FAE TECHNOLOGY

SENTIMATE

Multi sensor and multi wireless
Product Accelerator for IoT

Summary

1. INTRODUCTION

This data sheet provides the description of the SENTIMATE product accelerator for IoT.
SENIMATE is a complete electronics board and plastic housing system that includes short range wireless communication capabilities and multi sensor technology, powered by external DC supply or from a couple of AA non rechargeable batteries.

As product accelerator, SENTIMATE can be used from makers, developers, professional engineers and from all who want the benefit of an off the shelf industrialized system and doesn't have time and/or money to invest in a custom solution.

For details about Product Accelerators, please visit:
www.fae.technology
https://fae.technology/product-accelerator-program/

2. SENTIMATE IMAGES

3. DESCRIPTION AND BLOCK DIAGRAM

Based on TE AmbiMate sensor, Bluetooth 5, Zigbee, Thread and Z-Wave from Silicon Labs, its construction and market certifications, its embedded power path and battery or 5-40V input power makes SENTIMATE ideal for test and Proof of Concept in the field.

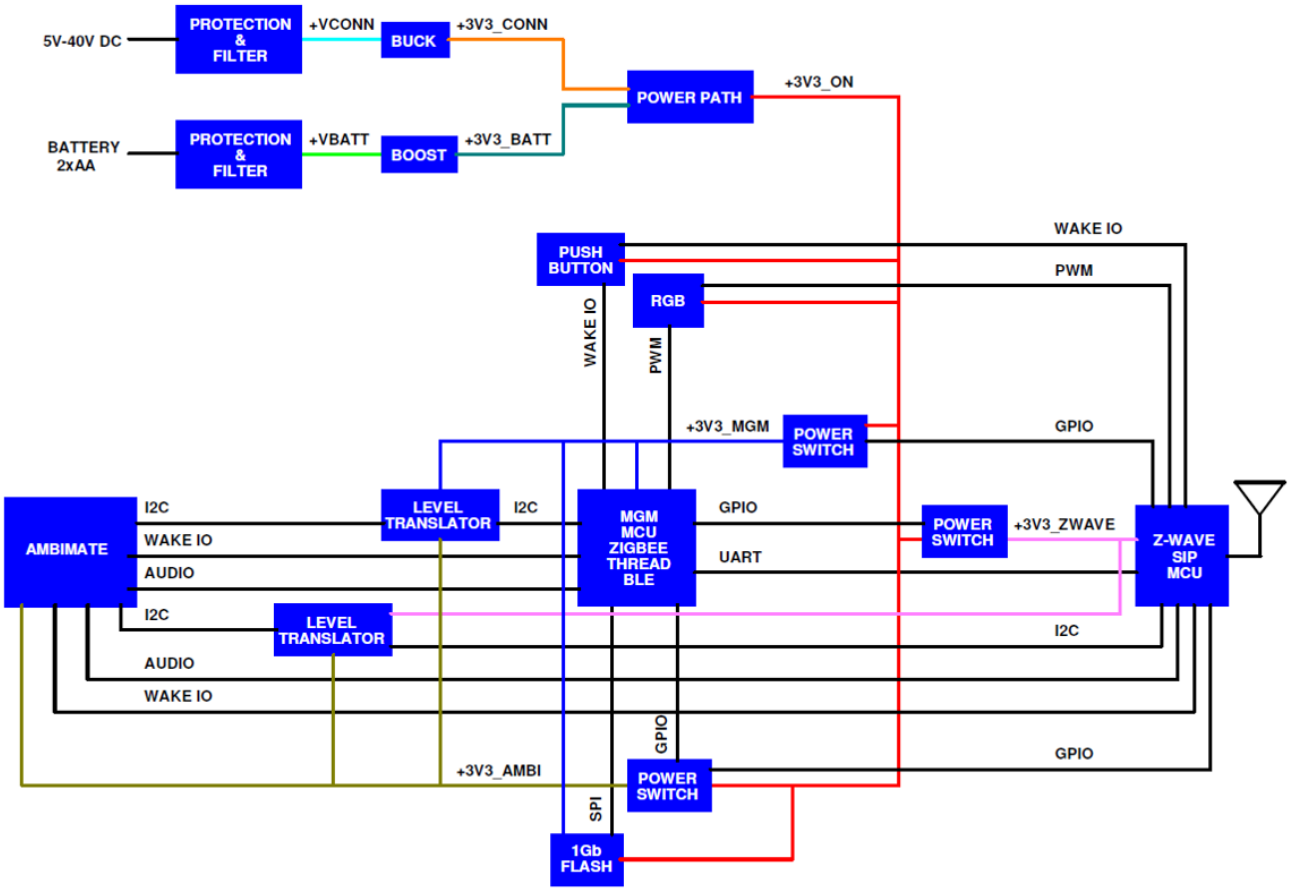
Ready to go
Electronics, plastics and accessories present in the kit and ready to use in the market for PoC.

Silicon Labs Simplicity Studio
Easy firmware development with the free of charge programming tool from Silicon Labs with examples and drivers specifics for SENTIMATE.

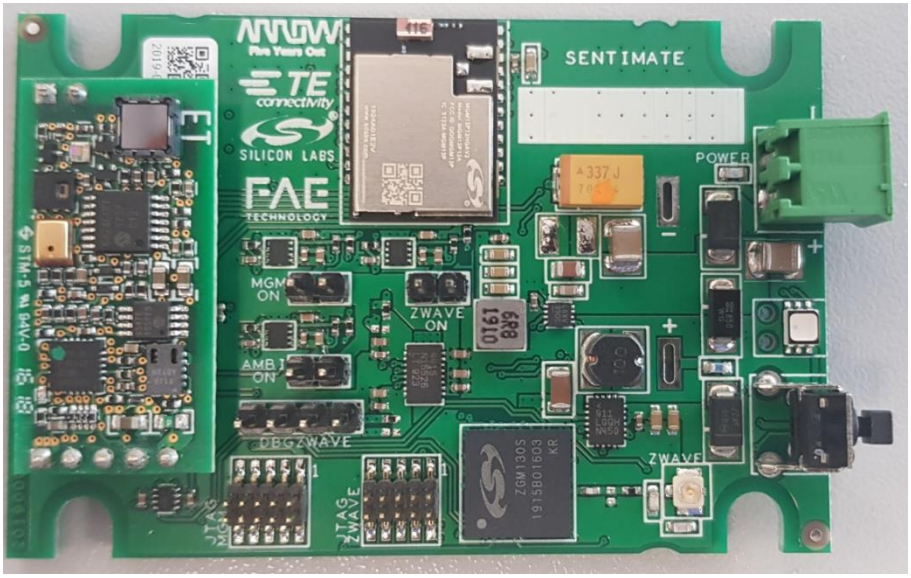
Smart home device oriented
SENTIMATE is the perfect product accelerator for the smart home applications in which environmental sensors and multi radio protocols are embedded to help any developer to develop applications with several standards.

Multisensor solution
AmbiMate sensor module from TE embeds temperature, humidity, VOC, eCO2, microphone and PIR motion for a complete environmental analysis.

Below is the block diagram of the SENTIMATE.

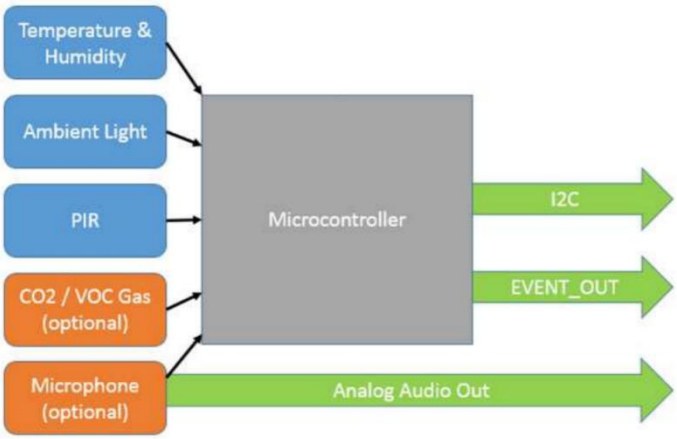


4. HARDWARE & COMPONENTS DETAIL



4.1. AmbiMate sensor module

TE Connectivity (TE)'s AmbiMate sensor module MS4 series provides an application specific set of sensors on a ready to attach PCB assembly for easy integration into a host product. Design resources are freed and time to market accelerated by integrating the MS4 series pre-engineered, four core sensor solution for Motion / Light / Temperature / Humidity into your next product. The MS4 series sensor modules embedded in the SENTIMATE includes VOC (Volatile Organic Compound), eCO2 (equivalent carbon dioxide) and sound detection. Add the capability to monitor air quality through the capture of VOC concentrations. The MS4 series with a microphone can be used to augment motion detection or to listen for sound events. All MS4 series sensor modules offer the flexibility of sharing a common seven position connection.



