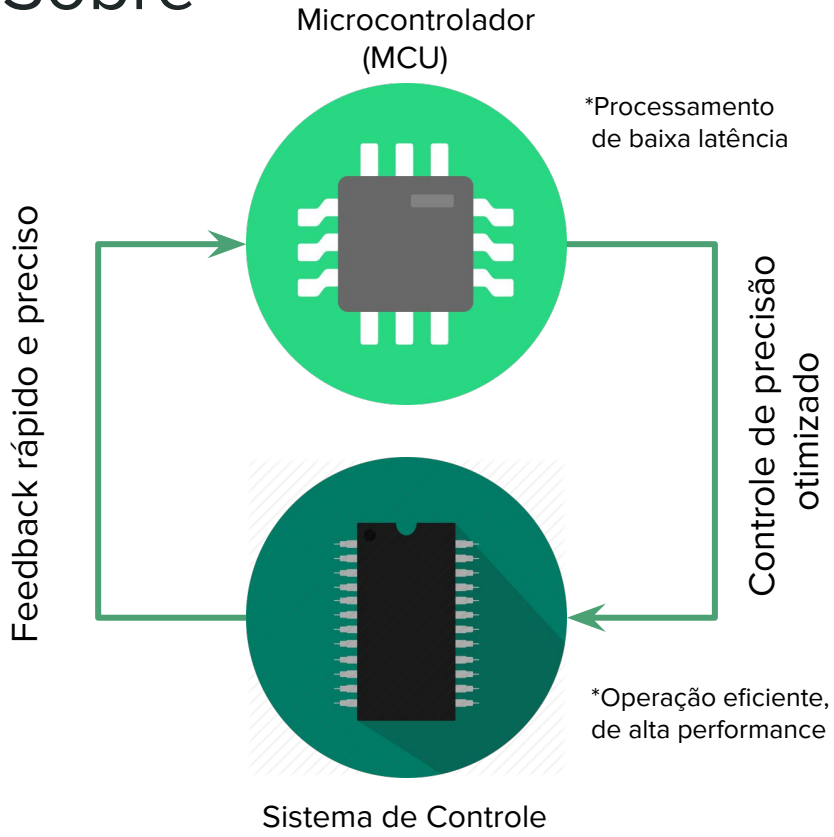
Plataformas Comerciais para Sistemas Embarcados

