**DETAILED DESCRIPTION OF ELECTRICAL DIAGRAM**

**1. POWER SYSTEM**

**Main Power Source**

* **Battery**: 12V DC
* **Main Switch (SW1)**: Controls entire system power via ON/OFF switch that interrupts battery positive terminal

**Voltage Regulation**

* **LM2596 Step-Down Module**:
  + Input: 12V from main bus (after switch)
  + Output: Adjustable 5V via potentiometer
  + Type: Buck switching converter (high efficiency ~92%)
  + Includes operation indicator LED
  + Powers servo motor exclusively

**Power Distribution**

* **12V Bus**: Directly powers:
  + L298N Motor Driver (VS terminal)
  + Arduino R4 WiFi (via DC Jack)
  + LM2596 regulator input
* **Arduino 5V Bus**: Powers:
  + 3 HC-SR04 sensors
  + Pixy Camera
  + Start button pull-up

**2. MAIN CONTROLLER**

**Arduino UNO R4 WiFi**

* Processor: Renesas RA4M1 (ARM Cortex-M4 @ 48MHz)
* Integrated WiFi connectivity
* Power: 12V via DC Jack (internal regulation to 5V)
* Provides regulated 5V for peripherals

**3. MOTION SYSTEM**

**DC Motor**

* Controlled by L298N driver
* L298N Connections:
  + **ENB** → Pin D6 (PWM speed control)
  + **IN3** → Pin D8 (direction)
  + **IN4** → Pin D7 (direction)
  + **OUT3/OUT4** → DC motor terminals
  + **VS** → 12V from main bus
  + **GND** → Common ground

**Servo Motor SG90**

* Vehicle steering control
* Connections:
  + **PWM** → Pin D9 (control signal)
  + **VCC** → 5V from LM2596 regulator (dedicated power)
  + **GND** → Common ground

**4. SENSOR SYSTEM**

**Three HC-SR04 Ultrasonic Sensors**

**1. RIGHT Sensor:**

* TRIG → Pin D2
* ECHO → Pin D3
* VCC → Arduino 5V
* GND → Common ground

**2. LEFT Sensor:**

* TRIG → Pin D4
* ECHO → Pin D5
* VCC → Arduino 5V
* GND → Common ground

**3. FRONT Sensor:**

* TRIG → Pin A1
* ECHO → Pin A2
* VCC → Arduino 5V
* GND → Common ground

**Pixy Camera (CMUcam5)**

* SPI interface for computer vision
* SPI Connections:
  + **MISO** → Pin D12
  + **MOSI** → Pin D11
  + **SCK** → Pin D13
  + **SS** → Pin A0
  + **VCC** → Arduino 5V
  + **GND** → Common ground

**5. CONTROL SYSTEM**

**START Button**

* Connected to Pin D10
* 10kΩ pull-up resistor to 5V
* Pressing connects pin to ground (inverse logic)
* Allows robot program initialization

**6. DETAILED CONNECTIONS**

**Digital Pins Used:**

* D2: Right sensor TRIG
* D3: Right sensor ECHO
* D4: Left sensor TRIG
* D5: Left sensor ECHO
* D6: Motor ENB (PWM)
* D7: Motor IN4
* D8: Motor IN3
* D9: Servo PWM
* D10: Start button
* D11: MOSI (SPI - Pixy)
* D12: MISO (SPI - Pixy)
* D13: SCK (SPI - Pixy)

**Analog Pins Used:**

* A0: SS (Pixy Camera)
* A1: Front sensor TRIG
* A2: Front sensor ECHO

**7. POWER FLOW**

1. **12V Battery** → **ON/OFF Switch** → **12V Bus**
2. **12V Bus** splits to:
   * → **Arduino DC Jack** (internal regulation)
   * → **L298N VS** (motor power)
   * → **LM2596 IN** (to generate 5V)
3. **Arduino 5V pin** → **HC-SR04 Sensors + Pixy + Pull-up**
4. **LM2596 OUT** → **Servo motor** (dedicated 5V)

**8. IMPORTANT FEATURES**

**Common Ground (GND)**

* All components share same ground reference
* Ground bus connects: battery, Arduino, L298N, LM2596, sensors, servo, and Pixy

**Protections**

* Main switch for complete power cutoff
* Separate regulation for servo (prevents voltage drops)
* Pull-up on Start button (prevents erratic readings)

**Diagram Color Codes**

* **Thick black**: Main power lines
* **Thin black**: Digital signals
* **Blue**: Motor control signals
* **Green**: Ultrasonic sensor signals
* **Orange**: Servo PWM signal
* **Purple**: Pixy SPI bus
* **Red**: 5V from regulator to servo

**9. DESIGN ADVANTAGES**

1. **Robust power supply**: Separate regulation prevents interference
2. **Modular**: Easy to add/remove components
3. **Diagnostics**: LED on LM2596 indicates operation
4. **Flexibility**: Integrated WiFi allows remote control
5. **Safety**: Main switch cuts all power
6. **Complete navigation**: 3 sensors cover 180° vision

This design enables an autonomous navigation robot capable of detecting obstacles in three directions, with computer vision and precise motion control, all with a robust and well-organized electrical architecture.