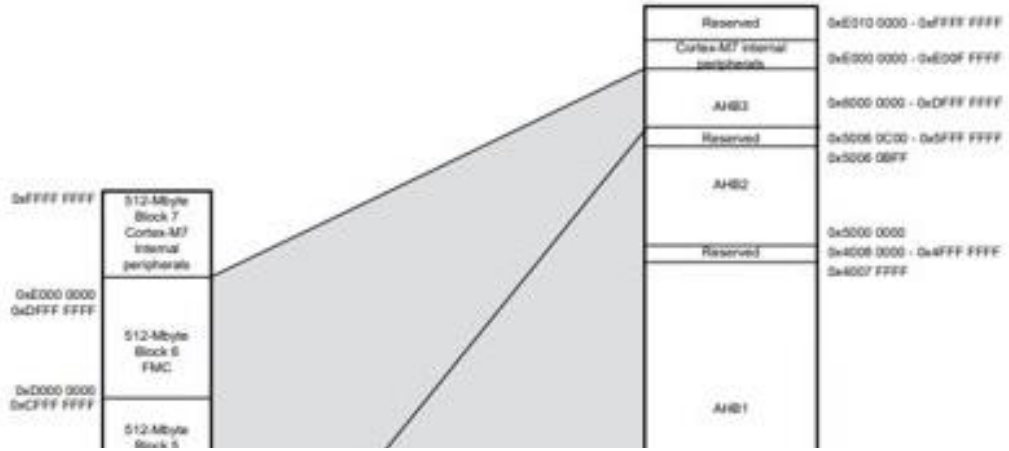
MATT SPEED
& ANDY NORMINGTON

EMBEDDED SOFTWARE DEVELOPMENT

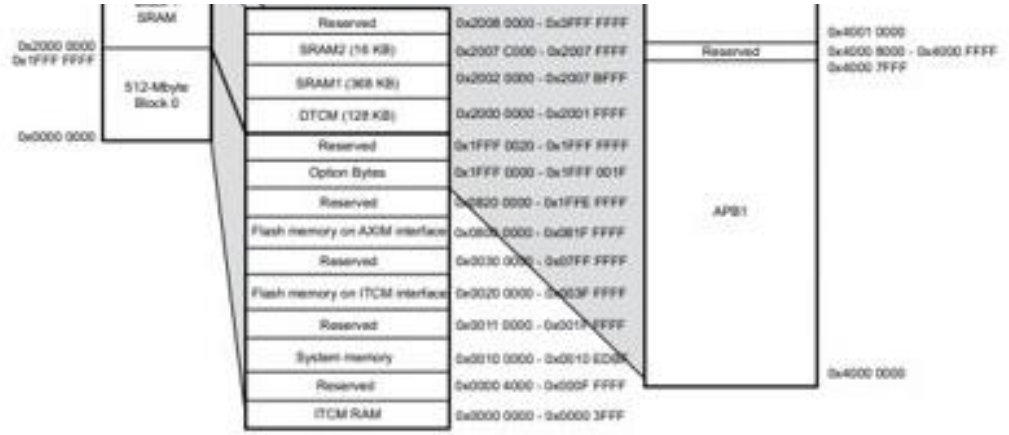
A WILD RIDE!

Embedded Software Development is not Desktop Software Development

Microcontrollers
are not
Typical Microprocessors



Programming is harder when you don't have much memory.



The range of available devices is very broad!

Word Size

Memory Arch

Memory Size

Clock Speed

Instruction Set

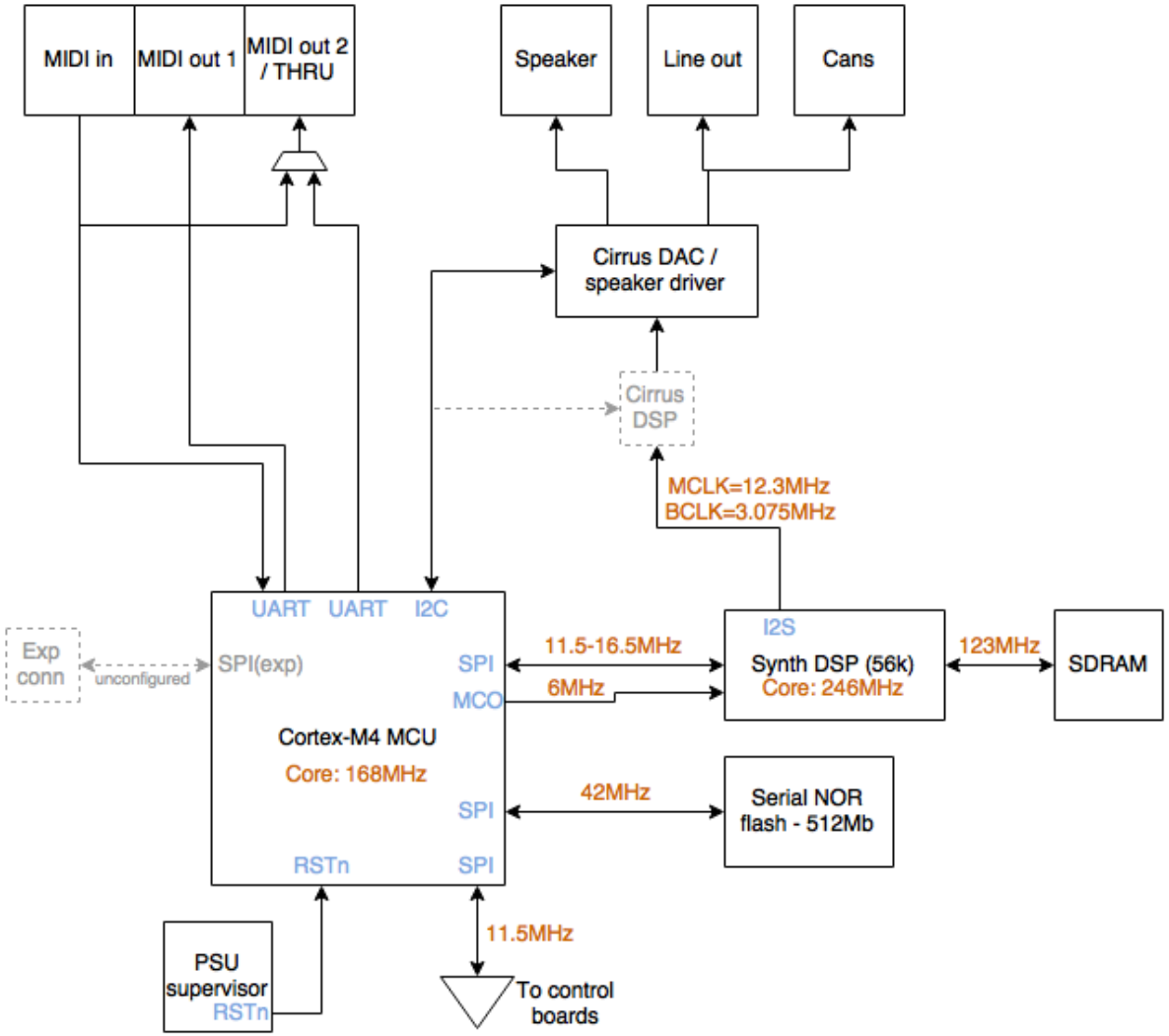
Vendor

Package

Peripheral Set

Device Family

Build up a picture of what the MCU needs to do



Choose a device, thinking about how we should configure it

Pick a family…

Pick a device…

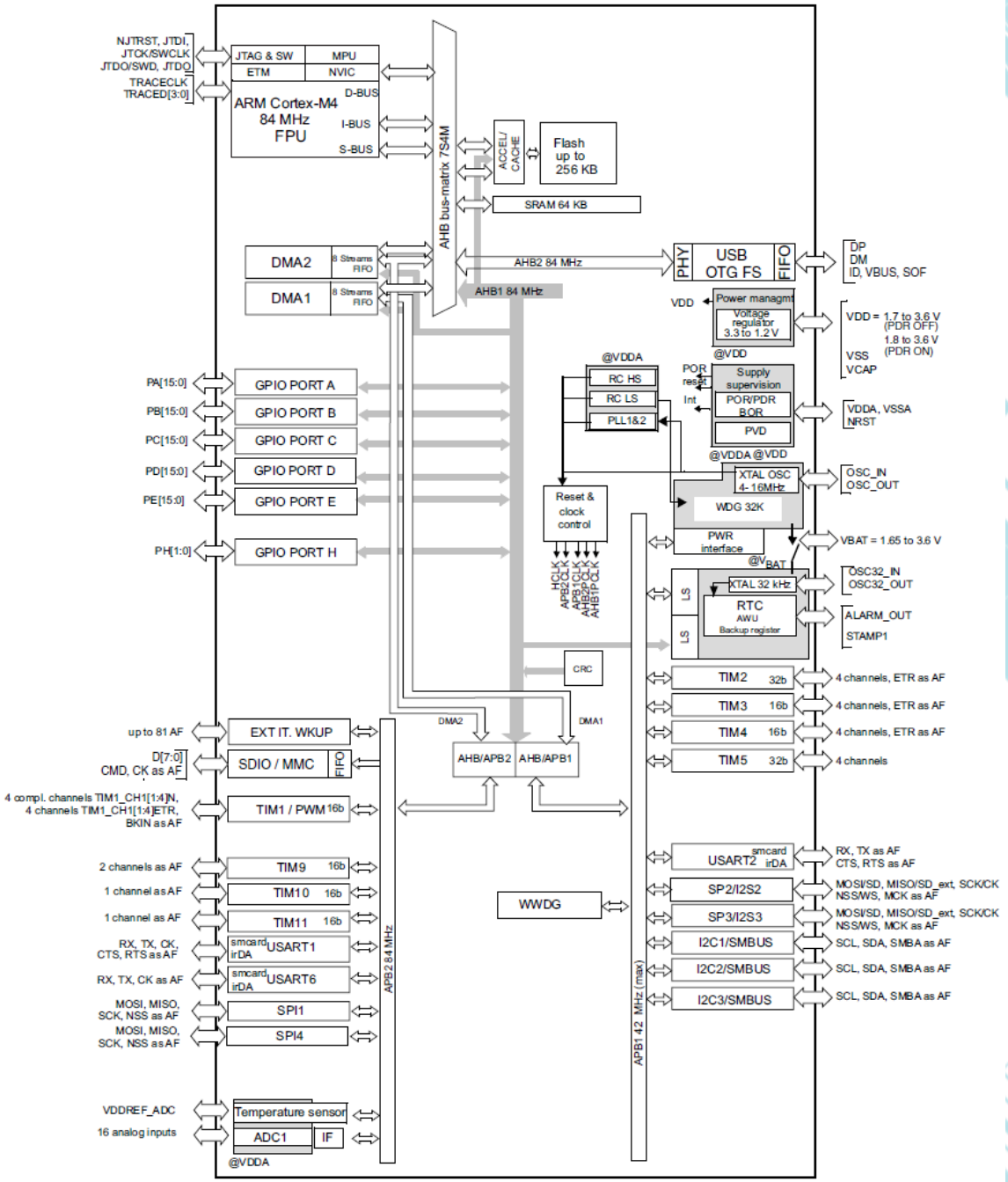
STM32F4 MCU Series
32-bit Arm® Cortex®-M4 – Up to 180 MHz

