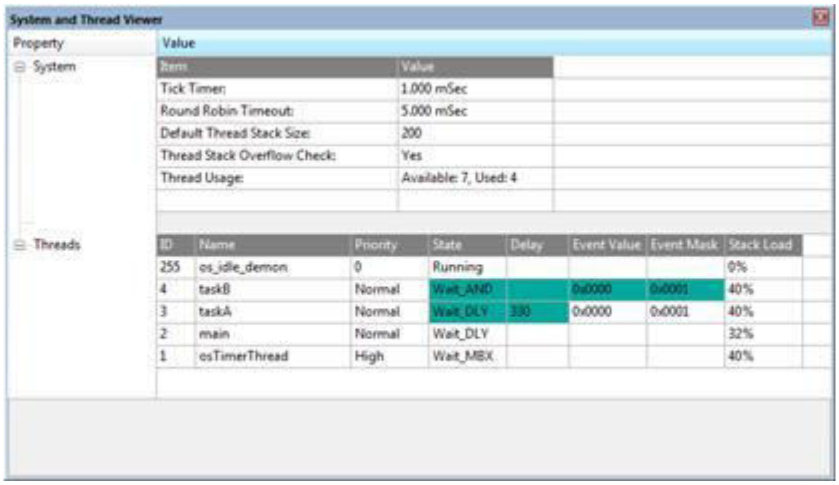
☐ LSU: Load Store Unit Cycles

☐ FOLD: Folded Instructions

☐ EXCTRC: Exception Tracing

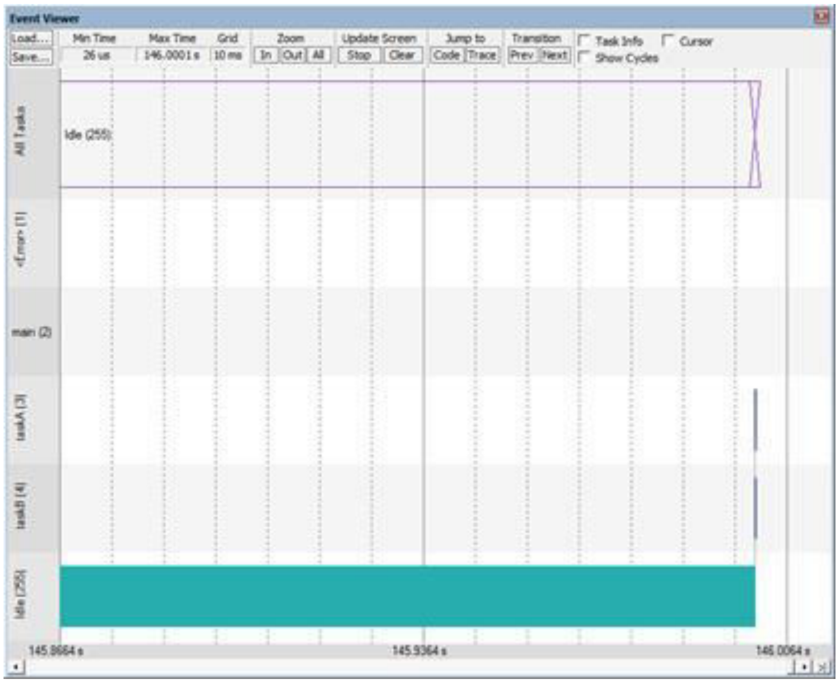
ITM Stimulus Ports

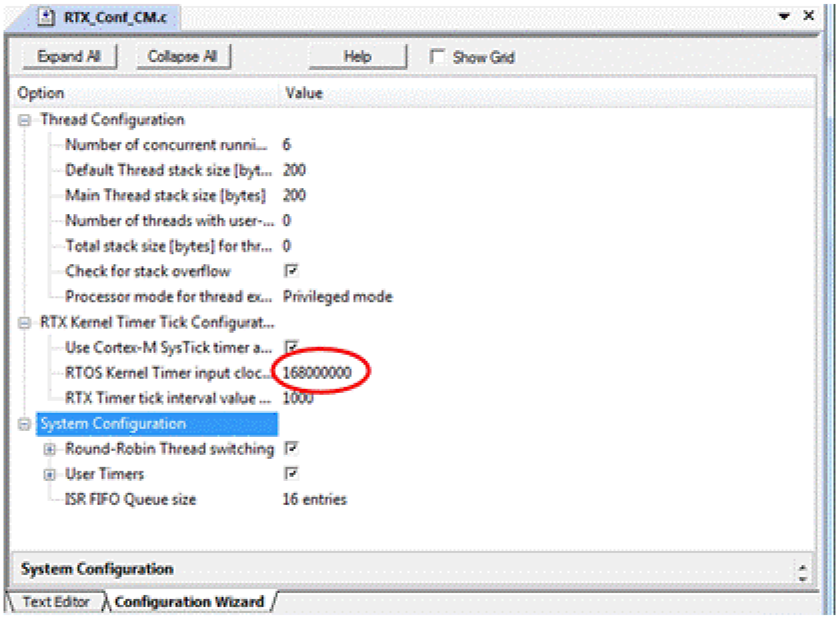
	31 Port 24	23 Port 16	15 Port 8	7 Port 0
Enable: 0xFFFFFFFF	☑☑☑☑☑☑☑☑	☑☑☑☑☑☑☑☑	☑☑☑☑☑☑☑☑	☑☑☑☑☑☑☑☑
Privilege: 0x00000008	Port 31..24 ☑	Port 23..16 ☐	Port 15..8 ☐	Port 7..0 ☐



Item	Value
Tick Timer:	1.000 mSec
Round Robin Timeout:	5.000 mSec
Default Thread Stack Size:	200
Thread Stack Overflow Check:	Yes
Thread Usage:	Available: 7, Used: 4

ID	Name	Priority	State	Delay	Event Value	Event Mask	Stack Load
255	os_idle_demon	0	Running				0%
4	taskB	Normal	Wait_AND		0x0000	0x0001	40%
3	taskA	Normal	Wait_DLY	330	0x0000	0x0001	40%
2	main	Normal	Wait_DLY				32%
1	osTimerThread	High	Wait_MBX				40%

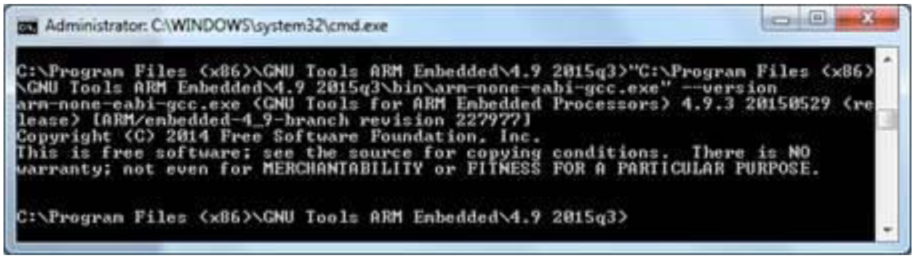




Option	Value
⊟ Thread Configuration	
Number of concurrent runni...	6
Default Thread stack size [byt...	200
Main Thread stack size [bytes]	200
Number of threads with user-...	0
Total stack size [bytes] for thr...	0
Check for stack overflow	☑
Processor mode for thread ex...	Privileged mode
⊟ RTX Kernel Timer Tick Configurat...	
Use Cortex-M SysTick timer a...	☑
RTOS Kernel Timer input cloc...	168000000
RTX Timer tick interval value ...	1000
⊟ System Configuration	
⊞ Round-Robin Thread switching	☑
⊞ User Timers	☑
ISR FIFO Queue size	16 entries

