Wall-E

Building the project:

- idf.py build # Command for building the code

Flashing the code command:

idf.py -p PORT [-b BAUD] flash

(PORT → Stands for the Serial Port Number of ESP-32)

(BAUD → Stands for the Baud Rate (rate of information transfer to the ESP-32)

Example ports -

for Linux : /dev/ ttyUSB0

for MacOS : /dev/ cu.usbserial-0001

for Windows: /COM1#/2/3/...

Checking ports:

for linux : dmesg | grep tty

for MacOS : /dev/cu.*

for windows : (from Device manager)

Monitoring the output from ESP-32

We can achieve this by going into the project directory via the terminal and giving the command:

idf.py monitor

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LED (Light emitting diode) is a semiconductor device that emits light when an electric current is passed through it.

Decimal	Hex
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	A
11	B
12	C
13	D
14	E
15	F
16	

Convert 960 into hex.

	hex
960/16 → 60	0
60/16 → 3, 12	C
3/16 → 0, 3	3

$\therefore (960)_{10} = (3C0)_{16}$

Hex	Binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

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SRA - dev - Board includes:

- Microcontroller (ESP32)
- Motor drivers (TB6612FNG)
- Push buttons
- MPV and LSA
- onboard power management
- OLED and servo motors

Microcontroller:
Single Integrated circuit (IC) that is typically used for a specific application and designed to implement certain tasks.

ESP-IDF
IDF → IDF stands for IOT development framework.
IDF is ESP's i.e Espressif's own authentically created official toolchain to work on and program build compile code on ESP based microcontroller

Buck converter :- It is a voltage regulator, maintains a constant voltage even though the input voltage changes.
→ Converts input voltage to 5V.

AMS1117: Converts input voltage to 3.3V

Motor Driver : [TB6612FNG]
IC used as a motor controlling device (as in adjusts the voltage applied to the motors).

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ADC (Analog to digital converters)

Used to convert an analog signal to digital form so that it can be read and processed by a microcontroller.

Analog signals	Digital signals
• Continuous signals	• Discontinuous
• Represented by sine waves.	• Represented by square waves.
• Human voice, analog electronic devices	• Computers, optical drives
• Continuous values	• Discontinuous values
• Records sound waves as they are	• Converts into a binary waveform.

ADCs follow a sequence when converting analog signals to digital. They first sample the signal, then quantify it to determine the resolution of the signal. and finally set binary values and send it to the system to read the digital signal. Two aspects of ADC are its sampling rate and resolution.

ADC → includes 2 processes.

- Sampling
- Quantization

// Sampling: Process of measuring instantaneous values of continuous - sine signal in discrete form. Sample is a piece of data taken

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from the whole data which is continuous in the time domain.
This discretization of analog signal is called sampling.

Quantization:
Rounding off of the values which are approximately equal to the analog values. The method of sampling chooses a few points on the analog signal and then these points are joined to round off the value to a near stabilized value.

The quantizing of an analog signal is done by discretizing the signal with a number of quantization levels. Quantization is representing the sampled values of the amplitude by a finite set of levels, which means converting a continuous-amplitude sample into a discrete time signal.

- No. of quantization levels $= 2^n$

- Quantizing a sequence of numbers produces a sequence of quantization errors which is sometimes modeled as an additive random signal called quantization noise because of its stochastic behaviour.

The more levels a quantizer uses, the lower is its quantization noise power.

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LSA [Line sensor array]

LSA has set of LED's which emit light and after reflection the light is absorbed by photo diode. Now there is a catch, the reflection part, that is the reflection percentage are not same for white and black surfaces and then this becomes differentiating factor.

- Light from LED after reflecting from surface falls on the reverse biased photodiode
- Should be kept close to the ground
- photo diode should be surrounded by a shield to minimize effect of ambient light.

IC LM324

14 pin IC consisting of four operational Amplifiers (op-Amps) in a single package

- Op-Amps is a high gain amplifier.

used to amplify current with constant voltage we need to increase the significance of very small current at photo diode.

