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Refrigerants are crucial components in temperature regulation inside air conditioner units and refrigerators. Conventional refrigerants used in these appliances tend to have a high global warming potential (GWP), and current legislation worldwide is pushing to replace them with other types of refrigerants, such as A2L, which are low-toxicity and have low GWP (Global Warming Potential). However, A2L refrigerants are mildly flammable. Thus, modern appliances must include a sensor to continuously monitor refrigerant levels and prevent potential fire hazards. These sensor modules require an MCU to control operation and calculate the levels from the sensors. TI's MSPM0 MCUs are an excellent choice for integration into these applications, thanks to their low power consumption, high-performance features such as accurate ADCs and flexible communication modules, and competitive pricing.



Figure 1. Refrigerant Application Example

What do A2L sensor modules consist of?

There are three A2L sensors used in industry: the NDIR Sensor, the TC (Thermal Conductivity) Sensor, and the MOS Sensor (MOS does not meet the latest UL-60335-2-40 requirements due to its lower accuracy compared to the other sensors). However, the NDIR sensor is used in most applications thanks to its reliability and long lifetime. Therefore, we will focus our attention on the A2L sensor modules using this sensor. Other components used around the sensors are the following.

- **A2L Sensor:** Detects the level of A2L refrigerant in a system.
- **MCU:** Leverages integrated digital and analog modules to receive the readings from the A2L sensor, calculate the allowed levels of the refrigerant, control the sensor, communicate back to the main control board, and detect the degradation failure of the sensor.
- **Communication transceiver:** The sensor communicates with the main control board from the MCU. RS-485 is a popular choice for most A2L sensor modules.
- **AFE:** Helps to adjust the detection band to the target gas range. Depending on the cost, the user can choose a dedicated or discrete design.

More information on the sensor module design considerations can be found in [A2L Refrigerant Adoption: Considerations and Requirements](#).

A2L Sensor	MCU	AFE	Communication Transceiver
NDIR	MSPM0Cxxxx Arm Cortex M0+ 24/32MHz	Configurable AFE for (NDIR) Sensing Applications LMP9105x	5V RS-485 transceiver THVD1500
	MSPM0Lxxxx Arm Cortex M0+ 32MHz		
TC	MSPM0Hxxxx Arm Cortex M0+ 32MHz MCUs	Dual, ultra-high-precision zero-drift low-input-bias-current op amp TLV2387	
MOS	MSPM0Gxxxx Arm Cortex M0+ 80MHz		

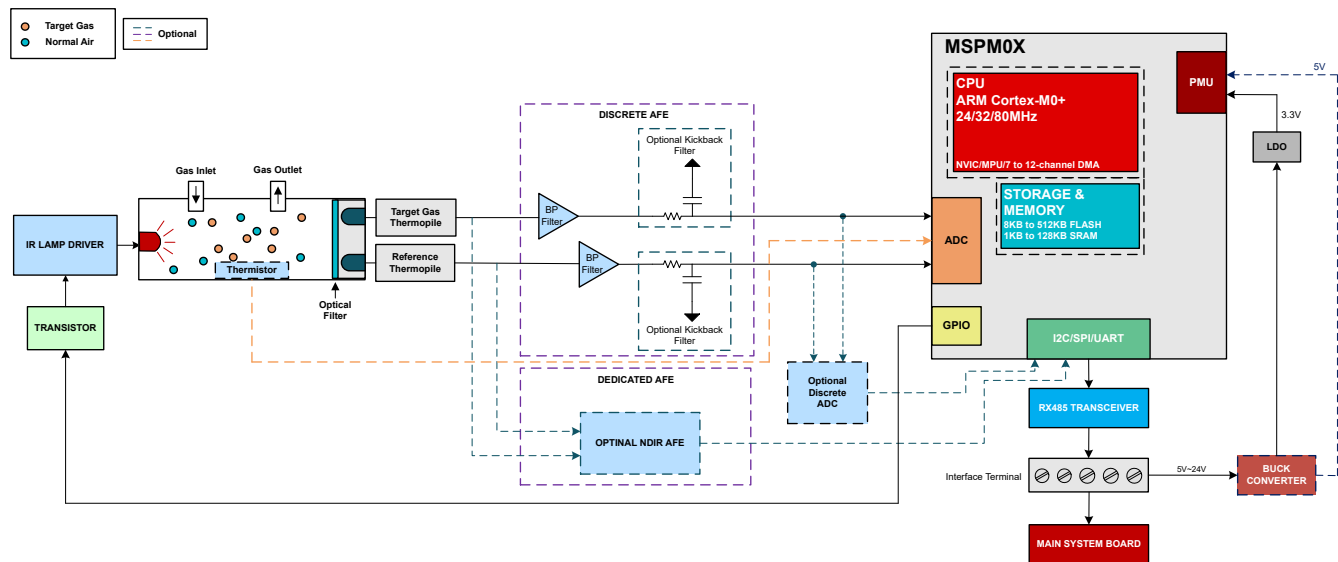


Figure 2. A2L Sensor Module High Level Block Diagram

Why select MSPM0 for A2L sensor module applications?

Texas Instruments' scalable MSPM0 MCU portfolio features an Arm® 32-bit Cortex-M0+ core with a maximum CPU speed of 24MHz, 32MHz, or 80MHz, depending on the device. The pin-to-pin compatible portfolio covers 4KB to 512KB of flash memory with scalable analog integration. With extensive digital, analog, and interface integration, MSPM0 offers a high-performance, robust option for A2L sensor modules.