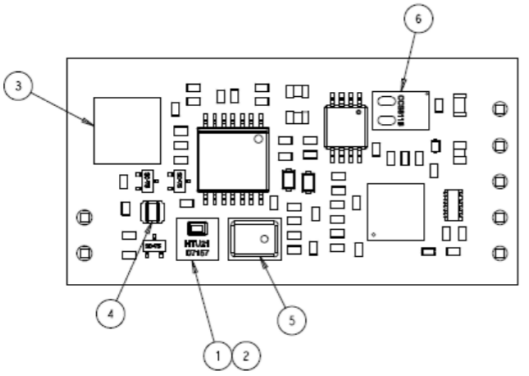


Figure 1. AmbiMate Layout

1: Temperature, 2: Humidity, 3: Motion, 4: Light, 5: Audio, 6: eCO_2/VOC

4.1.1. Temperature Sensor:

The temperature sensor is combined with the relative humidity sensor in the same package. The sensor's I 2C output is read by the AmbiMate's microcontroller. Note: Actual performance may vary due to customer enclosure design. Enclosure should allow for air circulation to ensure sensor is responding to temperature changes within the intended environment of use. Please refer to 108- 133092 for performance of product. 3.4.2

4.1.2. Relative Humidity Sensor:

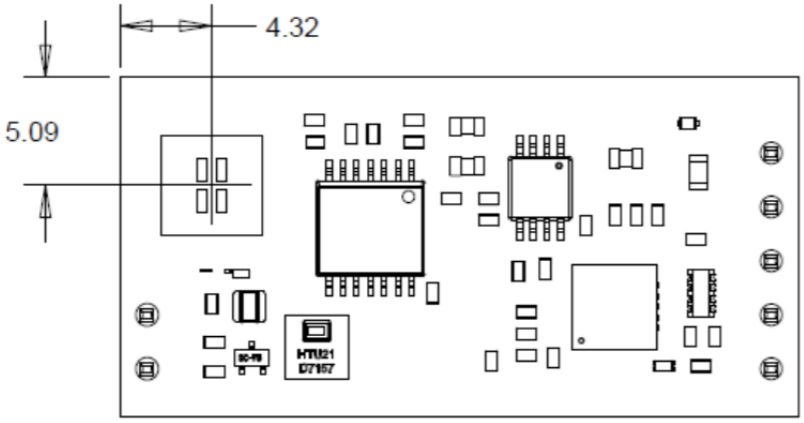
The relative humidity sensor is combined with the temperature sensor in the same package. The sensor's I 2C output is read by the AmbiMate's microcontroller. Note: Actual performance may vary due to customer enclosure design. Enclosure should allow for air circulation to ensure sensor is responding to humidity changes within the intended environment of use. Please refer to 108-133092 for performance of product. 3.4.3

4.1.3. Ambient Light Photo Sensor:

The photo sensor mimics the responsivity of the human eye. The analog output from the sensor is read by the AmbiMate's microcontroller's analog to digital converter. Note: Ambient light impinges directly on the sensor, no light pipe. If in the final application the photo sensor becomes shadowed, then a light pipe will be required to achieve optimum performance. The light pipe design is dependent upon the final application and use and is beyond the scope of this application specification. Please refer to 108-133092 for performance of product.

4.1.4. Passive Infrared Motion Sensor (PIR):

The PIR senses motion. The output from the sensor is read by the AmbiMate's microcontroller. During design-in and mounting the AmbiMate consideration should be given for placement of the device on a ceiling, wall or in a corner to maximize the PIR sensors effectiveness. A Fresnel lens is required, please contact TE customer support for information on the lens. During a motion event, the Event_Out pin will go high. Related to the PIR sensor is the motion event LED. When the AmbiMate senses motion the motion event LED will illuminate. For enhanced motion detection, please contact TE customer support



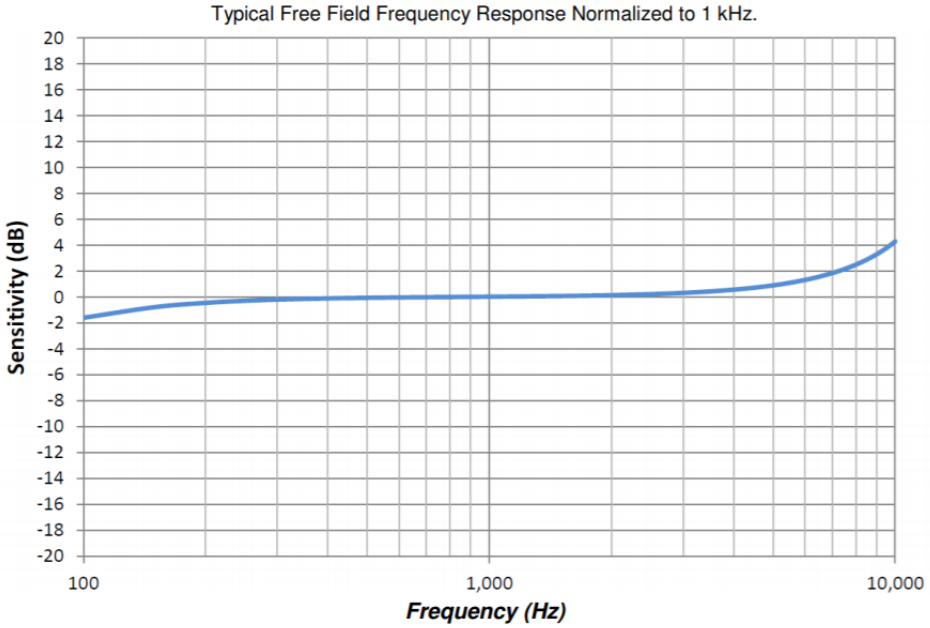
4.1.5. Acoustic Microphone with Pre-Amp

The microphone is omnidirectional with an analog output. The analog output from the microphone is read by the AmbiMate's microcontroller's analog to digital converter and is available to the host application via the 2-pin connector. The AmbiMate is configured to identify an audio event which can be set by writing to register 0xC1. At audio levels below 75 dB, quantization of the ADC will limit reported values to the following: 20, 58, 64, 67, 70, 73, 75. Above 75 dB, the AmbiMate will report in 1 dB increments. The preset sound level can be adjusted by the host. The analog output can be used to define a specific gain circuit. Please refer to the 108-133092 for detailed test data on the analog output. The characteristics of the microphone are summarized in the table below:

Conditions: 23 ±2°C, 55 ±20% R.H.

Parameter	Symbol	Specification		SPECIFICATION		
			Units	Min	Typ.	Max
Sensitivity[1]	S	94 dB SPL @ 1 kHz	dBV/Pa	-25	-22	-19
S/N ratio	SNR	94 dB SPL @ 1 kHz, A-weighted	dB(A)	-	59	-
Total Harmonic Distortion	THD	94dB SPL @ 1 kHz, S=Typ	%	-	-	1
Acoustic Overload Point	AOP	10% THD @ 1 kHz, S=Typ	dB SPL	115	-	-
Directivity[1]	Omnidirectional					

Note: Actual performance may vary due to customer enclosure design. Customer enclosure design should be optimized to avoid resonances. Please refer to 108-133092 for performance of product.