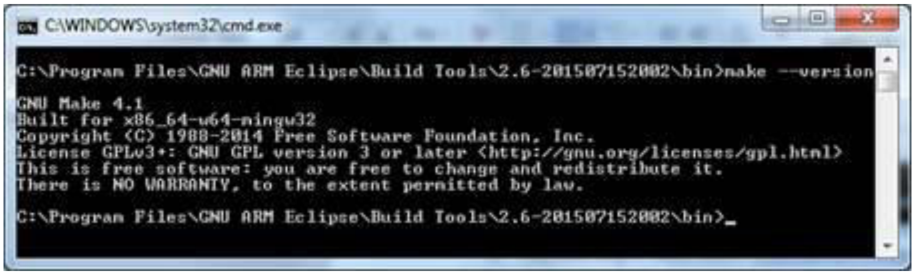
System Configuration

Chapter 9 : Embedded Toolchain



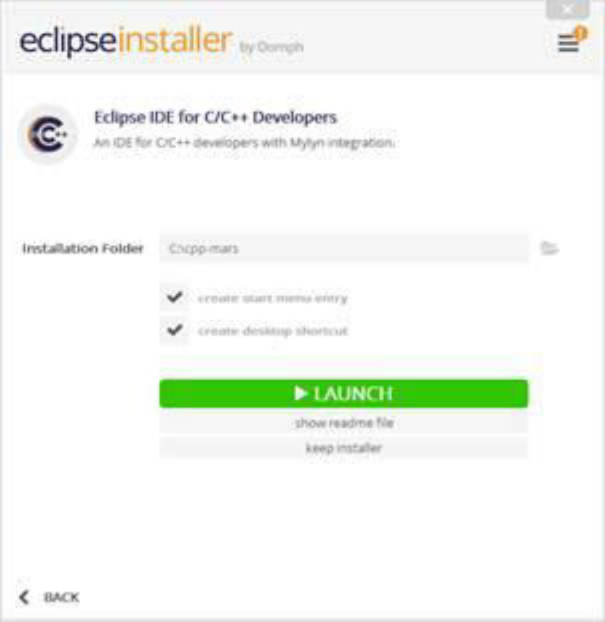
Administrator: C:\WINDOWS\system32\cmd.exe

```
C:\Program Files (x86)\GNU Tools ARM Embedded\4.9 2015q3>"C:\Program Files (x86)
\GNU Tools ARM Embedded\4.9 2015q3\bin\arm-none-eabi-gcc.exe" --version
arm-none-eabi-gcc.exe (GNU Tools for ARM Embedded Processors) 4.9.3 20150529 (re
lease) [ARM/embedded-4_9-branch revision 227977]
Copyright (C) 2014 Free Software Foundation, Inc.
This is free software; see the source for copying conditions.  There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

C:\Program Files (x86)\GNU Tools ARM Embedded\4.9 2015q3>
```



C:\WINDOWS\system32\cmd.exe

```
C:\Program Files\GNU ARM Eclipse\Build Tools\2.6-201507152002\bin>make --version

GNU Make 4.1
Built for x86_64-w64-mingw32
Copyright (C) 1988-2014 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.

C:\Program Files\GNU ARM Eclipse\Build Tools\2.6-201507152002\bin>_
```



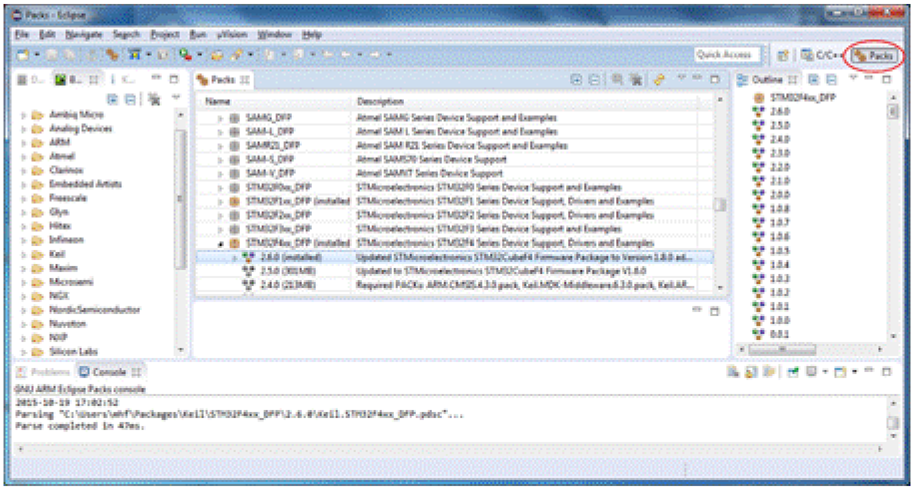
Eclipse IDE for C/C++ Developers

An IDE for C/C++ developers with Mylyn integration.

