IoT-ALE: Demystifying MCUs with Arduino

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FIGURE 1. The Sunbeam Radiant Control toaster.



Arduino

• ATMEGA328

• Key parameters [edit]

Parameter	Value
CPU type	8-bit AVR
Performance	20 MIPS at 20 MHz ^[2]
Flash memory	32 kB
SRAM	2 kB
EEPROM	1 kB
Pin count	28 or 32 pin: PDIP-28, MLF-28, TQFP-32, MLF-32 ^[2]
Maximum operating frequency	20 MHz
Number of touch channels	16
Hardware QTouch Acquisition	No
Maximum I/O pins	23
External interrupts	2
USB Interface	No
USB Speed	-

ESP8266

- Processor: L106 32-bit <u>RISC</u> microprocessor core based on the <u>Tensilica</u> Xtensa Diamond Standard 106Micro running at 80 MHz^[5]
- Memory:
 - 32 KiB instruction RAM
 - 32 KiB instruction cache RAM
 - 80 KiB user-data RAM
 - 16 KiB ETS system-data RAM
- External QSPI flash: up to 16 MiB is supported (512 KiB to 4 MiB typically included)
- <u>IEEE 802.11</u> b/g/n <u>Wi-Fi</u>
 - Integrated <u>TR switch</u>, <u>balun</u>, <u>LNA</u>, <u>power amplifier</u> and <u>matching network</u>
 - <u>WEP</u> or <u>WPA/WPA2</u> authentication, or open networks
- 16 <u>GPIO</u> pins
- <u>SPI</u>
- <u>I²C</u> (software implementation)^[6]
- <u>I²S</u> interfaces with DMA (sharing pins with GPIO)
- <u>UART</u> on dedicated pins, plus a transmit-only UART can be enabled on GPIO2
- 10-bit <u>ADC</u> (successive approximation ADC)

ESP32

- Processors:
 - CPU: Xtensa dual-core (or single-core) 32-bit LX6 microprocessor, operating at 160 or 240 MHz and performing at up to 600 <u>DMIPS</u>
 - Ultra low power (ULP) co-processor
- Memory: 520 KiB SRAM
- Wireless connectivity:
 - Wi-Fi: <u>802.11</u> b/g/n
 - Bluetooth: v4.2 BR/EDR and BLE
- Peripheral interfaces:
 - 12-bit <u>SAR ADC</u> up to 18 channels
 - 2 × 8-bit <u>DACs</u>
 - 10 × touch sensors (<u>capacitive sensing</u> GPIOs)
 - Temperature sensor
 - 4 × <u>SPI</u>
 - $2 \times \underline{I^2S}$ interfaces
 - $2 \times \underline{I^2C}$ interfaces
 - 3 × <u>UART</u>
 - •

ESP32 Con't

- <u>SD/SDIO/CE-ATA/MMC/eMMC</u> host controller
- SDIO/SPI slave controller
- <u>Ethernet MAC interface with dedicated DMA and IEEE 1588 Precision Time</u>
 <u>Protocol</u> support
- <u>CAN bus</u> 2.0
- Infrared remote controller (TX/RX, up to 8 channels)
- Motor <u>PWM</u>
- LED <u>PWM</u> (up to 16 channels)
- Hall effect sensor
- Ultra low power analog pre-amplifier
 - •

ESP32 Con't

- security:
 - IEEE 802.11 standard security features all supported, including WFA, WPA/WPA2 and WAPI
 - Secure boot
 - Flash encryption
 - 1024-bit OTP, up to 768-bit for customers
 - Cryptographic hardware acceleration: <u>AES</u>, <u>SHA-2</u>, <u>RSA</u>, <u>elliptic</u> <u>curve cryptography</u> (ECC), <u>random number generator</u> (RNG)
- Power management:
 - Internal low-dropout regulator
 - Individual power domain for RTC
 - 5uA deep sleep current
 - Wake up from GPIO interrupt, timer, ADC measurements, capacitive touch sensor interrupt

