Complete Pinout Table for Autonomous Robot System

📌 Master Pin Configuration Table

Component	Pin Name	GPIO #	Physical Pin	Wire Color	Notes
Motor Driver (L298N)					
	IN1	GPIO 24	Pin 18	Orange	Motor direction control 1
	IN2	GPIO 23	Pin 16	Yellow	Motor direction control 2
	ENA	GPIO 13	Pin 33	Green	Motor PWM speed control
	GND	GND	Pin 6/9/14/20/25/30/34/39	Black	Common ground
Servo Motor (SG90)					
	Signal	GPIO 18	Pin 12	Yellow/Orange	PWM control signal
	VCC	5V	Pin 2 or 4	Red	5V power
	GND	GND	Pin 6/9/14/20/25/30/34/39	Brown/Black	Ground
VL53L0X Sensors (All 4)					
	VCC	3.3V	Pin 1 or 17	Red	3.3V power (shared)

	GND	GND	Pin 6/9/14/20/25/30/34/39	Black	Ground (shared)
	SDA	GPIO 2	Pin 3	Blue	I²C data (shared)
	SCL	GPIO 3	Pin 5	Yellow	I²C clock (shared)
	XSHUT (Right)	GPIO 22	Pin 15	Purple	Right sensor shutdown
	XSHUT (Left)	GPIO 27	Pin 13	Gray	Left sensor shutdown
	XSHUT (Back)	GPIO 17	Pin 11	White	Back sensor shutdown
	XSHUT (Front)	GPIO 26	Pin 37	Orange	Front sensor shutdown
Control Switch					
	Switch	GPIO 25	Pin 22	Green	Start/Stop switch
	GND	GND	Pin 6/9/14/20/25/30/34/39	Black	Switch ground
Status LED					
	LED (+)	GPIO 6	Pin 31	Blue	Status indicator (+ 220Ω resistor)
	LED (-)	GND	Pin 6/9/14/20/25/30/34/39	Black	LED ground

🔌 Raspberry Pi 4 GPIO Pinout Diagram

```
   3.3V [ 1] [ 2] 5V      ← VL53L0X VCC here
I²C SDA=2 [ 3] [ 4] 5V    ← Servo VCC here
I²C SCL=3 [ 5] [ 6] GND   ← Common GND
          [ 7] [ 8]
      GND [ 9] [10]
```

```
 Back XSHUT=17 [11] [12] 18=Servo Signal
 Left XSHUT=27 [13] [14] GND
Right XSHUT=22 [15] [16] 23=Motor IN2
       GND [17] [18] 24=Motor IN1
           [19] [20] GND
           [21] [22] 25=Switch
           [23] [24]
       GND [25] [26]
           [27] [28]
           [29] [30] GND
  LED=6    [31] [32]
Motor ENA=13 [33] [34] GND
           [35] [36]
Front XSHUT=26 [37] [38]
       GND [39] [40]
```

🎨 Color-Coded Wiring Scheme

Function	Recommended Color	Example Components
3.3V Power	Red (thin)	VL53L0X sensors
5V Power	Red (thick)	Servo, L298N logic
Ground	Black	All components
I²C SDA	Blue	All VL53L0X sensors
I²C SCL	Yellow	All VL53L0X sensors
PWM Signals	Orange/Green	Servo, Motor ENA
Digital Control	Various colors	Motor IN1/IN2, XSHUT pins

📊 Pin Usage Summary

GPIO Pin	Function	Type	Voltage
GPIO 2	I²C SDA	Bidirectional	3.3V

GPIO 3	I²C SCL	Output	3.3V
GPIO 6	Status LED	Output	3.3V
GPIO 13	Motor ENA (PWM)	Output	3.3V
GPIO 17	Back Sensor XSHUT	Output	3.3V
GPIO 18	Servo PWM	Output	3.3V
GPIO 22	Right Sensor XSHUT	Output	3.3V
GPIO 23	Motor IN2	Output	3.3V
GPIO 24	Motor IN1	Output	3.3V
GPIO 25	Start/Stop Switch	Input (Pull-up)	3.3V
GPIO 26	Front Sensor XSHUT	Output	3.3V
GPIO 27	Left Sensor XSHUT	Output	3.3V