Installation Folder: C:\cpp-mars

✓ create start menu entry

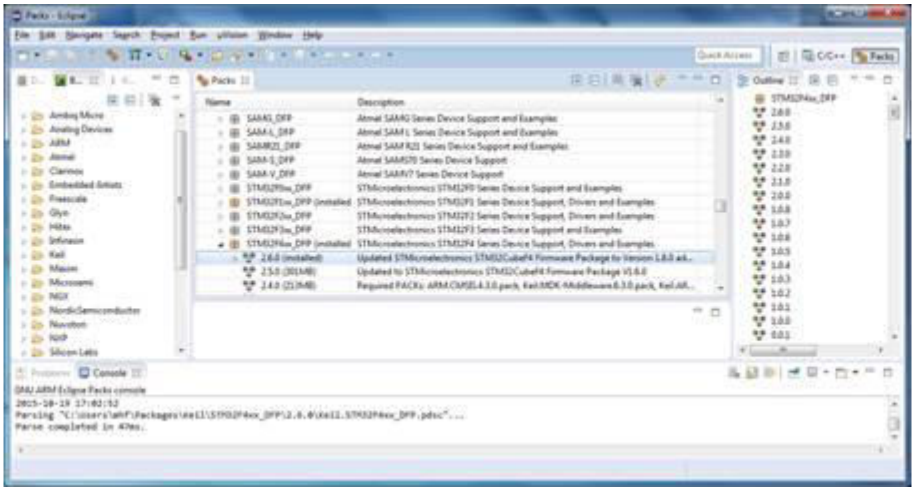
✓ create desktop shortcut



Name	Description
SAMG_DFP	Atmel SAMG Series Device Support and Examples
SAM-L_DFP	Atmel SAM L Series Device Support and Examples
SAMR21_DFP	Atmel SAM R21 Series Device Support and Examples
SAM-S_DFP	Atmel SAMS70 Series Device Support
SAM-V_DFP	Atmel SAMV7 Series Device Support
STM32F0xx_DFP	STMicroelectronics STM32F0 Series Device Support and Examples
STM32F1xx_DFP (installed	STMicroelectronics STM32F1 Series Device Support, Drivers and Examples
STM32F2xx_DFP	STMicroelectronics STM32F2 Series Device Support, Drivers and Examples
STM32F3xx_DFP	STMicroelectronics STM32F3 Series Device Support and Examples
STM32F4xx_DFP (installed	STMicroelectronics STM32F4 Series Device Support, Drivers and Examples
2.6.0 (installed)	Updated STMicroelectronics STM32CubeF4 Firmware Package to Version 1.8.0 ad...
2.5.0 (301MB)	Updated to STMicroelectronics STM32CubeF4 Firmware Package V1.8.0
2.4.0 (213MB)	Required PACKs: ARM.CMSIS.4.3.0.pack, Keil.MDK-Middleware.6.3.0.pack, Keil.AR...

GNU ARM Eclipse Packs console

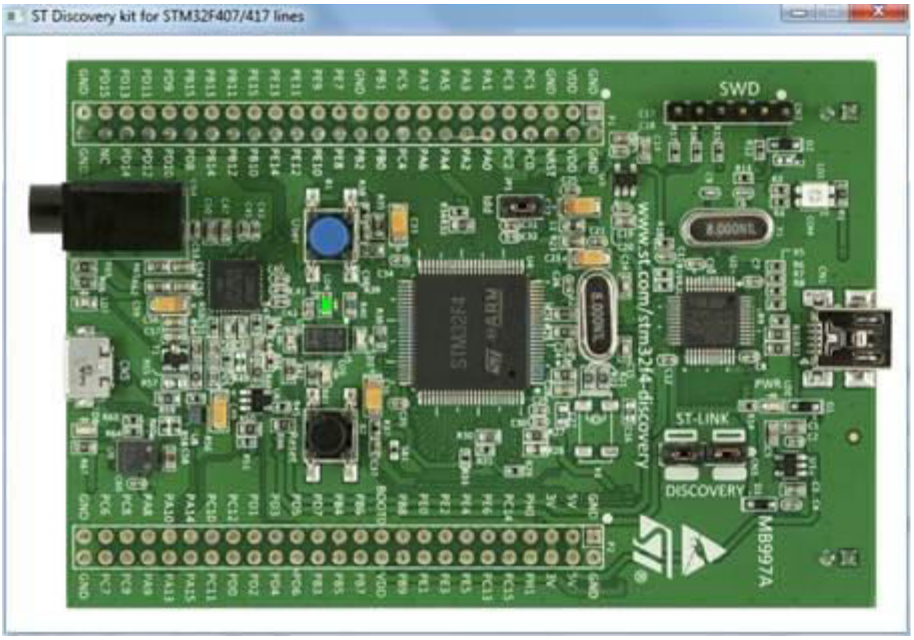
```
2015-10-19 17:02:52
Parsing "C:\Users\mhf\Packages\Keil\STM32F4xx_DFP\2.6.0\Keil.STM32F4xx_DFP.pdsc"...
Parse completed in 47ms.
```

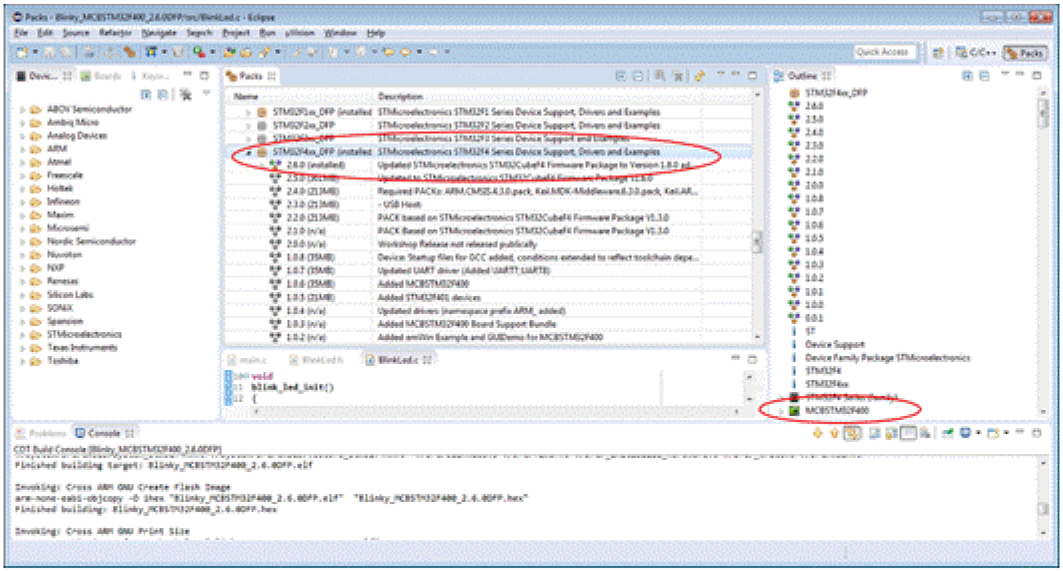


Name	Description
SAMG_DFP	Atmel SAMG Series Device Support and Examples
SAM-L_DFP	Atmel SAM L Series Device Support and Examples
SAMR21_DFP	Atmel SAM R21 Series Device Support and Examples
SAM-S_DFP	Atmel SAMS70 Series Device Support
SAM-V_DFP	Atmel SAMV7 Series Device Support
STM32F0xx_DFP	STMicroelectronics STM32F0 Series Device Support and Examples
STM32F1xx_DFP (installed	STMicroelectronics STM32F1 Series Device Support, Drivers and Examples
STM32F2xx_DFP	STMicroelectronics STM32F2 Series Device Support, Drivers and Examples
STM32F3xx_DFP	STMicroelectronics STM32F3 Series Device Support and Examples
STM32F4xx_DFP (installed	STMicroelectronics STM32F4 Series Device Support, Drivers and Examples
2.6.0 (installed)	Updated STMicroelectronics STM32CubeF4 Firmware Package to Version 1.8.0 ad...
2.5.0 (301MB)	Updated to STMicroelectronics STM32CubeF4 Firmware Package V1.8.0
2.4.0 (213MB)	Required PACKs: ARM.CMSIS.4.3.0.pack, Keil.MDK-Middleware.6.3.0.pack, Keil.AR...

