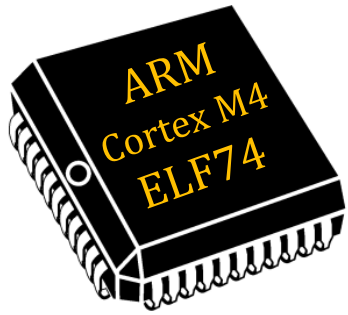
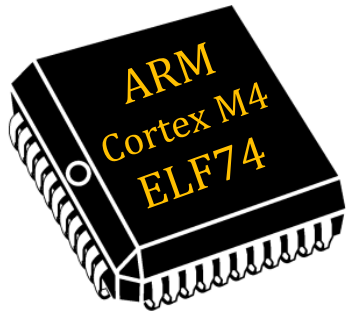




- Keil
- TivaWare
- FreeRTOS

Sistemas Embarcados: (ELF74)

Prof: DaLuz

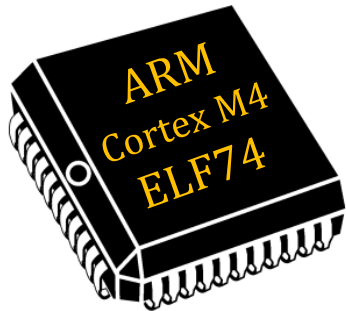


FreeRTOS - *Project Setup*



- Keil
- TivaWare
- FreeRTOS

- ❏ O intuito deste tutorial é criar um projeto no ambiente **Keil** contendo **FreeRTOS**, **TivaWare** e um microcontrolador **Cortex-M4F**.
- ❏ Utilizando o **Source-Code** do **FreeRTOS** e configurando todos os itens para o **Core** funcionar sem utilizar nenhum pacote pré-configurado do **Keil**.



FreeRTOS - *Project Setup*

- Utilizaremos a versão **10.0.1** do **FreeRTOS**.
- Utilizaremos também o **SDK TivaWare**.

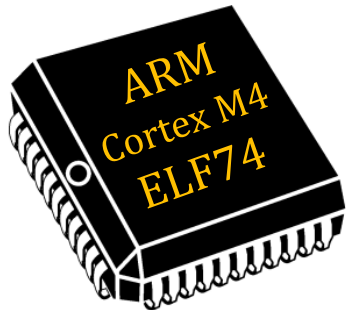
Verificar/Executar o outro **Tutorial** de como instalar e compilar este **SDK**.

[http://www.elf74.daeln.com.br/Pdfs/Tutorial Keil TivaWare Projeto.pdf](http://www.elf74.daeln.com.br/Pdfs/Tutorial%20Keil%20TivaWare%20Projeto.pdf)

<http://www.elf74.daeln.com.br/FreeRTOS/FreeRTOSv10.0.1.zip>

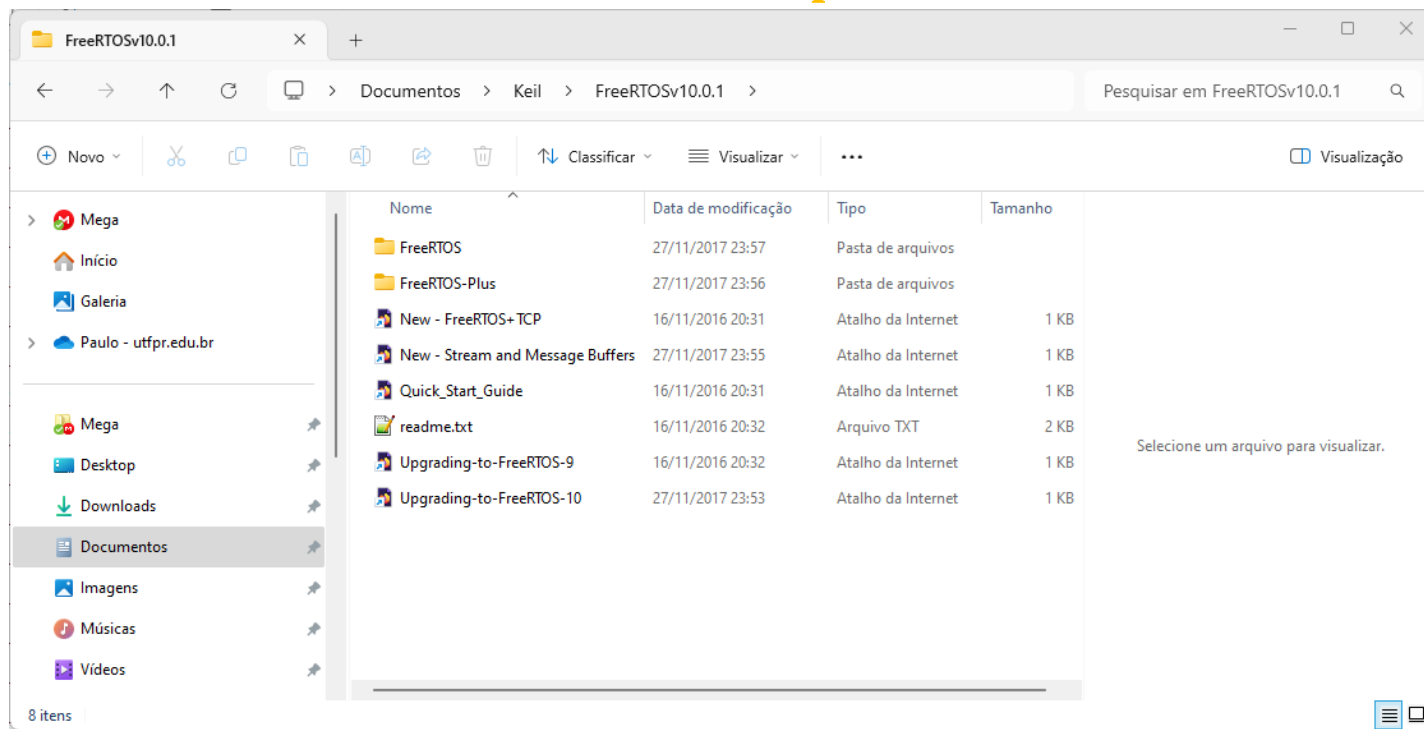


- Keil
- TivaWare
- FreeRTOS

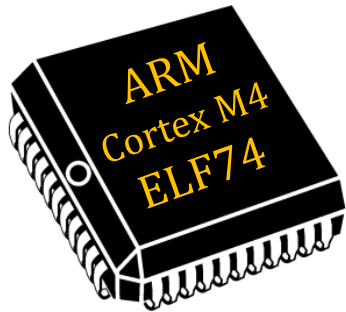


FreeRTOS - *Project Setup*

- Após fazer o *download* da versão **10.0.1** do **FreeRTOS**.
Descompactar o fonte.
- Precisamos deletar os **demos** e **ports** desnecessários.

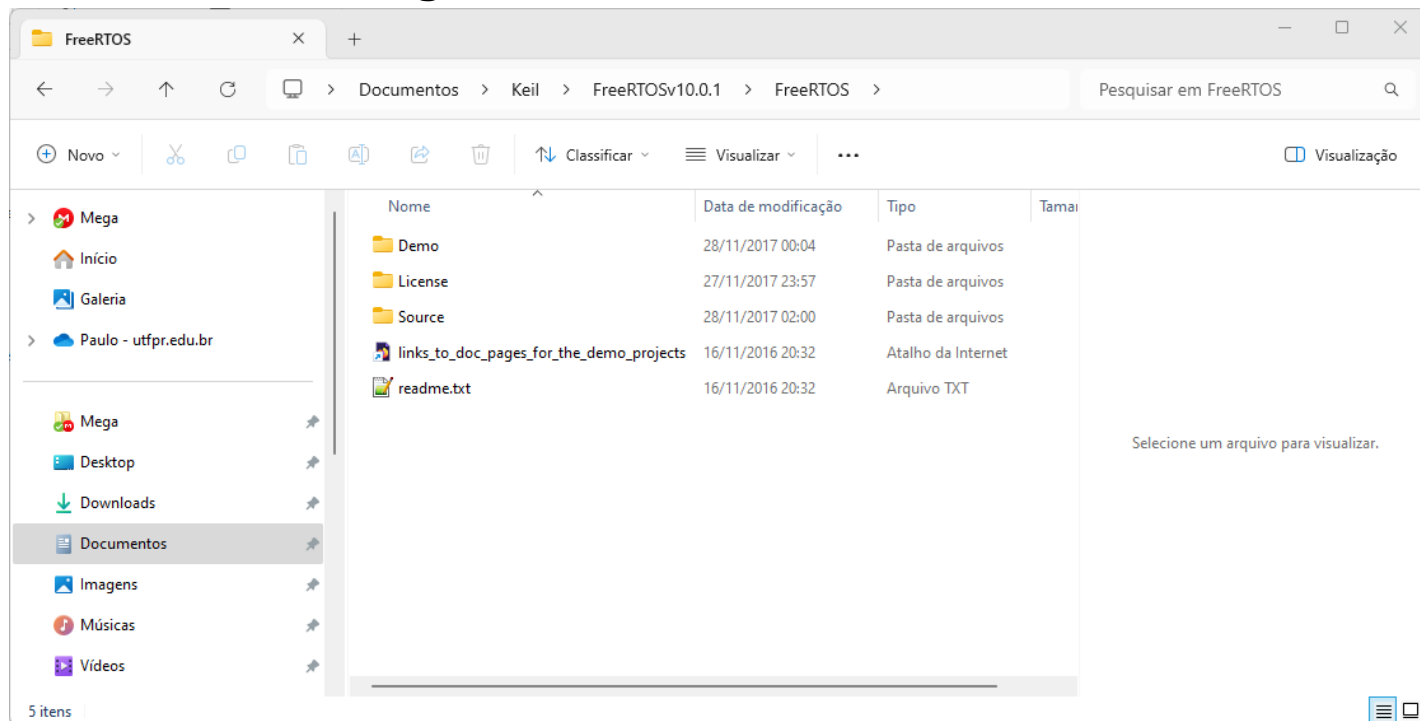


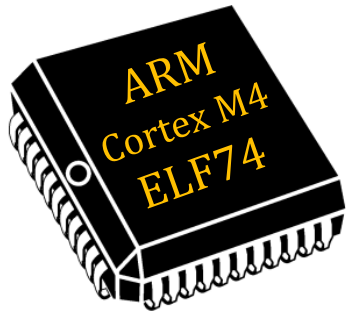
- Keil
- TivaWare
- FreeRTOS



FreeRTOS - *Project Setup*

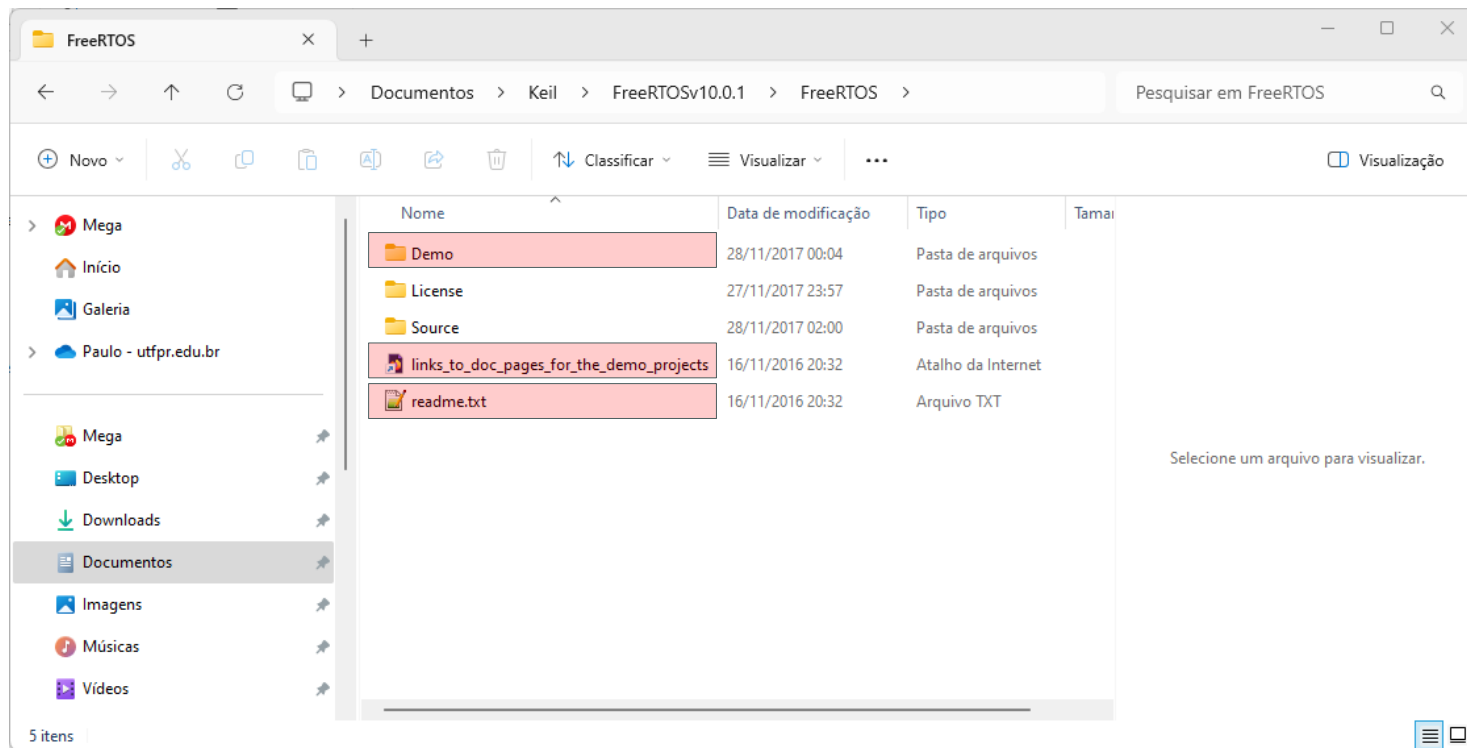
- ❏ Copiar somente a pasta **FreeRTOS** para a pasta do projeto. Esta pasta contém o core do **RTOS**, a pasta **FreeRTOS-PLUS**, contém os códigos **AWS** adicionais.



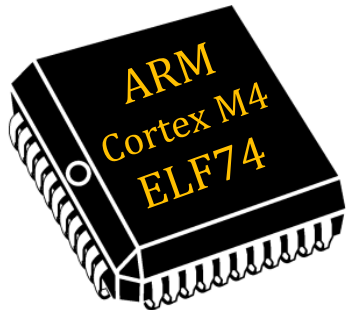


FreeRTOS - *Project Setup*

 Deletar a pasta **Demo** e os **arquivos** marcados na figura.

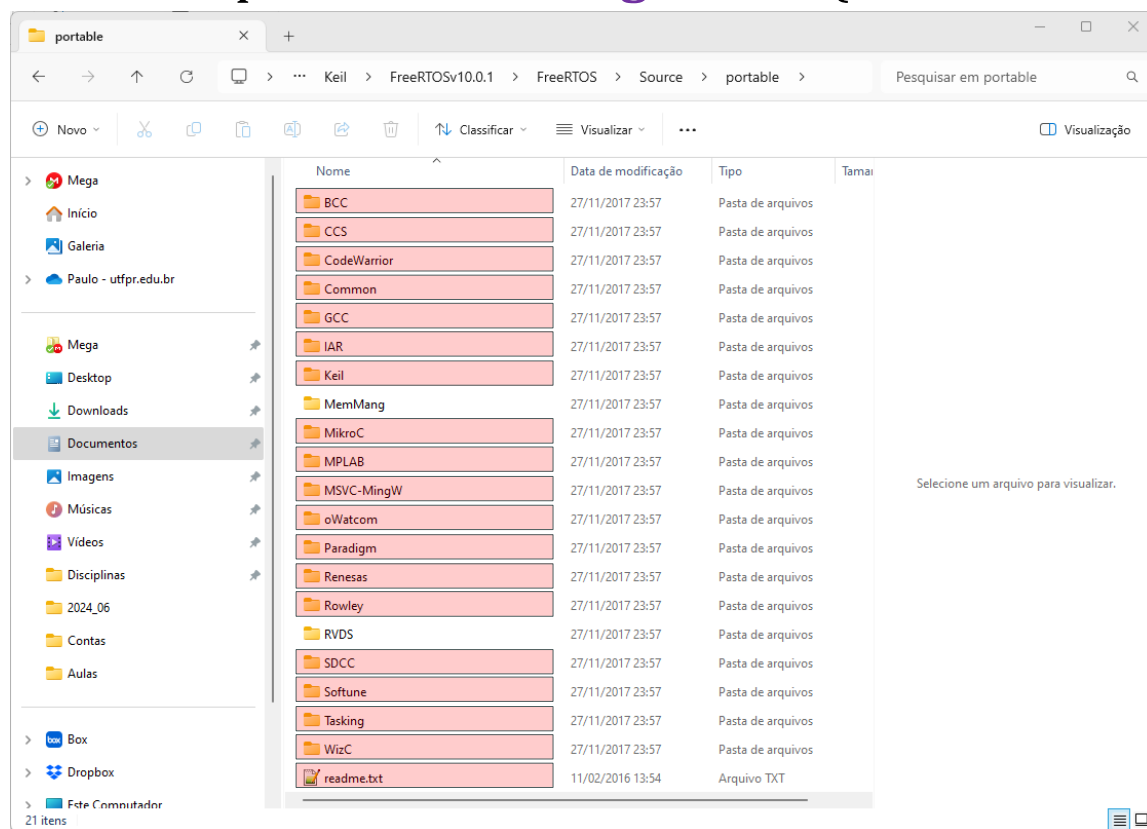


- Keil
- TivaWare
- FreeRTOS

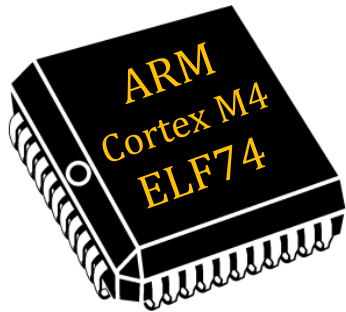


FreeRTOS - *Project Setup*

- Na a pasta `\FreeRTOS\Source\portable`, deixaremos somente as pastas **MemMang** e **RVDS**(Ports dos Cortex-M).