- ART Accelerator™
- SDIO
- USART, SPI, I²C
- I²S + audio PLL
- 16 and 32-bit timers
- 12-bit ADC (0.41 µs)
- True Random Number Generator
- Batch Acquisition Mode
- Low voltage 1.7 to 3.6 V
- Temperature:
- -40 °C to 125 °C

Product line	F_{CPU} (MHz)	Flash (KB)	RAM (KB)	Ethernet I/F IEEE 1588	2x CAN	Camera I/F	SDRAM I/F	Dual Quad-SPI	SAI	SPDIF RX	Chrom-ART Graphic Accelerator™	TFT LCD Controller	MIPI DSI
Advanced lines													
STM32F469[2]	180	512 K to 2056 K	384	•	•	•	•	•	•		•	•	•
STM32F429[2]	180	512 K to 2056 K	256	•	•	•	•		•		•	•	
STM32F427[2]	180	1024 K to 2056 K	256	•	•	•	•		•		•		
Foundation lines													
STM32F446	180	256 K to 512 K	128		•	•	•	•	•	•			
STM32F407[2]	168	512 K to 1024 K	192	•	•	•							
STM32F405[2]	168	512 K to 1024 K	192		•								

Product line	F_{CPU} (MHz)	Flash (KB)	RAM (KB)	RUN current (µa/MHz)	STOP current (µa)	Small package (mm)	FSMC (NOR/ PSRAM/LCD) support	QSPI	DFSDM	DAC	TRNG	DMA Batch Acquisition mode	USB 2.0 OTG FS
Access lines													
STM32F401	84	128 K to 512 K	up to 96	Down to 128	Down to 10	Down to 3x3							•
STM32F410	100	64 K to 128 K	32	Down to 89	Down to 6	Down to 2.553x 2.579				•	•	BAM	-
STM32F411	100	256 K to 512 K	128	Down to 100	Down to 12	Down to 3.034x 3.22						BAM	•
STM32F412	100	512 K to 1024 K	256	Down to 112	Down to 18	Down to 3.653x 3.651	•	•	•		•	BAM	• +LPM[1]
STM32F413[2]	100	1024 K to 1536 K	320	Down to 115	Down to 18	Down to 3.951x 4.039	•	•	•	•	•	BAM	• +LPM[1]

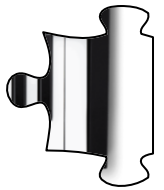
…and decide how to set it up

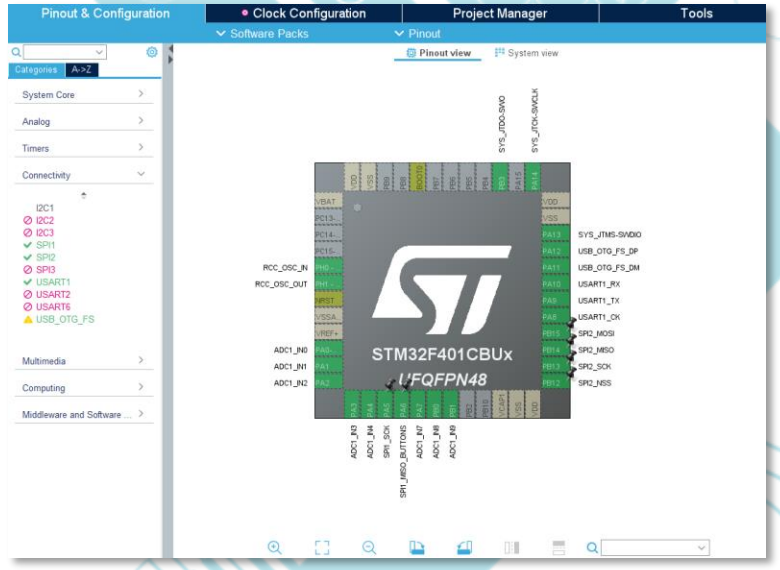


UQFN	WLCSP	LQFP	LQFP	UFBGA	after reset)(1)	Pin	I/O s	N		
13	E4	17	26	L3	PA3	I/O	FT	-	USART2_RX, TIM2_CH4, TIM5_CH4, TIM9_CH2, EVENTOUT	ADC1_IN3
-	-	18	27	-	VSS	S	-	-	-	-
-	-	19	28	-	VDD	S	-	-	-	-
-	-	-	-	E3	BYPASS_ REG	I	FT	-	-	-
14	G6	20	29	M3	PA4	I/O	FT	-	SPI1_NSS, SPI3_NSS/I2S3_WS, USART2_CK, EVENTOUT	ADC1_IN4
15	F5	21	30	K4	PA5	I/O	FT	-	SPI1_SCK, TIM2_CH1/TIM2_ETR, EVENTOUT	ADC1_IN5
16	F4	22	31	L4	PA6	I/O	FT	-	SPI1_MISO, TIM1_BKIN, TIM3_CH1, EVENTOUT	ADC1_IN6
17	F3	23	32	M4	PA7	I/O	FT	-	SPI1_MOSI, TIM1_CH1N, TIM3_CH2, EVENTOUT	ADC1_IN7
-	-	24	33	K5	PC4	I/O	FT	-	EVENTOUT	ADC1_IN14
-	-	25	34	L5	PC5	I/O	FT	-	EVENTOUT	ADC1_IN15
18	G5	26	35	M5	PB0	I/O	FT	-	TIM1_CH2N, TIM3_CH3, EVENTOUT	ADC1_IN8
19	G4	27	36	M6	PB1	I/O	FT	-	TIM1_CH3N, TIM3_CH4, EVENTOUT	ADC1_IN9
20	G3	28	37	L6	PB2	I/O	FT	-	EVENTOUT	BOOT1
-	-	-	38	M7	PE7	I/O	FT	-	TIM1_ETR, EVENTOUT	-
-	-	-	39	L7	PE8	I/O	FT	-	TIM1_CH1N, EVENTOUT	-
-	-	-	40	M8	PE9	I/O	FT	-	TIM1_CH1, EVENTOUT	-