GNU ARM Eclipse Packs console

```
2015-10-19 17:02:52
Parsing "C:\Users\mhf\Packages\Keil\STM32F4xx_DFP\2.6.0\Keil.STM32F4xx_DFP.pdsc"...
Parse completed in 47ms.
```


ST Discovery kit for STM32F407/417 lines
SWD
www.st.com/stm32f4-discovery
STM32F4
ARM
8.000MHz
ST-LINK
PWR
DISCOVERY
MB997A


Packs - Blinky_MCBSTM32F400_2.6.0DFP/src/BlinkLed.c - Eclipse
File Edit Source Refactor Navigate Search Project Run µVision Window Help
Quick Access
C/C++
Packs
Devic...
Boards
Keyw...
Packs
Outline
main.c
BlinkLed.h
BlinkLed.c
Problems
Console

- ABOV Semiconductor
- Ambiq Micro
- Analog Devices
- ARM
- Atmel
- Freescale
- Holtek
- Infineon
- Maxim
- Microsemi
- Nordic Semiconductor
- Nuvoton
- NXP
- Renesas
- Silicon Labs
- SONiX
- Spansion
- STMicroelectronics
- Texas Instruments
- Toshiba

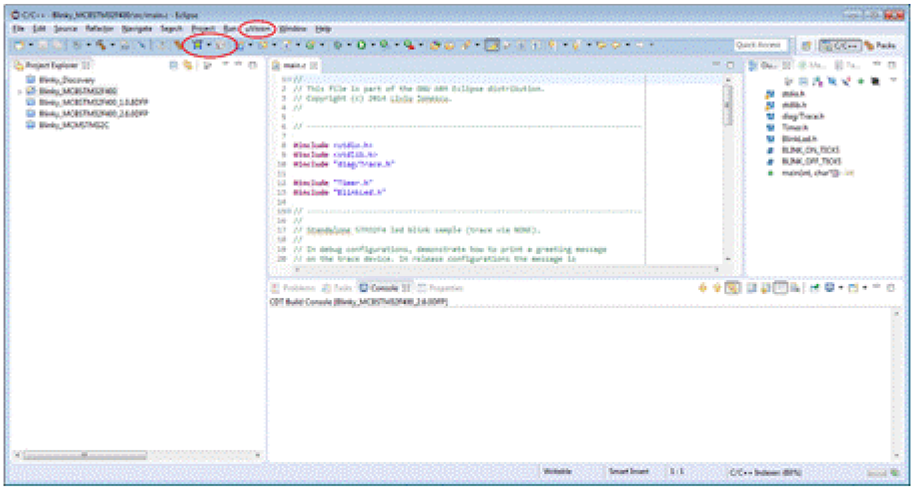
Name	Description
STM32F1xx_DFP (installed	STMicroelectronics STM32F1 Series Device Support, Drivers and Examples
STM32F2xx_DFP	STMicroelectronics STM32F2 Series Device Support, Drivers and Examples
STM32F3xx_DFP	STMicroelectronics STM32F3 Series Device Support and Examples
STM32F4xx_DFP (installed	STMicroelectronics STM32F4 Series Device Support, Drivers and Examples
2.6.0 (installed)	Updated STMicroelectronics STM32CubeF4 Firmware Package to Version 1.8.0 ad...
2.5.0 (36.1MB)	Updated to STMicroelectronics STM32CubeF4 Firmware Package V1.8.0
2.4.0 (21.3MB)	Required PACKs: ARM.CMSIS.4.3.0.pack, Keil.MDK-Middleware.6.3.0.pack, Keil.AR...
2.3.0 (21.3MB)	- USB Host
2.2.0 (21.3MB)	PACK based on STMicroelectronics STM32CubeF4 Firmware Package V1.3.0
2.1.0 (n/a)	PACK Based on STMicroelectronics STM32CubeF4 Firmware Package V1.3.0
2.0.0 (n/a)	Workshop Release not released publically
1.0.8 (35MB)	Device: Startup files for GCC added, conditions extended to reflect toolchain depe...
1.0.7 (35MB)	Updated UART driver (Added UART7, UART8)
1.0.6 (35MB)	Added MCBSTM32F400
1.0.5 (21MB)	Added STM32F401 devices
1.0.4 (n/a)	Updated drivers (namespace prefix ARM_ added)
1.0.3 (n/a)	Added MCBSTM32F400 Board Support Bundle
1.0.2 (n/a)	Added emWin Example and GUIDemo for MCBSTM32F400

```
10 void
11 blink_led_init()
12 {
```

STM32F4xx_DFP
2.6.0
2.5.0
2.4.0
2.3.0
2.2.0
2.1.0
2.0.0
1.0.8
1.0.7
1.0.6
1.0.5
1.0.4
1.0.3
1.0.2
1.0.1
1.0.0
0.0.1
ST
Device Support
Device Family Package STMicroelectronics
STM32F4
STM32F4xx
STM32F4 Series (family)
MCBSTM32F400

CDT Build Console [Blinky_MCBSTM32F400_2.6.0DFP]

```
Finished building target: Blinky_MCBSTM32F400_2.6.0DFP.elf

Invoking: Cross ARM GNU Create Flash Image
arm-none-eabi-objcopy -O ihex "Blinky_MCBSTM32F400_2.6.0DFP.elf"  "Blinky_MCBSTM32F400_2.6.0DFP.hex"
Finished building: Blinky_MCBSTM32F400_2.6.0DFP.hex

Invoking: Cross ARM GNU Print Size
```

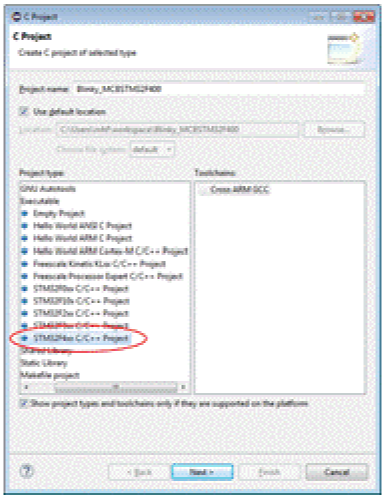


Blinky_Discovery
Blinky_MCBSTM32F400
Blinky_MCBSTM32F400_1.0.0FP
Blinky_MCBSTM32F400_2.0.0FP
Blinky_MCBSTM32C

```
//
// This file is part of the GNU ARM Eclipse distribution.
// Copyright (c) 2014 Liviu Ionescu.
//

// ----------------------------------------------------------------------------

#include <stdio.h>
#include <stdlib.h>
#include "diag/Trace.h"

#include "Timer.h"
#include "BlinkLed.h"

// ----------------------------------------------------------------------------
//
// Standalone STM32F4 led blink sample (trace via NONE).
//
// In debug configurations, demonstrate how to print a greeting message
// on the trace device. In release configurations the message is
```

stdio.h
stdlib.h
diag/Trace.h
Timer.h
BlinkLed.h
BLINK_ON_TICKS
BLINK_OFF_TICKS
main(int, char*[]) : int

CDT Build Console [Blinky_MCBSTM32F400_2.0.0FP]



C Project

Create C project of selected type

Project name: Blinky_MCBSTM32F400

☑ Use default location

Location: C:\Users\...\workspace\Blinky_MCBSTM32F400

Choose file system: default

Project type:

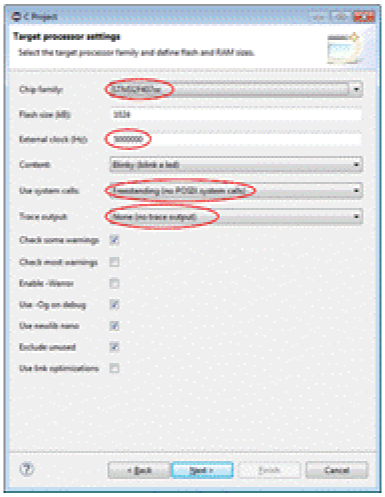
GNU Autotools
Executable
- Empty Project
- Hello World ANSI C Project
- Hello World ARM C Project
- Hello World ARM Cortex-M C/C++ Project
- Freescale Kinetis KLxx C/C++ Project
- Freescale Processor Expert C/C++ Project
- STM32F0xx C/C++ Project
- STM32F10x C/C++ Project
- STM32F2xx C/C++ Project
- STM32F3xx C/C++ Project
- STM32F4xx C/C++ Project

Shared Library
Static Library
Makefile project

Toolchains:

Cross ARM GCC

☑ Show project types and toolchains only if they are supported on the platform



Target processor settings

Select the target processor family and define flash and RAM sizes.