C2000 Piccolo TMS320F2802x

João Marcus Maia Rocha
João Gabriel Carneiro Medeiros

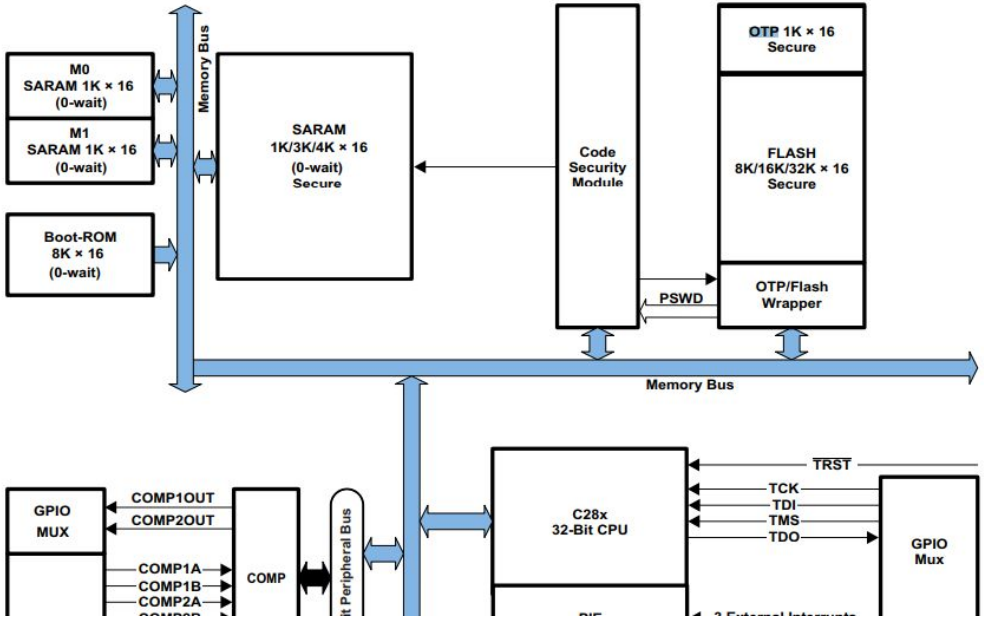
Sobre



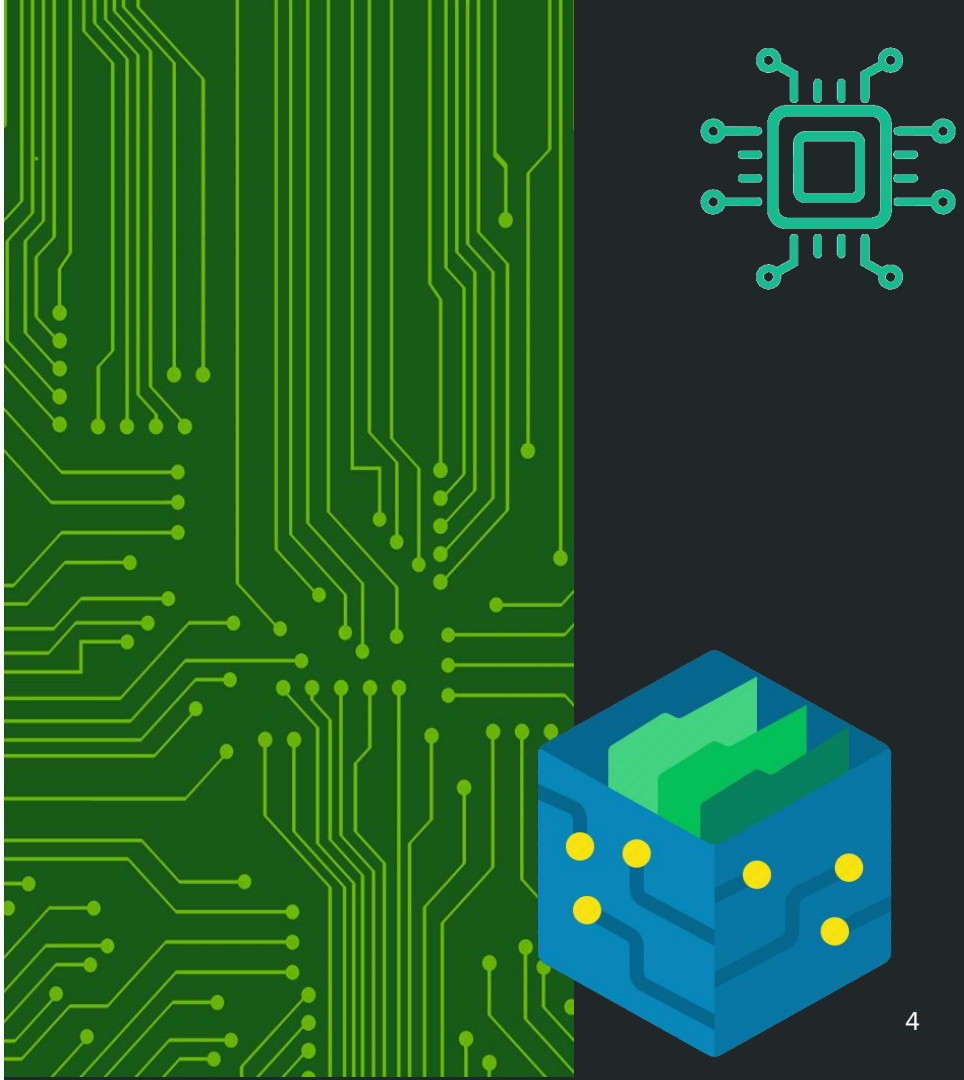
- Microcontroladores de 32 bits
- Otimiza processamento, detecção e atuação em controle de malhas fechadas em tempo real:
  - Motores Industriais
  - Inversores solares
  - Carros elétricos
- Periféricos de controle integrados
- Núcleo C28x

Memória

- On-chip memory
  - Flash
  - SARAM
  - OTP
  - Boot ROM
- Arquitetura Harvard



Part number	Flash memory (KB)	RAM (KB)
TMS320F2802	64	12
TMS320F28022	32	12
TMS320F28023	64	12
TMS320F28026	32	12
TMS320F28026F	32	12
TMS320F28027	64	12
TMS320F28027F	64	12
TMS320F28021	64	10
TMS320F280230	32	8
TMS320F280270	32	8
TMS320F28020	32	6
TMS320F280200	16	6
TMS320F280260	16	6



Clock

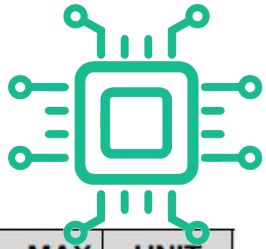


Table 5-7. 2802x Clock Table and Nomenclature (40-MHz Devices)