Microphone Sensitivity Vs Frequency Curve

4.1.6. Equivalent CO2 / VOC Gas Sensor

The gas sensor measures TVOC or equivalent-CO2 with a digital output via an I2C interface. The output from the sensor is read by the AmbiMate's microcontroller. The eCO2/VOC sensor is suitable to perform optimal in office conditions. Please be aware that any type of silicones, cause sensor poisoning and will reduce the sensitivity irrecoverably. The sensor will perform an automatic baseline correction every 24 hours. The characteristics of the sensor are summarized in the table below

Operating Conditions: 25°C

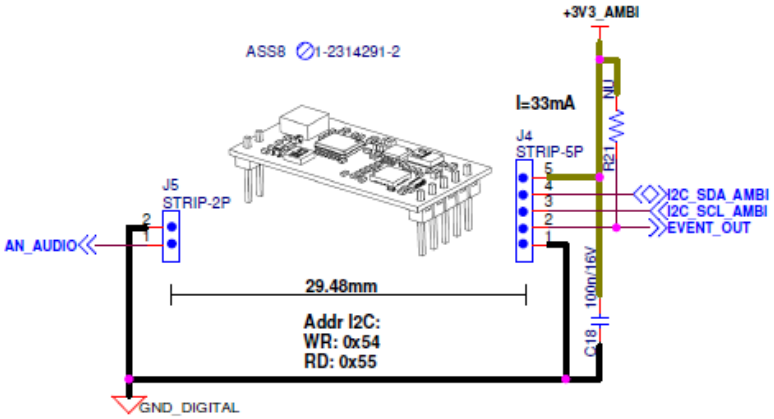
Parameter	Specification or Condition		SPECIFICATION		
		Units	Min	Typ.	Max
Operating Temperature Range	Operating temperature limits to remain within spec	°C	-5	-	50
Operating Humidity Range	Operating temperature limits to remain within spec	%RH	5	-	95
VOC measurement range	Measurement range for TVOC (Total Volatile Organic Compounds)	ppb	0	-	1187
CO2 measurement range (note 1)	Measurement range for eCO2 (Equivalent CO2)	ppm	400	-	8192
Sample Interval	Time between sample measurements	seconds	-	60	-

Notes:

- *eCO_2 concentration is inferred from VOC measurement.*
- *The equivalent CO_2 output range is from 400ppm to 8192ppm. Values outside this range can be ignored.*
- *The Total Volatile Organic Compound (TVOC) output range is from 0ppb to 1187ppb, Values outside this range can be ignored.*
- *Early life use (burn-in): The gas sensor performance and sensitivity will change during early life use. It is recommended to run the sensor for approximately 24 hours initially to ensure stable sensor performance. All values read in the first 24 hours must be ignored.*
- *For a sensor that is burned in, after a power down, the stabilization takes 20 minutes after power up.*

4.1.7. AmbiMate connection to MCUs

AmbiMate MS4 sensor module is connected to SENTIMATE MCUs (the two microcontrollers integrated in the Silicon Labs wireless modules) through I2C, analog and digital signals; here in after is reported the pinout of the AmbiMate module.



Below the table of the connections on the MGM13P 2.4GHz module and on ZGM130S Z-Wave module. Both the SoM have inside a Cortex-M4 microcontroller and can manage the sensor module itself independently from each other.

AmbiMate signal	MGM13P connection pin	ZGM130S connection pin	Description
I2C SDA	PC10	PC11	Data line of the I2C
I2C SCL	PC11	PC10	Clock line of the I2C
EVENT OUT	PA2	PB13	Event line output
AN_AUDIO	PF6	PB14	Audio analog output

See the related MGM and ZGM paragraph for more detail about the development.

See also the document "SENTIMATE board - Getting started and FW examples Rev5_ENG.pdf" for more details on AmbiMate registers and commands for reading and writing it.

4.2. MGM13P 2.4GHz wireless module

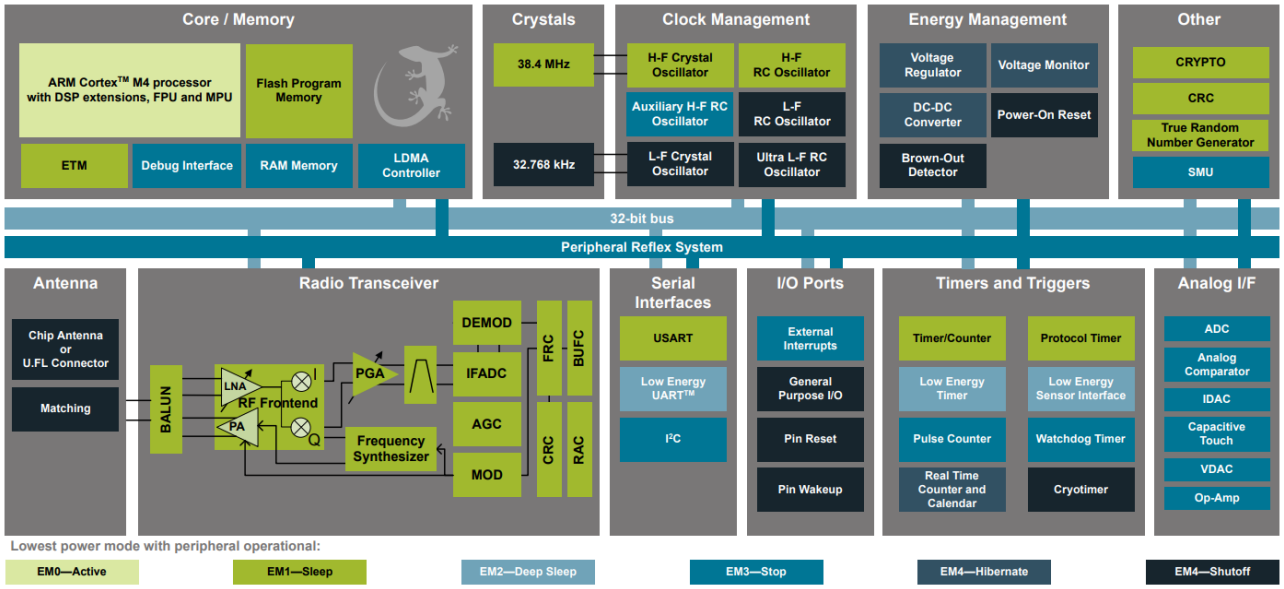
The MGM13P is Silicon Labs' first PCB module solution for 802.15.4 Mesh and multiprotocol networking that supports Bluetooth 5.0 LE, including long range, high throughput, and regular BLE PHYs.
Based on the Silicon Labs EFR32MG13 Mighty Gecko SoC, the MGM13P delivers robust RF performance, low energy consumption, a wide selection of MCU peripherals, regulatory test certificates for various regions and countries, and a simplified development experience, all in a small form factor. Together with the certified software stacks and powerful tools also offered by Silicon Labs, the MGM13P can minimize the engineering efforts and development costs associated with adding Zigbee, Thread, Bluetooth 5.0 LE, or multi-protocol connectivity to any product, accelerating its time-to-market.

The MGM13P is intended for a broad range of applications, including:

- IoT multi-protocol end-node devices and gateways
- Connected home
- Lighting
- Metering
- Building automation and security
- Health and wellness

Key features:

- Zigbee, Thread, BLE, or multi-protocol connectivity
- Antenna or U.FL variants
- Up to +19 dBm TX power
- -94.6 dBm BLE RX sensitivity at 1 Mbps
- -102.1 dBm 802.15.4 RX sensitivity
- 32-bit ARM® Cortex®-M4 core at 38.4 MHz
- 512/64 kB of flash/RAM memory
- Robust security features
- Wide selection of MCU peripherals
- Integrated DC-DC converter
- 25 GPIO pins
- 12.9 mm × 17.8 mm × 2.3 mm



Feature List

Supported Protocols

- Zigbee
- Thread
- Bluetooth 5.0 LE
- Multi-protocol

Wireless System-on-Chip.