Your devices and networking



Hybrid solution: Local access + cloud access

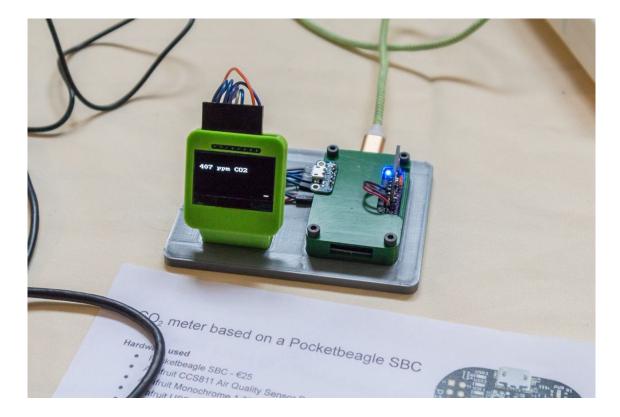
Your devices and networking



Cloud only access, no local network

Your devices and networking

No access because you forgot to install the wifi firmware :)



Labs

- IDE/Board Setup
 - Install Python if needed
 - Install Arduino IDE
 - Install ESP32 board interface
- Blinky
 - \circ $\,$ $\,$ Open and upload to board $\,$
- WiFi
 - Open from examples menu
 - Upload
- Sensors
 - Install library from library manager
 - Open example
 - Modify example to work with the current board

IDE Setup

https://www.arduino.cc/en/Guide/Linux

- sudo chmod 666 /dev/ttyUSB0 if it won't upload
- <u>https://www.arduino.cc/en/Guide/Windows</u>

• <u>https://www.arduino.cc/en/Guide/MacOSX</u>

Setting up the ESP32 board drivers

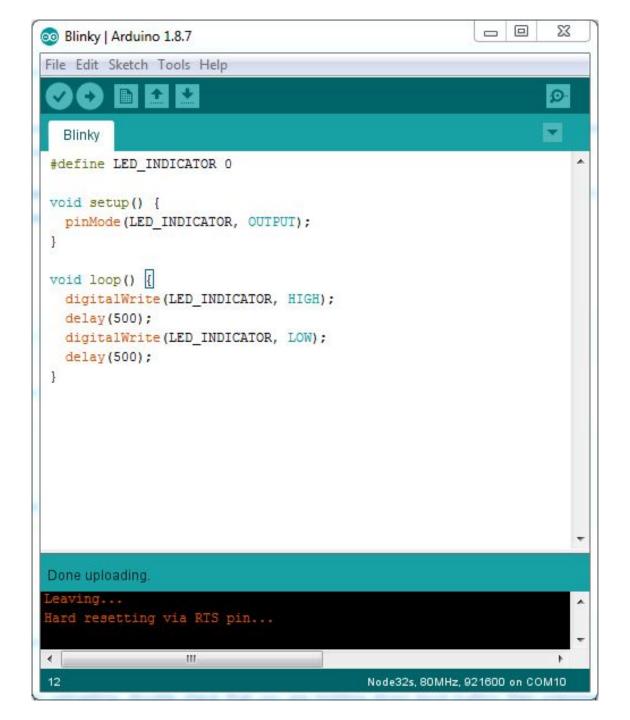
(https://dl.espressif.com/dl/package_esp32_index.json)