		MIN	NOM	MAX	UNIT
SYSCLKOUT	$t_{c(SCO)}$, Cycle time	25		500	ns
	Frequency	2		40	MHz
LSPCLK (1)	$t_{c(LCO)}$, Cycle time	25	100 (2)		ns
	Frequency		10 (2)	40	MHz
ADC clock	$t_{c(ADCCLK)}$, Cycle time	25			ns
	Frequency			40	MHz

Table 5-8. 2802x Clock Table and Nomenclature (50-MHz Devices)

		MIN	NOM	MAX	UNIT
SYSCLKOUT	$t_{c(SCO)}$, Cycle time	20		500	ns
	Frequency	2		50	MHz
LSPCLK (1)	$t_{c(LCO)}$, Cycle time	20	80 (2)		ns
	Frequency		12.5 (2)	50	MHz
ADC clock	$t_{c(ADCCLK)}$, Cycle time	20			ns
	Frequency			50	MHz

Clock

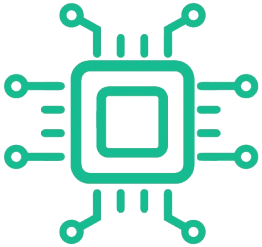


Table 5-9. 2802x Clock Table and Nomenclature (60-MHz Devices)

		MIN	NOM	MAX	UNIT
SYSCLKOUT	$t_{c(SCO)}$, Cycle time	16.67		500	ns
	Frequency	2		60	MHz
LSPCLK (1)	$t_{c(LCO)}$, Cycle time	16.67	66.67 (2)		ns
	Frequency		15 (2)	60	MHz
ADC clock	$t_{c(ADCCLK)}$, Cycle time	16.67			ns
	Frequency			60	MHz

Periféricos

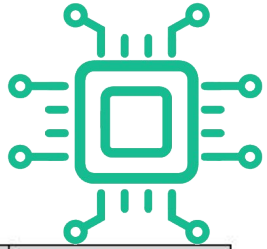


Table 4. TMS320F2802x Peripheral Selection Guide

Peripheral	Lit. No.	Type[1]	28027, 28026, 28023, 28022	28021, 28020, 280200
System Control and Interrupts	Please see SPRUI09 for all F2802x peripherals shown here	–	X	X
Boot ROM		–	X	X
Analog-to-Digital Converter (ADC)[2]		3	X	X
Analog-to-Digital Converter Wrapper		1	X	X
Comparator Module (COMP)		0	X	X
Serial Communications Interface (SCI)		0	X	X
Serial Peripheral Interface (SPI)		1	X	X
Enhanced Pulse Width Modulator Module (ePWM)		1	X	X
Enhanced Capture Module (eCAP)		0	X	X
Inter-Integrated Circuit (I2C)		0	X	X
High-Resolution Pulse-Width Modulator (HRPWM)		1	X	–
InstaSPIN-FOC	SPRUHJ1	–	X[3]	X[3]

Energia

Table 5-1. TMS320F2802x/F280200[1] Current Consumption at 40-MHz SYSCLKOUT

MODE	TEST CONDITIONS	VREG ENABLED				VREG DISABLED					
		I_{DDIO}[2]		I_{DDA}[3]		I_{DD}		I_{DDIO}[2]		I_{DDA}[3]	
		TYP[4]	MAX	TYP[4]	MAX	TYP[4]	MAX	TYP[4]	MAX	TYP[4]	MAX
Operational (Flash)	The following peripheral clocks are enabled: • ePWM1/2/3/4 • eCAP1 • SCI-A • SPI-A • ADC • I2C • COMP1/2 • CPU Timer0/1/2 All PWM pins are toggled at 40 kHz. All I/O pins are left unconnected.[5] Code is running out of flash with 1 wait-state. XCLKOUT is turned off.	70 mA	80 mA	13 mA	18 mA	62 mA	70 mA	15 mA	18 mA	13 mA	18 mA
IDLE	Flash is powered down. XCLKOUT is turned off. All peripheral clocks are off.	13 mA	16 mA	53 µA	58 µA	15 mA	17 mA	120 µA	400 µA	53 µA	58 µA
STANDBY	Flash is powered down. Peripheral clocks are off.	3 mA	6 mA	10 µA	15 µA	3 mA	6 mA	120 µA	400 µA	10 µA	15 µA
HALT	Flash is powered down. Peripheral clocks are off. Input clock is disabled.[6]	50 µA		10 µA	15 µA	15 µA		25 µA		10 µA	15 µA