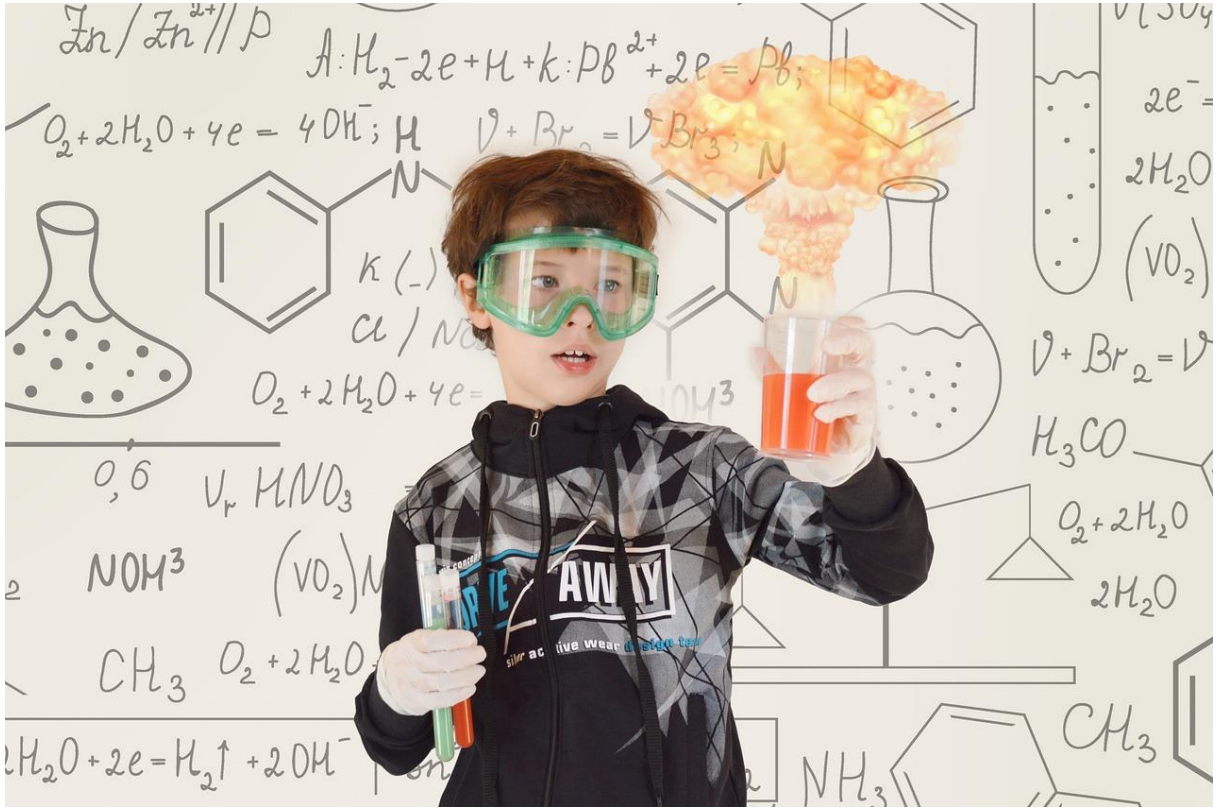
Tile 0 Audio													Polarity
I/O	1b	4b	8b	16b	Link		Link	16b	8b	4b	1b	I/O	
X0D00	A[0]						L0[1]0	B[15]	D[7]			X0D43	VBUS-VLOW(n)	n
X0D01	B[0]						L0[0]0	B[14]	D[6]			X0D42		
X0D02		A[0]	A[0]	A[0]			L0[0]1	B[13]	D[5]			X0D41		
X0D03		A[1]	A[1]	A[1]			L0[1]1	B[12]	D[4]			X0D40		
X0D04		B[0]	A[2]	A[2]	BT0			B[11]	D[3]		P[0]	X0D39	MCLK-IN(512BR) (Tile 0)	
X0D05		B[1]	A[3]	A[3]	BT1			B[10]	D[2]		O[0]	X0D38	CODEC-LRCLK	
X0D06		B[2]	A[4]	A[4]	BT2			B[9]	D[1]		N[0]	X0D37	CODEC-BCLK	
X0D07		B[3]	A[5]	A[5]				B[8]	D[0]		M[0]	X0D36	UBS-FRAME-REF	
X0D08		A[2]	A[6]	A[6]			L7[2]0				L[0]	X0D35	CODEC-ADC-1-2	
X0D09		A[3]	A[7]	A[7]			L7[1]0				K[0]	X0D34	CODEC-RESET(n)	n
X0D10	C[0]								B[7]	C[7]	E[3]	X0D33	SPI0-SCLK	
X0D11	D[0]								B[6]	C[6]	E[2]	X0D32	SPI0-MOSI	
X0D12	E[0]								B[5]	C[5]	F[3]	X0D31		
X0D13	F[0]								B[4]	C[4]	F[2]	X0D30	ADC-M1	
X0D14		C[0]	B[0]	A[8]					B[3]	C[3]	F[1]	X0D29	ADC-M0	
X0D15		C[1]	B[1]	A[9]					B[2]	C[2]	F[0]	X0D28		
X0D16		D[0]	B[2]	A[10]	L4[4]1		L7[4]0	B[1]	C[1]	E[1]		X0D27		
X0D17		D[1]	B[3]	A[11]	L4[3]1		L7[3]0	B[0]	C[0]	E[0]		X0D26		
X0D18		D[2]	B[4]	A[12]	L4[2]1		L7[0]0				J[0]	X0D25	CODEC-DAC-1-2	
X0D19		D[3]	B[5]	A[13]	L4[1]1		L7[0]1				I[0]	X0D24		
X0D20		C[2]	B[6]	A[14]							H[0]	X0D23		
X0D21		C[3]	B[7]	A[15]							G[0]	X0D22	DAC-INT-12(n)	n

Port	AF00	AF01	AF02	AF03	AF04	AF05	AF06	AF07	AF08	AF09	AF10	AF11	AF12	AF1
	SYS_AF	TIM1/TIM2	TIM3/ TIM4/ TIM5	TIM9/ TIM10/ TIM11	I2C1/I2C2/ I2C3	SPI1/SPI2/ I2S2/SPI3/ I2S3/SPI4	SPI2/I2S2/ SPI3/ I2S3	SPI3/I2S3/ USART1/ USART2	USART6	I2C2/ I2C3	OTG1_FS		SDIO	
PB0	-	TIM1_CH2N	TIM3_CH3	-	-	-	-	-	-	-	-	-	-	-
PB1	-	TIM1_CH3N	TIM3_CH4	-	-	-	-	-	-	-	-	-	-	-
PB2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PB3	JTDO-SWO	TIM2_CH2	-	-	-	SPI1_SCK	SPI3_SCK/ I2S3_CK	-	-	I2C2_SDA	-	-	-	-
PB4	JTRST	-	TIM3_CH1	-	-	SPI1_ MISO	SPI3_MISO	I2S3ext_S D	-	I2C3_SDA	-	-	-	-
PB5	-	-	TIM3_CH2	-	I2C1_ SMBA	SPI1 _MOSI	SPI3_MOSI/ I2S3_SD	-	-	-	-	-	-	-
PB6	-	-	TIM4_CH1	-	I2C1_SCL	-	-	USART1_ TX	-	-	-	-	-	-
PB7	-	-	TIM4_CH2	-	I2C1_SDA	-	-	USART1_ RX	-	-	-	-	-	-
PB8	-	-	TIM4_CH3	TIM10_CH1	I2C1_SCL	-	-	-	-	-	-	-	SDIO_ D4	-
PB9	-	-	TIM4_CH4	TIM11_CH1	I2C1_SDA	SPI2_NSS/I 2S2_WS	-	-	-	-	-	-	SDIO_ D5	-
PB10	-	TIM2_CH3	-	-	I2C2_SCL	SPI2_SCK/I 2S2_CK	-	-	-	-	-	-	-	-
PB11	-	TIM2_CH4	-	-	I2C2_SDA	-	-	-	-	-	-	-	-	-
PB12	-	TIM1_BKIN	-	-	I2C2_ SMBA	SPI2_NSS/I 2S2_WS	-	-	-	-	-	-	-	-
PB13	-	TIM1_CH1N	-	-	-	SPI2_SCK/I 2S2_CK	-	-	-	-	-	-	-	-
PB14	-	TIM1_CH2N	-	-	-	SPI2_MISO	I2S2ext_SD	-	-	-	-	-	-	-