- 2.4 GHz radio
- TX power up to +19 dBm
- High Performance 32-bit 38.4 MHz ARM Cortex®-M4 with DSP instruction and floating-point unit for efficient signal processing
- 512 kB flash program memory
- 64 kB RAM data memory
- Embedded Trace Macrocell (ETM) for advanced debugging
- Integrated DC-DC

High Receiver Performance

- -102.1 dBm sensitivity (1% PER) at 250 kbps DSSSOQPSK
- -102.8 dBm sensitivity (0.1% BER) at 125 kbit/s GFSK
- -98.4 dBm sensitivity (0.1% BER) at 500 kbit/s GFSK
- -94.6 dBm sensitivity (0.1% BER) at 1 Mbit/s GFSK
- -91 dBm sensitivity (0.1% BER) at 2 Mbit/s GFSK
- Low Energy Consumption
- 11 mA RX current at 250 kbps, DSSS-OQPSK
- 9.9 mA RX current at 1 Mbps, GFSK
- 8.5 mA TX current at 0 dBm output power
- 87 µA/MHz in Active Mode (EM0)
- 1.4 µA EM2 DeepSleep current (64 kB RAM retention and RTCC running from LFXO) • 1.3 µA EM2 DeepSleep current (16 kB RAM retention and RTCC running from LFRCO)
- Wake on Radio with signal strength detection, preamble pattern detection, frame detection and timeout

Support for Internet Security

- General Purpose CRC
- True Random Number Generator (TRNG)
- 2 × Hardware Cryptographic Acceleration for AES 128/256, SHA-1, SHA-2 (SHA-224 and SHA-256) and ECC

Wide Selection of MCU Peripherals

- 12-bit 1 Msps SAR Analog to Digital Converter (ADC)
- 2 × Analog Comparator (ACMP)
- 2 × Digital to Analog Converter (VDAC)
- 3 × Operational Amplifier (Opamp)
- Digital to Analog Current Converter (IDAC)
- Low-Energy Sensor Interface (LESENSE)
- Multi-channel Capacitive Sense Interface (CSEN)
- 25 pins connected to analog channels (APORT) shared between analog peripherals
- 25 General Purpose I/O pins with output state retention and asynchronous interrupts
- 8 Channel DMA Controller
- 12 Channel Peripheral Reflex System (PRS)
- 2 × 16-bit Timer/Counter
- 3 or 4 Compare/Capture/PWM channels

- 1 × 32-bit Timer/Counter
- 3 Compare/Capture/PWM channels
- 32-bit Real Time Counter and Calendar
- 16-bit Low Energy Timer for waveform generation
- 32-bit Ultra Low Energy Timer/Counter for periodic wake-up from any Energy Mode
- 16-bit Pulse Counter with asynchronous operation
- 2 × Watchdog Timer
- 3 × Universal Synchronous/Asynchronous Receiver/Transmitter (UART/SPI/SmartCard (ISO 7816)/IrDA/I2S)
- Low Energy UART (LEUART™)
- 2 × I2C interface with SMBus support and address recognition in EM3 Stop

For more information about this module see this link: https://www.silabs.com/documents/public/data-sheets/mgm13p-datasheet.pdf

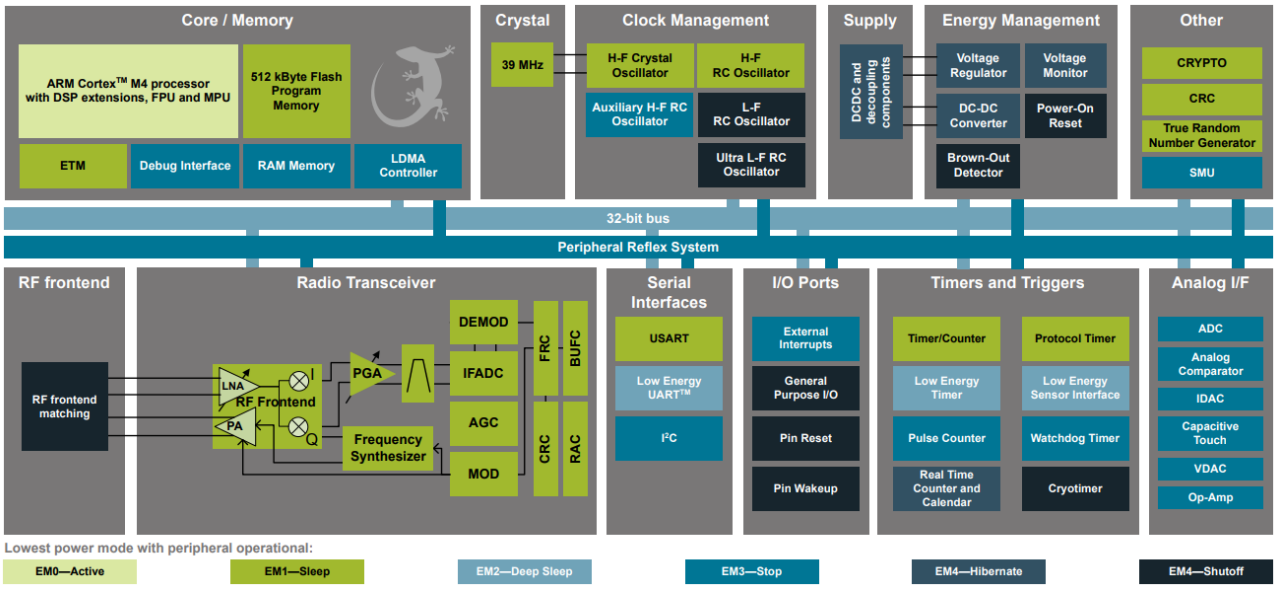
4.3. ZGM130S Z-Wave module

The Silicon Labs Z-Wave 700 SiP Module, ZGM130S, is a fully integrated Z-Wave module, enabling rapid development of Z-Wave solutions.
It is an ideal solution for energy-friendly smart home control applications such as motion sensors, door/window sensors, access control, appliance control, building automation, energy management, lighting, and security networks in the "Internet of Things".
Built with low-power Gecko technology, which includes innovative low energy techniques, fast wake-up times and energy saving modes, the ZGM130S reduces overall power consumption and maximizes battery life.
The module contains a native security stack and a comprehensive set of hardware peripherals usable for advanced device functionality, and offers 64 kB of flash memory for OEM applications.
Z-Wave 700 ZGM130S modules can be used in a wide variety of applications:

- Smart Home
- Security
- Lighting
- Health and Wellness
- Metering
- Building Automation

Key features:

- TX power up to 13 dBm
- RX sensitivity @ 100 kbps: -97.5 dBm
- Range: up to 100 meters
- 9.8 mA RX current at 100 kbps, GFSK, 868 MHz
- 13.3 mA TX current at 0 dBm output power at 908 MHz
- 0.8 µA EM4H current (128 Byte RAM retention and RTCC running from LFRCO)
- 32-bit ARM® Cortex®-M4 core at 39 MHz
- Flash memory: 512 kB (64 kB Application)
- RAM: 64 kB (8 kB Application)
- Autonomous Hardware Crypto Accelerator and Random Number Generator
- Integrated DC-DC Converter
- Robust peripheral set and up to 32 GPIO
- External SAW filter optional



Feature List

The ZGM130S highlighted features are listed below.

Low Power Wireless System-on-Chip.

