Adafruit 9-DOF Absolute Orientation IMU Fusion Breakout - BNO055 (ADA2472)

---

1. Overview of BNO055

The BNO055 is a 9-axis Inertial Measurement Unit (IMU) with on-chip sensor fusion, which provides absolute orientation data without the need for complex calculations. It includes:

- Accelerometer: Measures linear acceleration + gravity along X, Y, Z axes
- Gyroscope: Measures angular velocity along X, Y, Z axes
- Magnetometer: Measures magnetic field vector along X, Y, Z axes
- Processor: 32-bit ARM Cortex-M0 for sensor fusion
- Outputs:
- Euler angles (heading, roll, pitch)
- Quaternions (x, y, z, w)
- Angular velocity (deg/sec)
- Linear acceleration (m/s^2)
- Gravity vector (m/s^2)
- Magnetic field vector (µT)
- Temperature (°C)
- Advantages: On-chip sensor fusion provides accurate orientation without complex calculations.

---

2. Hardware Connections

BNO055 Pins

Pin	Function
VIN	Power input (3.3V or 5V)
GND	Ground
SDA	I^2C Data line
SCL	I^2C Clock line
RST	Reset (optional, tie high if unused)
INT	Interrupt (optional)

Raspberry Pi 4 I^2C Pins

Pin	Function
Pin 1	3.3V
Pin 2	5V

Pin	Function
Pin 3	SDA1 (I^2C Data)
Pin 5	SCL1 (I^2C Clock)
Pin 6	GND

Wiring

Connect as follows:

BNO055	Raspberry Pi 4	Notes
VIN	3.3V (Pin 1) or 5V (Pin 2)	Power
GND	GND (Pin 6)	Ground
SDA	SDA1 (Pin 3)	I^2C Data
SCL	SCL1 (Pin 5)	I^2C Clock
RST	Optional	Can tie to 3.3V
INT	Optional	For interrupts

Keep wires short (<30 cm) for stable communication. Use 4.7kΩ–10kΩ pull-up resistors on SDA/SCL if not built-in.

---

3. I^2C / I2C Communication

I^2C (Inter-Integrated Circuit) is a two-wire protocol allowing communication between multiple devices over SDA (data) and SCL (clock). Each device has a unique address (BNO055 default: 0x28). Raspberry Pi acts as the master and BNO055 as the slave. Multiple devices can share the same two lines.

---

4. Sensor Modes

Mode	Description
CONFIG_MODE	Setup or configure settings
NDOF	Full 9-DOF sensor fusion (default)
IMU_MODE	6-DOF (accelerometer + gyroscope)
COMPASS_MODE	Magnetometer only
M4G_MODE	6-DOF + magnetometer, no gyro
ACCONLY / MAGONLY / GYRONLY	Single sensor modes

---

5. Calibration

- BNO055 self-calibrates for accurate readings.
- Calibration components:
- Gyroscope: angular velocity
- Accelerometer: linear acceleration + gravity
- Magnetometer: magnetic field
- System: overall calibration status
- Calibration status: 0 (uncalibrated) to 3 (fully calibrated)
- Procedure:
- Keep sensor stationary to stabilize gyro and accelerometer.
- Rotate along all axes slowly.
- Rotate in figure-8 motions for magnetometer.
- Achieve status 3 for all components for accurate orientation.
- Calibration offsets can be saved for future use.

---

6. Common Issues & Solutions

- I^2C Communication Errors: Use short wires, ensure stable connections.
- Heading Drift: Avoid magnetic interference, recalibrate as needed.
- Orientation Jumps: Ensure sensor fully calibrated and powered correctly.
- Voltage Mismatch: Verify logic levels match the system.

---

7. Best Practices

- Keep sensor away from magnetic and electromagnetic interference.
- Calibrate periodically for accurate readings.
- Store calibration offsets for faster startup.
- Monitor calibration status to maintain accuracy.

---

8. Bash Commands for Raspberry Pi 4 Setup

Update System Packages

```
sudo apt update
sudo apt upgrade -y
```

Enable I^2C Interface

```
sudo raspi-config
# Interface Options → I2C → Enable
sudo reboot
```

Install Required I²C Tools

```
sudo apt install -y i2c-tools
sudo apt install -y python3-smbus python3-pip
```

Detect BNO055 on I²C Bus

```
i2cdetect -y 1
```

- Expected output: 0x28

Install Adafruit CircuitPython BNO055 Library

```
sudo pip3 install adafruit-circuitpython-bno055
sudo pip3 install adafruit-circuitpython-busdevice
```

Verify I²C Kernel Module Loaded (Optional)

```
lsmod | grep i2c
```

- Should show i2c_dev and i2c_bcm2835 modules

---

9. References & Resources

- Adafruit BNO055 Guide
- Adafruit CircuitPython BNO055 Library
- BNO055 Datasheet