EECE-4710 "IoT and TinyML"

Tiny ML Kit -Testing the Sensors

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BE THE DIFFERENCE.

Hardware Overview

Microcontroller	nRF52840 (datasheet)
Operating Voltage	3.3V
Input Voltage (limit)	21V
DC Current per I/O Pin	15mA
Clock Speed	64MHz
CPU Flash Memory	1MB (nRF52840)
SRAM	256KB (nRF52840)
EEPROM	none
Digital Input / Output Pins	14
PWM Pins	all digital pins
UART	1
SPI	1
12C	1

Analog Input Pins	8 (ADC 12 bit 200 ksamples)
Analog Output Pins	Only through PWM (no DAC)
External Interrupts	all digital pins
LED_BUILTIN	13
USB	Native in the nRF52840 Processor
IMU	LSM9DS1 (datasheet)
Microphone	MP34DT05 (datasheet)
Gesture, light, proximity	APDS9960 (datasheet)
Barometric pressure	LPS22HB (datasheet)
Temperature, humidity	HTS221 (datasheet)
Length	45 mm
Width	18 mm
Weight	5 gr (with headers)

TinyML Kit Tests – Part 2

→ Inertial Module - LSM9DS1
 → Digital MEMs Microphone - MP34DTOS-A
 → Camera Module - OV7675

IMU

• LSM9DS1

- System-in-package
- 3D digital linear acceleration sensor
- 3D digital angular rate sensor
- 3D digital magnetic sensor

Comm

- I2C serial bus interface (standard and fast mode)
- SPI serial standard interface



life.augmented

Features

- 3 acceleration channels, 3 angular rate
- channels, 3 magnetic field channels • ±2/±4/±8/±16 g linear acceleration full scale

LGA-24L (3.5x3x1.0 mm)

- ±2/±4/±8/±12/±16 gauss magnetic full scale
- ±245/±500/±2000 dps angular rate full scale
- 16-bit data output
- SPI / I²C serial interfaces
- Analog supply voltage 1.9 V to 3.6 V
- "Always-on" eco power mode down to 1.9 mA
 Programmable interrupt generators
- Embedded temperature sensor
- Embedded FIFO
- Position and motion detection functions
- Click/double-click recognition
- · Intelligent power saving for handheld devices
- ECOPACK[®], RoHS and "Green" compliant

LSM9DS1

iNEMO inertial module:

3D accelerometer, 3D gyroscope, 3D magnetometer

Datasheet - production data

- Applications
- Indoor navigation
- Smart user interfaces
- Advanced gesture recognition
- Gaming and virtual reality input devices
- Display/map orientation and browsing

Description

The LSM9DS1 is a system-in-package featuring a 3D digital linear acceleration sensor, a 3D digital angular rate sensor, and a 3D digital magnetic sensor.

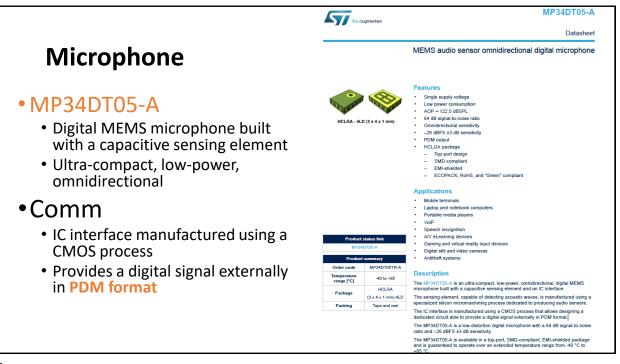
The LSM9DS1 has a linear acceleration full scale of $\pm 2g/\pm 4g/\pm 8/\pm 16$ g, a magnetic field full scale of $\pm 4/\pm 8/\pm 12/\pm 16$ gauss and an angular rate of $\pm 245/\pm 500/\pm 2000$ dps.

The LSM9DS1 includes an I²C serial bus interface supporting standard and fast mode (100 kHz and 400 kHz) and an SPI serial standard interface.

Magnetic, accelerometer and gyroscope sensing can be enabled or set in power-down mode separately for smart power management.

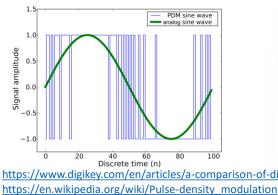
The LSM9DS1 is available in a plastic land grid array package (LGA) and it is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

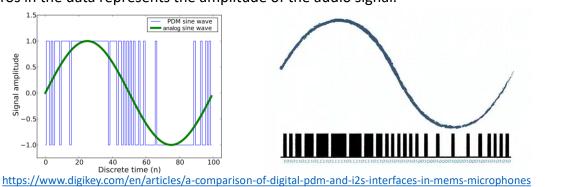
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Testin	g IMU		Welcome to the IMU test for the built-in IMU on the Nano 33 BLE Sense
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File Edit Sketch Tools Help New Ctrl+N Open Ctrl+O Open Recent > Sketchbook >		م ۲	g - display gyroscope readings in deg/s in x, y, and z directions m - display magnetometer readings in uT in x, y, and z directions
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********//	Adafruit SHT31 Library Adafruit SPIFlash	>	20.0
// Initialize IMU	Adafruit SSD1306	>	
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	SdFat - Adafruit Fork INCOMPATIBLE	<u></u>	
1	T	Arduine Nane 33 BLE on COM4	Repeat test for 'g' and 'm'