Energia

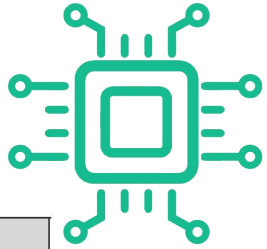


Table 5-2. TMS320F2802x Current Consumption at 50-MHz SYSCLKOUT

MODE	TEST CONDITIONS	VREG ENABLED				VREG DISABLED					
		I_{DDIO} (1)		I_{DDA} (2)		I_{DD}		I_{DDIO} (1)		I_{DDA} (2)	
		TYP (3)	MAX	TYP (3)	MAX	TYP (3)	MAX	TYP (3)	MAX	TYP (3)	MAX
Operational (Flash)	The following peripheral clocks are enabled: • ePWM1/2/3/4 • eCAP1 • SCI-A • SPI-A • ADC • I2C • COMP1/2 • CPU Timer0/1/2 All PWM pins are toggled at 40 kHz. All I/O pins are left unconnected. (4) Code is running out of flash with 1 wait-state. XCLKOUT is turned off.	80 mA	90 mA	13 mA	18 mA	71 mA	80 mA	15 mA	18 mA	13 mA	18 mA
IDLE	Flash is powered down. XCLKOUT is turned off. All peripheral clocks are off.	16 mA	19 mA	64 µA	69 µA	17 mA	20 mA	120 µA	400 µA	64 µA	69 µA
STANDBY	Flash is powered down. Peripheral clocks are off.	4 mA	7 mA	10 µA	15 µA	4 mA	7 mA	120 µA	400 µA	10 µA	15 µA
HALT	Flash is powered down. Peripheral clocks are off. Input clock is disabled. (5)	50 µA		10 µA	15 µA	15 µA		25 µA		10 µA	15 µA

Energia

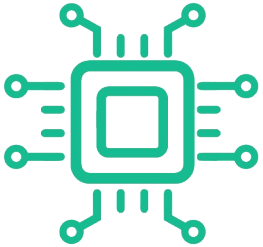


Table 5-3. TMS320F2802x Current Consumption at 60-MHz SYSCLKOUT

MODE	TEST CONDITIONS	VREG ENABLED				VREG DISABLED					
		I_{DDIO} (1)		I_{DDA} (2)		I_{DD}		I_{DDIO} (1)		I_{DDA} (2)	
		TYP (3)	MAX	TYP (3)	MAX	TYP (3)	MAX	TYP (3)	MAX	TYP (3)	MAX
Operational (Flash)	The following peripheral clocks are enabled: • ePWM1/2/3/4 • eCAP1 • SCI-A • SPI-A • ADC • I2C • COMP1/2 • CPU-TIMER0/1/2 All PWM pins are toggled at 60 kHz. All I/O pins are left unconnected. (4) Code is running out of flash with 2 wait states. XCLKOUT is turned off.	90 mA	100 mA	13 mA	18 mA	80 mA	90 mA	15 mA	18 mA	13 mA	18 mA
IDLE	Flash is powered down. XCLKOUT is turned off. All peripheral clocks are turned off.	18 mA	23 mA	75 µA	80 µA	19 mA	24 mA	120 µA	400 µA	75 µA	80 µA
STANDBY	Flash is powered down. Peripheral clocks are off.	4 mA	7 mA	10 µA	15 µA	4 mA	7 mA	120 µA	400 µA	10 µA	15 µA
HALT	Flash is powered down. Peripheral clocks are off. Input clock is disabled. (5)	50 µA		10 µA	15 µA	15 µA		25 µA		10 µA	15 µA