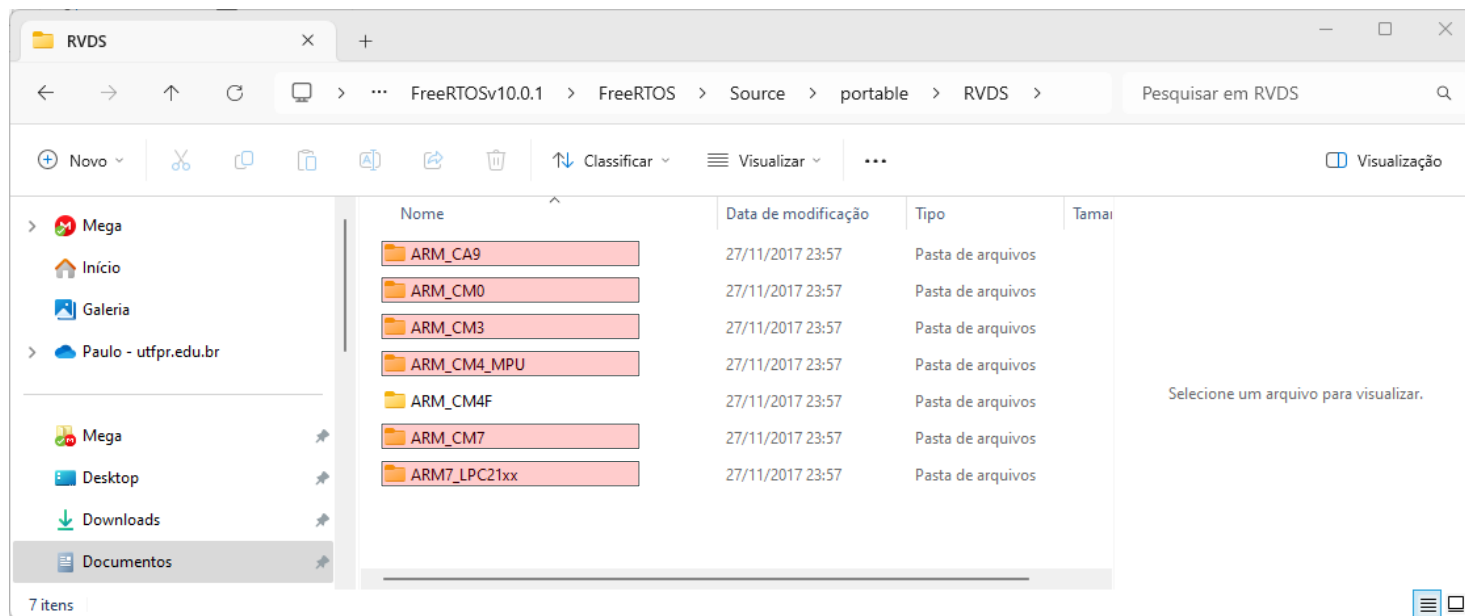


- Keil
- TivaWare
- FreeRTOS

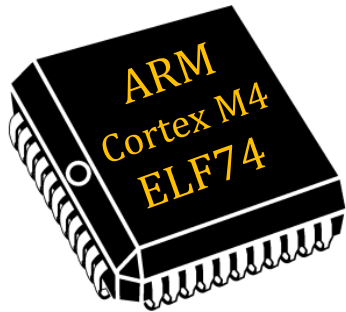


FreeRTOS - *Project Setup*

- Na a pasta \FreeRTOS\Source\portable\RVDS, deixaremos só a pasta **ARM_CM4F**(Port do Cortex-M4F).



- Keil
- TivaWare
- FreeRTOS



FreeRTOS - *Project Setup*

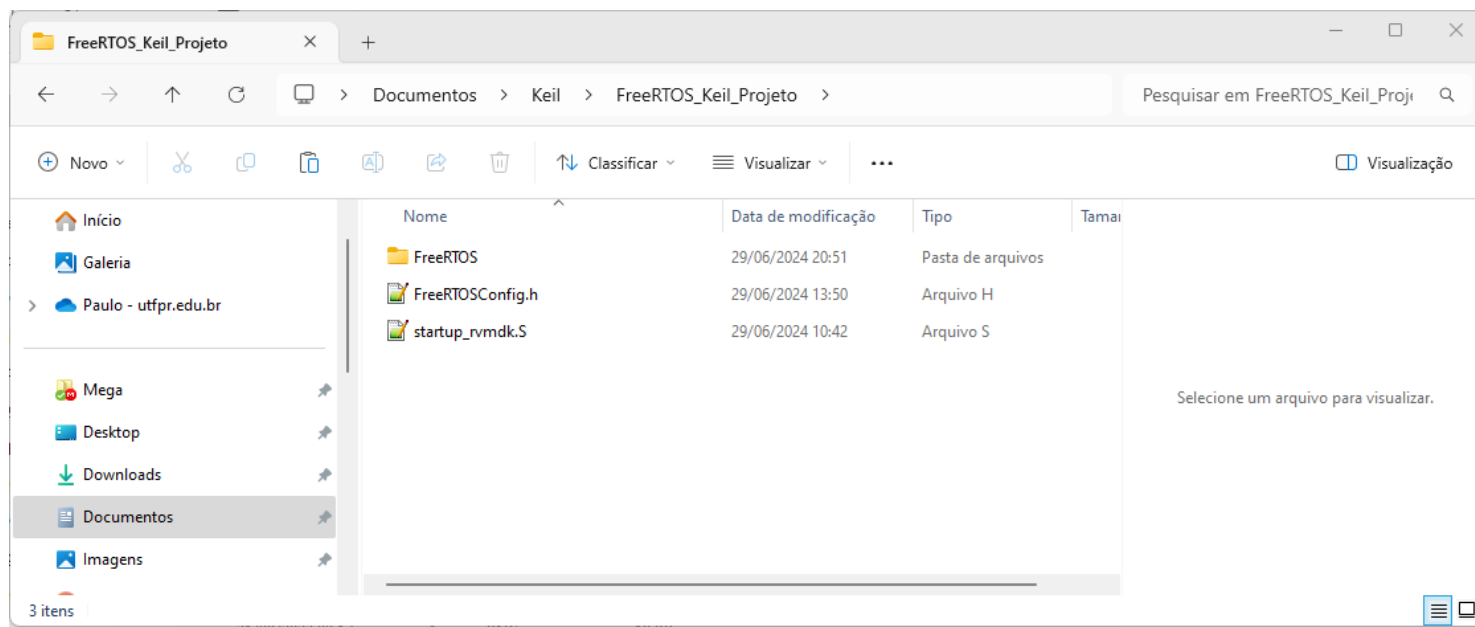
📁 Precisamos adicionar **2** arquivos na pasta do projeto:

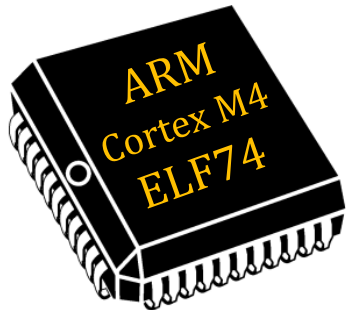
📁 **FreeRTOSConfig.h** - <http://www.elf74.daeln.com.br/FreeRTOS/FreeRTOSConfig.h>

Obs: Neste arquivo estão diversas configurações do RTOS, e não iremos explorar isto neste tutorial.

📁 **Startup_rvmdk.S** - http://www.elf74.daeln.com.br/FreeRTOS/startup_rvmdk_original.S

Obs: Neste arquivo estão as definições iniciais do sistema e vetores de interrupção, versão mínima para funcionar.





FreeRTOS - *Project Setup*

📁 Neste ponto temos a pasta do Projeto contendo:

Documentos > Keil > FreeRTOS_Keil_Projeto

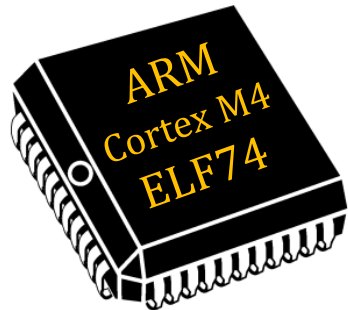
Nome	Data de modificação	Tipo
FreeRTOS	29/06/2024 20:51	Pasta de arquivos
FreeRTOSConfig.h	29/06/2024 13:50	Arquivo H
startup_rvmdk.S	29/06/2024 10:42	Arquivo S

Documentos > Keil > FreeRTOS_Keil_Projeto > FreeRTOS

Nome	Data de modificação	Tipo
License	27/11/2017 23:57	Pasta de arquivos
Source	28/11/2017 02:00	Pasta de arquivos

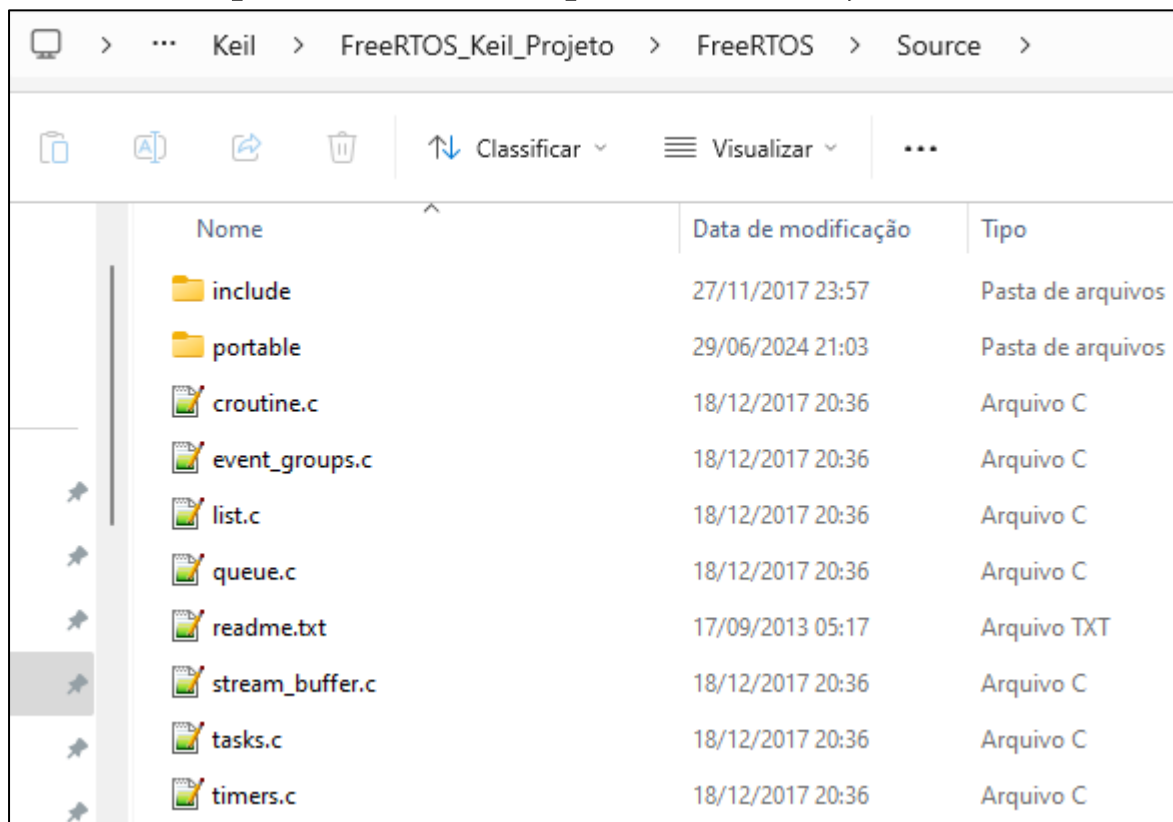


- Keil
- TivaWare
- FreeRTOS



FreeRTOS - *Project Setup*

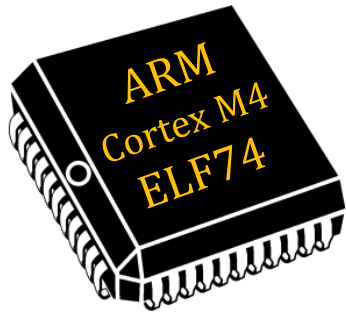
Neste ponto temos a pasta do Projeto contendo:



Nome	Data de modificação	Tipo
include	27/11/2017 23:57	Pasta de arquivos
portable	29/06/2024 21:03	Pasta de arquivos
croutine.c	18/12/2017 20:36	Arquivo C
event_groups.c	18/12/2017 20:36	Arquivo C
list.c	18/12/2017 20:36	Arquivo C
queue.c	18/12/2017 20:36	Arquivo C
readme.txt	17/09/2013 05:17	Arquivo TXT
stream_buffer.c	18/12/2017 20:36	Arquivo C
tasks.c	18/12/2017 20:36	Arquivo C
timers.c	18/12/2017 20:36	Arquivo C



- Keil
- TivaWare
- FreeRTOS



FreeRTOS - *Project Setup*

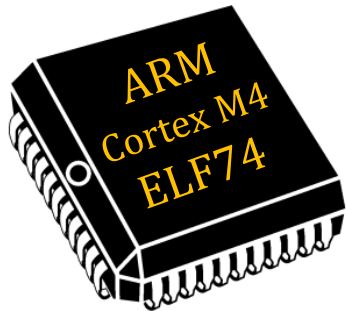
📁 Neste ponto temos a pasta do Projeto contendo:

Nome	Data de modificação	Tipo
MemMang	27/11/2017 23:57	Pasta de arquivos
RVDS	29/06/2024 21:08	Pasta de arquivos