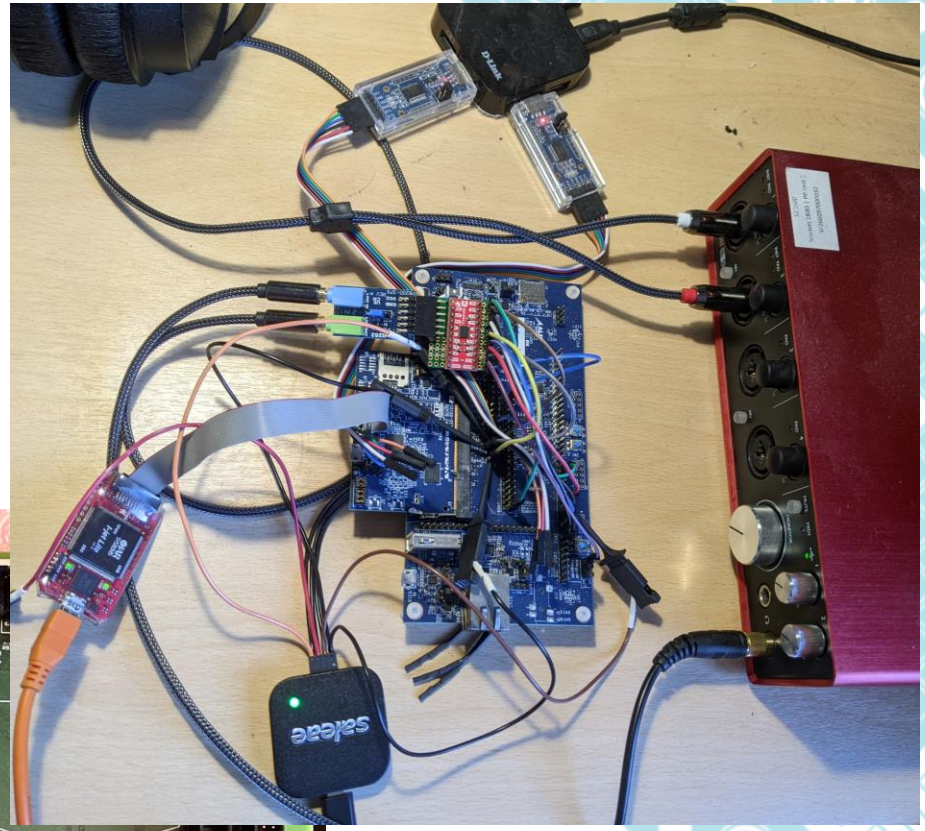


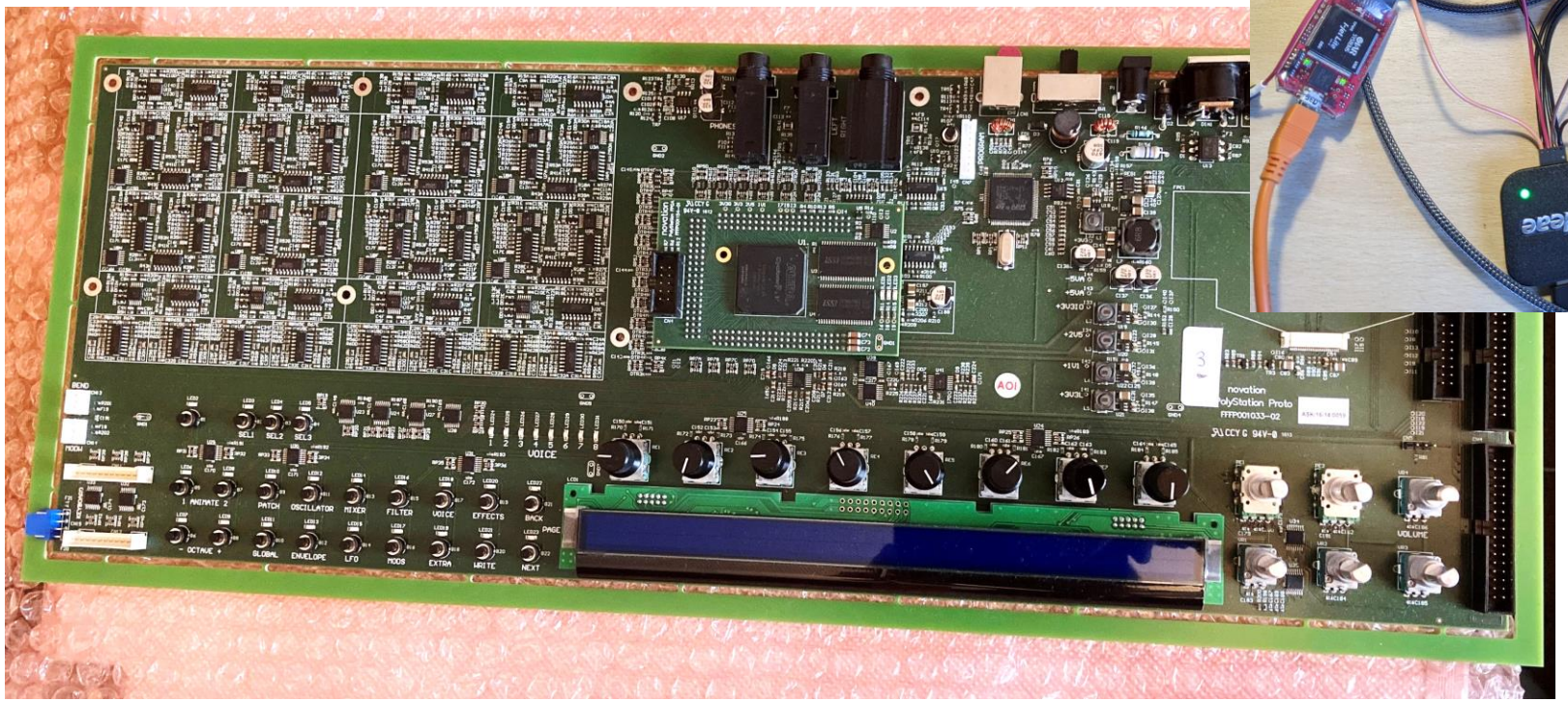


What could possibly go wrong?

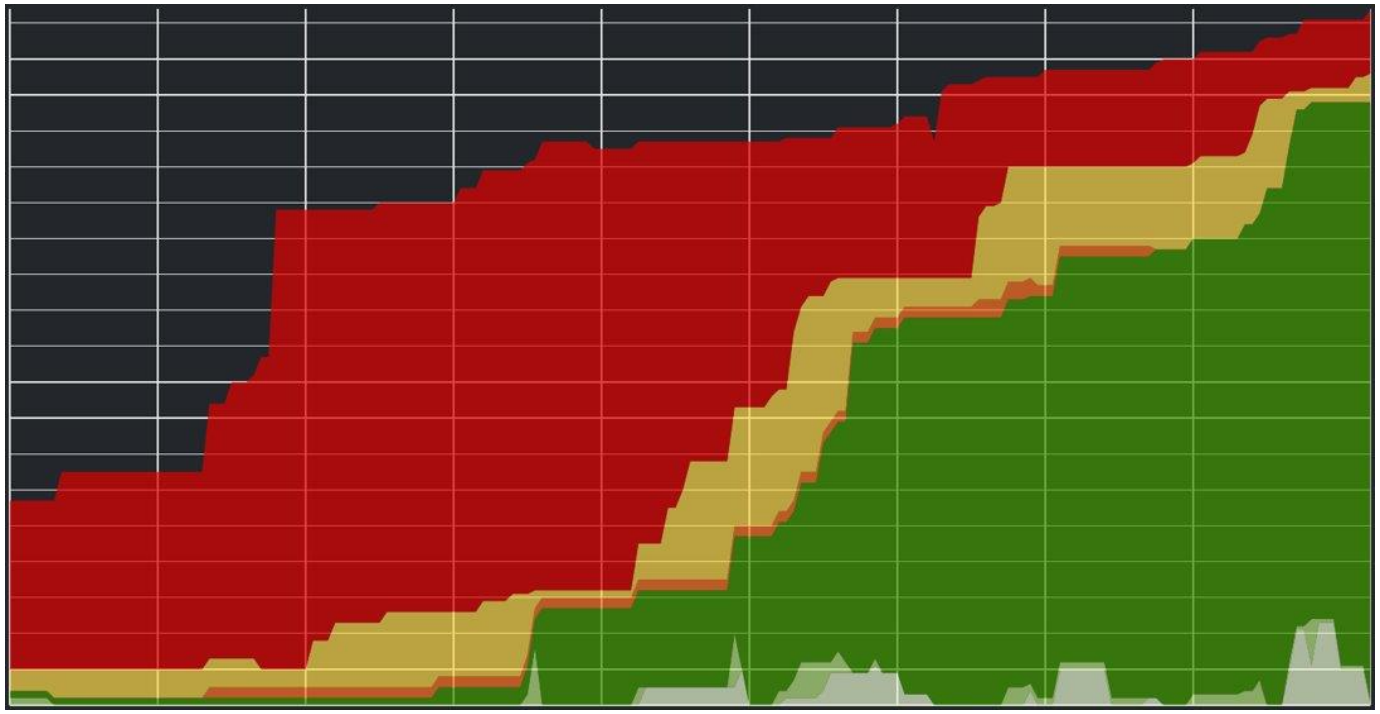


Just enough hardware to get started

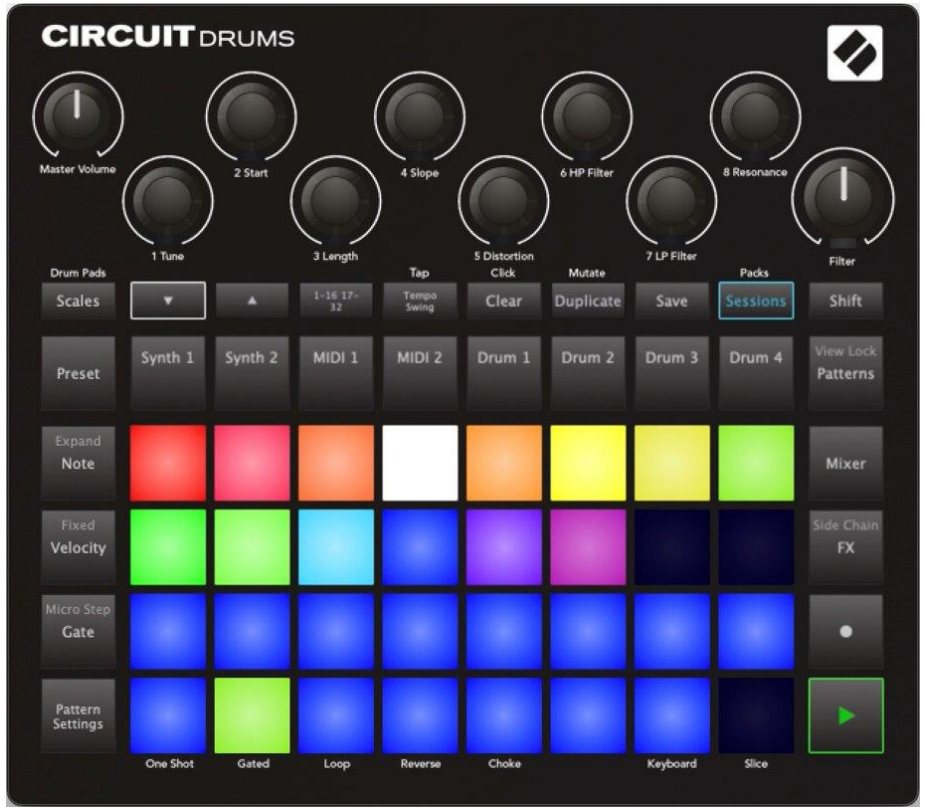




Firmware engineers
join
multi-disciplinary teams...