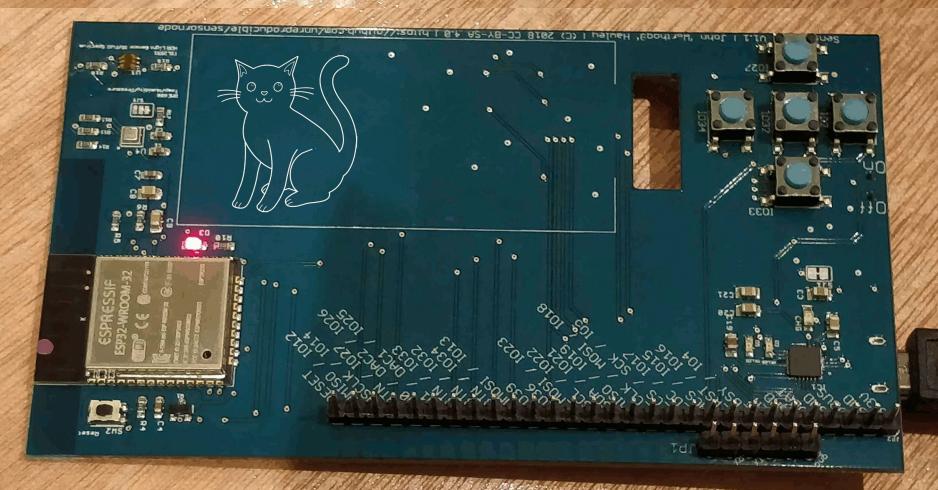
Preferences				
Settings Network				
Sketchbook location:				
(
/home/ka6sox/Arduino/Sketch		Browse		
Editor language:	System Default v (requires restart of Arduino)			
Editor font size:	12			
Interface scale:	Automatic 100 💭 % (requires restart of Arduino)			
Theme:	Default theme 💌 (requires restart of Arduino)			
Show verbose output during:	Compilation upload			
Compiler warnings:	None 🔻			
Display line numbers				
Enable Code Folding				
Verify code after upload				
Use external editor				
Aggressively cache compile	ed core			
Check for updates on start	dr			
✓ Update sketch files to new	extension on save (.pde -> .ino)			
Save when verifying or uplo	pading			
Additional Boards Manager UR	Ls: https://dl.espressif.com/dl/package_esp32_index.json			
More preferences can be edite	d directly in the file			
/home/ka6sox/.arduino15/pref	erences.txt			
(edit only when Arduino is not r	unning)			
	OK	Cancel		

Blinky

- File > Open
- Open the Blinky file in the Blinky folder
- Upload the program to the board
- sudo chmod 666 /dev/ttyUSB0 if it won't upload







Wifi Scan

ile Edi	it Sketch	Tools Help	-				
Ne	ew	Ctrl+N				₽	
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25	pen Recent	1					
	etchbook						
	amples				_		
1000	ose	Ctrl+W	1	Examples for Node32s			
	ive	Ctrl+S		ArduinoOTA	•		
Sa	ve As	Ctrl+Shift+S	1	BluetoothSerial	•		
Pa	ige Setup	Ctrl+Shift+P	1	DNSServer	•	5	
	int	Ctrl+P	1	EEPROM	•		
-	ang an		1	ESP32	•	ETH_LAN8720	
Pr	eferences	Ctrl+Comma	1	ESP32 Async UDP	1	ETH_LAN8720_interna	al_clock
Q	uit	Ctrl+Q	1	ESP32 Azure IoT Arduino	1	ETH_TLK110	
				ESP32 BLE Arduino	1	SimpleWiFiServer	
			1	ESPmDNS	•	WiFiBlueToothSwitch	í.
			1	HTTPClient	1	WiFiClient	
			1	NetBIOS	•	WiFiClientBasic	
				Preferences	1	WiFiClientEnterprise	
				SD(esp32)	1	WiFiClientEvents	
			1	SD_MMC	1	WiFiClientStaticIP	
			1	SimpleBLE	1	WiFiIP√6	
			1	SPI	1	WiFiMulti	
			1	SPIFFS	1	WiFiScan	
1				Ticker	1	WiFiSmartConfig	
arcs.				Update	1	WiFiTelnetToSerial	
			1	WebServer	1	WiFiUDPClient	
				WiFi	1	WPS	
			1	WiFiClientSecure	+	1	

Wifi Monitor (Tools > Serial Monitor)