↳ Amplified outputs are RAW LSA SENSOR values from about 400 (BLACK) to 2000 (WHITE) - mapped from 0 (BLACK) to 1000 (WHITE) for convinience.

Defining constraints -

CONSTRAINT_LSA_LOW - 0

CONSTRAINT_LSA_HIGH - 1000

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Communication protocols

Communication

Parallel	Serial
• 8-bits are transferred in corresponding 8 channels, every channel transmits a bit and a byte of data is recieved simultaneously	• word of 8-bits in length is sent sequentially and is received after all 8-bits are sent, one at a time. the bits are then assembled back into one byte which is initial communication
• Faster	• Slower
• More connections, therefore distorted signals.	• Fewer connections, cleaner signals.
• Less suitable since distorted signals	• More suitable
• More space to accomodate	• Utilizes minimal space

Asynchronous devices

- No clock wire
- Start and stop bits are used.
- Caps are also used

  Eg - UART

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// Synchronous

- clock wire is present
- No need for start / stop bits and gaps.

Eg - SPI , I2C

UART (Universal Asynchronous receiver transmission).

Steps to follow :

- Start (Data line goes low for one bit
- Data (send data bits)
- Parity (send parity bit for error checking)
- Stop (send stop it)

Error detecting codes -
Additional data added to a given digital msg to help us detect if an error occurred during transmission of the message
Simple ex - parity check.

Parity - it contains even number of 1 bits or odd number of 1 bits

10011010 → Even 1's ⇒ Parity : 1

10111010 → Odd 1's ⇒ Parity : 0

working -

- Sender will calculate parity
- Transmitter will transmit data
- Receiver will receive
- Receiver will check parity
- If parity matches ⇒ process data

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- Baud rate: rate at which information is transferred in communication channel commonly used in serial communication.
- In serial port context, "9600 baud" means that port is capable of transfering a maximum of 9600 bits per second.

Required configs for UART:
- Regulatory bits (start and stop bits)
- Baud rate
- Parity bit

Advantages
- Configurable speed
- No need of clock wire
- Parity bit ensures basic error checking

Disadvantages
- Size of data frame is limited
- Less speed of data transmission
- No confirmation about successful recieving of data from reciever to transmitter.

Steps for UART communication

1) Transmitting UART receives data from the data bus in parallel.
2) Transmitting UART adds the start, parity and stop bit to the data packet.
3) The entire packet is sent from the transmitting

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UART to receiving UART serially. Using the configured baud rate the receiving UART samples the data packet.

4) UART converts the data back to its original form and then transfers it to the data bus where it can be used or visualized.

// I2C (Inter-integrated circuit)

(+)
- Each bit of data is sent through a digital pin
- Therefore 8 pins are required for 8 bits of data

(-) ~ Requires lots of pins
Can't connect more devices.

→ Lines/pins involved in I2C communication

SDA (Serial Data) - line for master and slave to send and receive data.

SCL (Serial clock) - Line that carries the clock signal

- I2C is serial communication, data is transferred bit by bit along single wire
- Clock signal is always controlled by the master.

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Working -

- I2C master sends out one start bit
- I2C master calls out to a specific I2C slave using a 7-bit address
- Slave corresponds
- Master sends specific command to slave
- Slave answer's master's request.
- Master acknowledges the 1st bit of data before slave continues delivering info.
- Slave now sends the next byte of data
- After receiving data master ends the communication

Address frame - A 7 or 10 bit sequence unique to each slave that identifies the slave when the master wants to talk to it.

Read / write Bit: - A single bit specifying whether the master is sending data to the slave (low voltage) or requesting data from it. (high voltage)

ACK/NACK Bit: Each frame in a message is followed by an acknowledge / no-acknowledge bit. If an address frame or data frame was successfully received, an ACK bit is returned to the sender from the receiving data

Start condition → SDA line switches from a high voltage level to a low voltage level before the SCL line switches from high to low.

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Stop condition:

SDA line switches from a low voltage level to a high voltage level after the SCL line switches from low to high.