Energia

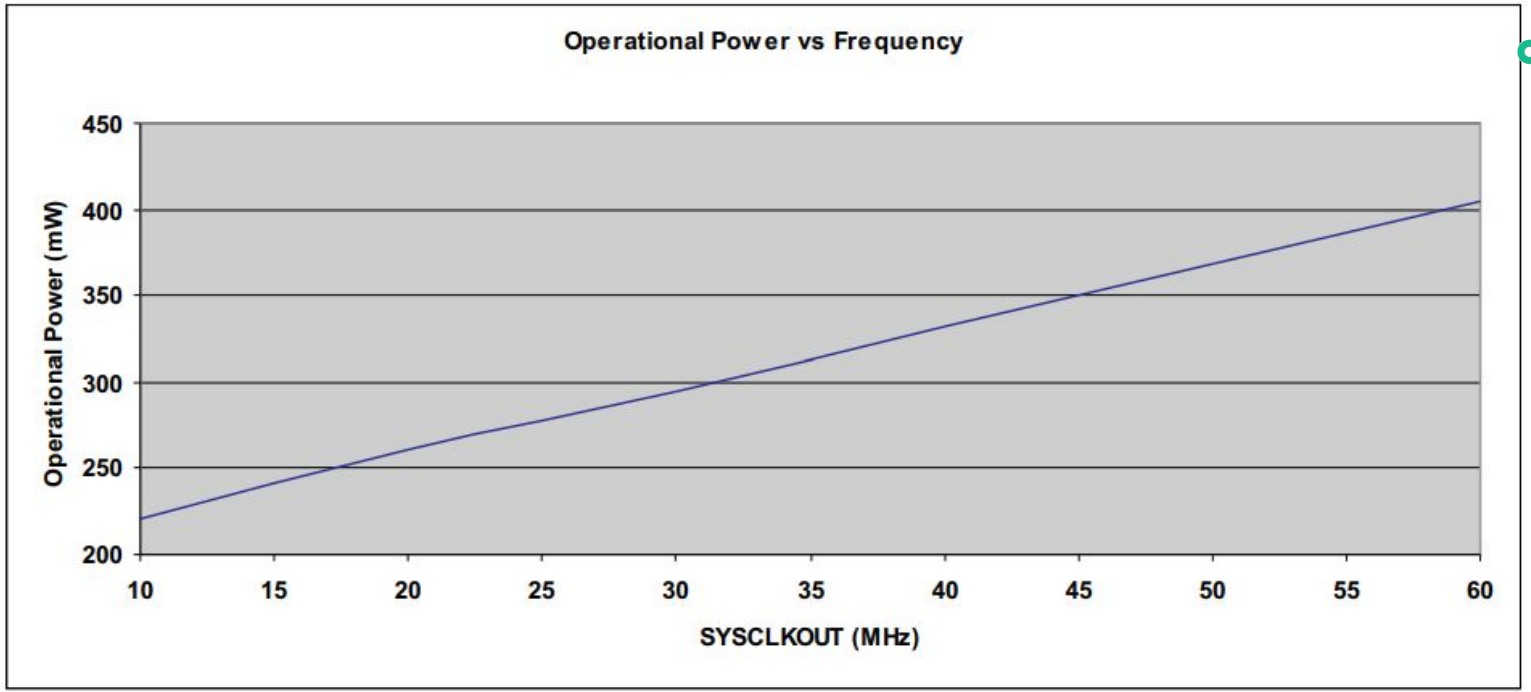


Figure 5-2. Typical Operational Power Versus Frequency (F2802x/F280200)

Energia

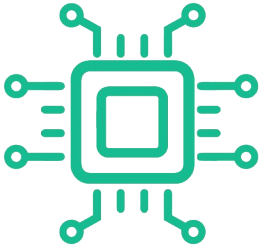
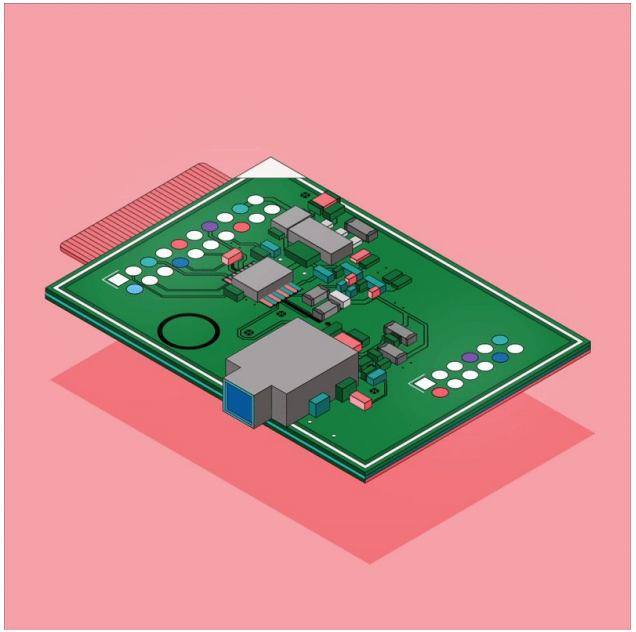


Table 5-4. Typical Current Consumption by Various Peripherals (at 60 MHz)[1]