Chip family: STM32F407xx

Flash size (kB): 1024

External clock (Hz): 8000000

Content: Blinky (blink a led)

Use system calls: Freestanding (no POSIX system calls)

Trace output: None (no trace output)

Check some warnings ☑

Check most warnings □

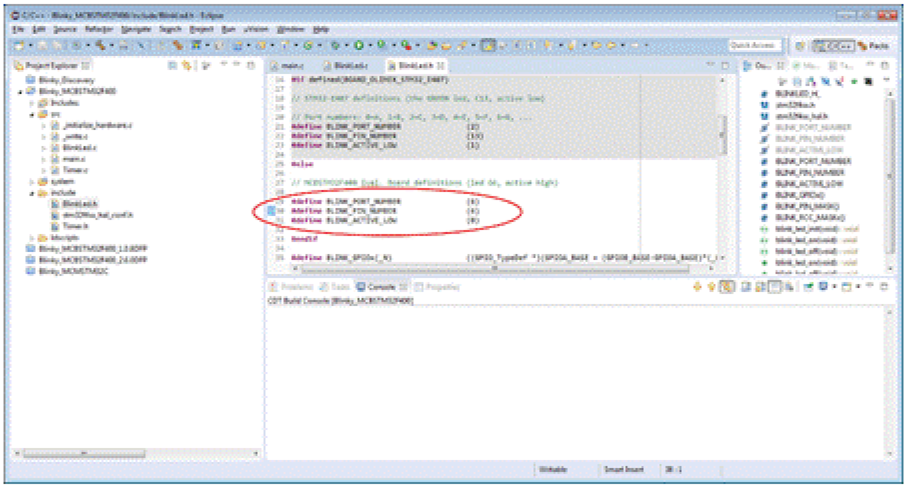
Enable -Werror □

Use -Og on debug ☑

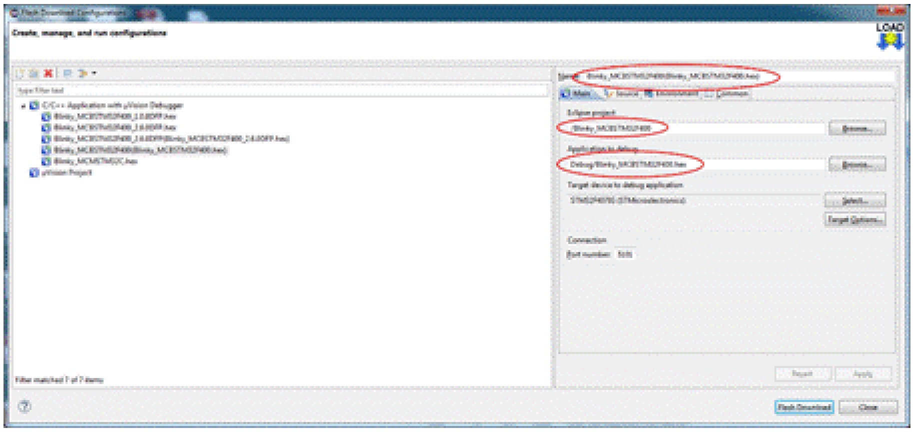
Use newlib nano ☑

Exclude unused ☑

Use link optimizations □



```
#if defined(BOARD_OLIMEX_STM32_E407)

// STM32-E407 definitions (the GREEN led, C13, active low)

// Port numbers: 0=A, 1=B, 2=C, 3=D, 4=E, 5=F, 6=G, ...
#define BLINK_PORT_NUMBER               (2)
#define BLINK_PIN_NUMBER                (13)
#define BLINK_ACTIVE_LOW                (1)

#else

// MCBSTM32F400 Eval. board definitions (led D0, active high)

#define BLINK_PORT_NUMBER               (8)
#define BLINK_PIN_NUMBER                (6)
#define BLINK_ACTIVE_LOW                (0)

#endif

#define BLINK_GPIOx(_N)                 ((GPIO_TypeDef *)(GPIOA_BASE + (GPIOB_BASE-GPIOA_BASE)*(_N
```



Create, manage, and run configurations

Name: Blinky_MCBSTM32F400\Blinky_MCBSTM32F400.hex

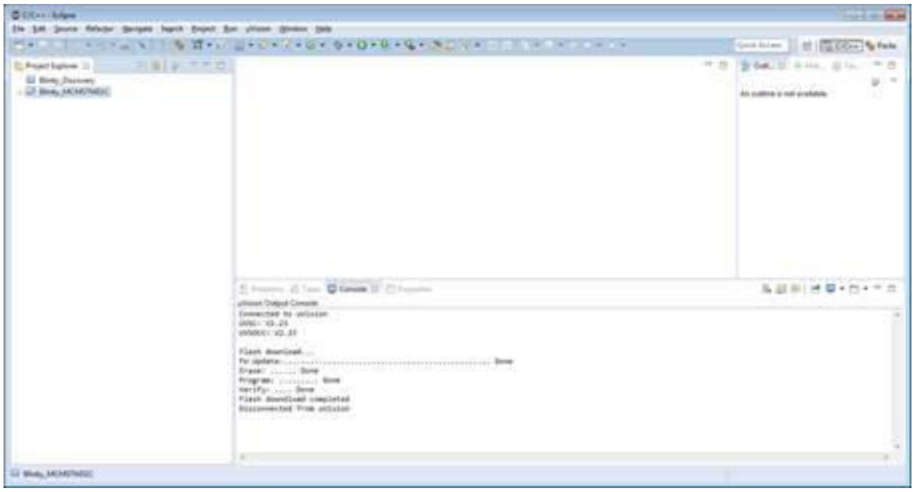
Eclipse project: /Blinky_MCBSTM32F400

Application to debug: Debug/Blinky_MCBSTM32F400.hex

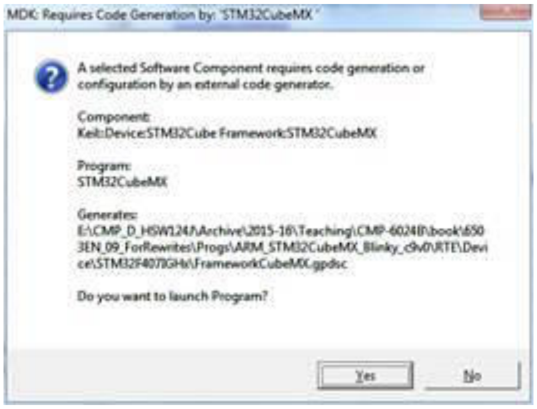
Target device to debug application: STM32F407IG (STMicroelectronics)