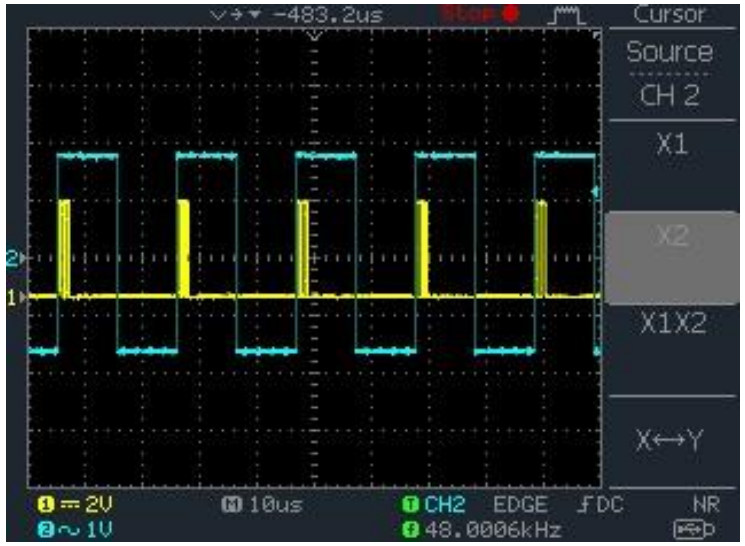


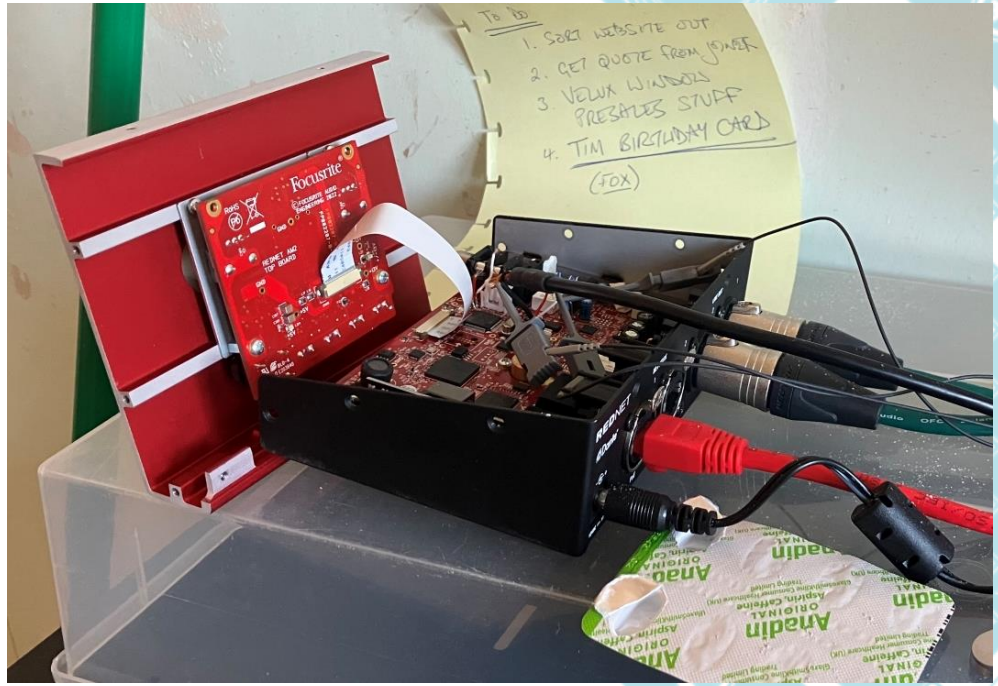
..but must also couple tightly to software & hardware development



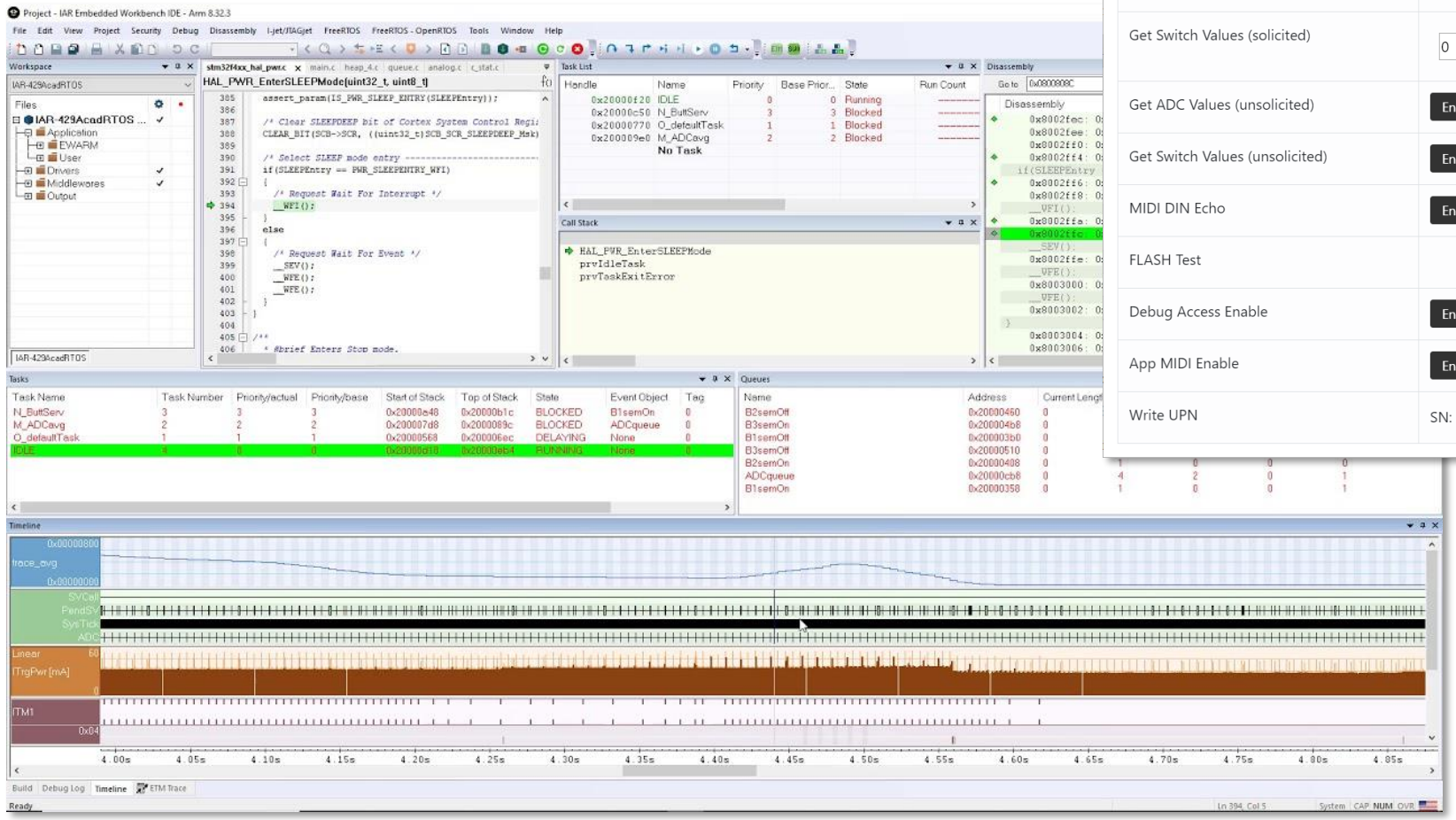
Debugging together – choose tools that keep the barrier to entry low