Nome	Data de modificação	Tipo
ARM_CM4F	27/11/2017 23:57	Pasta de arquivos

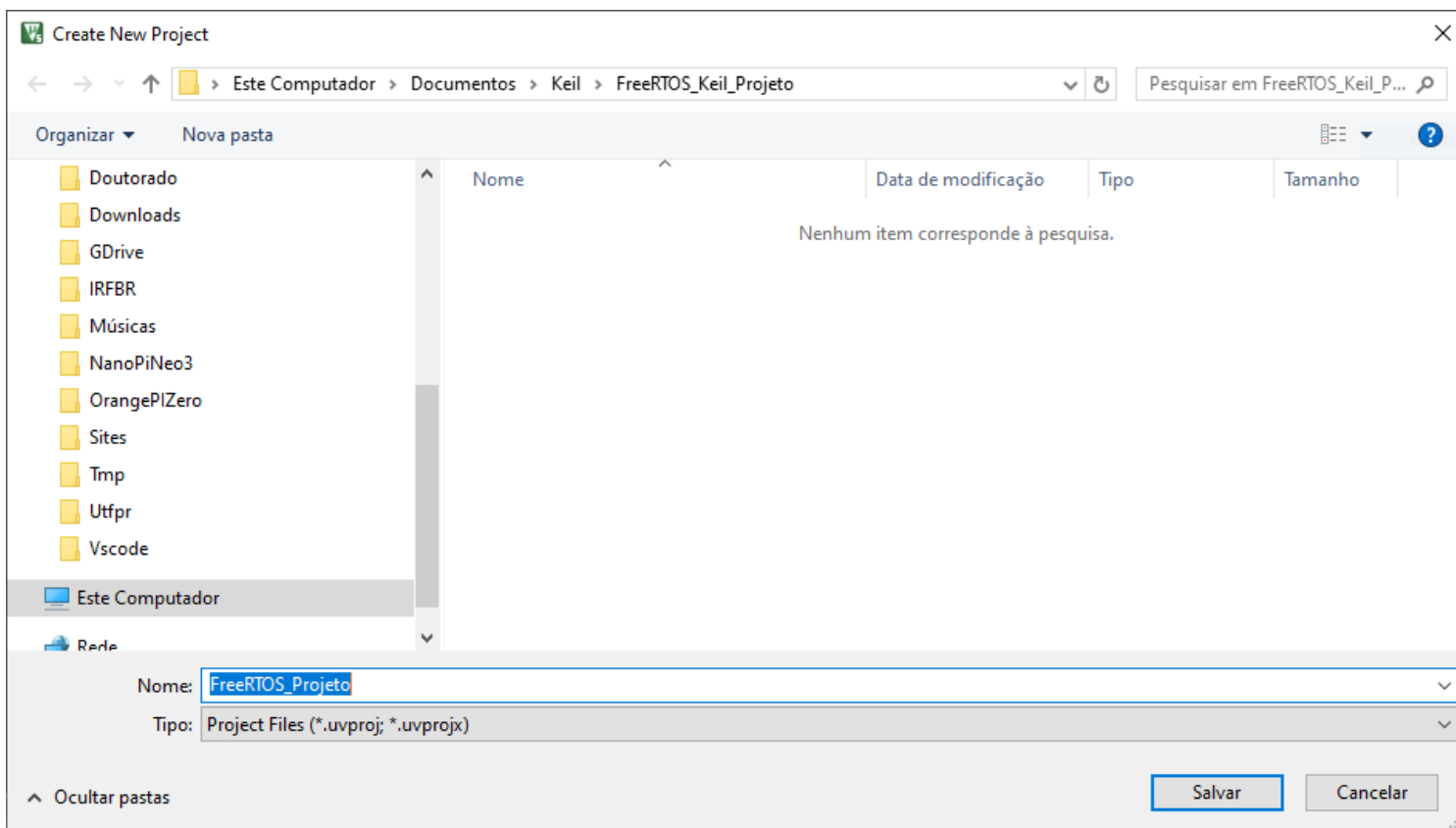


- Keil
- TivaWare
- FreeRTOS

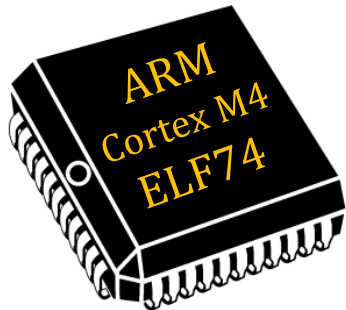


FreeRTOS - *Project Setup*

Com o Keil aberto clicar em: **Project -> New uVision Project**



- Keil
- TivaWare
- FreeRTOS

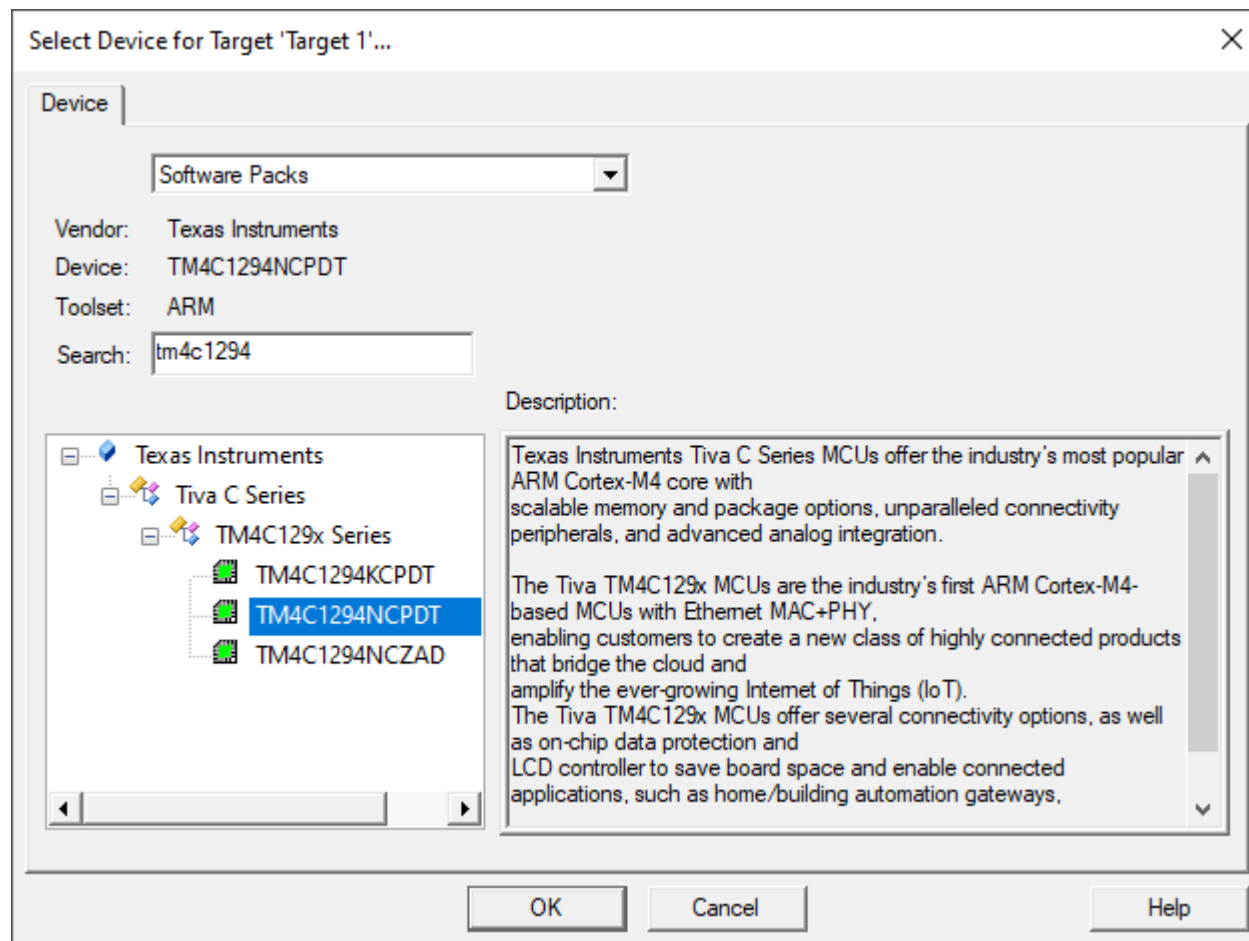


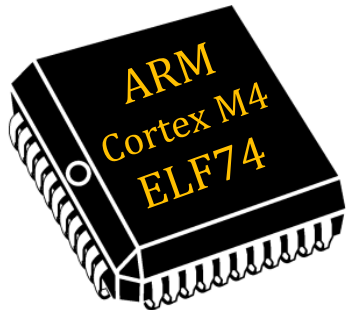
FreeRTOS - *Project Setup*

Após nomear o Projeto, escolher o microcontrolador.



- Keil
- TivaWare
- FreeRTOS



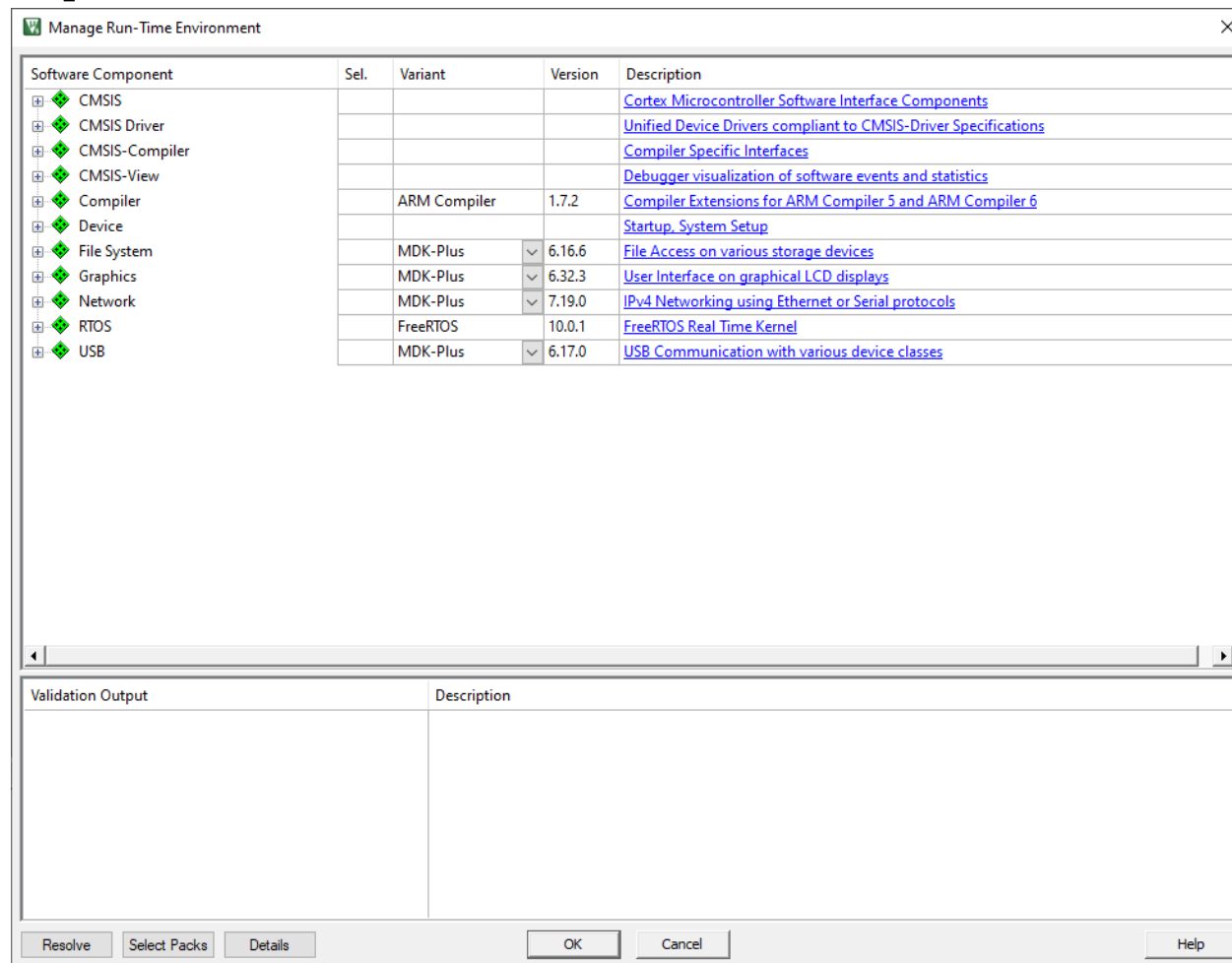


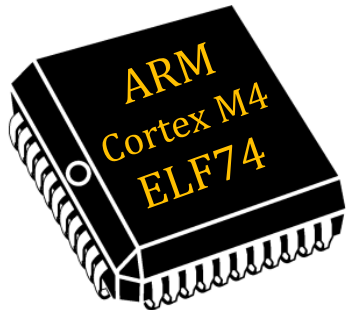
FreeRTOS - *Project Setup*

☞ Após escolher o **Device**, não selecionar nada:



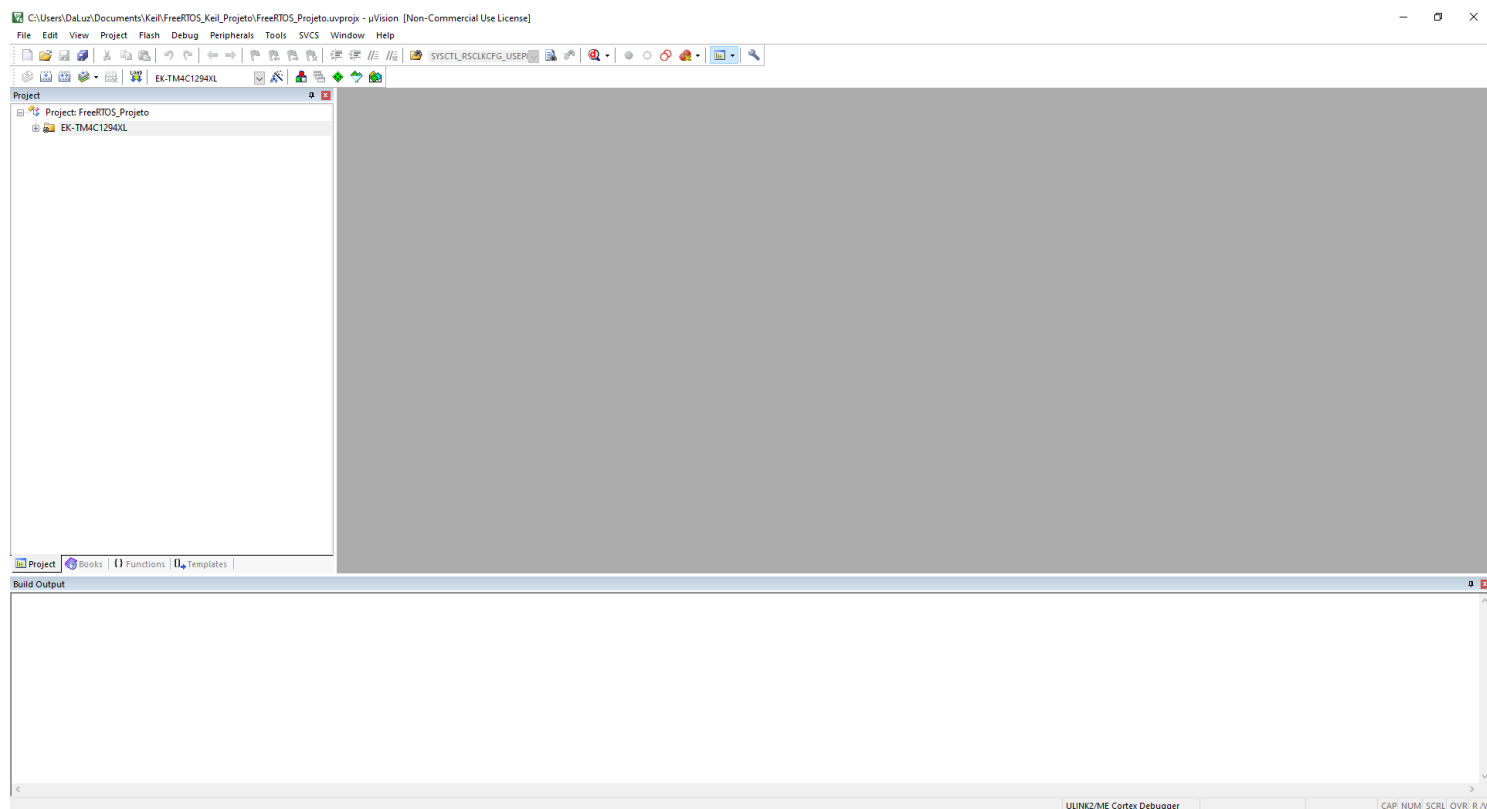
- Keil
- TivaWare
- FreeRTOS



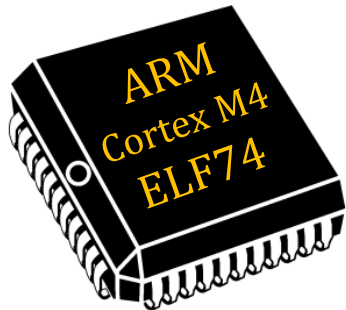


FreeRTOS - *Project Setup*

- 📖 Projeto a ser configurado tela inicial:
- 📖 ***Alterar Target 1 -> EK-TM4C1294XL***