Connection

Port number: 5101



```
uVision Output Console
Connected to uVision
UVSC: V2.23
UVSOCK: V2.23

Flash download...
FW Update:..................................................... Done
Erase: ...... Done
Program: ........ Done
Verify: ..... Done
Flash download completed
Disconnected from uVision
```



MDK: Requires Code Generation by: 'STM32CubeMX '

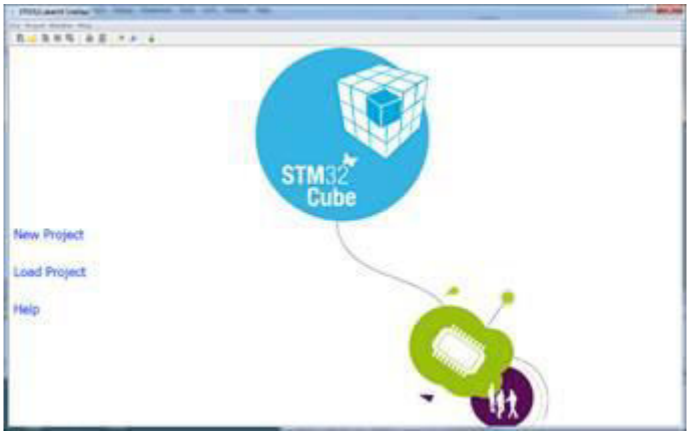
A selected Software Component requires code generation or configuration by an external code generator.

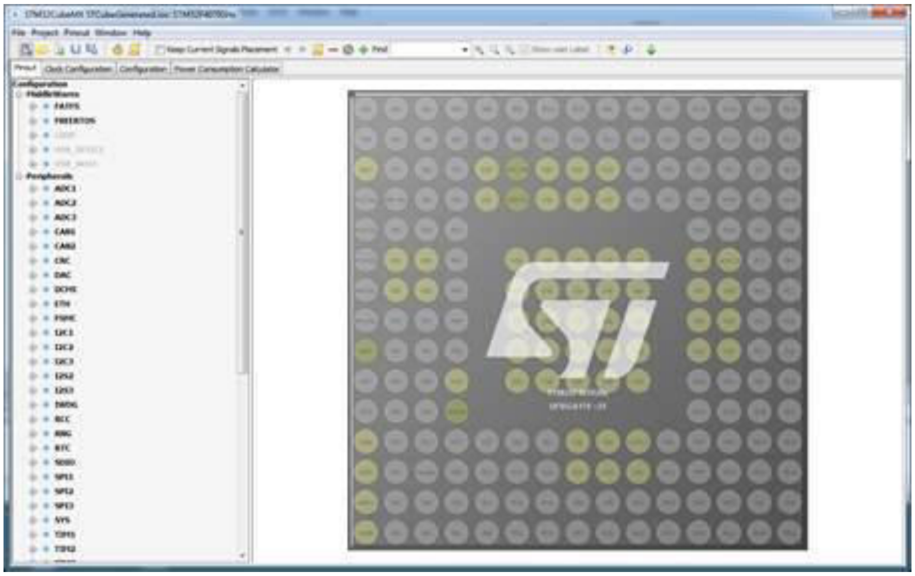
Component:
Keil::Device:STM32Cube Framework:STM32CubeMX

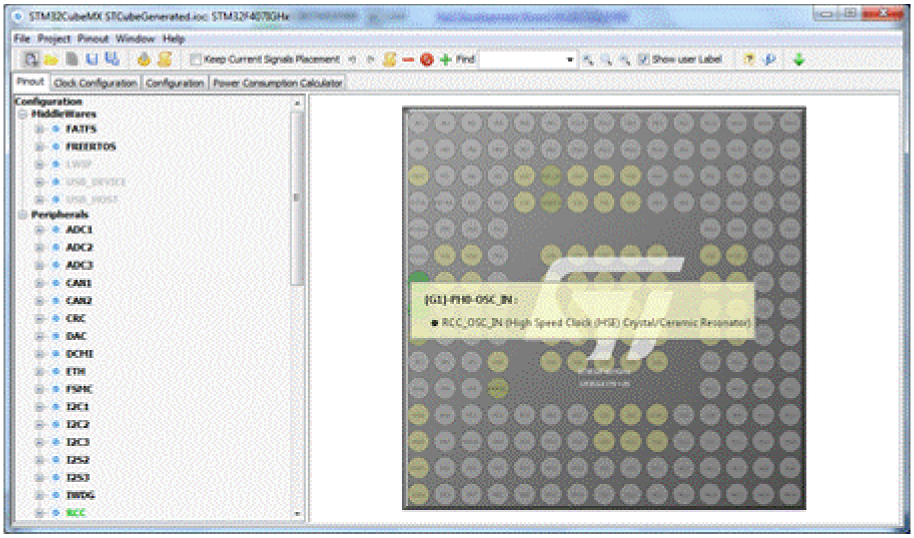
Program:
STM32CubeMX

Generates:
E:\CMP_D_HSW124J\Archive\2015-16\Teaching\CMP-6024B\book\650
3EN_09_ForRewrites\Progs\ARM_STM32CubeMX_Blinky_c9v0\RTE\Devi
ce\STM32F407IGHx\FrameworkCubeMX.gpdsc

Do you want to launch Program?

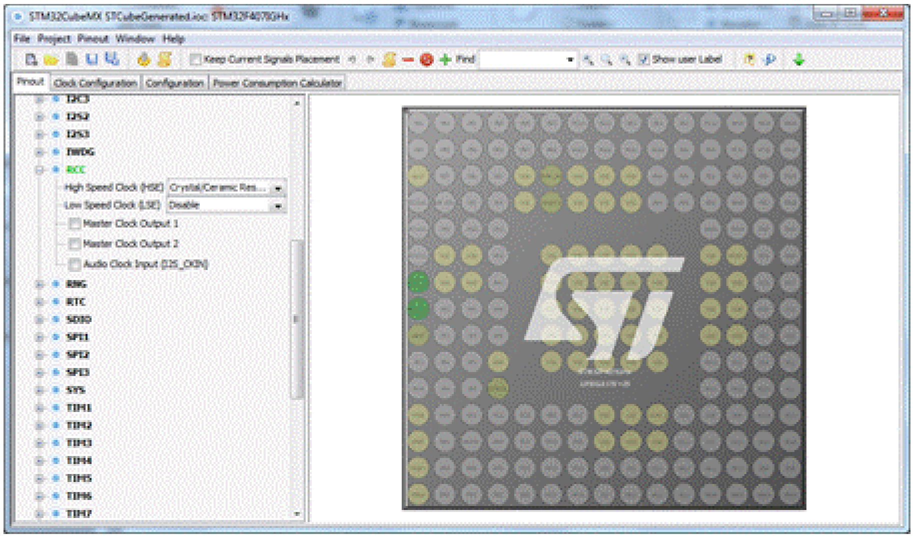






[G1]-PH0-OSC_IN :