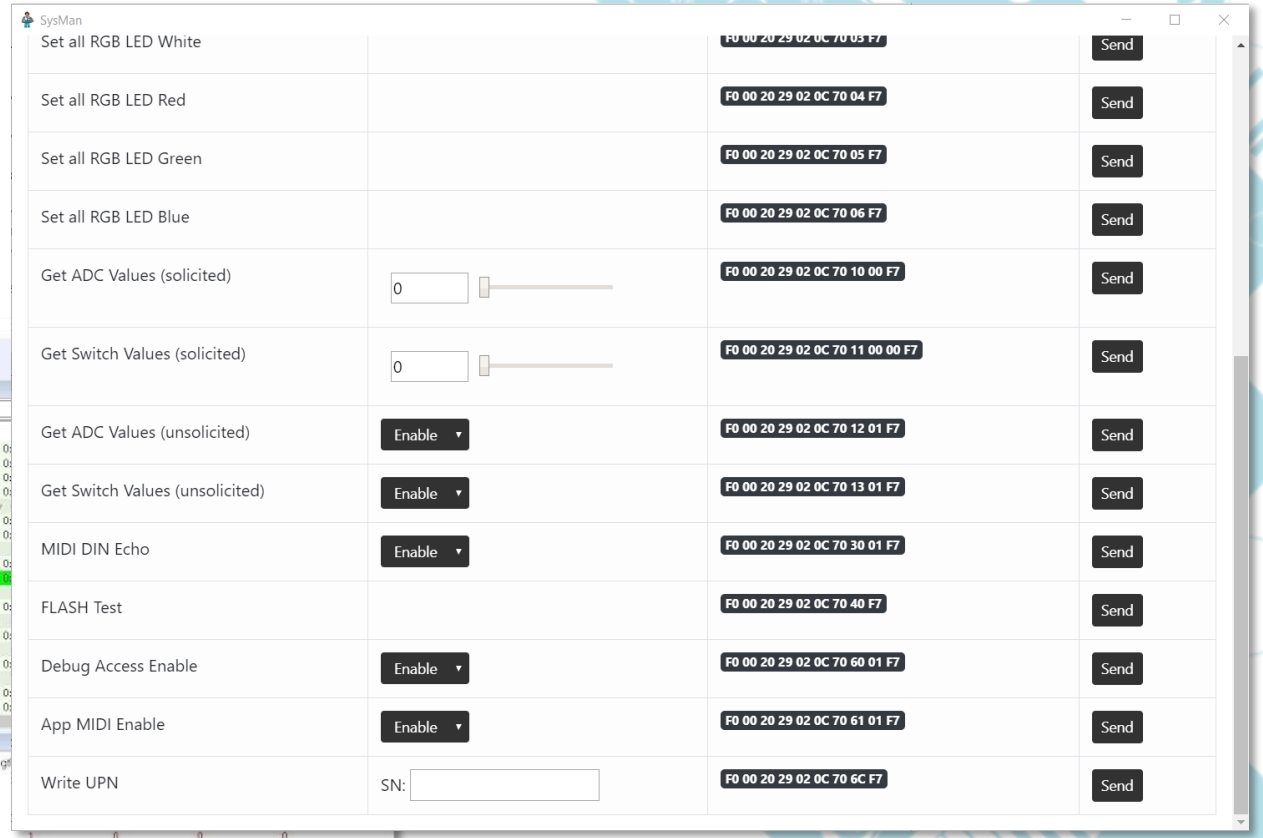
Finding out what's going on inside



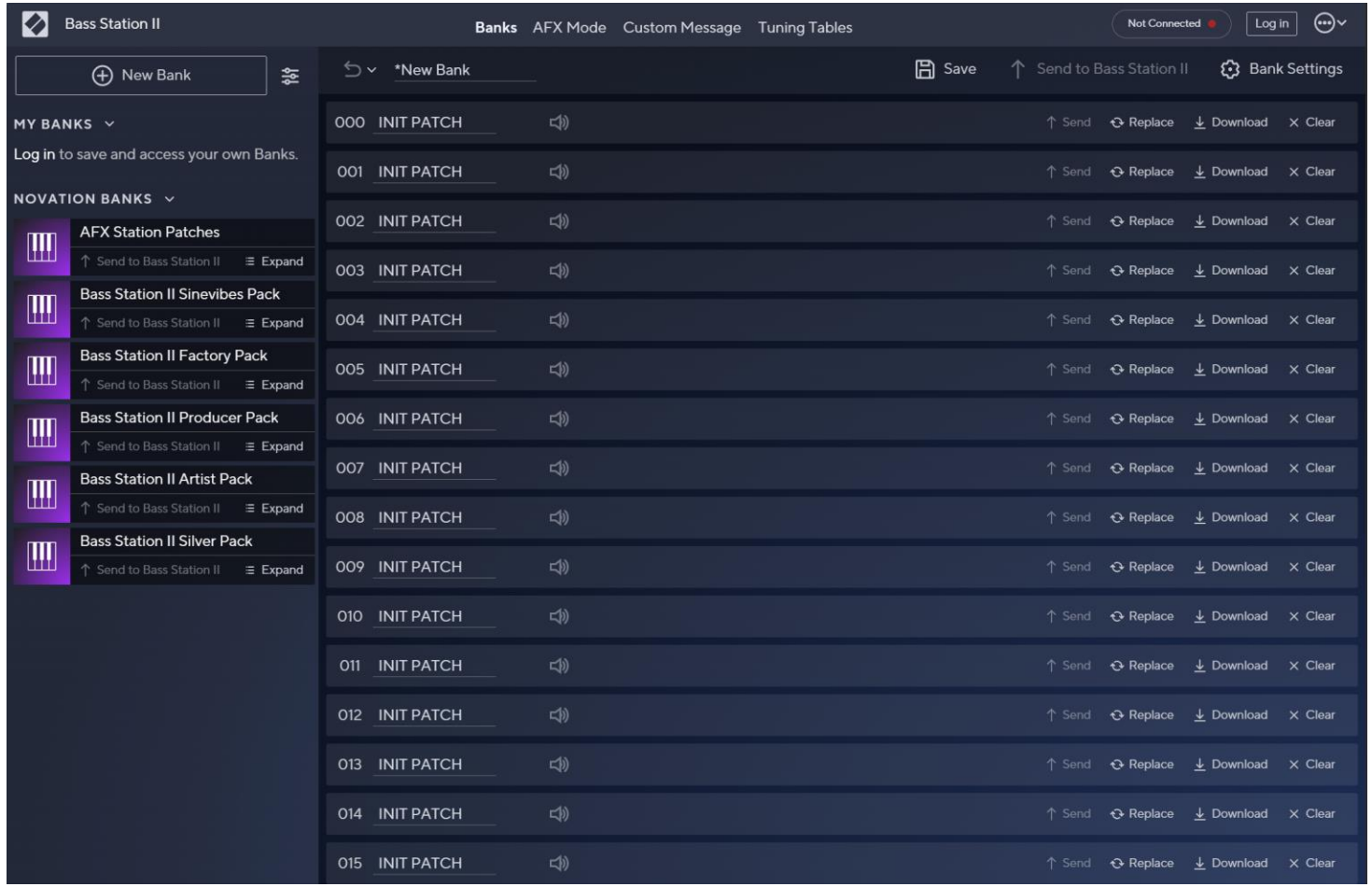


Finding out what's going on inside

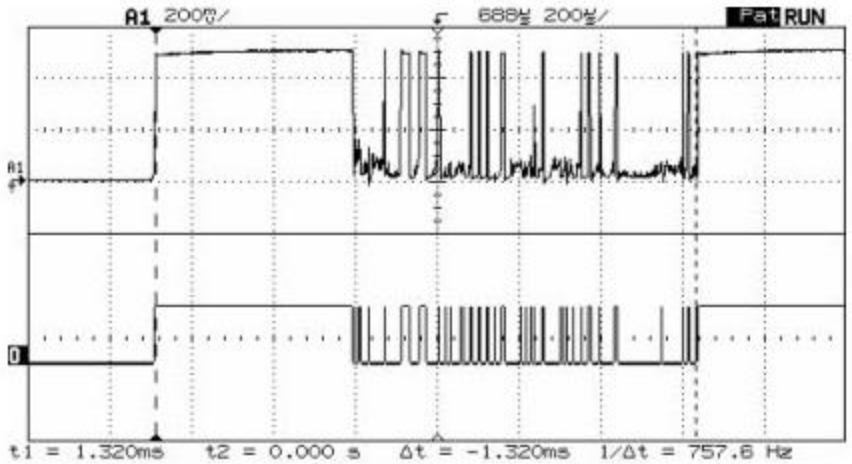




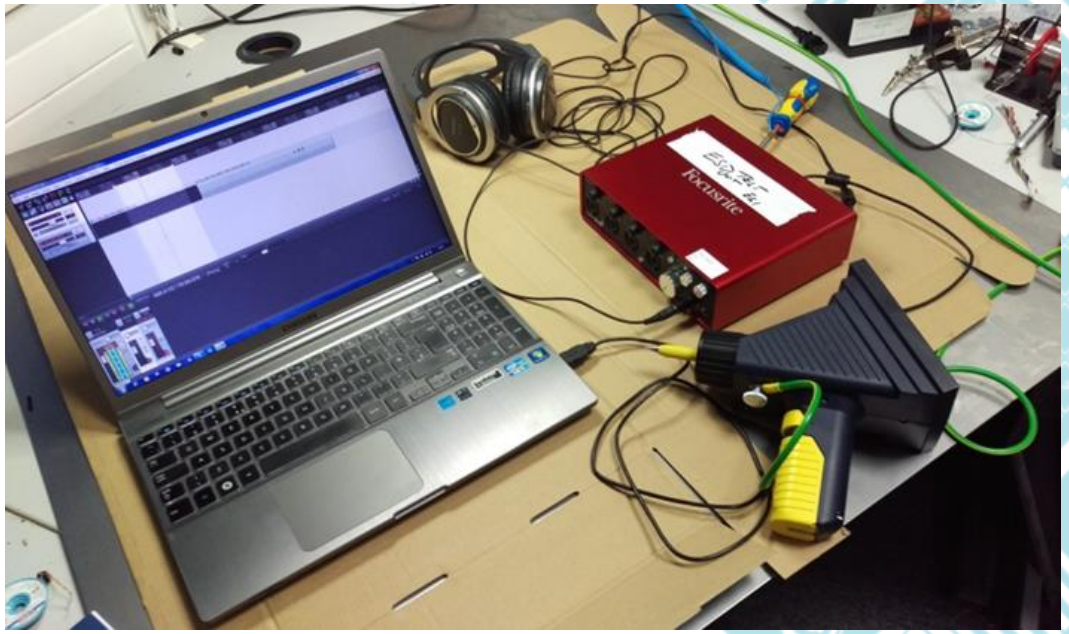
Implement Reliable Field Update