- High Performance 32-bit, 39 MHz ARM Cortex ®-M4 with DSP instruction and floating-point unit for efficient signal processing
- Embedded Trace Macrocell (ETM) for advanced debugging
- 512 kB flash program memory (64 kB available for user applications)
- 64 kB RAM data memory (8kB available for user applications)
- TX power up to 13 dBm
- Supports optional external SAW filter

Low Energy Consumption

- 9.8 mA RX current at 100 kbps, GFSK, 868 MHz
- 40.7 mA TX current at 13 dBm output power at 868 MHz
- 13.3 mA TX current at 0 dBm output power at 908 MHz
- 69 µA/MHz in Active Mode (EM0)
- 0.8 µA EM4 current (128 Byte RAM retention and RTCC running from LFRCO)

High Receiver Performance

- -97.9 dBm sensitivity at 100 kbit/s GFSK, 868 MHz
- -97.5 dBm sensitivity at 100 kbit/s GFSK, 915 MHz

Supported Protocols

- Z-Wave

Support for Internet Security

- General Purpose CRC
- True Random Number Generator (TRNG)
- 2 × Hardware Cryptographic Acceleration for AES 128/256, SHA-1, SHA-2 (SHA-224 and SHA-256) and ECC

Wide selection of MCU peripherals

- 12-bit 1 Msps SAR Analog to Digital Converter (ADC)
- 2 × Analog Comparator (ACMP)
- 2 × Digital to Analog Converter (VDAC)
- 3 × Operational Amplifier (Opamp) • Digital to Analog Current Converter (IDAC)

- Low-Energy Sensor Interface (LESENSE)
- Multi-channel Capacitive Sense Interface (CSEN)
- 32 pins connected to analog channels (APORT) shared between analog peripherals
- 32 General Purpose I/O pins with output state retention and asynchronous interrupts
- 8 Channel DMA Controller
- 12 Channel Peripheral Reflex System (PRS)
- 2 × 16-bit Timer/Counter
- 3 or 4 Compare/Capture/PWM channels
- 1 × 32-bit Timer/Counter
- 3 Compare/Capture/PWM channels
- 32-bit Real Time Counter and Calendar
- 16-bit Low Energy Timer for waveform generation
- 32-bit Ultra Low Energy Timer/Counter for periodic wake-up from any Energy Mode
- 16-bit Pulse Counter with asynchronous operation
- 2 × Watchdog Timer
- 3 × Universal Synchronous/Asynchronous Receiver/Transmitter (UART/SPI/SmartCard (ISO 7816)/IrDA/I2S)
- Low Energy UART (LEUART ™)
- 2 × I2C interface with SMBus support and address recognition in EM3 Stop

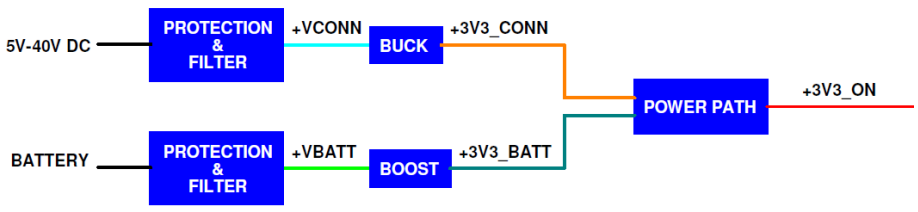
Wide Operating Range

- 1.8 V to 3.8 V single power supply
- Integrated DC-DC

For more information about this module see this link: https://www.silabs.com/documents/public/data-sheets/zgm130s-datasheet.pdf

4.4. Power supply

SENTIMATE integrate a very efficient power supply system based on Analog Devices' Power by Linear power management ICs.
The power stage has to be ultra low power and high efficiency when the system is powered from battery and wide range and high efficiency when powered from an external DC voltage source. In both the options of power input the system has to work selecting the proper stabilized voltage that is generated from one input or the other. Obviously in case of external power supply and battery present the system has to be powered from the external DC source in order to prevent the discharge of the battery that becomes active through the power path only when the external source is missing. Below the block diagram of the input power stage of the SENTIMATE in which the two path are shown, each one get its voltage input and generates 3,3V and a power path select which one has to be the general 3,3V of the entire board.



4.4.1. Battery input path

For high efficiency and ultra low power has been selected the ADI LTC3106 that is a buck-boost switching regulator, with the following features.

- Dual Input Buck-Boost with Integrated PowerPath™ Manager
- Ultralow Start-Up Voltages: 850mV Start with No Backup Source, 300mV with a Backup Source

- Compatible with Primary or Rechargeable Backup Batteries
- Digitally Selectable VOUT and VSTORE
- Maximum Power Point Control
- Ultralow Quiescent Current: 1.6µA
- Regulated Output with VIN or VSTORE Above, Below or Equal to the Output
- Optional Backup Battery Trickle Charger
- Shelf Mode Disconnect Function to Preserve Battery Shelf Life
- Burst Mode® Operation
- Accurate RUN Pin Threshold
- Power Good Output Voltage Indicator
- Selectable Peak Current Limit: 90mA/650mA
- Available in Thermally Enhanced 3mm × 4mm 16-Pin QFN and 20-Pin TSSOP Packages

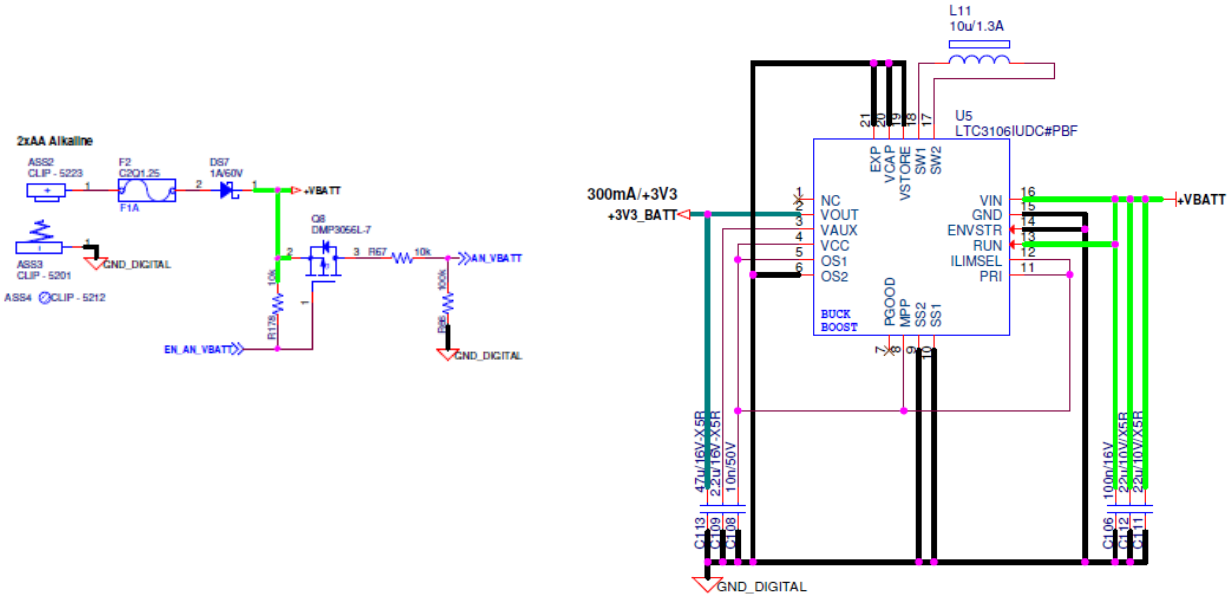
The LTC3106 is a highly integrated, ultralow voltage buck-boost DC/DC converter with automatic PowerPath management optimized for multisource, low power systems. At no load, the LTC3106 draws only 1.6µA .
Zero power Shelf Mode ensures that the backup battery will remain charged if left connected to the LTC3106 for an extended time.
Additional features include an accurate turn-on voltage, a power good indicator for VOUT, a user selectable 100mA peak current limit setting for lower power applications, thermal shutdown as well as user selectable backup power and output voltages.

Implementation of the LT3106 on SENTIMATE board

SENTIMATE board implement the boost configuration of the LTC3106 with only one input source that comes from battery.

With two alkaline batteries the input voltage is around 3V and the boost stage will elevate at a 3,3V the voltage at its output maintaining stable in all the batteries input variation range (from 1,8V to 3V) delivering up to 300mA to the circuits of the SENTIMATE board.

See below the schematics of this input power stage of the SENTIMATE.