- RCC_OSC_IN (High Speed Clock (HSE) Crystal/Ceramic Resonator)


STM32CubeMX STCubeGenerated.ioc: STM32F407IGHx
File Project Pinout Window Help
Keep Current Signals Placement
Find
Show user Label
Pinout
Clock Configuration
Configuration
Power Consumption Calculator
I2C3
I2S2
I2S3
IWDG
RCC
RNG
RTC
SDIO
SPI1
SPI2
SPI3
SYS
TIM1
TIM2
TIM3
TIM4
TIM5
TIM6
TIM7

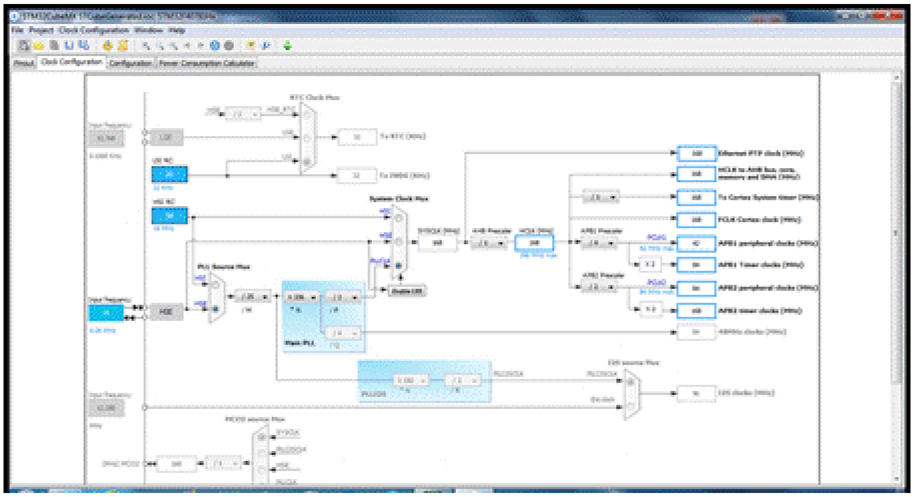
High Speed Clock (HSE): Crystal/Ceramic Res...

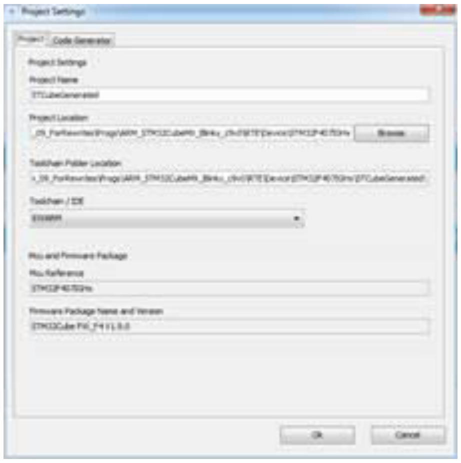
Low Speed Clock (LSE): Disable

□ Master Clock Output 1

□ Master Clock Output 2

□ Audio Clock Input (I2S_CKIN)





Project Settings

Project Name: STCubeGenerated

Project Location: _09_ForRewrites\Progs\ARM_STM32CubeMX_Blinky_ch\RTE\Device\STM32F407IGHx

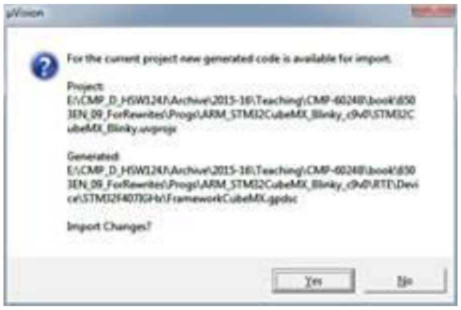
Toolchain Folder Location: ..._09_ForRewrites\Progs\ARM_STM32CubeMX_Blinky_ch\RTE\Device\STM32F407IGHx\STCubeGenerated\

Toolchain / IDE: EWARM

Mcu and Firmware Package

Mcu Reference: STM32F407IGHx

Firmware Package Name and Version: STM32Cube FW_F4 V1.8.0



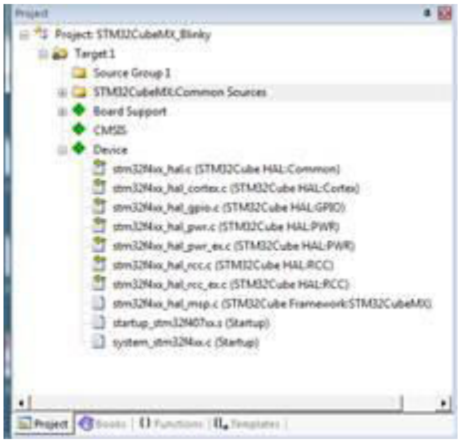
µVision

For the current project new generated code is available for import.

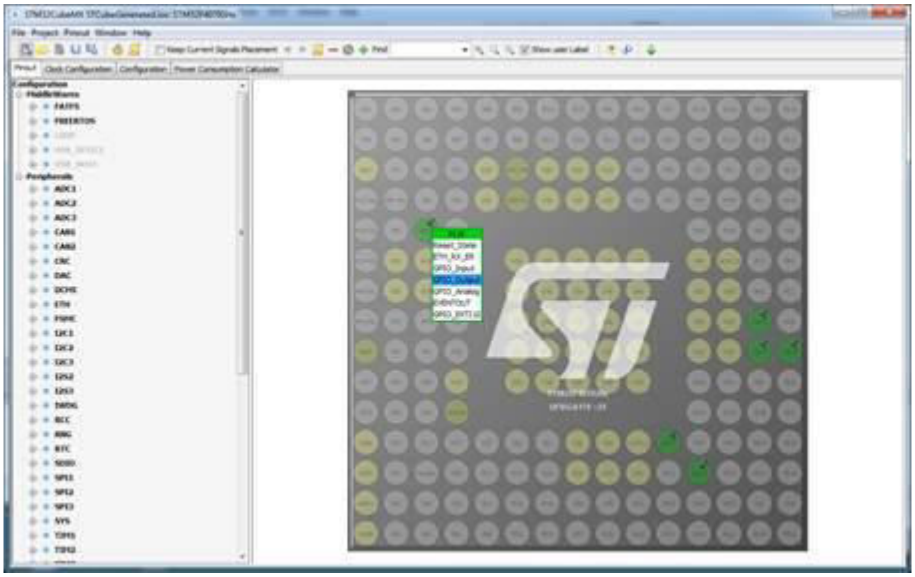
Project:
E:\CMP_D_HSW124\\Archive\2015-16\Teaching\CMP-6024B\book\850
3EN_09_ForRewrites\Progs\ARM_STM32CubeMX_Blinky_c9v0\STM32C
ubeMX_Blinky.uvprojx