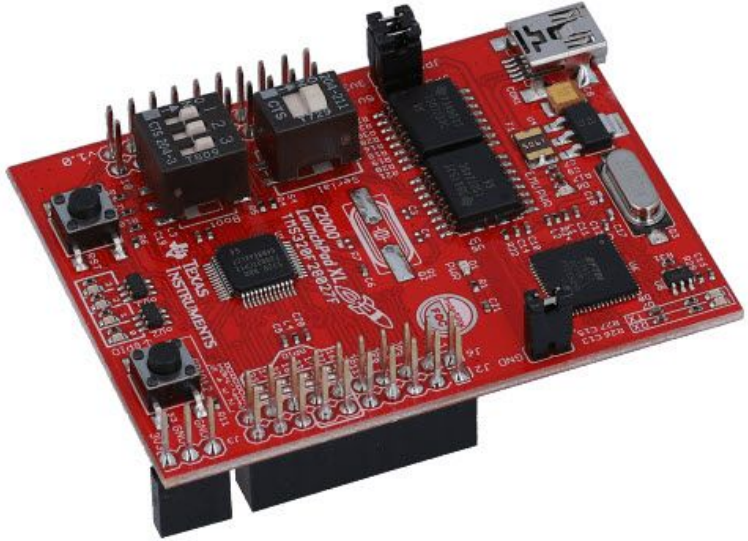
PERIPHERAL MODULE[2]	I_{DD} CURRENT REDUCTION (mA)
ADC	2[3]
I2C	3
ePWM	2
eCAP	2
SCI	2
SPI	2
COMP/DAC	1
HRPWM	3
CPU-TIMER	1
Internal zero-pin oscillator	0.5

Ferramentas de Desenvolvimento

- Extensa linha de ferramentas de desenvolvimento
  - Avalia o desempenho do dispositivo
  - Geração de código
  - Desenvolvimento de soluções



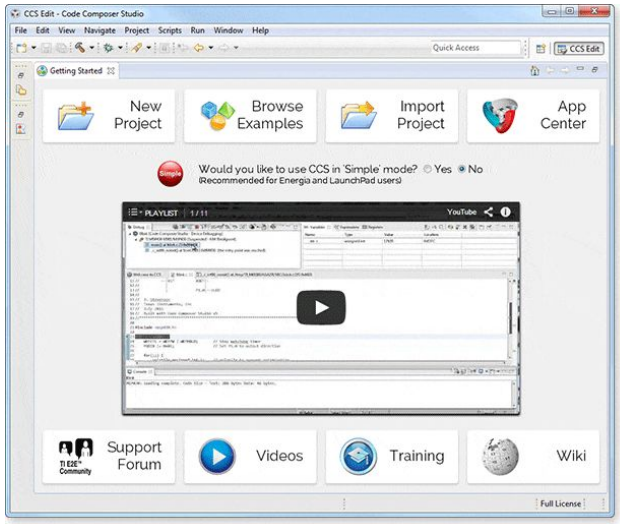
Kit de Desenvolvimento - LaunchPad™



- Modular
- Baixo custo
- Ponto de partida para:
  - Controle de motor
  - Sensoriamento de precisão

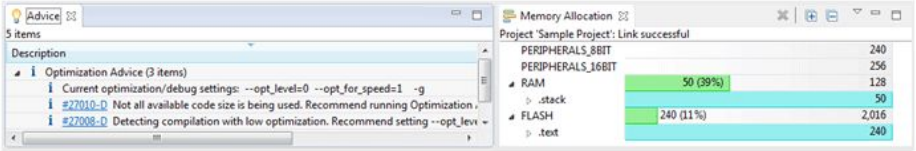
LAUNCHXL-F28027F C2000™ Piccolo MCU F28027F LaunchPad™ development kit board

Code Composer Studio - CCS

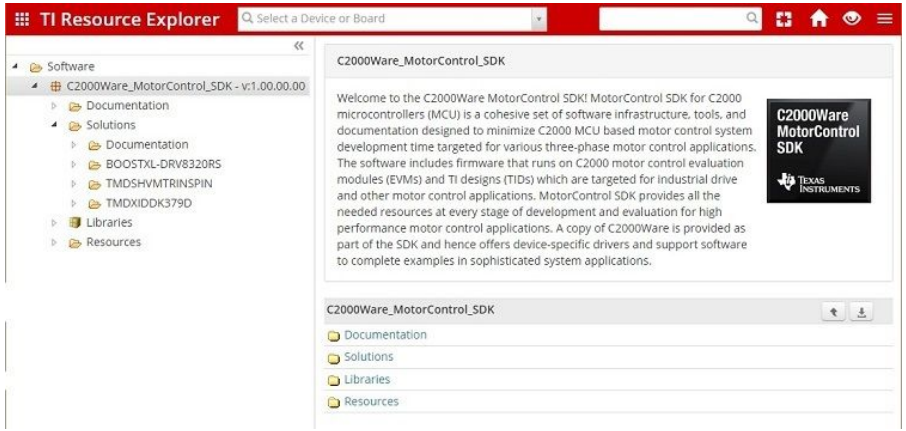


- IDE que suporta microcontroladores da TI
- Inclue:
  - Compilador C/C++ otimizado
  - Depurador
  - Ambiente de desenvolvimento
  - Build
  - Perfil