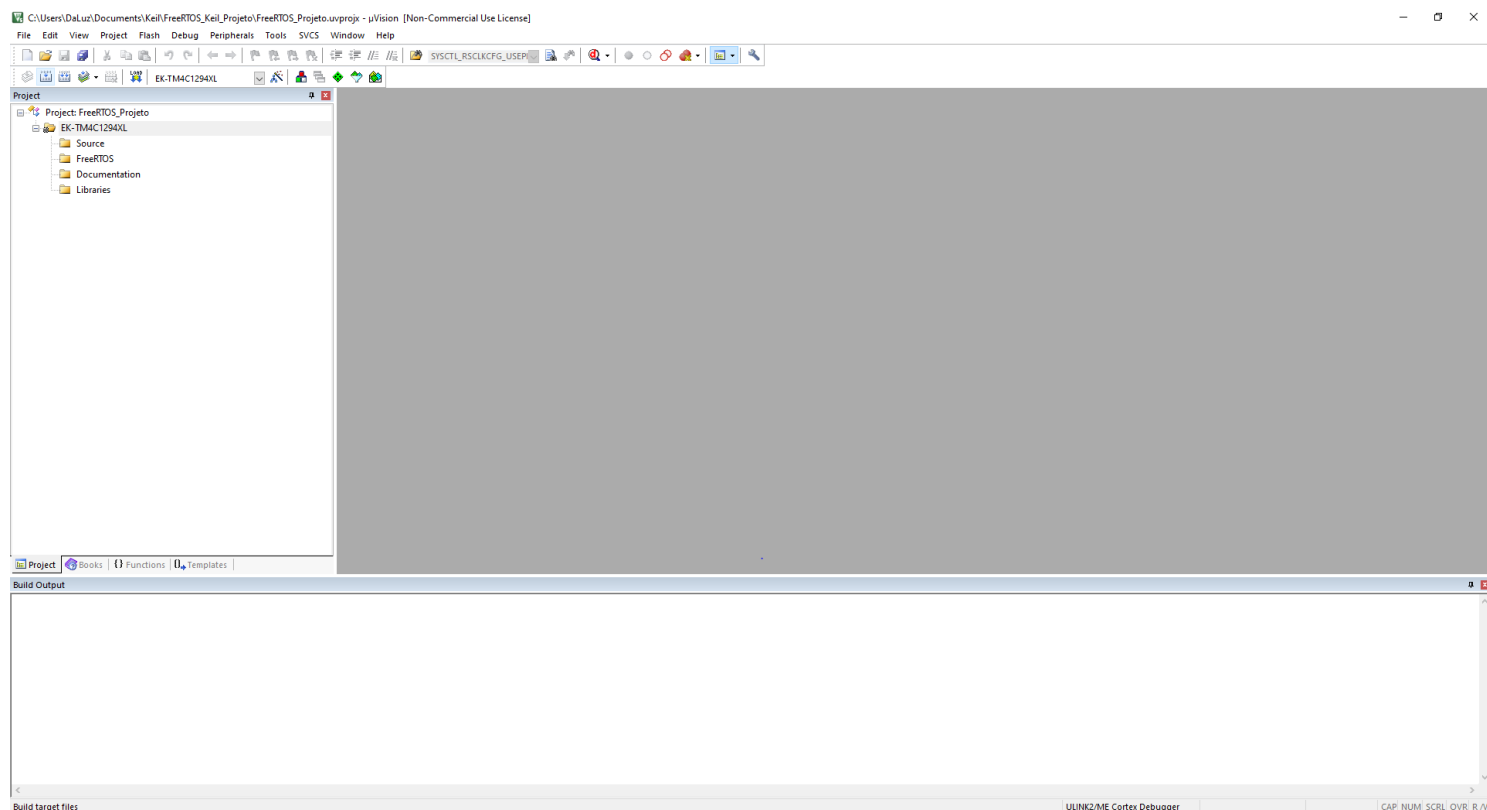


- Keil
- TivaWare
- FreeRTOS

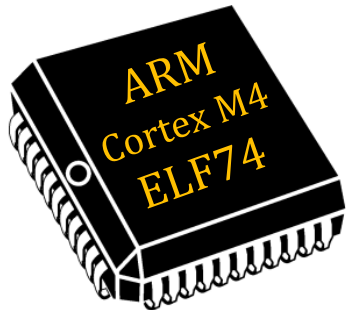


FreeRTOS - *Project Setup*

- Após alterar o **Target 1**, inserir 3 novos Grupos:
 - (FreeRTOS | Documentation | Libraries) e (Source Group 1 -> Source)



- Keil
- TivaWare
- FreeRTOS



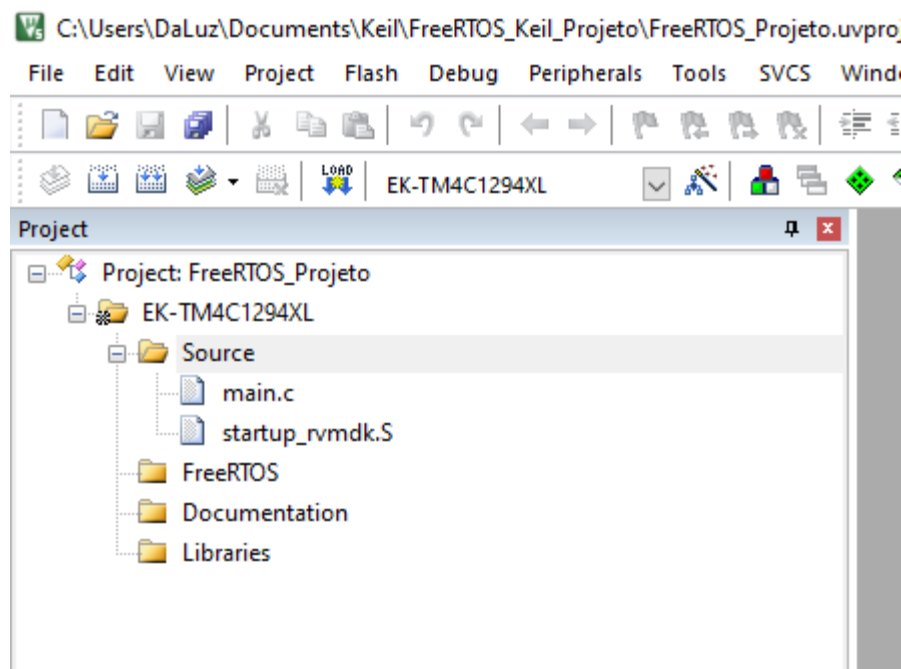
FreeRTOS - *Project Setup*

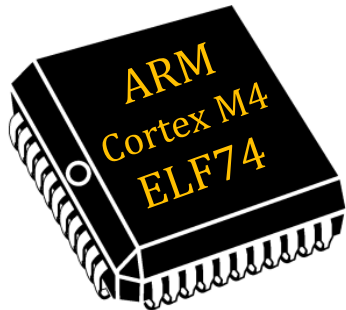
📁 Inserir no grupo **Source**:

📁 (**main.c** | **startup_rvmdk.S**)



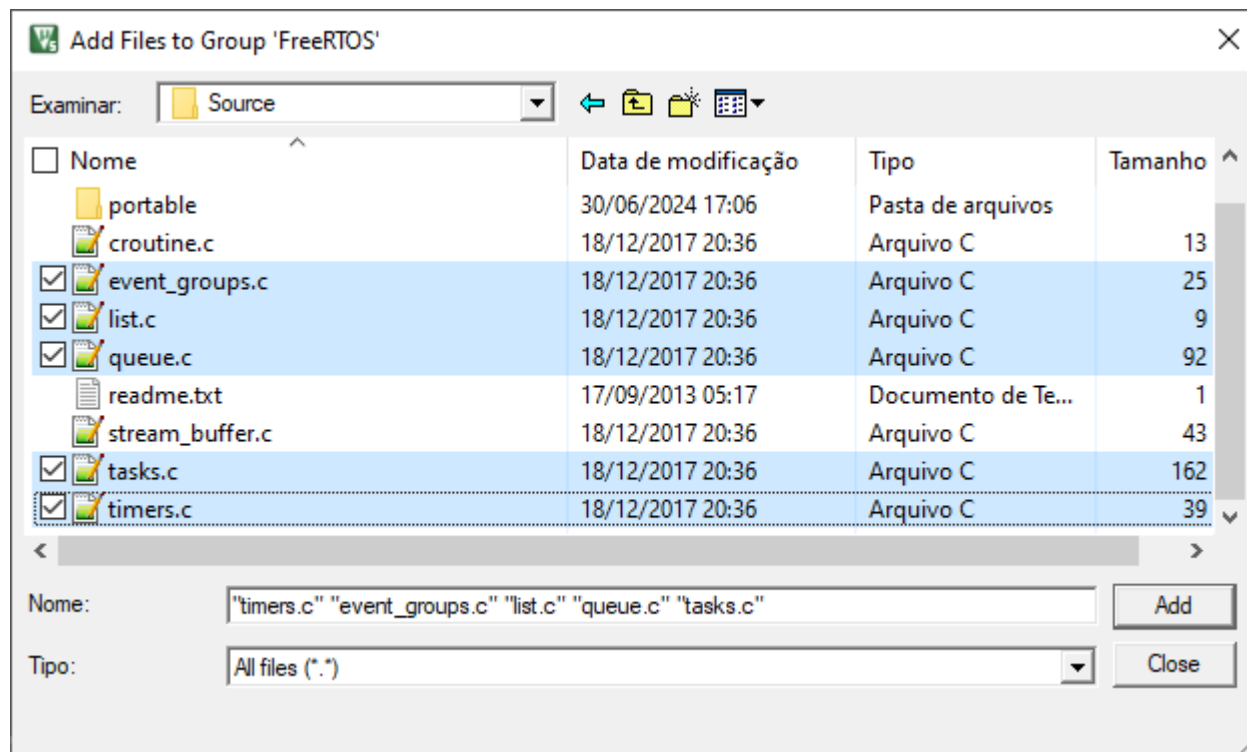
- Keil
- TivaWare
- FreeRTOS



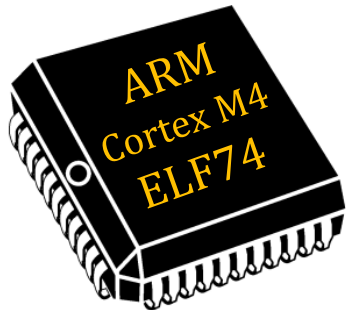


FreeRTOS - *Project Setup*

- 📁 Inserir no grupo **FreeRTOS**:
- 📁 (**event_groups.c** | **list.c** | **queue.c** | **tasks.c** | **timers.c**)



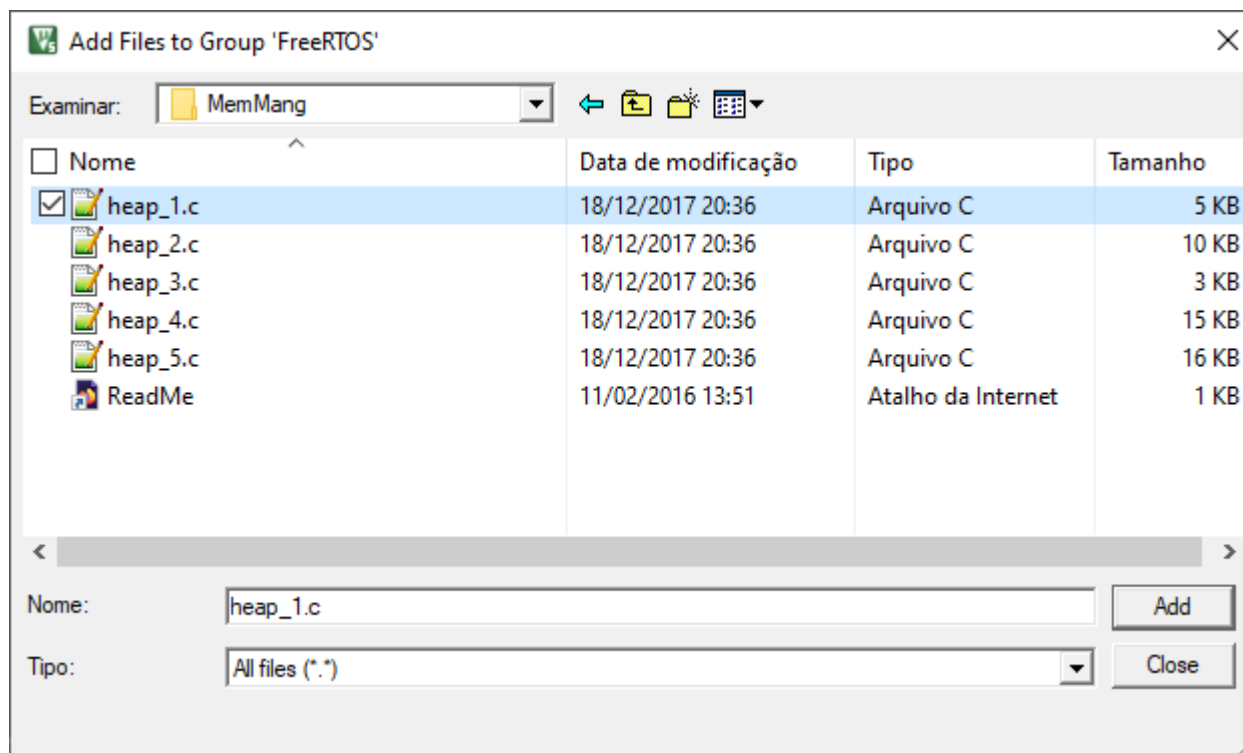
- Keil
- TivaWare
- FreeRTOS



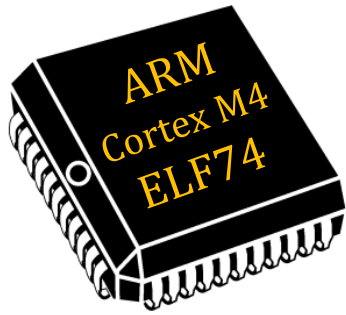
FreeRTOS - *Project Setup*

📁 Inserir no grupo **FreeRTOS**:

📁 **(heap_1.c)**

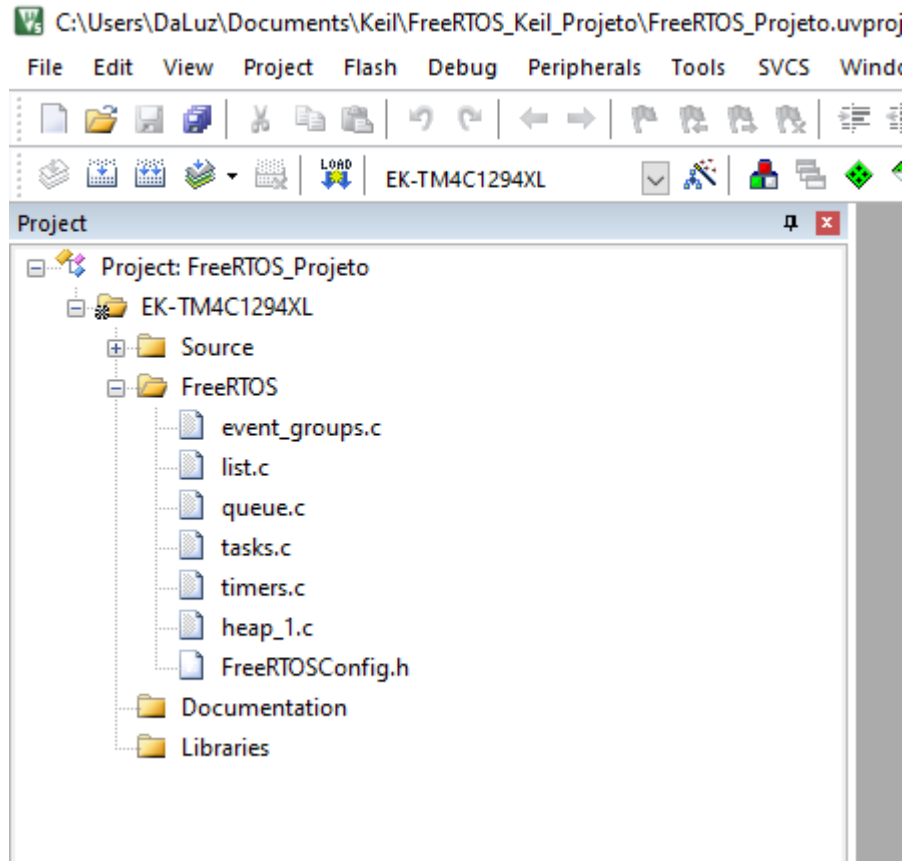


- Keil
- TivaWare
- FreeRTOS

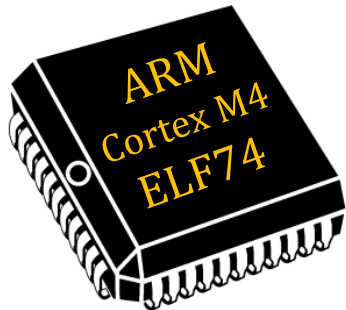


FreeRTOS - *Project Setup*

Grupo **FreeRTOS**:



- Keil
- TivaWare
- FreeRTOS

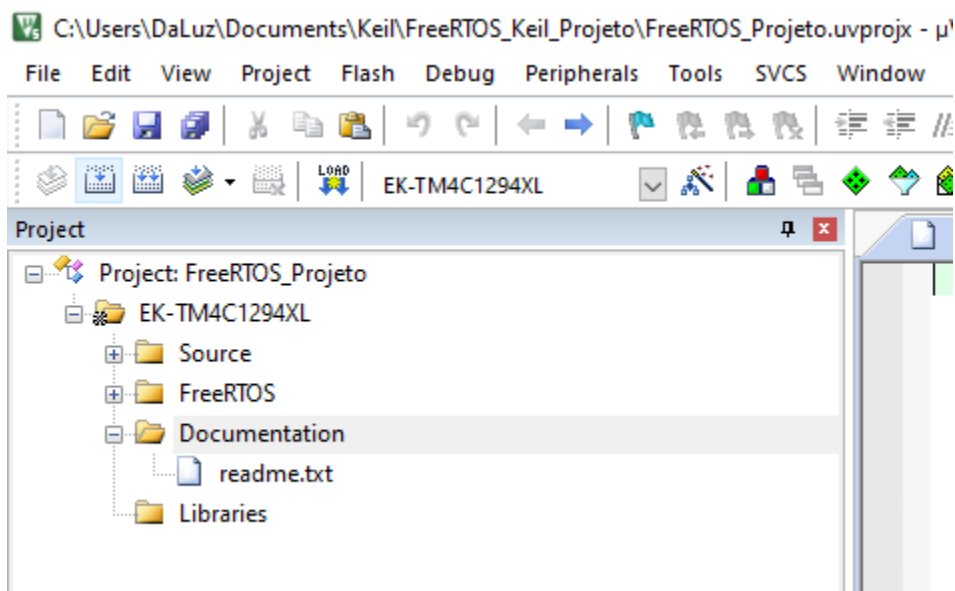


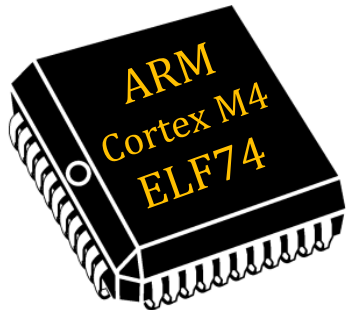
FreeRTOS - *Project Setup*



- Keil
- TivaWare
- FreeRTOS

📁 Inserir o **readme.txt** no grupo **Documentation**:





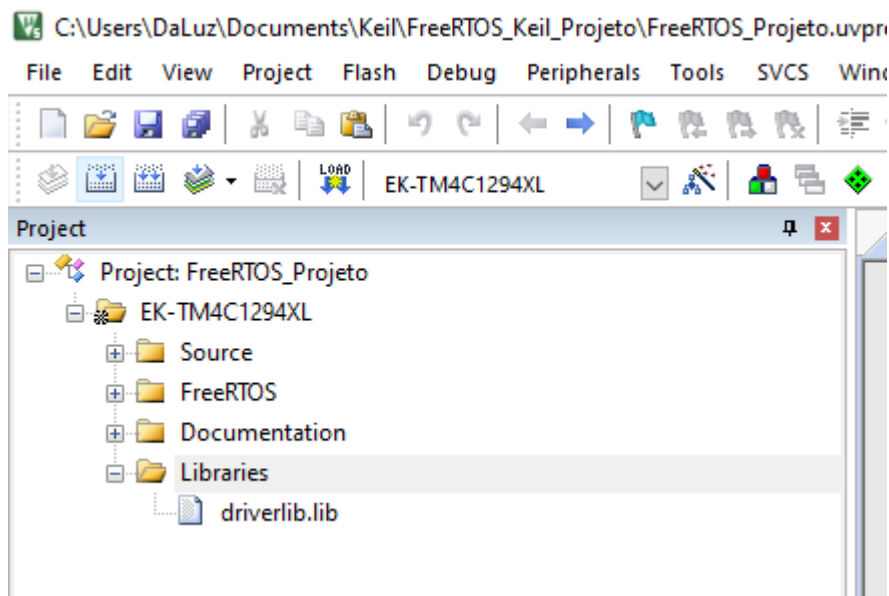
FreeRTOS - *Project Setup*

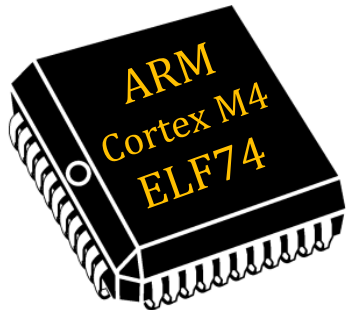


- Keil
- TivaWare
- FreeRTOS

📖 Inserir o **driverlib.lib** (TivaWare) no grupo **Libraries**:

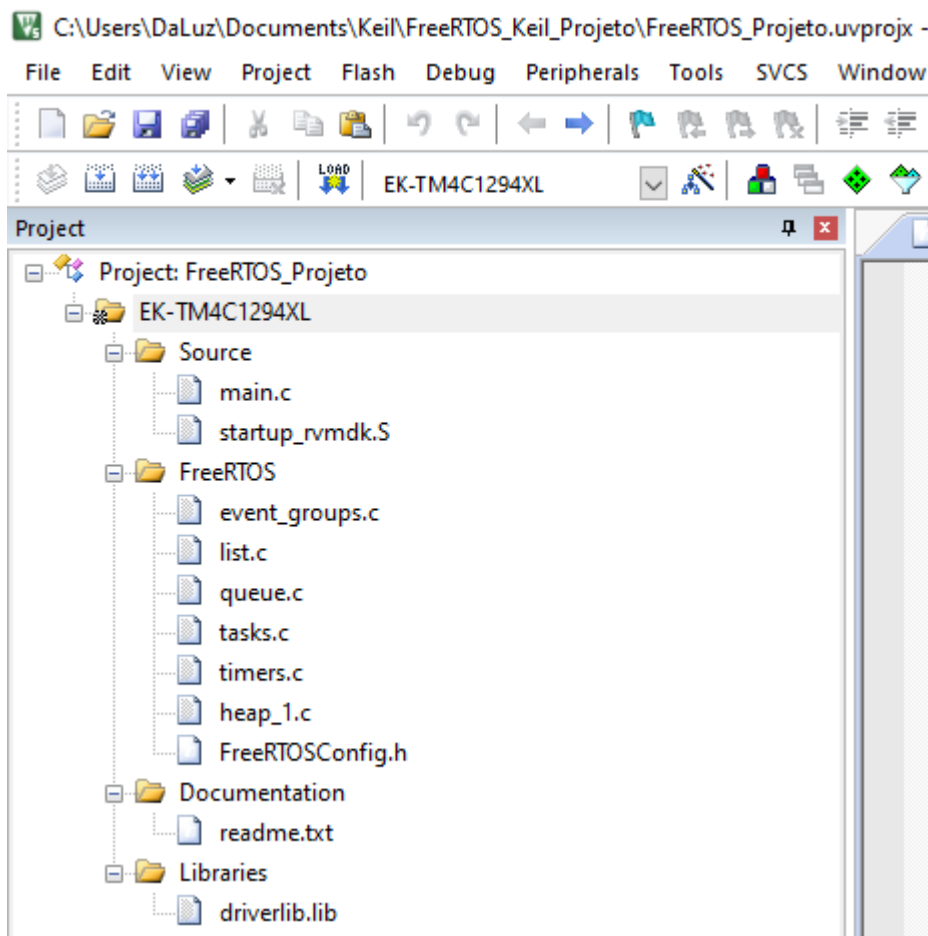
📖 Localizar a pasta: `\TivaWare_C_Series-2.2.0.295\driverlib\rvmdk`



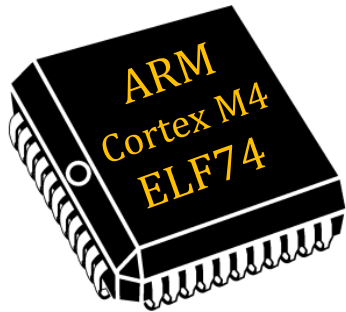


FreeRTOS - *Project Setup*

📁 Árvore completa do Projeto:



- Keil
- TivaWare
- FreeRTOS



FreeRTOS - *Project Setup*



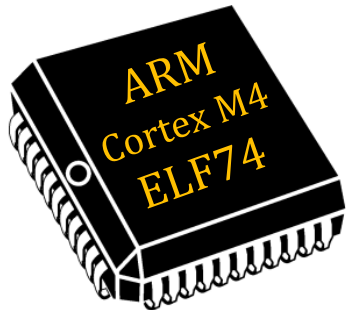
- Keil
- TivaWare
- FreeRTOS

❏ Configurar o **FreeRTOS** no *startup*:

❏ As rotinas principais do Core devem ser configuradas ... Ver o arquivo *FreeRTOSConfig.h*

```
111  
112 /* Map the FreeRTOS port interrupt handlers to their CMSIS standard names. */  
113 #define xPortPendSVHandler      PendSV_Handler  
114 #define vPortSVCHandler        SVC_Handler  
115 #define xPortSysTickHandler    SysTick_Handler  
116
```





FreeRTOS - *Project Setup*

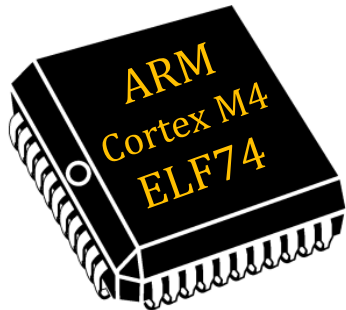


- Keil
- TivaWare
- FreeRTOS

❏ Configurar o **FreeRTOS** no **NVIC**:

❏ *As rotinas principais do Core devem ser configuradas ... Alterar o startup_rvmdk.S*

```
startup_rvmdk.S
80 ;*****
81 ;FreeRTOS - Handlers - Inseridos aqui do FreeRTOSConfig.h
82 EXTERN PendSV_Handler
83 EXTERN SVC_Handler
84 EXTERN SysTick_Handler
85
86 EXPORT __Vectors
87 __Vectors
88 DCD StackMem + Stack ; Top of Stack
89 DCD Reset_Handler ; Reset Handler
90 DCD NmiSR ; NMI Handler
91 DCD FaultISR ; Hard Fault Handler
92 DCD IntDefaultHandler ; The MPU fault handler
93 DCD IntDefaultHandler ; The bus fault handler
94 DCD IntDefaultHandler ; The usage fault handler
95 DCD 0 ; Reserved
96 DCD 0 ; Reserved
97 DCD 0 ; Reserved
98 DCD 0 ; Reserved
99 SVC_Handler ; SVCcall handler - Handler alterado para FreeRTOS
100 DCD IntDefaultHandler ; Debug monitor handler
101 DCD 0 ; Reserved
102 PendSV_Handler ; The PendSV handler - Handler alterado para FreeRTOS
103 SysTick_Handler ; The SysTick handler - Handler alterado para FreeRTOS
```



FreeRTOS - *Project Setup*



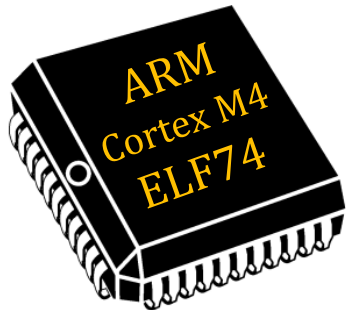
- Keil
- TivaWare
- FreeRTOS

❏ Configurar o **SystemClock** para o **FreeRTOS**:

❏ É definida pelo RTOS uma variável de Clock ... Arquivo *FreeRTOSConfig.h*

```
39  *
40  * See http://www.freertos.org/a00110.html.
41  *-----*/
42
43  #include <stdint.h>
44
45  extern uint32_t SystemCoreClock;
46
47  #define configCPU_CLOCK_HZ          (SystemCoreClock)
48  #define configTICK_RATE_HZ          ((TickType_t)1000)
49  #define configTOTAL_HEAP_SIZE       ((size_t)(1024)*12)
50  #define configMINIMAL_STACK_SIZE    ((unsigned short)(128)*2)
51  #define configCHECK_FOR_STACK_OVERFLOW 0
52  #define configMAX_PRIORITIES        (5)
53  #define configUSE_PREEMPTION        1
54  #define configIDLE_SHOULD_YIELD     1
55  #define configMAX_TASK_NAME_LEN     (10)
```





FreeRTOS - *Project Setup*

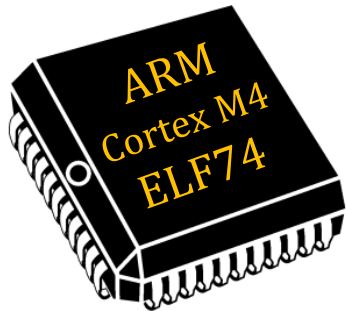


- Keil
- TivaWare
- FreeRTOS

❏ Configurar o **SystemClock** para o FreeRTOS:

❏ *A forma mais fácil de se fazer isso é criar uma variável global no main.c ...*

```
startup_rvmdk.S  main.c
1  /******
2  Prof. Paulo Denis Garcez da Luz - 2024/1S
3  Desenvolvido para a placa EK-TM4C1294XL com SDK TivaWare e FreeRTOS
4  Programa exemplo de blink usando 1 led e FreeRTOS.
5  *****/
6
7  /* TivaWare uC: Usado internamente para identificar o uC em alguns .h da TivaWare */
8  #define PART_TM4C1294NCPDT 1
9
10 #include <stdint.h>
11 #include <stdbool.h>
12 #include "inc/hw_memmap.h"
13 #include "driverlib/debug.h"
14 #include "driverlib/gpio.h"
15 #include "driverlib/sysctl.h"
16 #include "driverlib/systick.h"
17
18 /* Bibliotecas FreeRTOS */
19 #include <stdint.h>
20 #include "FreeRTOS.h"
21 #include "task.h"
22
23 /* Variável Global com o valor do SystemClock: */
24 uint32_t SystemCoreClock=16000000;
25
```

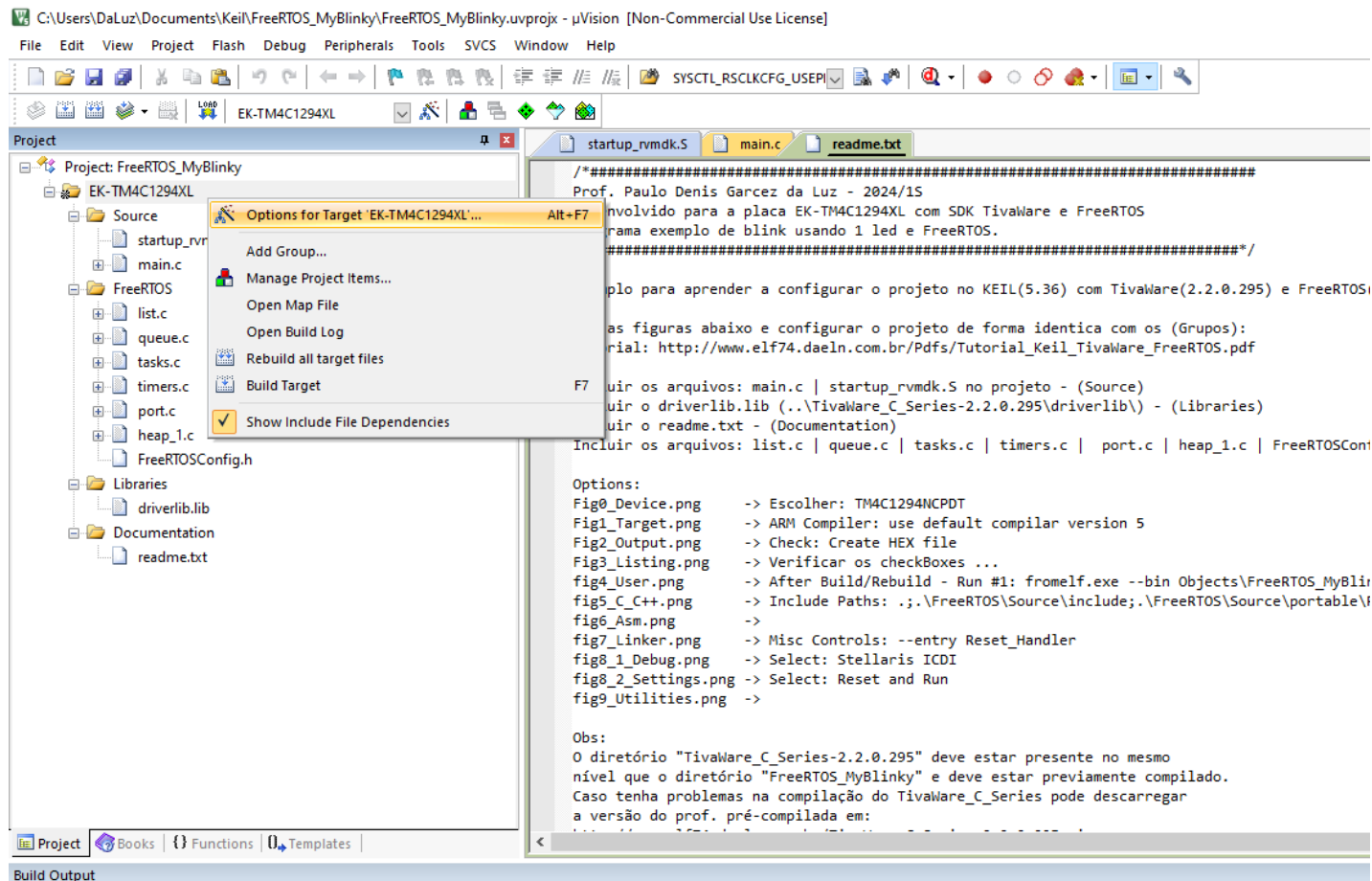


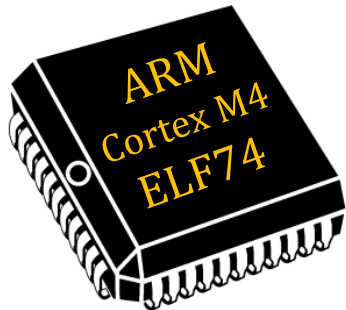
FreeRTOS - *Project Setup*



- Keil
- TivaWare
- FreeRTOS

Configurar Propriedades do Projeto:



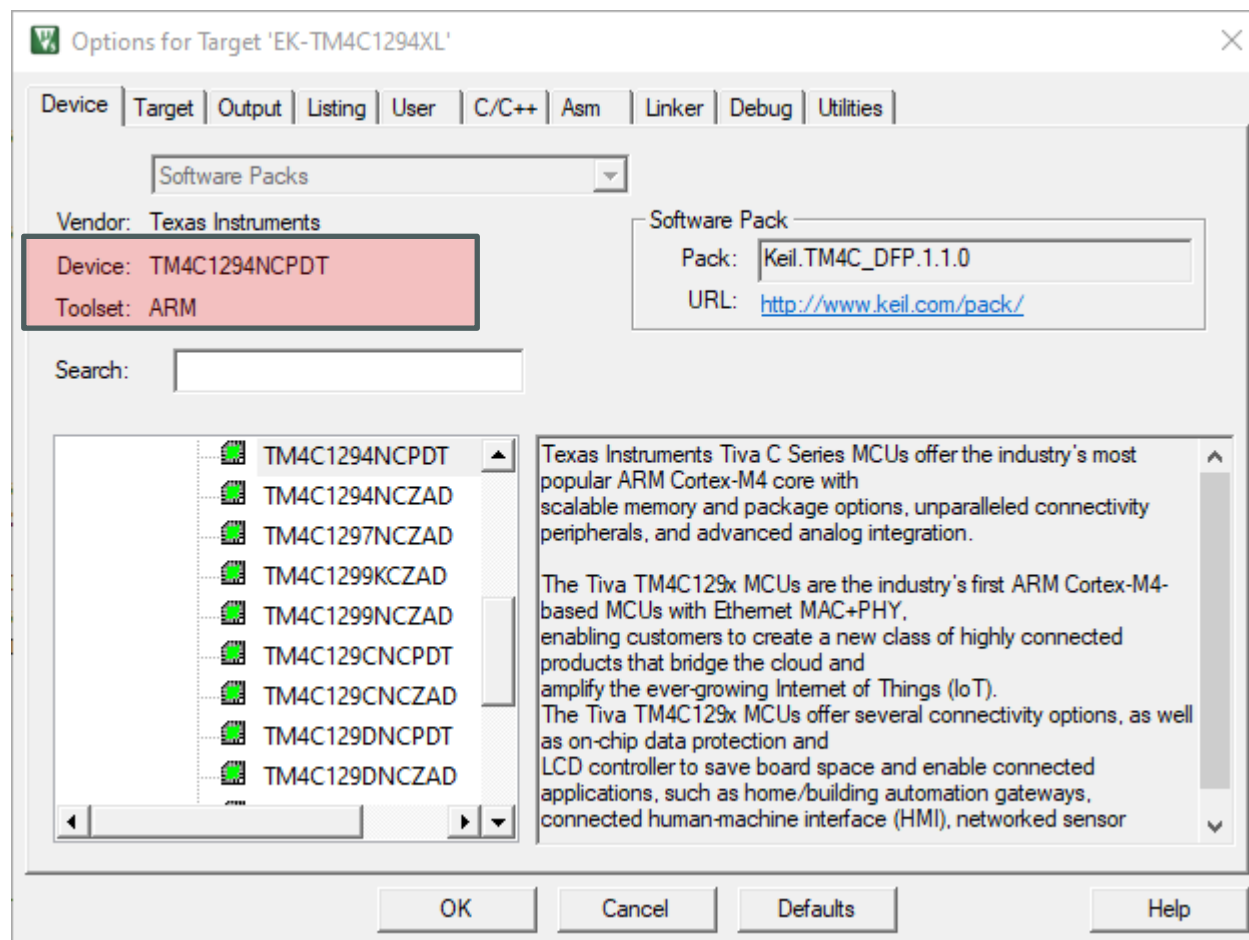


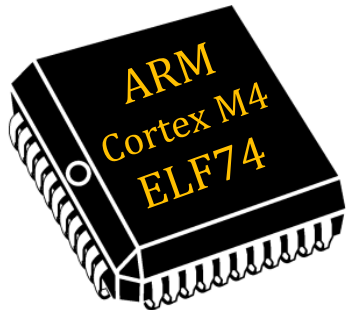
FreeRTOS - *Project Setup*



- Keil
- TivaWare
- FreeRTOS

Configurar Propriedades do Projeto: **(TM4C1294NCPDT)**





FreeRTOS - *Project Setup*



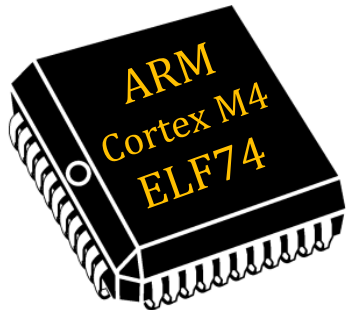
- Keil
- TivaWare
- FreeRTOS

Configurar Propriedades do Projeto: **(Use default compiler version 5)**

The image shows the 'Options for Target' dialog box for 'EK-TM4C1294XL'. The 'Code Generation' tab is selected, and the 'ARM Compiler' dropdown is set to 'Use default compiler version 5'. The 'Use MicroLIB' checkbox is checked, and the 'Floating Point Hardware' is set to 'Single Precision'. The 'Read/Only Memory Areas' and 'Read/Write Memory Areas' sections are also visible.

Read/Only Memory Areas				
default	off-chip	Start	Size	Startup
☐	ROM1:			☐
☐	ROM2:			☐
☐	ROM3:			☐
on-chip				
☒	IROM1:	0x0	0x100000	☒
☐	IROM2:			☐

Read/Write Memory Areas				
default	off-chip	Start	Size	NoInit
☐	RAM1:			☐
☐	RAM2:			☐
☐	RAM3:			☐
on-chip				
☒	IRAM1:	0x20000000	0x40000	☐
☐	IRAM2:			☐