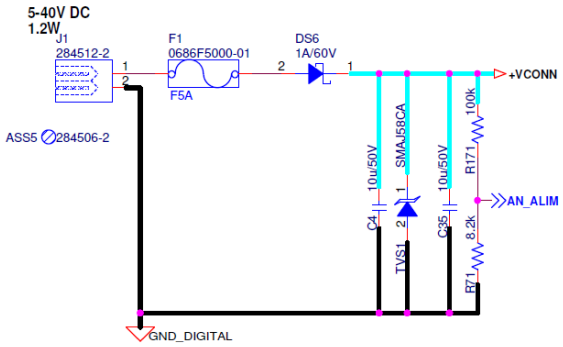
4.4.2. External DC input path

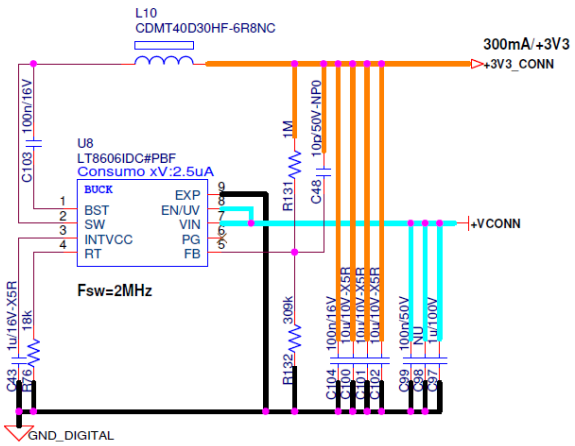
When power source comes from external DC supply the acceptable voltage range can accommodate the most used typical DC values like 5V, 12V and 24V; the input can be from 5 to 40Vdc.
In this extended voltage input with fixed 3,3V output one of the most important thing is the efficiency and then a switching buck configuration has been designed.
For this power section SENTIMATE integrate the ADI LT8606 that is a 42V, 350mA Synchronous Step-Down Regulator with 2.5µA Quiescent Current, with the following features.

- Wide Input Voltage Range: 3.0V to 42V
- Ultralow Quiescent Current Burst Mode® Operation:
  - <3µA IQ Regulating 12VIN to 3.3VOUT
  - Output Ripple <10mVP-P
- High Efficiency 2MHz Synchronous Operation:
  - >92% Efficiency at 0.35A, 12VIN to 5VOUT
- 350mA Maximum Continuous Output
- Fast Minimum Switch-On Time: 35ns
- Adjustable and Synchronizable: 200kHz to 2.2MHz
- Spread Spectrum Frequency Modulation for Low EMI
- Allows Use of Small Inductors
- Low Dropout
- Peak Current Mode Operation
- Accurate 1V Enable Pin Threshold
- Internal Compensation
- Output Soft-Start and Tracking
- Small Thermally Enhanced 10-Lead MSOP Package or 8-Pin 2mm × 2mm DFN Package

Implementation of the LT3106 on SENTIMATE board

The input connector accept voltage from 5V to 40V DC, here in after the circuit implemented in SENTIMATE board.

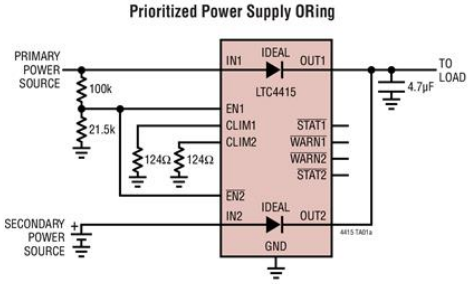




4.4.1. Power Path

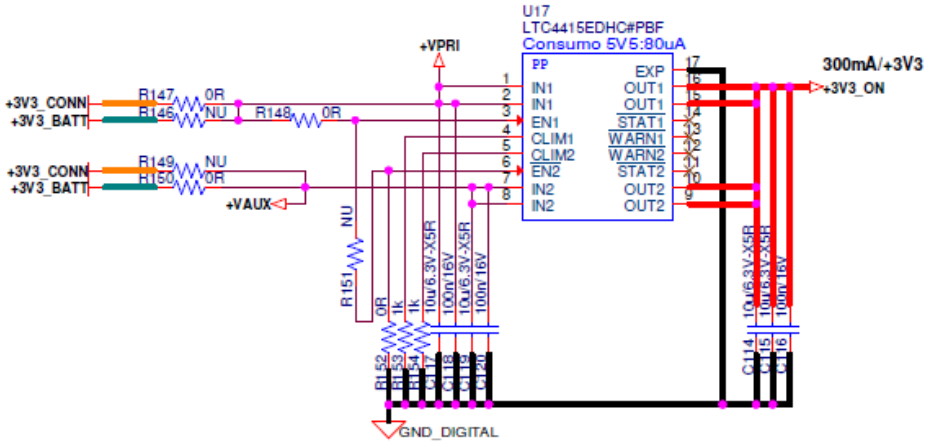
The two power stages described above produce both a 3,3V stabilized voltage and then only one of them are selected as main voltage source for the entire SENTIMATE board. This selection process is done by the LTC4415 dual 4A ideal diode from ADI.
The LTC4415 contains two monolithic PowerPath ideal diodes, each capable of supplying up to 4A with typical forward conduction resistance of 50mΩ. The diode voltage drops are regulated to 15mV during forward conduction at low currents, extending the power supply operating range and ensuring no oscillations during supply switchover. Less than 1µA of reverse current flows from OUT to IN making this device well suited for power supply ORing applications.

The two ideal diodes are independently enabled and prioritized using inputs EN1 and EN2. The output current limits can be adjusted independently from 0.5A to 4A using resistors on the CLIM pins. Furthermore, the ideal diode currents can be monitored via CLIM pin voltages.
Open-drain status pins indicate when the ideal diodes are forward conducting. When the die temperature approaches thermal shutdown, or if the output load exceeds the current limit threshold, the corresponding warning pins are pulled low.



Implementation of the LT3106 on SENTIMATE board

NU means Not Used and then the component is not present in the board. In



5. SENTIMATE CONNECTOR, LED AND PUSH BUTTON

CONNECTOR: Mounted on SENTIMATE TE P/N 284512-2

The external cable needs to be equipped with the matching connector and terminals as follow indicated:

- 3.00mm Female Dual Row Receptacle WR-MPC3 24 pins P/N 662024113322
- 3.00mm Female Crimp Terminal 20 to 24 AWG WR-MPC3 P/N 66200113722

Second source option from Molex:

- Micro-Fit 3.0 43025 Series Molex Connector Free Hanging - Pitch 3,0mm - 24 positions P/N 43025-2400.
- Crimp Contact P/N 43030-0038.

MANUAL CRIMPING TOOL FOR EXTERNAL CABLE THAT IS CONNECTED TO THE MAIN CONNECTOR

- http://katalog.we-online.de/en/em/MPC3_MANUAL_CRIMPING_TOOL
- https://www.mouser.it/datasheet/2/445/600619228180-537825.pdf
- https://www.mouser.it/ProductDetail/Wurth-Electronics/600619228180?qs=sGAEpiMZZMu-HCD5%2fnvq3Pm%2f4OyTZU0m%2fZJWzpKwypWDOt%252bCcrRLefg%3d%3d

6. RF ELECTRICAL SPECIFICATIONS

All these data come from the Silicon Labs MGM13P and ZGM130S data sheets because the RF functions are integrated in these modules, for more info visit www.silabs.com.