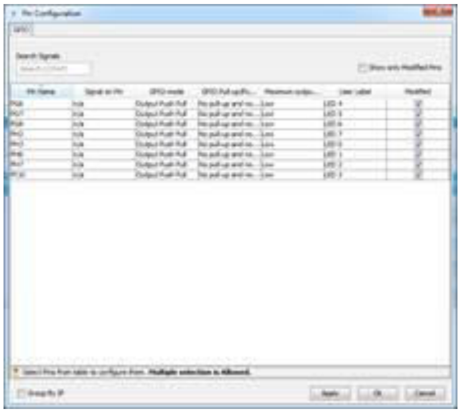
Generated:
E:\CMP_D_HSW124\\Archive\2015-16\Teaching\CMP-6024B\book\850
3EN_09_ForRewrites\Progs\ARM_STM32CubeMX_Blinky_c9v0\RTE\Devi
ce\STM32F407IGHx\FrameworkCubeMX.gpdsc

Import Changes?



```
Project
Project: STM32CubeMX_Blinky
  Target 1
    Source Group 1
    STM32CubeMX:Common Sources
    Board Support
    CMSIS
    Device
      stm32f4xx_hal.c (STM32Cube HAL:Common)
      stm32f4xx_hal_cortex.c (STM32Cube HAL:Cortex)
      stm32f4xx_hal_gpio.c (STM32Cube HAL:GPIO)
      stm32f4xx_hal_pwr.c (STM32Cube HAL:PWR)
      stm32f4xx_hal_pwr_ex.c (STM32Cube HAL:PWR)
      stm32f4xx_hal_rcc.c (STM32Cube HAL:RCC)
      stm32f4xx_hal_rcc_ex.c (STM32Cube HAL:RCC)
      stm32f4xx_hal_msp.c (STM32Cube Framework:STM32CubeMX)
      startup_stm32f407xx.s (Startup)
      system_stm32f4xx.c (Startup)
```





Pin Configuration

GPIO

Search Signals

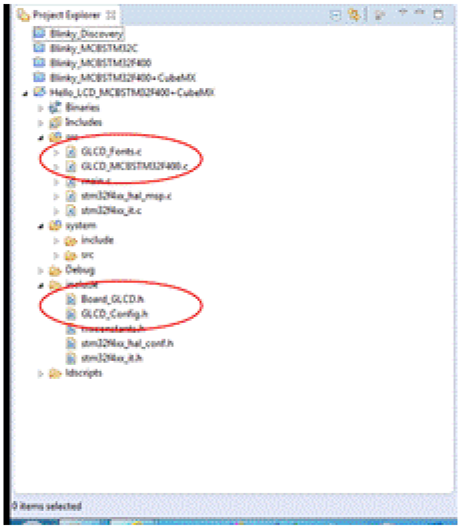
Search (Crtl+F)

□ Show only Modified Pins

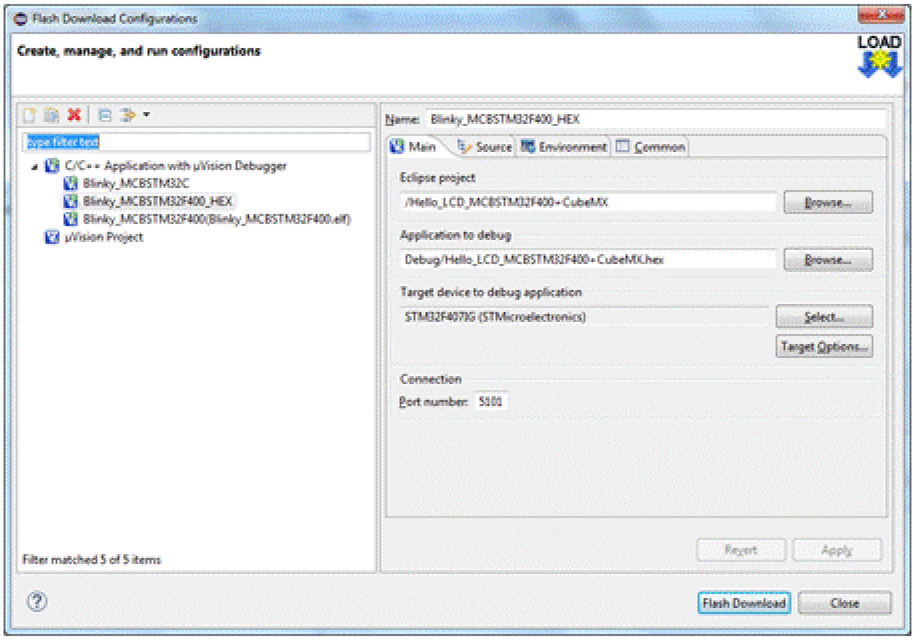
Pin Name	Signal on Pin	GPIO mode	GPIO Pull-up/Pu...	Maximum outpu...	User Label	Modified
PG6	n/a	Output Push Pull	No pull-up and no...	Low	LED 4	☑
PG7	n/a	Output Push Pull	No pull-up and no...	Low	LED 5	☑
PG8	n/a	Output Push Pull	No pull-up and no...	Low	LED 6	☑
PH2	n/a	Output Push Pull	No pull-up and no...	Low	LED 7	☑
PH3	n/a	Output Push Pull	No pull-up and no...	Low	LED 0	☑
PH6	n/a	Output Push Pull	No pull-up and no...	Low	LED 1	☑
PH7	n/a	Output Push Pull	No pull-up and no...	Low	LED 2	☑
PI10	n/a	Output Push Pull	No pull-up and no...	Low	LED 3	☑

Select Pins from table to configure them. **Multiple selection is Allowed.**

□ Group By IP



```
Project Explorer
    Blinky_Discovery
    Blinky_MCBSTM32C
    Blinky_MCBSTM32F400
    Blinky_MCBSTM32F400+CubeMX
  ◢ Hello_LCD_MCBSTM32F400+CubeMX
    ▷ Binaries
    ▷ Includes
    ◢ src
      ▷ GLCD_Fonts.c
      ▷ GLCD_MCBSTM32F400.c
      ▷ main.c
      ▷ stm32f4xx_hal_msp.c
      ▷ stm32f4xx_it.c
    ◢ system
      ▷ include
      ▷ src
    ▷ Debug
    ◢ include
        Board_GLCD.h
        GLCD_Config.h
        mxconstants.h
        stm32f4xx_hal_conf.h
        stm32f4xx_it.h
    ▷ ldscripts

0 items selected
```



Flash Download Configurations

Create, manage, and run configurations

type filter text

- C/C++ Application with µVision Debugger
  - Blinky_MCBSTM32C
  - Blinky_MCBSTM32F400_HEX
  - Blinky_MCBSTM32F400(Blinky_MCBSTM32F400.elf)
- µVision Project

Filter matched 5 of 5 items

Name: Blinky_MCBSTM32F400_HEX

Eclipse project: /Hello_LCD_MCBSTM32F400+CubeMX

Application to debug: Debug/Hello_LCD_MCBSTM32F400+CubeMX.hex

Target device to debug application: STM32F407IG (STMicroelectronics)

Connection

Port number: 5101