Total GPIO Pins Used: 12 out of 28 available

🔋 Power Distribution Table

Rail	Voltage	Max Current	Connected Components
3.3V	3.3V	500mA	4× VL53L0X sensors (~80mA total)
5V	5V	1.2A†	Servo motor (~200mA avg, 600mA peak)
Motor Power	7-12V	2A	DC motors (external battery)

† *After Raspberry Pi consumption (~800mA). Total 5V rail capacity is 3A with good USB-C supply.*

🛠️ L298N Motor Driver Connections

Raspberry Pi → L298N (Control Signals)

Pi GPIO	L298N Pin	Function
GPIO 24	IN1	Motor direction A
GPIO 23	IN2	Motor direction B
GPIO 13	ENA	Speed control (PWM)
GND	GND	Signal ground

L298N → Motor

L298N Pin	Connection
OUT1	Motor wire 1
OUT2	Motor wire 2

L298N Power

L298N Pin	Connection
12V	External battery (+) 7-12V
GND	External battery (-) AND Pi GND
5V (output)	**DO NOT USE** (remove jumper if present)

⚠️ **Important:** Always connect L298N GND to Raspberry Pi GND for common reference!

🧪 Testing Individual Components

Test 1: LED Blink (Verify GPIO Output)

python
```
import RPi.GPIO as GPIO
import time

GPIO.setmode(GPIO.BCM)
GPIO.setup(6, GPIO.OUT)

for _ in range(5):
    GPIO.output(6, GPIO.HIGH)
    time.sleep(0.5)
    GPIO.output(6, GPIO.LOW)
    time.sleep(0.5)


GPIO.cleanup()
```

Test 2: Switch Read (Verify GPIO Input)

python
```
import RPi.GPIO as GPIO
import time

GPIO.setmode(GPIO.BCM)
GPIO.setup(25, GPIO.IN, pull_up_down=GPIO.PUD_UP)

print("Press switch...")
while True:
    state = GPIO.input(25)
    print(f"Switch: {'PRESSED' if state == 0 else 'RELEASED'}")
    time.sleep(0.5)
```

Test 3: I²C Scan (Verify Sensor Connections)

bash
```
sudo i2cdetect -y 1
```
Expected output with all sensors powered:
```
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:          -- -- -- -- -- -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- -- -- 29 -- -- -- -- -- --
30: 30 31 32 -- -- -- -- -- -- -- -- -- -- -- -- --
```

```
(Shows sensors at 0x29, 0x30, 0x31, 0x32)

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## ⚡ Startup Sequence (Power-On Order)

1. **Connect all signal wires** (GPIO pins to components)
2. **Connect all grounds** (establish common reference)
3. **Connect sensor power** (3.3V to VL53L0X)
4. **Connect servo power** (5V to servo)
5. **Connect motor driver logic power** (5V to L298N if needed)
6. **Power on Raspberry Pi** (USB-C 5V 3A supply OR battery)
7. **Connect motor driver high power** (7-12V battery to L298N)

⚠️ **Never hot-swap connections while powered!**

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## 🔍 Quick Pin Reference Card (Print This!)
```

```
╔═══════════════════════════════════════╗
║   ROBOT PIN QUICK REFERENCE           ║
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║ MOTOR:                                ║
║  IN1=24 | IN2=23 | ENA=13             ║
║                                       ║
║ SERVO:                                ║
║  Signal=18                            ║
║                                       ║
║ SENSORS (I²C shared):                 ║
║  SDA=2 | SCL=3                        ║
║  Right XSHUT=22 | Left XSHUT=27       ║
║  Back XSHUT=17  | Front XSHUT=26      ║
║                                       ║
║ CONTROLS:                             ║
║  Switch=25 | LED=6                    ║
║                                       ║
║ POWER:                                ║
║  3.3V=Pin 1/17 | 5V=Pin 2/4           ║
║  GND=Pin 6,9,14,20,25,30,34,39        ║
╚═══════════════════════════════════════╝
```

📸 Pin Verification Checklist

Before powering on, verify:

- **All grounds connected** to Pi GND pins
- **No 5V to 3.3V pins** (sensor damage risk!)
- **No shorts** between adjacent pins
- **Servo on 5V rail**, not 3.3V
- **Sensors on 3.3V rail**, not 5V
- **Motor driver GND shared** with Pi GND
- **Switch configured with pull-up** (internal or external)
- **LED has current-limiting resistor** (220Ω recommended)
- **All XSHUT pins connected** to correct GPIOs
- **I²C bus shared** by all 4 sensors (SDA + SCL)