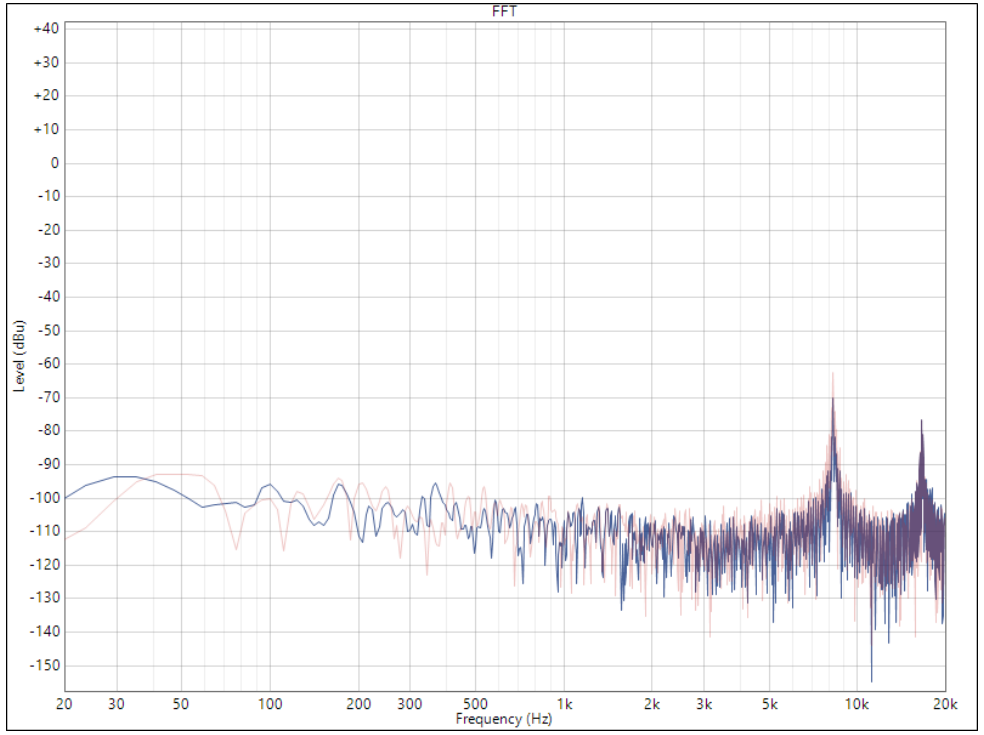
The real world looks a bit funny

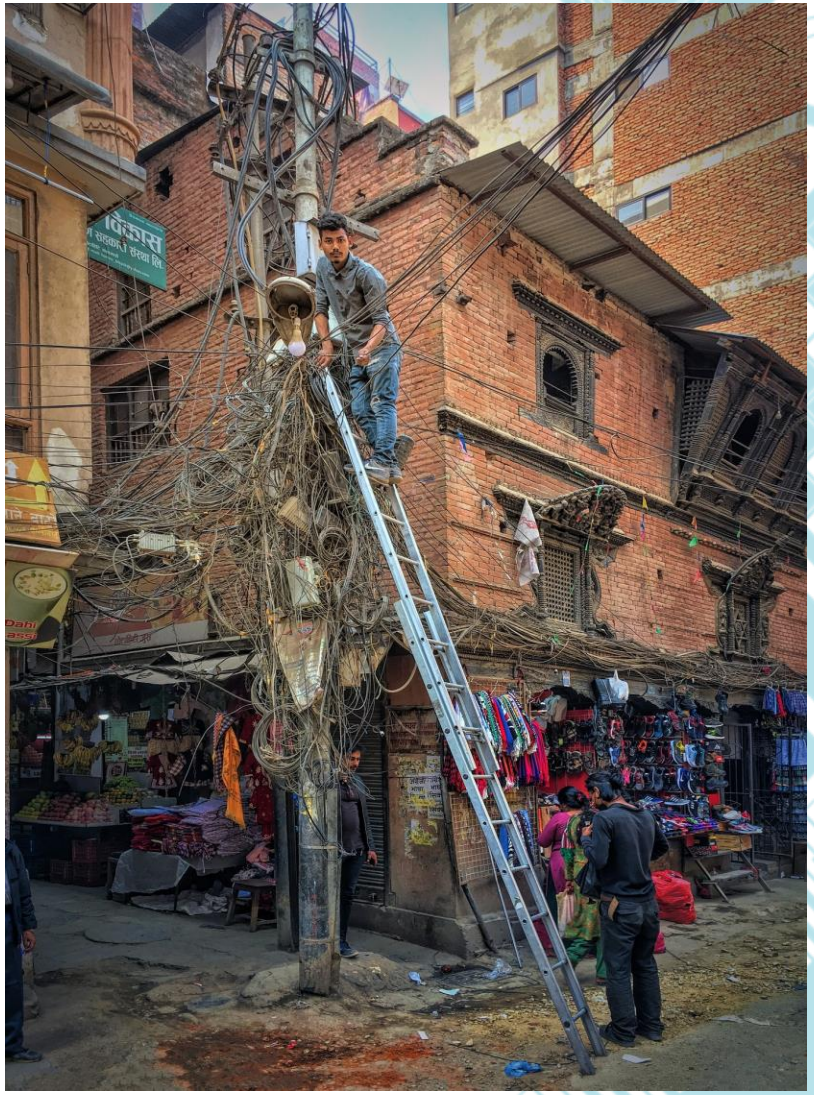


From Jack Ganssle's blog – worth checking out!

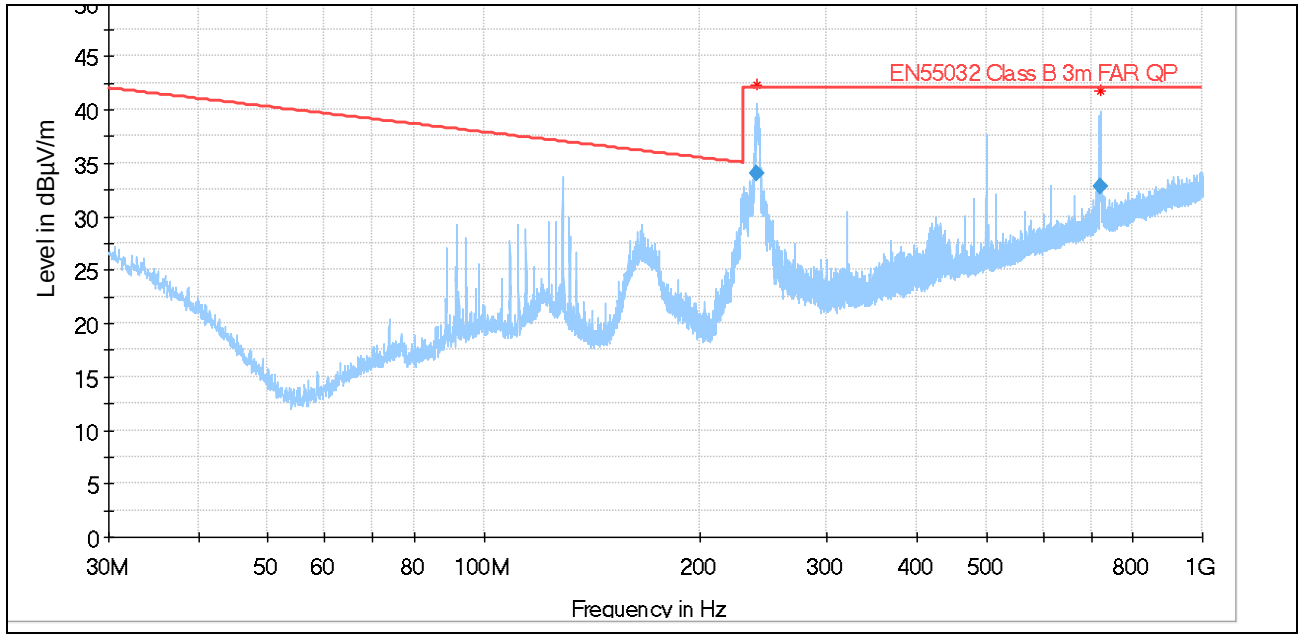


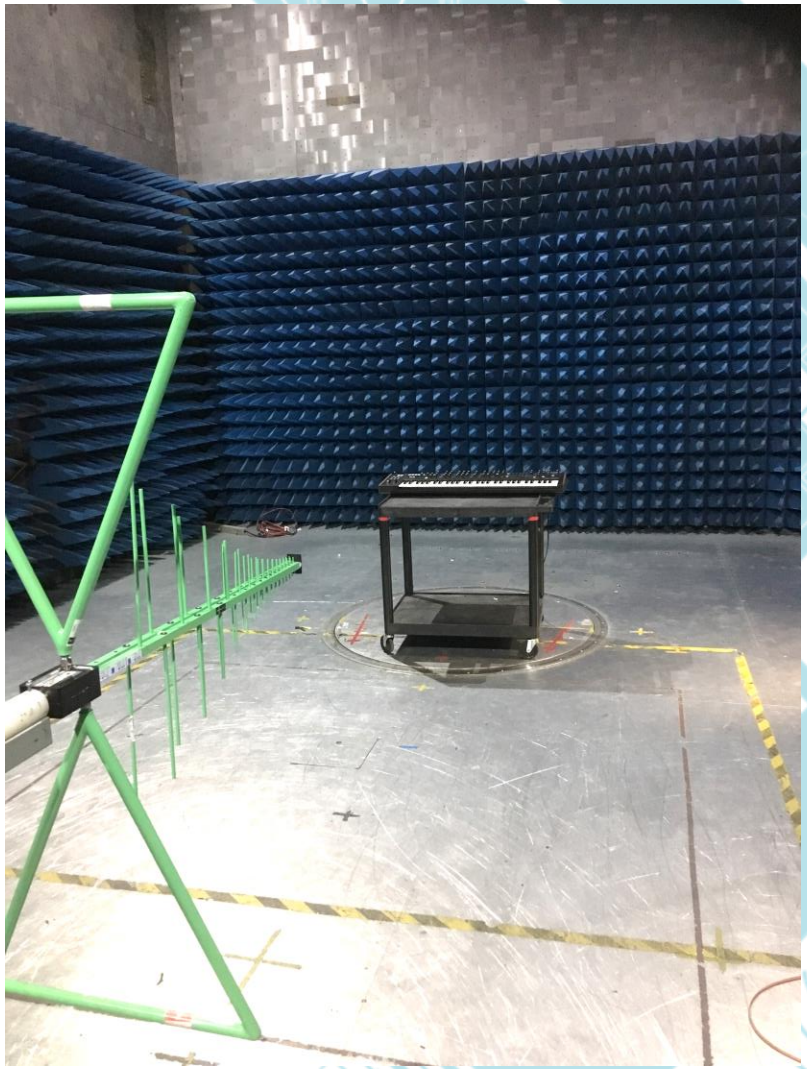
Sometimes *we* cause the problems for ourselves