💿 СОМ10	
	Send
scan start	
scan done	
2 networks found	
1: lfevents (-78)* 2: lfevents (-94)*	
	Change to 115200 baud
V Autoscroll 🔲 Show timestamp	Newline 👻 115200 baud 👻 Clear output

Library Manager (for sensors)

Auto Format Archive Sketch Fix Encoding & Reload Manage Libraries	Ctrl+T Ctrl+Shift+I)
Fix Encoding & Reload Manage Libraries	Ctrl+Shift+I	5	1
Manage Libraries	Ctrl+Shift+I		
-	Ctrl+Shift+1		
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Serial Monitor	Ctrl+Shift+M	ld library,	
Serial Plotter	Ctrl+Shift+L	file you nee	d
WiFi101 Firmware Updater			=
Board: "Node32s"		•	
Jpload Speed: "921600"			L
Port: "COM10"		•	
		an AP if it we	
Set Doard Into		_	
Programmer: "AVRISP mkII"		•	
Burn Bootloader			
("Setup done");		1.1	
	WiFi101 Firmware Updater Board: "Node32s" Jpload Speed: "921600" Flash Frequency: "80MHz" Port: "COM10" Get Board Info Programmer: "AVRISP mkII" Burn Bootloader	WiFi101 Firmware Updater Board: "Node32s" Jpload Speed: "921600" Flash Frequency: "80MHz" Port: "COM10" Get Board Info Programmer: "AVRISP mkII" Burn Bootloader	Serial Plotter Ctrl+Shift+L WiFi101 Firmware Updater Board: "Node32s" Upload Speed: "921600" Flash Frequency: "80MHz" Port: "COM10" Get Board Info Programmer: "AVRISP mkII" Burn Bootloader

Sensors Library Installation

💿 Library Manager	23
Type All 🔹 Topic All 🔹 tsl2591	
Adafruit TSL2591 Library by Adafruit Library for the TSL2591 digital luminosity (light) sensors. Library for the TSL2591 digital luminosity (light) sensors. More info	*
BlueDot BME280 TSL2591 by BlueDot Version 1.0.4 INSTALLED BlueDot library for BME280 and TSL2591 sensors. Read temperature, relative humidity, pressure and illuminance with BME280 and TSL2591 sensors. More info Select version Install	
	*
	Close

Sensors Library Example

ile	Edit Sketch	<u>T</u> ools <u>H</u> elp		
	New Open Open Recent Sketchbook	Ctrl+N Ctrl+O		
	Examples		ArduinoOTA 🕨	rary,
	Close Save Save As	Ctrl+W Ctrl+S Ctrl+Shift+S	BluetoothSerial DNSServer EEPROM	ou need
	Page Setup Print	Ctrl+Shift+P Ctrl+P	ESP32 ESP32 Async UDP ESP32 Azure IoT Arduino	
	Preferences	Ctrl+Comma Ctrl+O	ESP32 BLE Arduino	if it wa
(delay(100) Serial.pr:		HTTPClient NetBIOS Preferences SD(esp32) SD_MMC SimpleBLE	*
	ving d resetting	via RTS pin.	SPI > SPIFFS > Ticker > Update >	*
)		III	WebServer •	00110
	_		WiFi WiFiClientSecure	on COM10
		-	Examples from Custom Libraries	
			BlueDot BME280 TSL2591	BME280_TSL2591_Te

Modifying it to Work



Expected Output

💿 COM10		
		Send
Temperature in Celsius:	20.97	·
Humidity in %:	39.11	
Pressure in hPa:	1019.05	
Altitude in Meters:	-50.26	
Illuminance in Lux:	2248.00	
Duration in Seconds:	214.05	
Temperature in Celsius:	20.97	
Humidity in %:	39.11	
Pressure in hPa:	1019.05	
Altitude in Meters:	-50.26	
Illuminance in Lux:	2251.00	
V Autoscroll 📄 Show timestamp		Newline 👻 9600 baud 👻 Clear output

Examples I Used:

github.com/chromenova/ sensornodeexamples