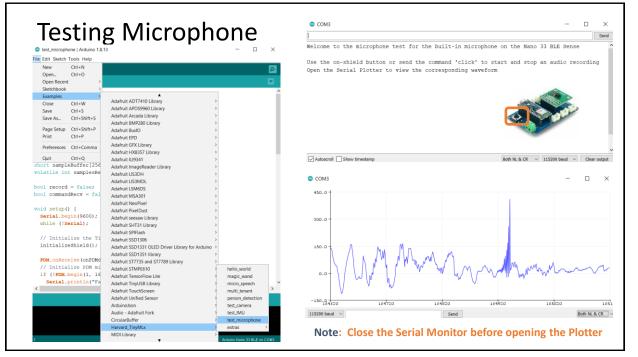


Pulse Density Modulation (PDM)

• A Pulse Density Modulation (PDM) microphone uses a Sigma-Delta modulator to oversample an acoustic signal at a high sampling rate. This digital PDM signal is output from the microphone as a 1-bit data word, where the density of ones and zeros in the data represents the amplitude of the audio signal.







OV7675 Camera Module

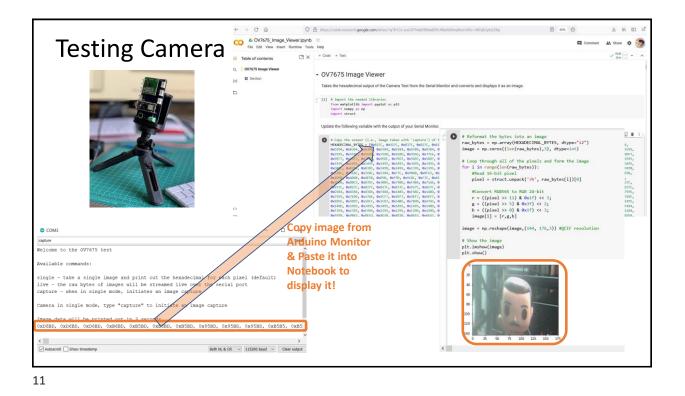
- 0.3 MP CMOS image sensor
- active array size: 640×480
- output formats: YUV422, Raw RGB, ITU656, RGB565
- input clock frequency: 1.5 ~ 27 MHz
- maximum image transfer rate: VGA 30fps, QVGA 60fps, QQVGA 240pfs
- pixel size: 2.5 μm x 2.5 μm
- image area: 1640 μm x 1220 μm



https://www.arducam.com/products/camera-breakout-board/0-3mp-ov7675/ https://github.com/ArduCAM/ArduCAM_USB_Camera_Shield https://github.com/ArduCAM/Arduino

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Credits

- A previous edition of this course was developed in collaboration with Dr. Susan C. Schneider of Marquette University.
- We are very grateful and thank all the following professors, researchers, and practitioners for jump-starting courses on TinyML and for sharing their teaching materials:
- Prof. Marcelo Rovai TinyML Machine Learning for Embedding Devices, UNIFEI
 - https://github.com/Mjrovai/UNIFEI-IESTI01-TinyML-2022.1
- Prof. Vijay Janapa Reddi CS249r: Tiny Machine Learning, Applied Machine Learning on Embedded IoT Devices, Harvard
 - https://sites.google.com/g.harvard.edu/tinyml/home
- Prof. Rahul Mangharam ESE3600: Tiny Machine Learning, Univ. of Pennsylvania
 - O <u>https://tinyml.seas.upenn.edu/#</u>
- Prof. Brian Plancher Harvard CS249r: Tiny Machine Learning (TinyML), Barnard College, Columbia University https://a2r-lab.org/courses/cs249r_tinyml/

F	References	
٠	Additional references from where information and other teaching materials were gathered include:	
•	Applications & Deploy textbook: "TinyML" by Pete Warden, Daniel Situnayake <u>https://www.oreilly.com/library/view/tinyml/9781492052036/</u> Deploy textbook "TinyML Cookbook" by Gian Marco Iodice <u>https://github.com/PacktPublishing/TinyML-Cookbook</u> 	
•	Jason Brownlee <u>https://machinelearningmastery.com/</u> TinyMLedu	
•	 <u>https://tinyml.seas.harvard.edu/</u> Professional Certificate in Tiny Machine Learning (TinyML) – edX/Harvard <u>https://www.edx.org/professional-certificate/harvardx-tiny-machine-learning</u> Introduction to Embedded Machine Learning, Courseare (Edge Learning) 	
•	Introduction to Embedded Machine Learning - Coursera/Edge Impulse <u>https://www.coursera.org/learn/introduction-to-embedded-machine-learning</u> Computer Vision with Embedded Machine Learning - Coursera/Edge Impulse <u>https://www.coursera.org/learn/computer-vision-with-embedded-machine-learning</u> 	13