https://www.ti.com/tool/CCSTUDIO

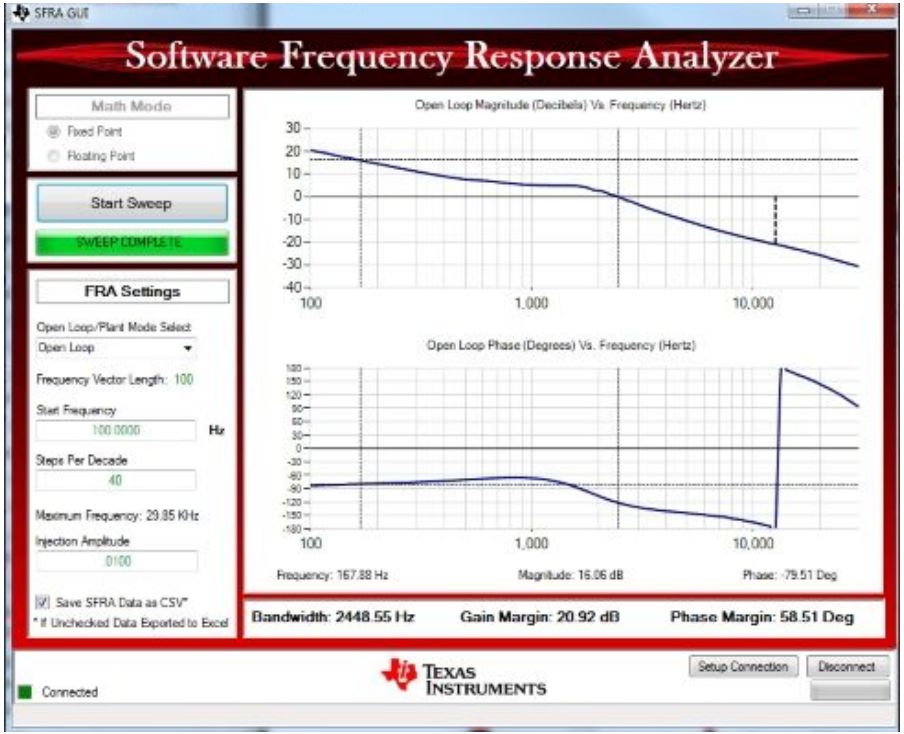


C2000Ware



- Drivers específicos
- Bibliotecas
  - IQMATH
  - AES
  - DSP
- Exemplos de periféricos (demos)

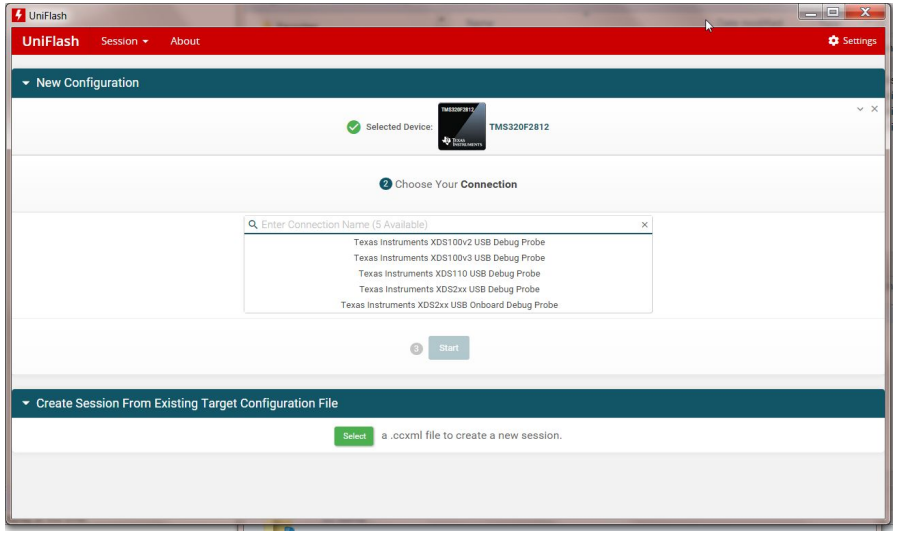
powerSUITE



- Software de design de fonte de alimentação digital
- Ferramentas para:
  - Fase de avaliação
  - Fase de desenvolvimento
  - Fase de teste de design