RF Transmitter General Characteristics for 2.4 GHz Band

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Maximum TX power[1]	$POUT_{MAX}$	19 dBm-rated part numbers.	—	19	—	dBm
		10 dBm-rated part numbers	—	10	—	dBm
Minimum active TX Power	$POUT_{MIN}$	CW		-27	—	dBm
Output power step size	$POUT_{STEP}$	-5 dBm< Output power < 0 dBm	—	0.5	—	dB
		0 dBm < output power < $POUT_{MAX}$	—	0.5	—	dB
Output power variation vs supply at $POUT_{MAX}$	$POUT_{VAR\_V}$	1.8 V < V_{VDD} < 3.3 V, DCDC in bypass, MGM13P12	—	4.74	—	dB
		2.4 V < V_{VDD} < 3.3 V, MGM13P02	—	0	—	dB
		2.4 V < V_{VDD} < 3.3 V using DC-DC converter, MGM13P12	—	1.9	—	dB
Output power variation vs temperature at $POUT_{MAX}$	$POUT_{VAR\_T}$	From -40 to +85 °C, MGM13P02	—	2.05	—	dB
		From -40 to +85 °C, MGM13P12	—	1.8	—	dB
Output power variation vs RF frequency at $POUT_{MAX}$	$POUT_{VAR\_F}$	Over RF tuning frequency range	—	0.11	—	dB
RF tuning frequency range	F_{RANGE}		2400	—	2483.5	MHz

RF Receiver General Characteristics for 2.4 GHz Band

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
RF tuning frequency range	F_{RANGE}		2400	—	2483.5	MHz
Receive mode maximum spurious emission	$SPUR_{RX}$	30 MHz to 1 GHz	—	-57	—	dBm
		1 GHz to 12 GHz	—	-47	—	dBm
Max spurious emissions during active receive mode, per FCC Part 15.109(a)	$SPUR_{RX\_FCC}$	216 MHz to 960 MHz, Conducted Measurement	—	-55.2	—	dBm
		Above 960 MHz, Conducted Measurement	—	-47.2	—	dBm

Sub-GHz RF Transmitter characteristics for 915 MHz Band

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
RF tuning frequency range	F_{RANGE}		902	—	930	MHz
Maximum TX Power[1]	$POUT_{MAX}$	4 dBm output power setting	—	4	—	dBm
Minimum active TX Power	$POUT_{MIN}$		—	-30	—	dBm
Output power step size	$POUT_{STEP}$	output power > 0 dBm	—	0.5	—	dB
Output power variation vs supply at $POUT_{MAX}$	$POUT_{VAR\_V}$	1.8 V < $V_{VREGVDD}$ < 3.3 V, T = 25 °C	—	2.72	—	dB
Output power variation vs temperature, peak to peak	$POUT_{VAR\_T}$	-40 to +85 °C	—	1.79	—	dB
Output power variation vs RF frequency	$POUT_{VAR\_F}$	T = 25 °C, Over specified RF tuning frequency range	—	1.11	—	dB
Spurious emissions of harmonics at 3 dBm output power, Conducted measurement, 3dBm match, Test Frequency = 908.4 MHz	$SPUR_{HARM\_FCC\_14}$	In restricted bands, per FCC Part 15.205 / 15.209	—	-49	-42	dBm
		In non-restricted bands, per FCC Part 15.231	—	-53	-20	dBc
Spurious emissions out-of-band at 3 dBm output power, Conducted measurement, 3dBm match, Test Frequency = 908.4 MHz	$SPUR_{OOB\_FCC\_14}$	In non-restricted bands, per FCC Part 15.231	—	-70	-20	dBc
		In restricted bands (30-88 MHz), per FCC Part 15.205 / 15.209	—	-58	-46	dBm
		In restricted bands (88-216 MHz), per FCC Part 15.205 / 15.209	—	-70	-56	dBm
		In restricted bands (216-960 MHz), per FCC Part 15.205 / 15.209	—	-70	-52	dBm
		In restricted bands (>960 MHz), per FCC Part 15.205 / 15.209	—	-66	-42	dBm
Power spectral density limit	PSD	PSD per FCC Part 15.247, 9.6Kbps	—	-0.7	—	dBm/ 3kHz
		PSD per FCC Part 15.247, 40Kbps	—	2.3	—	dBm/ 3kHz
		PSD per FCC Part 15.247, 100Kbps	—	-4.1	—	dBm/ 3kHz

Sub-GHz RF Receiver Characteristics for 915 MHz Band

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Tuning frequency range	F_{RANGE}		902	—	930	MHz
Max usable input level, 1% FER	SAT_{100K}	Desired is reference 100 kbps GFSK signal[1]	—	10	—	dBm
Sensitivity[2 3]	SENS	Desired is reference 100 kbps GFSK signal[1], 1% FER, frequency = 916 MHz, T ≤ 85 °C	—	-97.5	—	dBm
		Desired is reference 40 kbps 2FSK signal[4], 1% FER, frequency = 908.4 MHz, T ≤ 85 °C	—	-101.3	—	dBm
		Desired is reference 9.6 kbps 2FSK signal[5], 1% FER, frequency = 908.42 MHz, T ≤ 85 °C	—	-102.5	—	dBm
Level above which RFSENSE will trigger[6]	$RFSENSE_{TRIG}$	CW at 915 MHz	—	-28.1	—	dBm
Level below which RFSENSE will not trigger[6]	$RFSENSE_{THRES}$	CW at 915 MHz	—	-50	—	dBm
Image rejection, Interferer is CW at image frequency	C/I_{IMAGE}	Desired is 100 kbps GFSK signal[1] at 3dB above sensitivity level, 1% FER, frequency = 916 MHz	—	34.7	—	dB
		Desired is reference 40 kbps 2FSK signal[4] at 3dB above sensitivity level, 1% FER, frequency = 908.4 MHz	—	36.2	—	dB
		Desired is reference 9.6 kbps 2FSK signal[5] at 3dB above sensitivity level, 1% FER, frequency = 908.42 MHz	—	36.1	—	dB
Blocking selectivity, 1% FER. Desired is 100 kbps GFSK signal[1] at 3dB above sensitivity level, frequency = 916 MHz	$C/I_{BLOCKER\_100}$	Interferer CW at Desired ± 1 MHz	—	48.7	—	dB
		Interferer CW at Desired ± 2 MHz	—	54.8	—	dB
		Interferer CW at Desired ± 5 MHz	—	64.1	—	dB
		Interferer CW at Desired ± 10 MHz[7]	—	67.7	—	dB
		Interferer CW at Desired ± 100 MHz[7]	—	78.8	—	dB

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Blocking selectivity, 1% FER. Desired is 40 kbps 2FSK signal[4] at 3dB above sensitivity level, frequency = 908.4 MHz	$C/I_{BLOCKER\_40}$	Interferer CW at Desired ± 1 MHz	—	53.0	—	dB
		Interferer CW at Desired ± 2 MHz	—	58.9	—	dB
		Interferer CW at Desired ± 5 MHz	—	71.4	—	dB
		Interferer CW at Desired ± 10 MHz[7]	—	79.2	—	dB
		Interferer CW at Desired ± 100 MHz[7]	—	82.8	—	dB
Blocking selectivity, 1% FER. Desired is 9.6 kbps 2FSK signal[5] at 3dB above sensitivity level, frequency = 908.42 MHz	$C/I_{BLOCKER\_9p6}$	Interferer CW at Desired ± 1 MHz	—	54.2	—	dB
		Interferer CW at Desired ± 2 MHz	—	62.9	—	dB
		Interferer CW at Desired ± 5 MHz	—	72.4	—	dB
		Interferer CW at Desired ± 10 MHz[7]	—	80.4	—	dB
		Interferer CW at Desired ± 100 MHz[7]	—	84.0	—	dB
Intermod selectivity, 1% FER. CW interferers at 400 kHz and 800 kHz offsets	C/I_{IM}	Desired is 100 kbps GFSK signal[1] at 3dB above sensitivity level, frequency = 916 MHz	—	31.6	—	dB
Upper limit of input power range over which RSSI resolution is maintained	$RSSI_{MAX}$		—	—	5	dBm
Lower limit of input power range over which RSSI resolution is maintained	$RSSI_{MIN}$		-98	—	—	dBm
RSSI resolution	$RSSI_{RES}$	Over $RSSI_{MIN}$ to $RSSI_{MAX}$ range	—	0.25	—	dBm
Max spurious emissions during active receive mode, per FCC Part 15.109(a)	$SPUR_{RX\_FCC}$	216-960 MHz	—	-82.25	-49.2	dBm
		Above 960 MHz	—	-68.41	-41.2	dBm
Max spurious emissions during active receive mode,per ARIB STD-T108 Section 3.3	$SPUR_{RX\_ARIB}$	Below 710 MHz, RBW=100kHz	—	-69.17	-54	dBm
		710-900 MHz, RBW=1MHz	—	-71.76	-55	dBm
		900-915 MHz, RBW=100kHz	—	-72.55	-55	dBm
		915-930 MHz, RBW=100kHz	—	-73.07	-55	dBm
		930-1000 MHz, RBW=100kHz	—	-72.84	-54	dBm
		Above 1000 MHz, RBW=1MHz	—	-71.49	-47	dBm