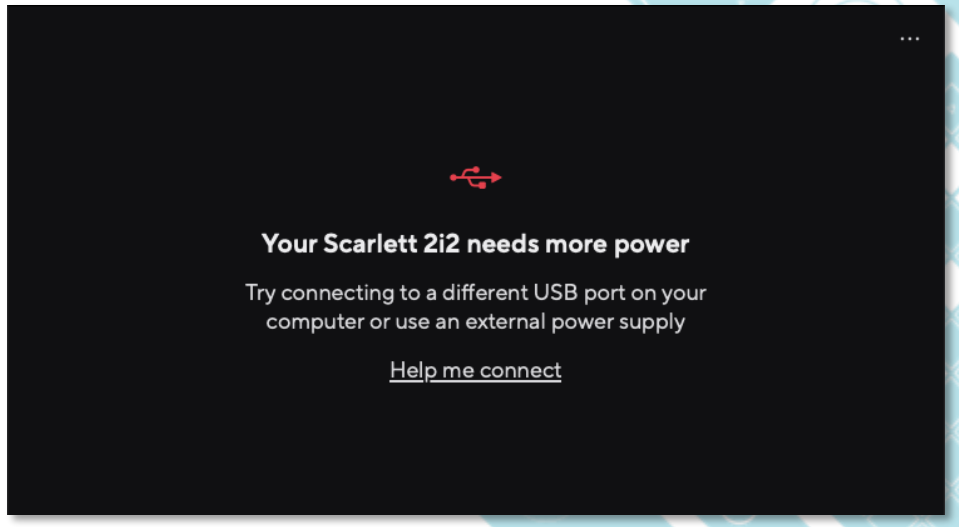


Playing nicely with others



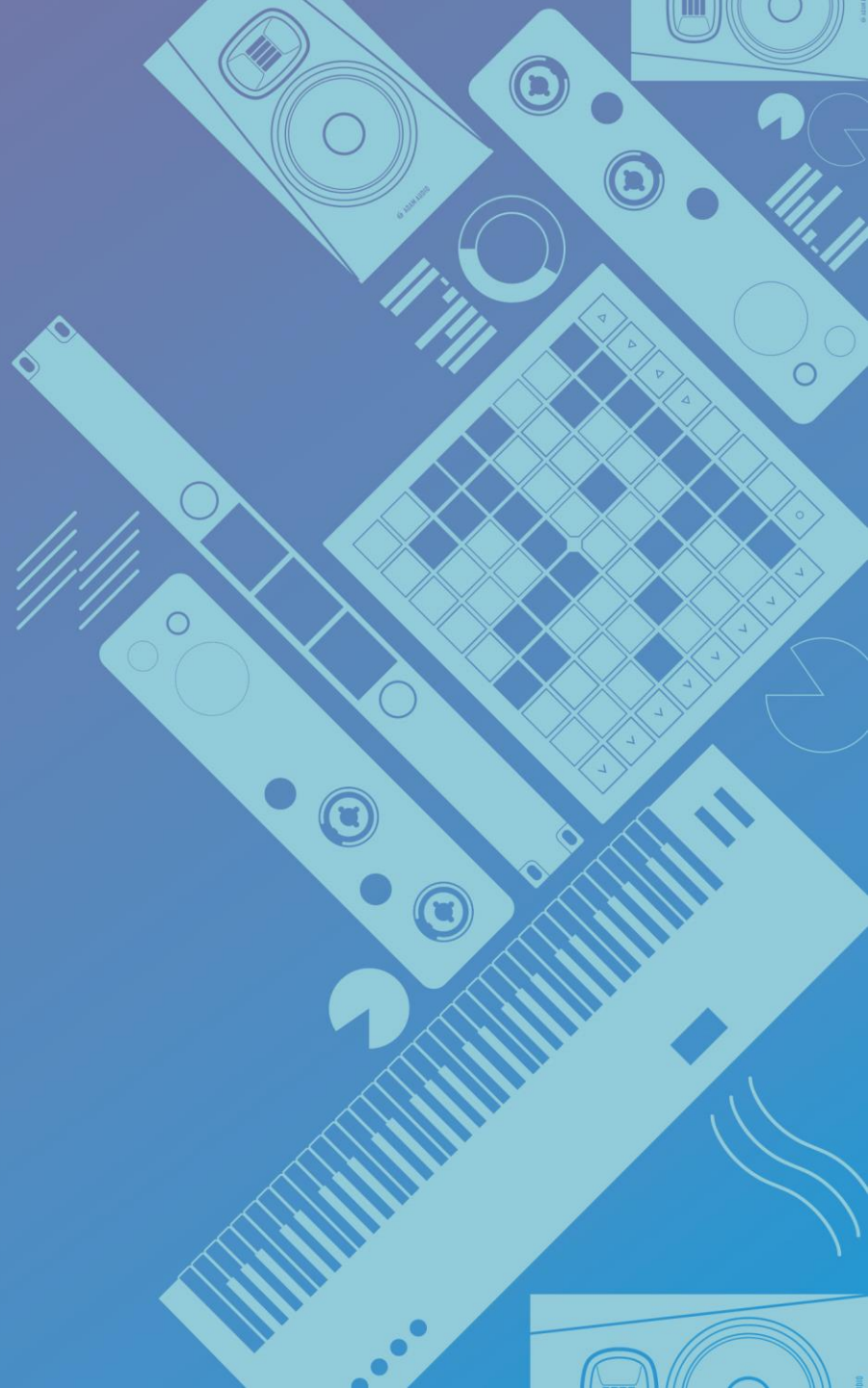


Standards help, but the goal is a good user experience



Embedded Software Development

A wild ride!



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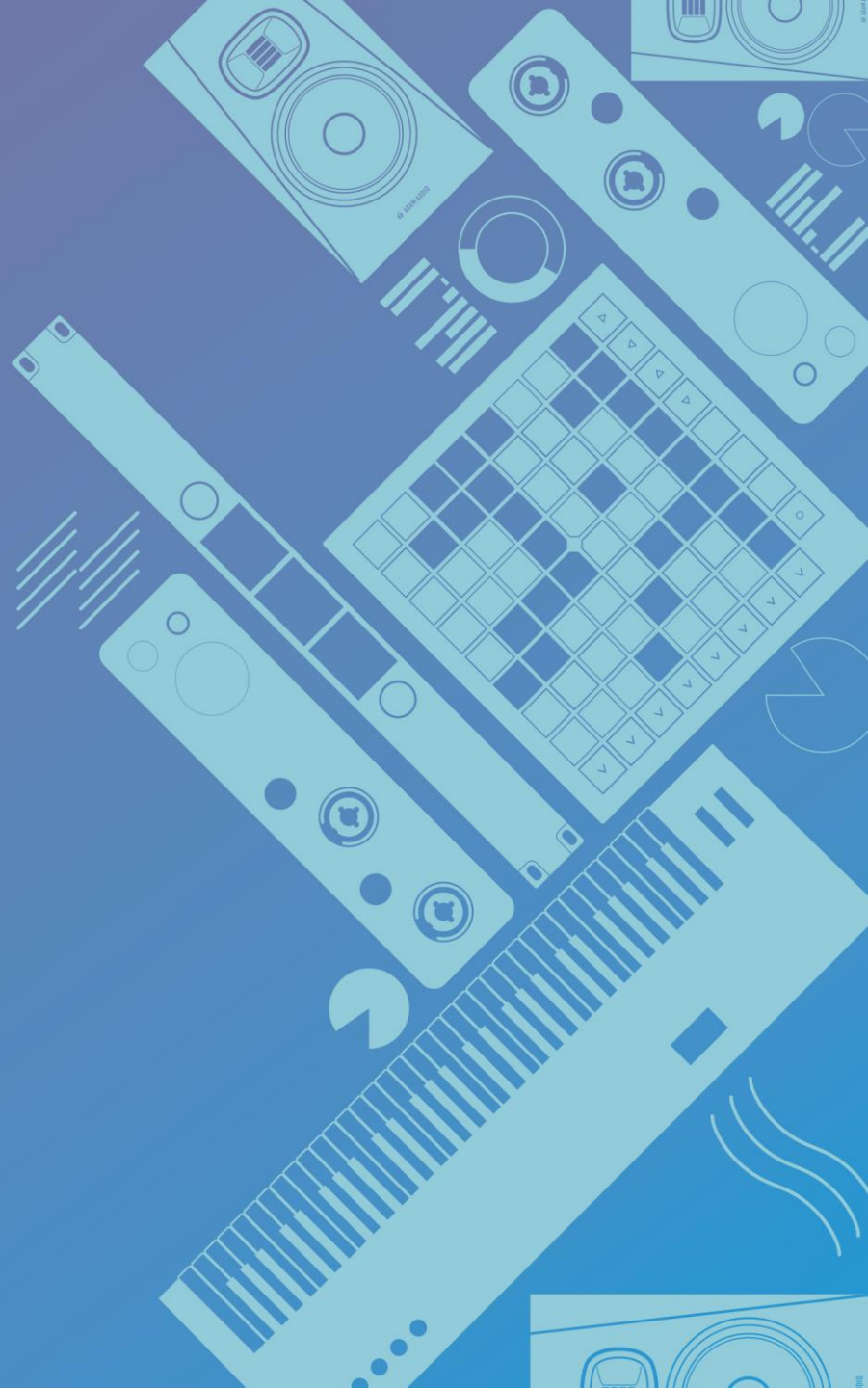
ADAM AUDIO · MARTIN AUDIO · Optimal Audio · SEQUENTIAL · LINEA RESEARCH

We're Hiring!



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