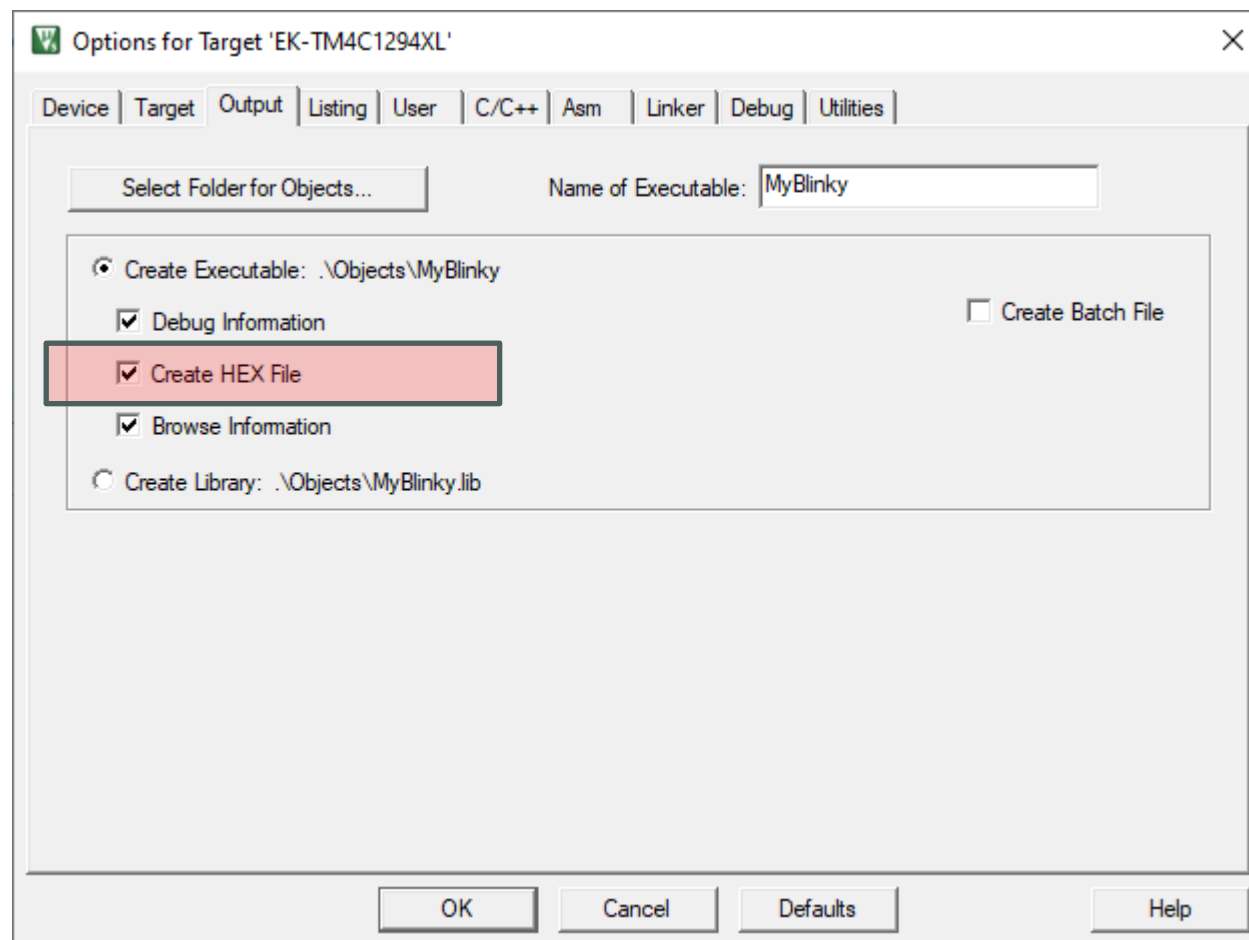


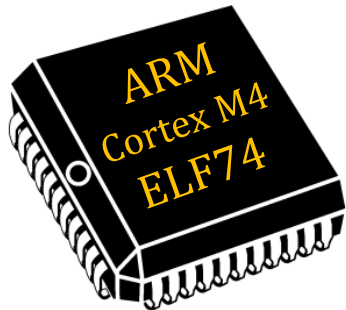
FreeRTOS - *Project Setup*



- Keil
- TivaWare
- FreeRTOS

Configurar Propriedades do Projeto: **(Output)**



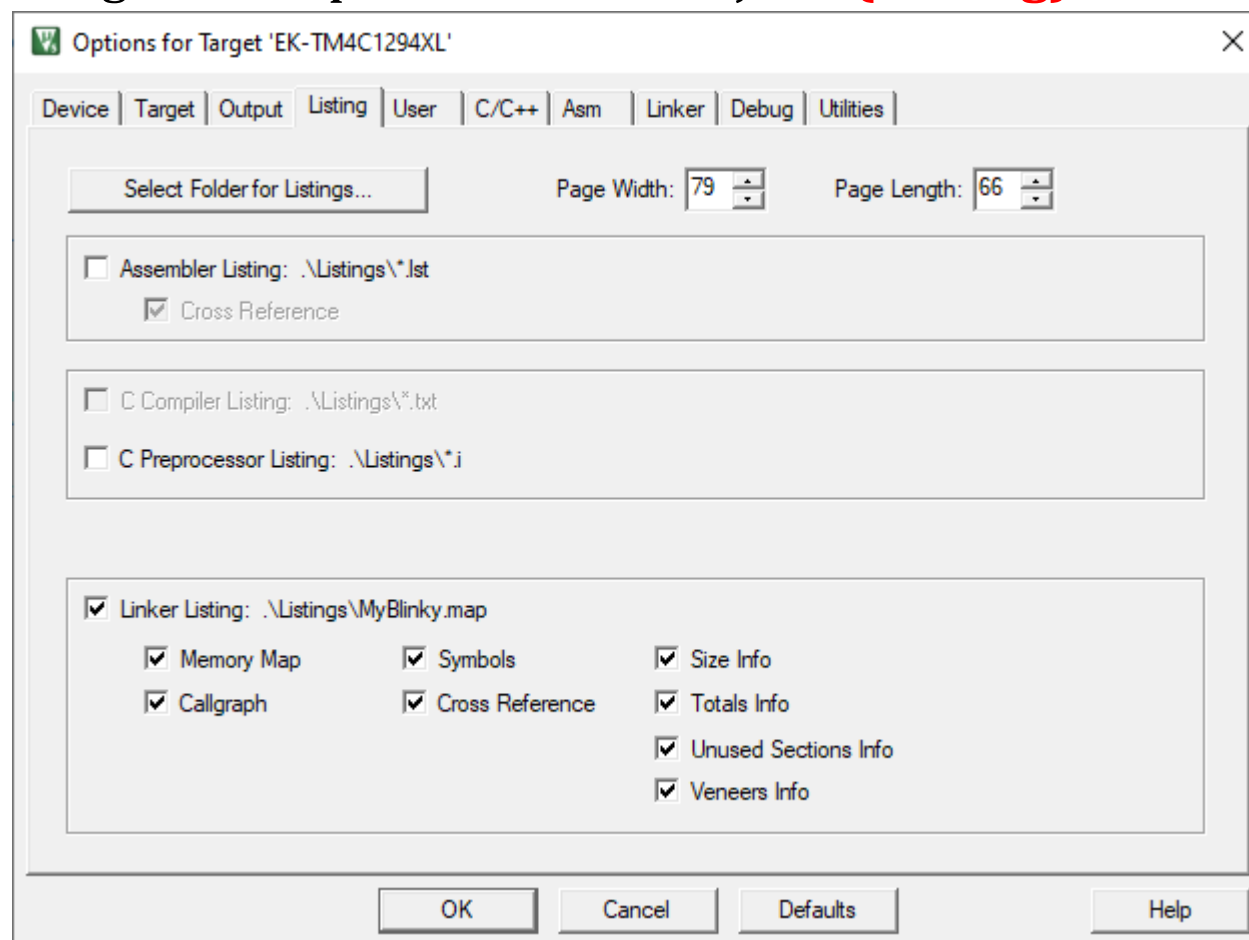


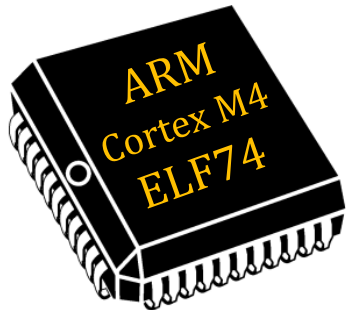
FreeRTOS - *Project Setup*



- Keil
- TivaWare
- FreeRTOS

Configurar Propriedades do Projeto: **(Listing)**





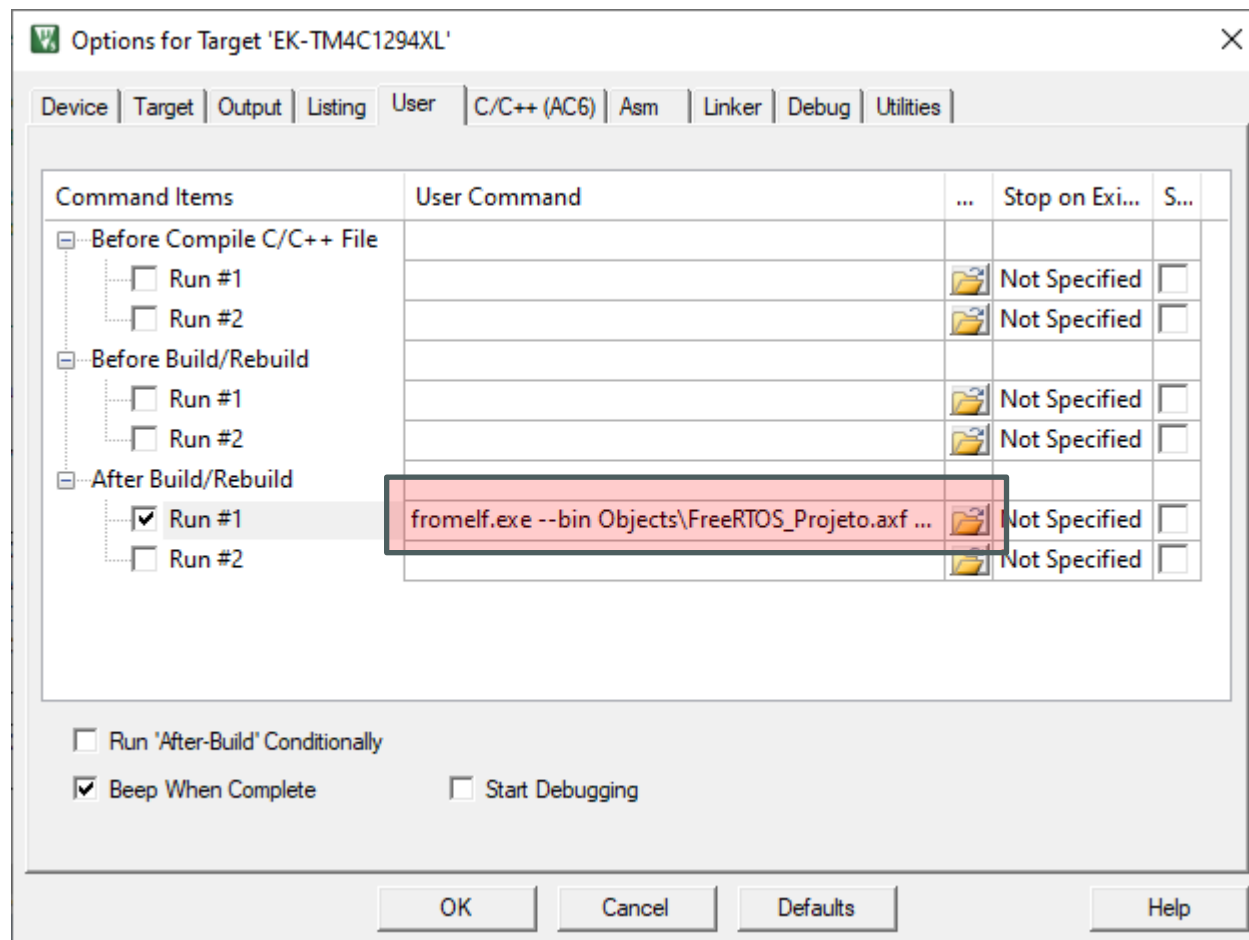
FreeRTOS - *Project Setup*

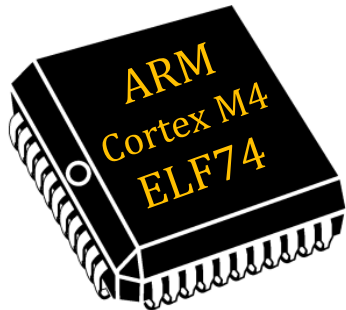
Configurar Propriedades do Projeto:

`fromelf.exe --bin Objects\FreeRTOS_Projeto.axf --output Objects\FreeRTOS_Projeto.bin`



- Keil
- TivaWare
- FreeRTOS

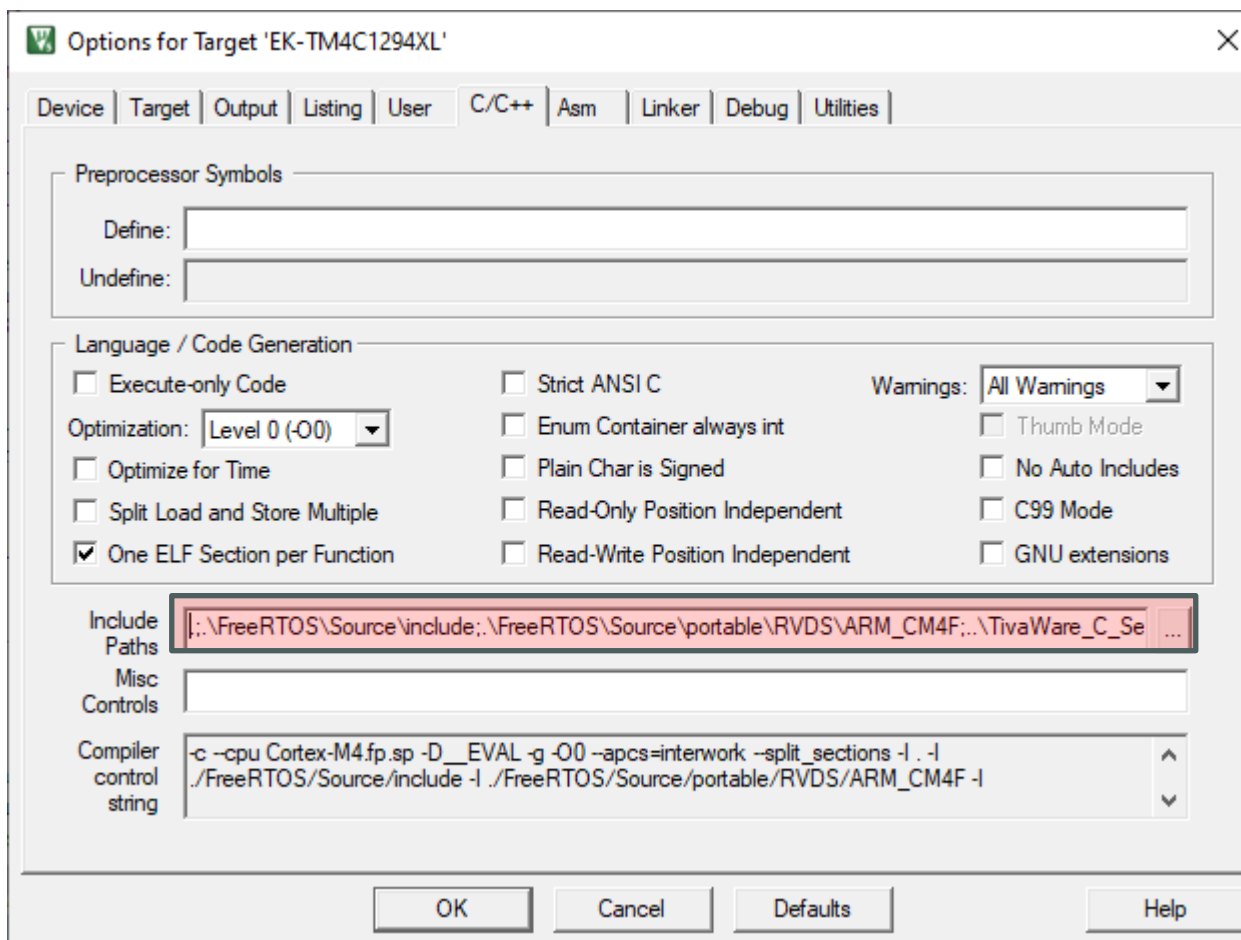




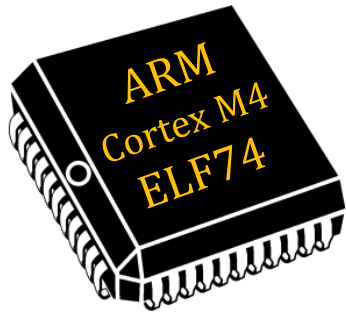
FreeRTOS - *Project Setup*

Configurar Propriedades do Projeto (4 paths):

`..\\FreeRTOS\\Source\\include;..\\FreeRTOS\\Source\\portable\\RVDS\\ARM_CM4F;..\\TivaWare_C_Series-2.2.0.295`



- Keil
- TivaWare
- FreeRTOS

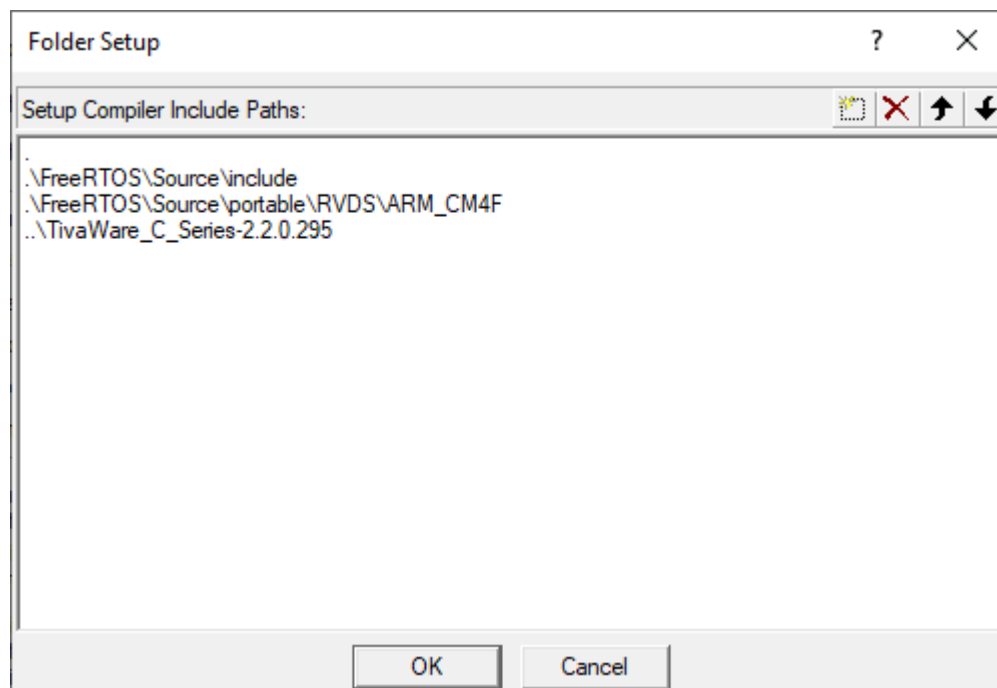


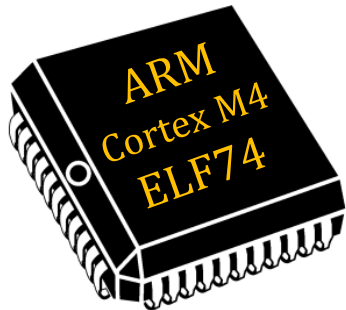
FreeRTOS - *Project Setup*



- Keil
- TivaWare
- FreeRTOS

- Configurar Propriedades do Projeto (4 paths):
- `..\\FreeRTOS\\Source\\include;..\\FreeRTOS\\Source\\portable\\RVDS\\ARM_CM4F;..\\TivaWare_C_Series-2.2.0.295`