https://www.ti.com/tool/SFRA

UniFlash



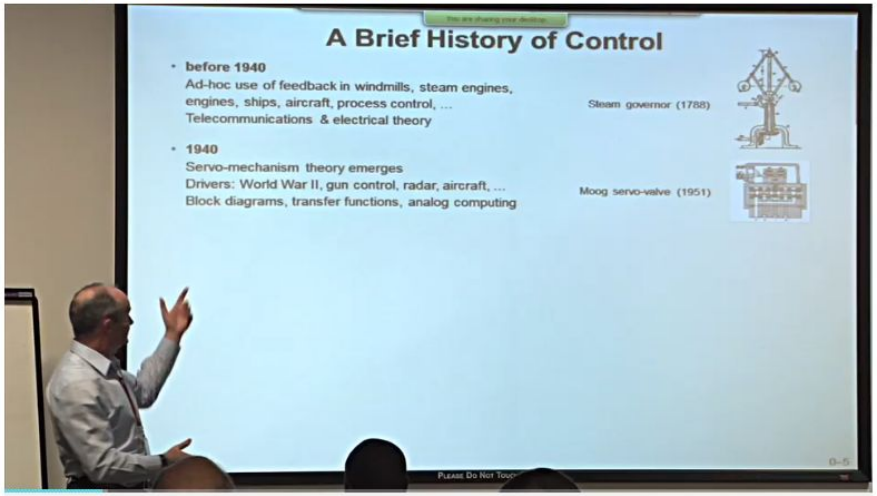
- Ferramenta autônoma (standalone)
- Programar a memória flash por meio de GUI, linha de comando ou interface de script.

https://www.ti.com/tool/UNIFLASH

Treinamento

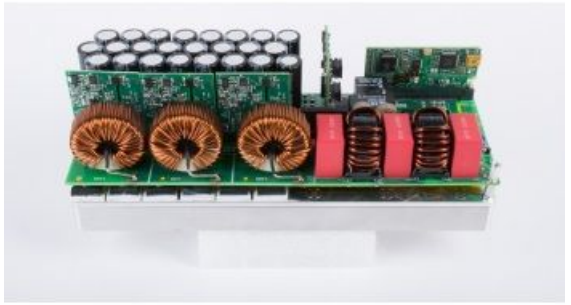
- Variedade de recursos de treinamento
  - Materiais de treinamento online
  - Workshops práticos
- Diminuir a curva de aprendizado
- Reduz tempo de desenvolvimento
- Acelerar o tempo de lançamento de produtos
- Workshop(exemplo): https://training.ti.com/c2000-f2802x-microcontroller-workshop

2.1 Control Theory Seminar - Part 1



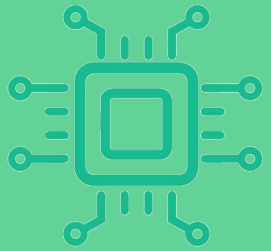
Aplicação - Veículos Elétricos

- Maior alcance por carga
- Carregamento mais rápido
- Maior densidade de potência
- Suportar regiões com diferentes tipos de infraestrutura da rede elétrica



TIDA-01604

Fontes



Conheça a Placa LaunchPad XL: https://eletronicadepotencia.com/placa-launchpad-xl-f28027/

TMS320F2802x Microcontrollers Datasheet: https://www.ti.com/lit/ds/symlink/tms320f28020.pdf?ts=1605910637348&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FTMS320F28020

C2000Ware for C2000 MCUs: https://www.ti.com/tool/C2000WARE

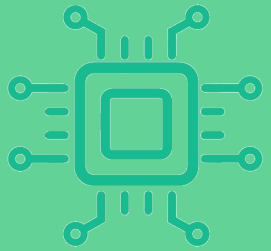
LAUNCHXL-F28027: https://www.ti.com/tool/LAUNCHXL-F28027?DCMP=c2x-launchpad&HQS=c2x-launchpad-pr-pf

Code Composer Studio (CCS): https://www.ti.com/tool/CCSTUDIO-C2000

powerSUITE: https://www.ti.com/tool/POWERSUITE

UniFlash: ti.com/tool/UNIFLASH

Fontes



C2000 real-time control MCUs – Electric vehicles:
https://www.ti.com/microcontrollers/c2000-real-time-control-mcus/applications/ev-inverter.html#high-voltage-dc-dc

98.6% Efficiency, 6.6-kW Totem-Pole PFC Reference Design for HEV/EV Onboard Charger:
https://www.ti.com/tool/TIDA-01604#0

C2000 Peripherals:
https://www.ti.com/lit/ug/spru566n/spru566n.pdf?ts=1605985174360&ref_url=https%253A%252F%252Fwww.ti.com%252Fmicrocontrollers%252Fc2000-real-time-control-mcus%252Foverview.html

-Obrigado!

Dúvidas?