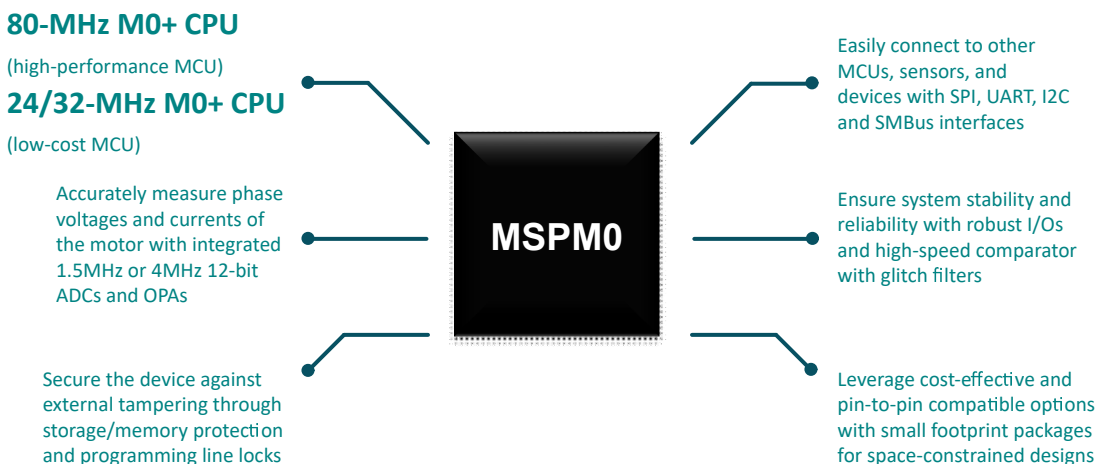


Figure 3. Advantages of the MSPM0 Platform

Key features the **MSPM0 MCUs** offer for these applications:

- 12-bit 1.5Msps to 4Msps analog-to-digital converter (ADC)
- Communication interfaces (UART, I2C, SPI)
- General-purpose inputs and outputs (GPIOs)
- Up to 512KB of flash storage and up to 128KB of RAM memory
- General-purpose and Advanced timers with complementary PWM outputs
- Advanced timer multiplier capable of doubling the frequency of the base device for the timer source (Up to 64MHz for 32MHz MSPM0s)

Software functions performed on the MCU:

- Control the GPIO outputs and inputs going into the sensor or the Main Control Board
- Capture Thermopile readings, and process them to calculate the levels of A2L refrigerants in the system
- Monitor the temperature of the thermistor of the sensor
- Detect the sensor degradation failure
- Communicate periodically with the Main Control Board through any of the communication ports

Which MSPM0 is right for an AL2 Sensor Module?

The MCU in the sensor module needs to take care of several tasks like controlling the IR Lamp of the A2L sensor through a GPIO (either directly, or with the help of a transistor), capture the readings from the sensor through its ADC channels or by communicating to an external ADC, process the readings and calculate the levels of A2L refrigerants, and send the calculations/report to the main control board. The MSPM0 MCUs can satisfy these basic requirements thanks to flexible communication, a vast number of IOs, and advanced analog modules. Moreover, all the MSPM0 devices offer security features, such as disabling the programming pins or protecting storage with passwords, to prevent external parties from tampering with the device. However, depending on the module's requirements, certain families fit better.

For applications for cost optimization

The best family of M0 devices for the implementation of low-cost A2L sensor modules is the MSPM0C family. This family of MCUs offers a low memory, low cost design with enough IOs and analog functionality for the sensor module to reliably operate. This family of devices offers 8KB to 64KB of FLASH storage, 1KB to 4KB of RAM, 18 to 45 I/Os, and a 12-bit ADC with a 1.5 to 1.6 Msps sampling rate.

For applications for power optimization

The best family of M0 devices for low-power A2L sensor module implementation is the MSPM0L family. This family of MCUs offers the lowest current/power consumption in the MSPM0 portfolio, with the lowest functional mode at 1 μ A and energy-efficient features (running most modules while in low power mode). This family of devices offers 32KB to 256KB of FLASH storage, 4KB to 32KB of RAM, 28 to 73 I/Os, and a 12-bit ADC with a 1.68 Msps sampling rate.

For applications for 5V systems

Most MSPM0 families require an LDO to convert the voltage source powering the MCU to the MCU's input voltage level of 3.3V or lower. However, the MSPM0H family is 5V tolerant, making it ideal for systems where size constraints or cost don't allow for an LDO, and where 5V is used in the module. This family of devices offers up to 64KB of FLASH storage, up to 8KB of RAM, up to 45 I/Os, and a 12-bit ADC with a 1.6 Msps sampling rate.

For applications for high performance

The best family of M0 devices for fast, high-performance A2L sensor modules implementation is the MSPM0G family. This family offers the highest oscillator frequency in the M0 family thanks to its internal Phase-locked loop, match accelerator hardware modules, and the largest storage and memory than MSPM0 MCUs can have. This family of devices offers 32KB to 512KB of FLASH storage, 16KB to 128KB of RAM, 60 to 94 I/Os, and a 12-bit ADC with a 4Msps sampling rate.

Resources

Order any of the MSPM0 LaunchPad™ development kits today. Jump-start a design with MSPM0 code examples and interactive online trainings. The following links show resources that are also available:

- [MSPM0-SDK](#)
- [MSPM0 overview page](#)
- [MSPM0 Academy](#)

MSPM0 LaunchPad Development Kits

- [LP-MSPM0C1104](#) LaunchPad development kit
- [LP-MSPM0C1106](#) LaunchPad development kit
- [LP-MSPM0L1306](#) Launchpad development kit
- [LP-MSPM0L1117](#) Launchpad development kit
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- [LP-MSPM0L2228](#) Launchpad development kit
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- [LP-MSPM0G3519](#) Launchpad development kit

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