STEPS OF I2C transmission:

1) Master sends start condition every connected slave. by switching SDA line
2) Master sends 7 or 10 bit Address of slave to start communication.
3) Each slave compares address, if address match send back ACK bit by pulling SDA line low for one bit. If address don't match slave leaves SDA line high
4) Master sends or receives data
5) After each data frame has been transferred the receiving device returns another ACK bit to the sender to acknowledge successful receipt of the frame.
6) Stop - master sends a stop condition to the slave by switching SCL high before switching SDA high.

Multiple masters with multiple slaves.

- If SDA line is low, this means that another master has control of the bus, and the master should wait to send the message. If the SDA line is high then its safe to transmit the message

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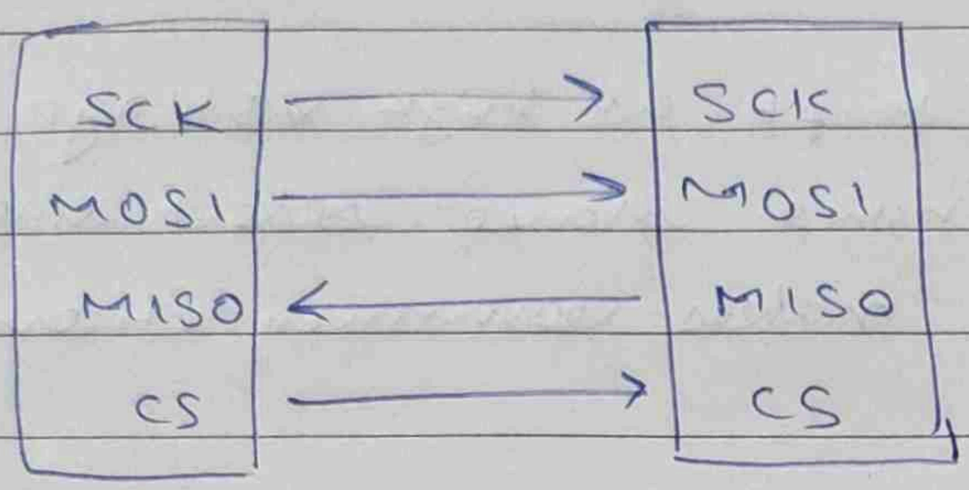
SPI (Serial peripheral interface)

PIN interface :



SCK → Serial clock

MOSI → master out slave in

MISO → master in slave out

SS/CS → Slave select/ Chip select.

SPI is serial and synchronous interface

How SPI works

The clock: communication always initiated by master, bus master controls the clock, using a frequency supported by the slave device.

one bit of data is transferred in each clock cycle, so speed is determined by frequency of clock cycle.

MOSI and MISO

Master sends data through MOSI in most significant bit

Slave sends back to master through MISO in least significant bit.

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Slave select:

- Master can choose which slave it wants by setting the slave's CS/SS line to low voltage.
- In idle line is kept at high voltage
- I2C doesn't have slave select lines like SPI so it makes communication by addressing.

= Steps of data transmission

1) Master outputs the clock signal
2) Master switches the SS/CS pin to low voltage
3) Master sends data one bit at a time through MOSI line
4) If response is needed slave responds through MISO line

Multiple slaves:

- Single master - single slave
- Single master - multiple slave
  → 2 ways
  - (Independent slave config) : master with multiple SS pins so slaves connected in parallel
  - (dependent slave config) : master with one SS pin so slaves connect daisy-chained

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Advantages

- No start and stop bits, so data can be streamed continuously without interruption
- Not complicated slave addressing
- fast data transfer
- Separate MOSI and MISO lines so data can be send and received at same time.

Dis advantages

- Uses four wires
- Now acknowledgement that data has been successfully received (I2C has this)
- No form of error checking
- only allows single master

	UART	SPI	I2C
wires used	2	4	2
Speed	upto 115200 baud usually 9600 baud	Upto 10Mbps	Upto 5Mbps
	Asynchronous Serial	Synchronous Serial	Synchronous Serial
Max masters	1	1	unlimited
max slaves	1	unlimited	128

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