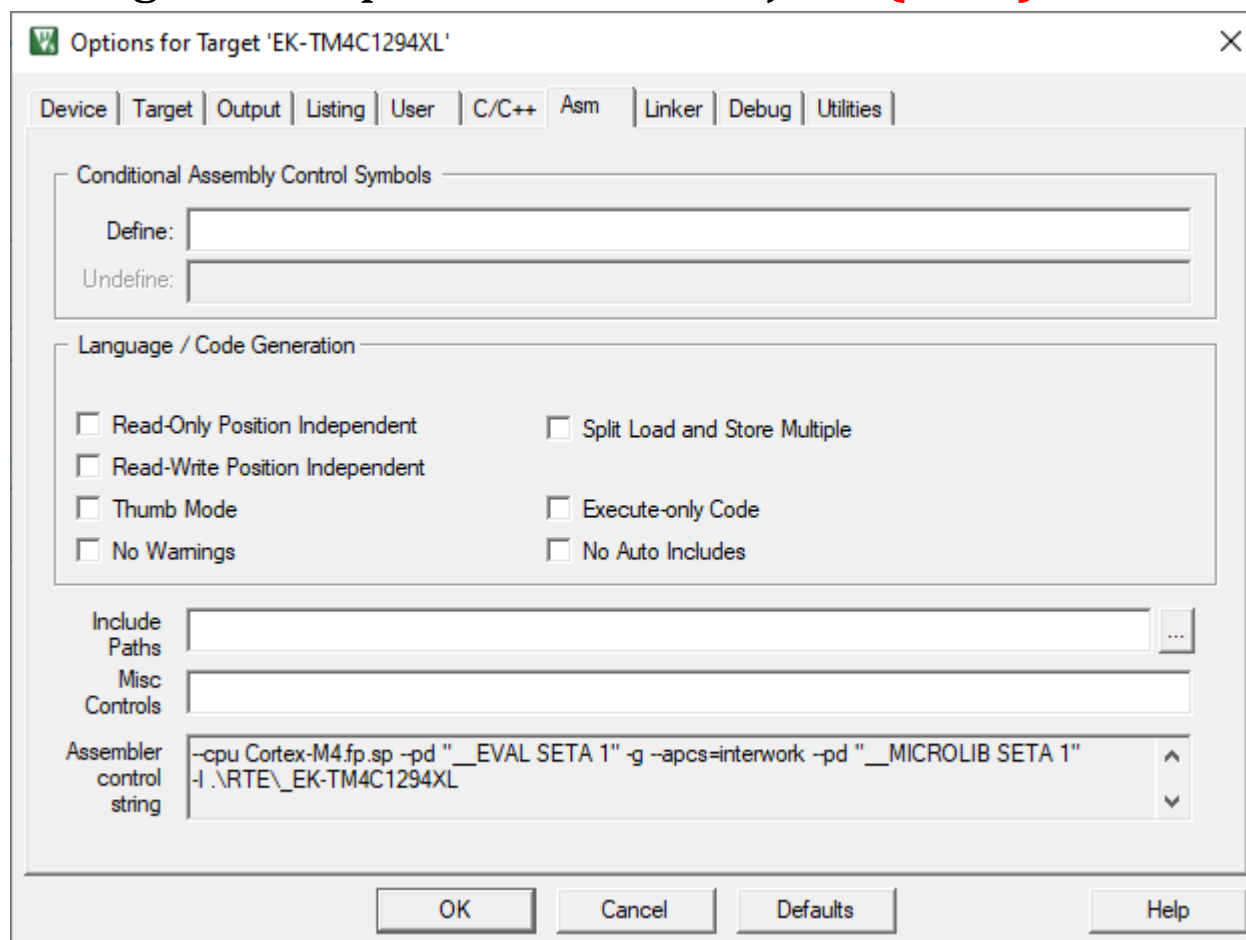


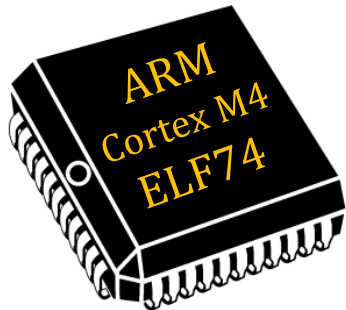
FreeRTOS - *Project Setup*



- Keil
- TivaWare
- FreeRTOS

Configurar Propriedades do Projeto: **(Asm)**



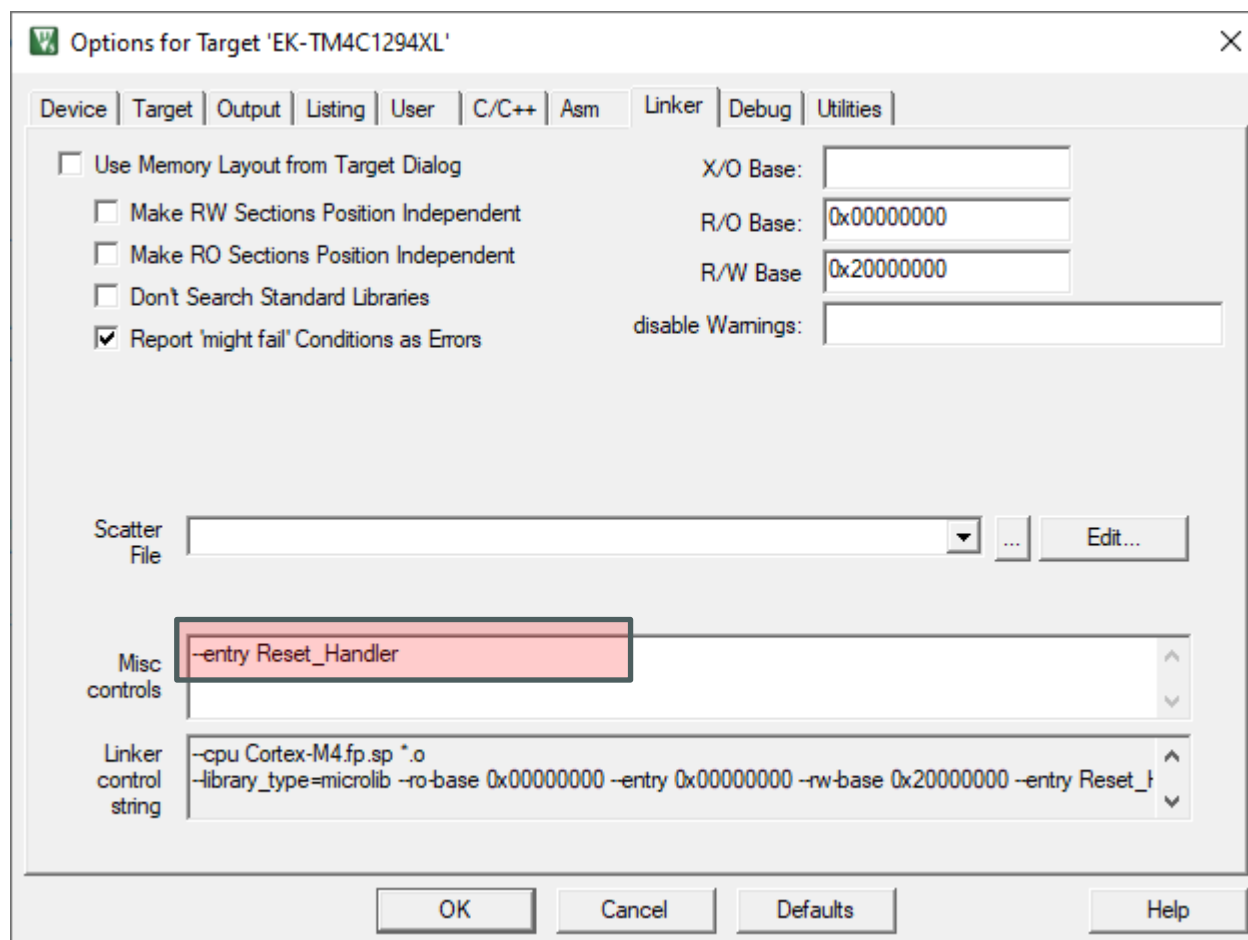


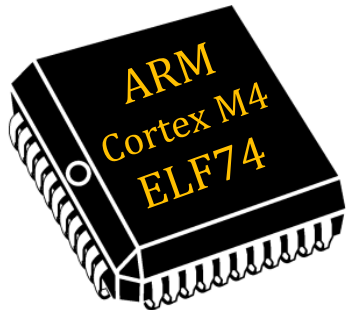
FreeRTOS - *Project Setup*



- Keil
- TivaWare
- FreeRTOS

Configurar Propriedades do Projeto: (**--entry Reset_Handler**)



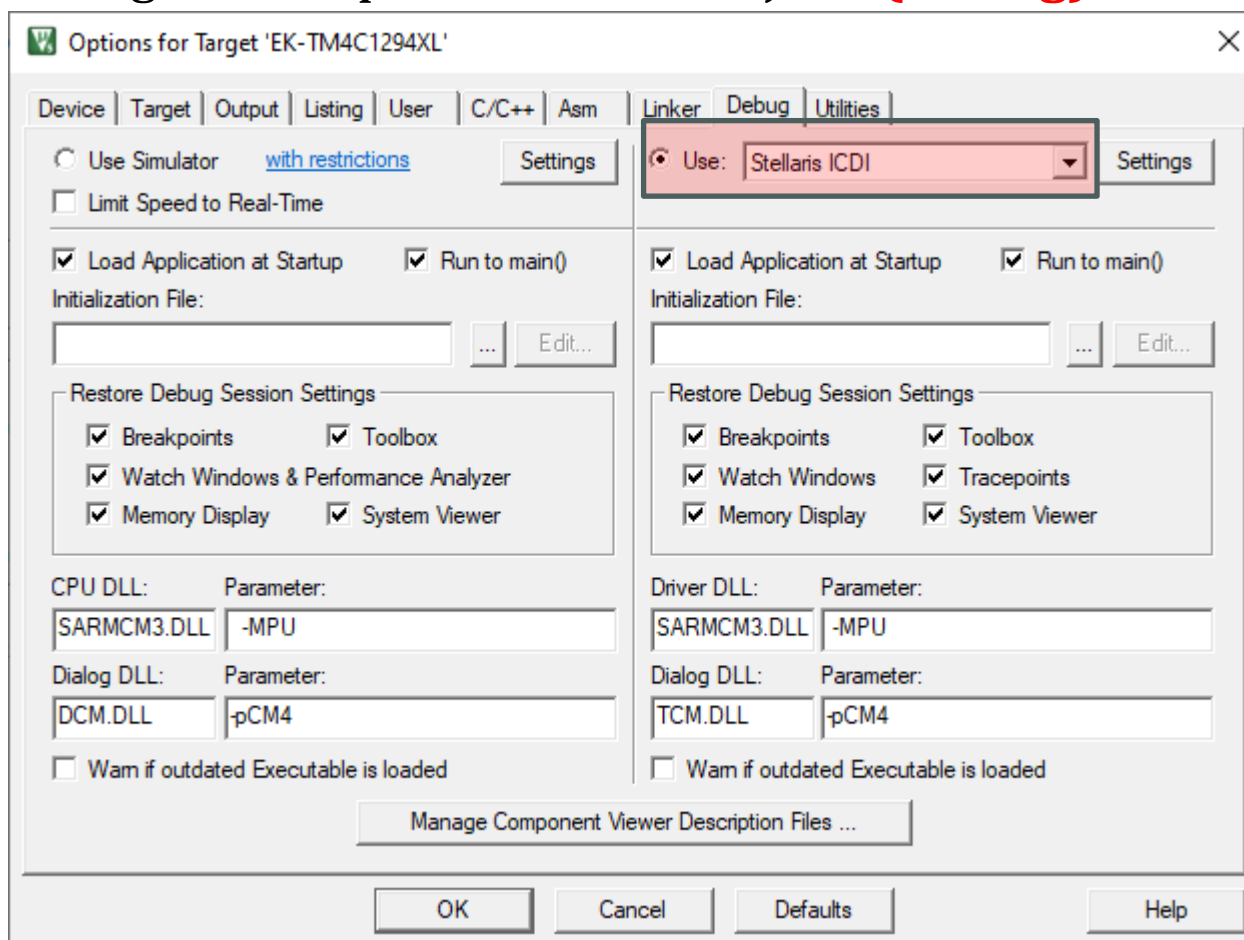


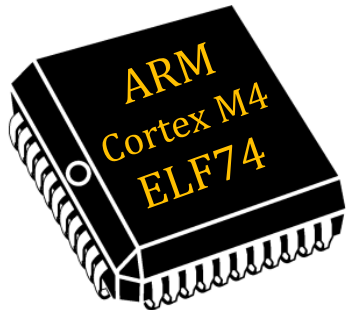
FreeRTOS - *Project Setup*



- Keil
- TivaWare
- FreeRTOS

Configurar Propriedades do Projeto: **(Debug)**



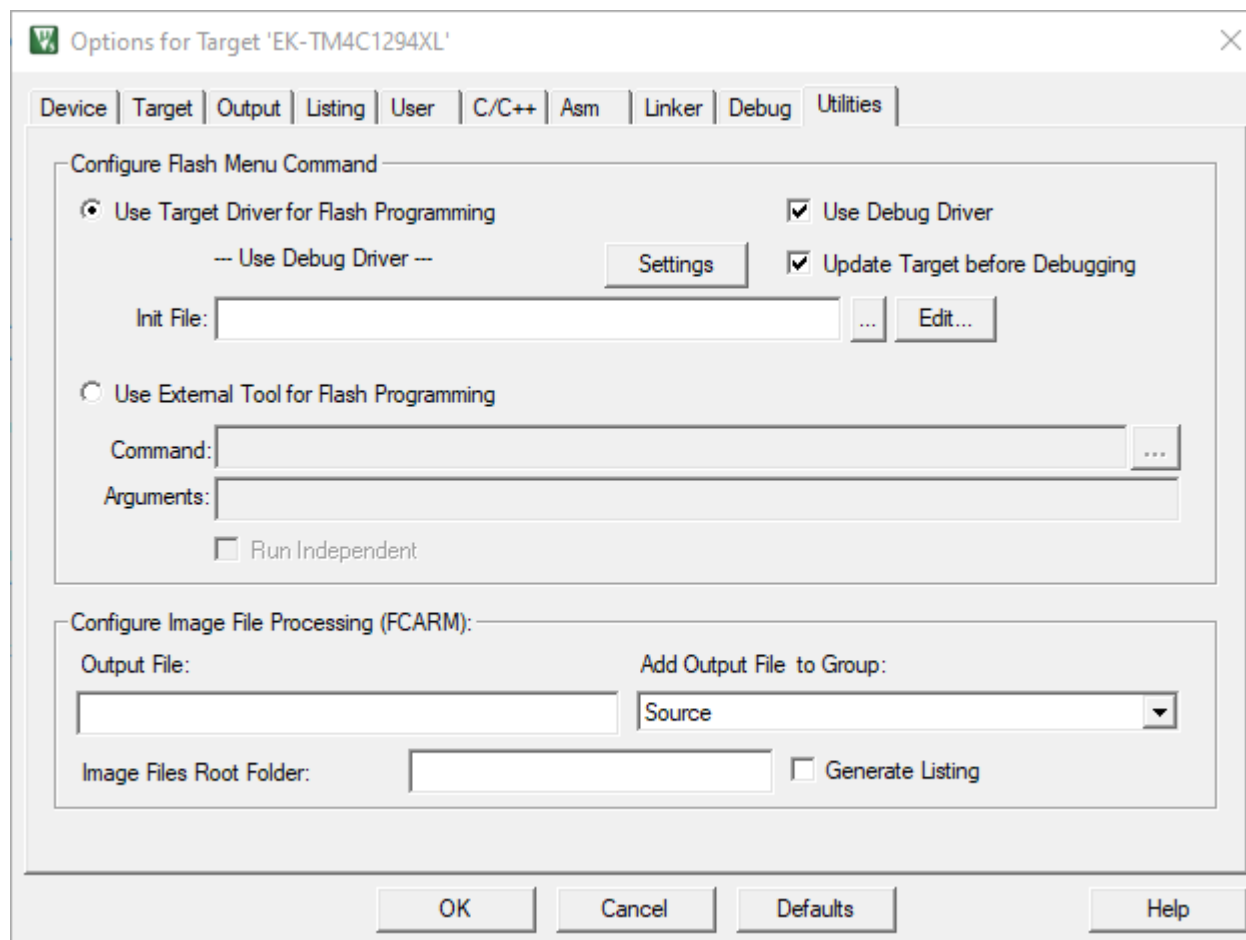


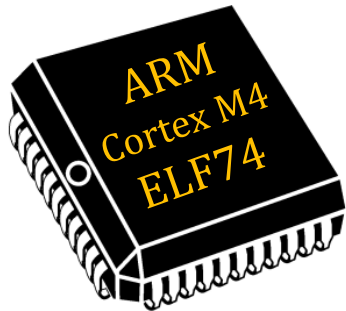
FreeRTOS - *Project Setup*



- Keil
- TivaWare
- FreeRTOS

Configurar Propriedades do Projeto: **(Utilities)**



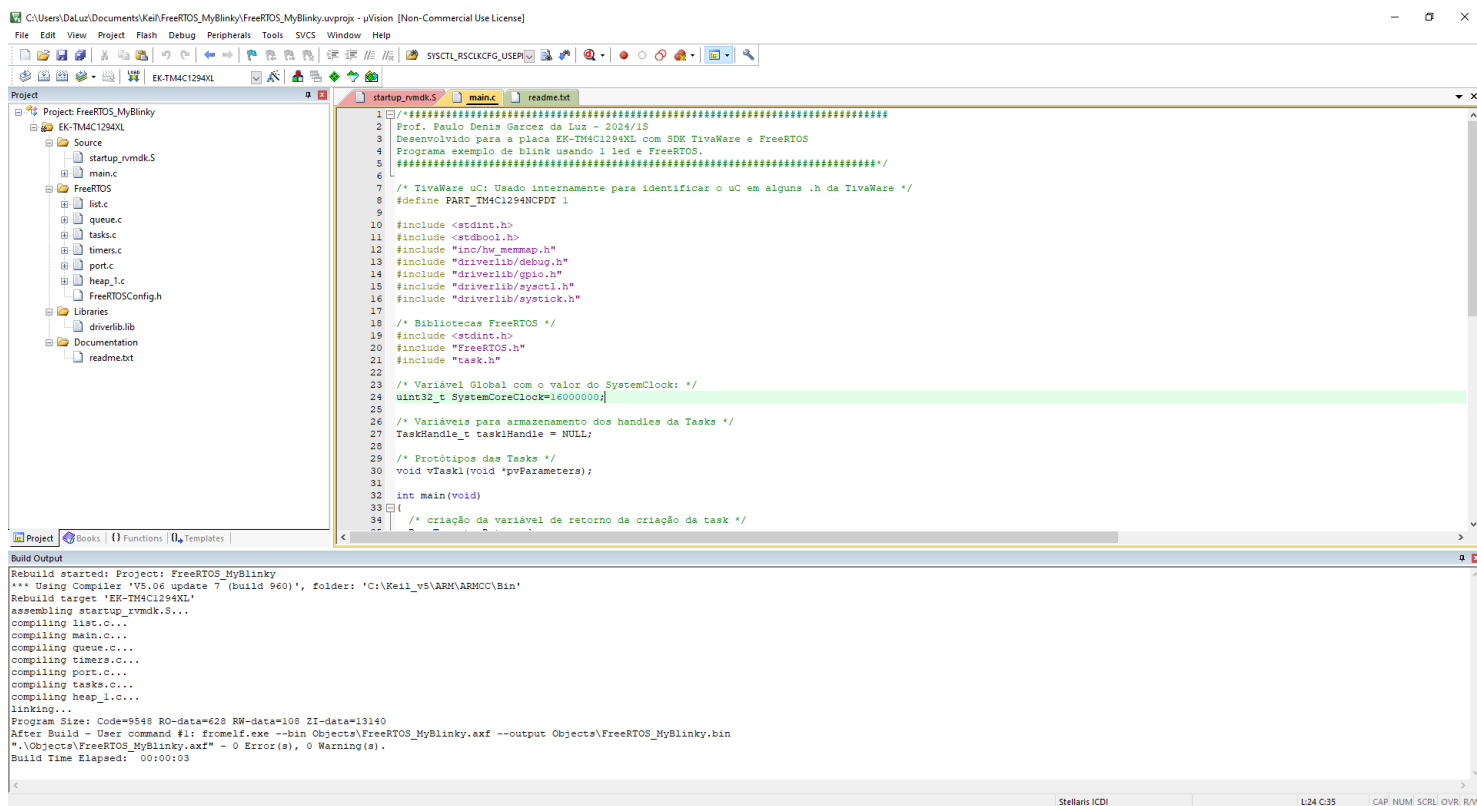


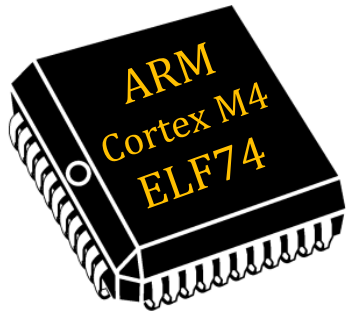
FreeRTOS - *Project Setup*



- Keil
- TivaWare
- FreeRTOS

📁 Projeto completo:





FreeRTOS - *Project Setup*



- Keil
- TivaWare
- Projeto

📁 Mini FreeRTOS pré-configurado para os Projetos:

📁 (.zip feito pelo professor)

http://www.elf74.daeln.com.br/FreeRTOS/FreeRTOSv10.0.1_cm4f.zip

📁 Exemplo Projeto FreeRTOS-MyBlinky:

📁 (projeto feito pelo professor)

http://www.elf74.daeln.com.br/FreeRTOS/FreeRTOS_MyBlinky.zip