Sub-GHz RF Transmitter characteristics for 868 MHz Band

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
RF tuning frequency range	F_{RANGE}		863	—	876	MHz
Maximum TX Power[1]	$POUT_{MAX}$	13 dBm output power setting	—	13	—	dBm
Minimum active TX Power	$POUT_{MIN}$		—	-30	—	dBm
Output power step size	$POUT_{STEP}$	output power > 0 dBm	—	0.5	—	dB
Output power variation vs supply at $POUT_{MAX}$	$POUT_{VAR\_V}$	1.8 V < $V_{VREGVDD}$ < 3.3 V, T = 25 °C	—	2.6	—	dB
Output power variation vs temperature, peak to peak	$POUT_{VAR\_T}$	-40 to +85 °C	—	1.4	—	dB
Output power variation vs RF frequency	$POUT_{VAR\_F}$	T = 25 °C, Over specified RF tuning frequency range	—	0.5	—	dB
Spurious emissions of harmonics, Conducted measurement, Test Frequency = 868.4 MHz	$SPUR_{HARM\_ETSI}$	Per ETSI EN 300-220, Section 7.8.2.1	—	-39	-30	dBm
Spurious emissions out-of-band, Conducted measurement, Test Frequency = 868.4 MHz	$SPUR_{OOB\_ETSI}$	Per ETSI EN 300-220, Section 7.8.2.1 (47-74 MHz, 87.5-118 MHz, 174-230 MHz, and 470-862 MHz)	—	-69	-54	dBm
		Per ETSI EN 300-220, Section 7.8.2.1 (other frequencies below 1 GHz)	—	-70	-36	dBm
		Per ETSI EN 300-220, Section 7.8.2.1 (frequencies above 1 GHz)	—	-66	-30	dBm

Sub-GHz RF Receiver Characteristics for 868 MHz Band

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Tuning frequency range	F_{RANGE}		863	—	876	MHz
Max usable input level, 1% FER	SAT_{100k}	Desired is reference 100 kbps GFSK signal[1]	—	10	—	dBm
Sensitivity[2] [3]	SENS	Desired is reference 100 kbps GFSK signal[1], 1% FER, frequency = 869.85 MHz, T ≤ 85 °C	—	-97.9	—	dBm
		Desired is reference 40 kbps 2FSK signal[4], 1% FER, frequency = 868.4 MHz, T ≤ 85 °C	—	-101.5	—	dBm
		Desired is reference 9.6 kbps 2FSK signal[5], 1% FER, frequency = 868.42 MHz, T ≤ 85 °C	—	-102.6	—	dBm
Level above which RFSENSE will trigger[6]	$RFSENSE_{TRIG}$	CW at 868 MHz	—	-28.1	—	dBm
Level below which RFSENSE will not trigger[6]	$RFSENSE_{THRES}$	CW at 868 MHz	—	-50	—	dBm
Image rejection, Interferer is CW at image frequency	C/I_{IMAGE}	Desired is 100kbps GFSK signal[1] at 3dB above sensitivity level, 1% FER, frequency = 869.85 MHz	—	33.4	—	dB
		Desired is reference 40 kbps 2FSK signal[4] at 3dB above sensitivity level, 1% FER, frequency = 868.4 MHz	—	34.5	—	dB
		Desired is reference 9.6 kbps 2FSK signal[5] at 3dB above sensitivity level, 1% FER, frequency = 868.42 MHz	—	35.3	—	dB
Blocking selectivity, 1% FER. Desired is 100 kbps GFSK signal[1] at 3 dB above sensitivity level, frequency = 869.85 MHz	$C/I_{BLOCKER\_100}$	Interferer CW at Desired ± 1 MHz	—	49.6	—	dB
		Interferer CW at Desired ± 2 MHz	—	55.6	—	dB
		Interferer CW at Desired ± 5 MHz	—	68.1	—	dB
		Interferer CW at Desired ± 10 MHz[7]	—	75.1	—	dB
		Interferer CW at Desired ± 100 MHz[7]	—	77.4	—	dB

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Blocking selectivity, 1% FER. Desired is 40 kbps 2FSK signal[4] at 3 dB above sensitivity level, frequency = 868.4 MHz	$C/I_{BLOCKER\_40}$	Interferer CW at Desired ± 1 MHz	—	53.4	—	dB
		Interferer CW at Desired ± 2 MHz	—	59.8	—	dB
		Interferer CW at Desired ± 5 MHz	—	71.9	—	dB
		Interferer CW at Desired ± 10 MHz[7]	—	79.5	—	dB
		Interferer CW at Desired ± 100 MHz[7]	—	81.1	—	dB
Blocking selectivity, 1% FER. Desired is 9.6 kbps 2FSK signal[5] at 3 dB above sensitivity level, frequency = 868.42 MHz	$C/I_{BLOCKER\_9p6}$	Interferer CW at Desired ± 1 MHz	—	54.8	—	dB
		Interferer CW at Desired ± 2 MHz	—	60.7	—	dB
		Interferer CW at Desired ± 5 MHz	—	72.8	—	dB
		Interferer CW at Desired ± 10 MHz[7]	—	80.3	—	dB
		Interferer CW at Desired ± 100 MHz[7]	—	82.1	—	dB
Upper limit of input power range over which RSSI resolution is maintained	$RSSI_{MAX}$		—	—	5	dBm
Lower limit of input power range over which RSSI resolution is maintained	$RSSI_{MIN}$		-98	—	—	dBm
RSSI resolution	$RSSI_{RES}$	Over $RSSI_{MIN}$ to $RSSI_{MAX}$ range	—	0.25	—	dBm
Max spurious emissions during active receive mode	$SPUR_{RX}$	30 MHz to 1 GHz	—	-67.46	-57	dBm
		1 GHz to 12 GHz	—	-69.7	-47	dBm

Note:

1. Definition of reference signal is 100 kbps 2GFSK, BT=0.6, Δf = 58 kHz, NRZ, '0' = F_center + Δf/2, '1' = F_center - Δf/2
2. Minimum Packet Error Rate floor will be ~0.5% for desired input signal levels between specified datasheet sensitivity level and -10dBm.
3. Minimum Packet Error Rate floor will be ~ 1% for desired input signal levels > -10dBm.
4. Definition of reference signal is 40 kbps 2FSK, Δf = 40 kHz, NRZ, '0' = F_center + Δf/2, '1' = F_center - Δf/2
5. Definition of reference signal is 9.6 kbps 2FSK, Δf = 40 kHz, Manchester, '0' = Transition from (F_center + 20k + Δf/2), '1' = Transition from (F_center + 20k - Δf/2)
6. RFSENSE performance is only valid from 0 to 85 °C. RFSENSE should be disabled outside this temperature range.
7. Minimum Packet Error Rate floor for signals in presecene of blocker will increase above 1% for blocker levels above -30dBm.

7. EU REGOLATORY DISCLOSURES

STATEMENT
Hereby, FAE TECHNOLOGY S.p.a. declares that this product is in compliance with Directive 2014/53/EU.
The full text of the EU declaration of conformity is available at the following internet address:

- https://fae.technology/product-accelerator-program/

The use of the Sentimate with wireless communications is restricted to indoor use only.

8. FCC COMPLIANCE STATEMENT (USA)

This device complies with Part 15 rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Non-modification Warning: Any changes or modifications to this device not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

RF Exposure Statement: This equipment complies with FCC/IC radiation exposure limits set forth for an uncontrolled environment and meets the FCC radio frequency (RF) Exposure Guidelines and RSS-102 of the IC radiofrequency (RF) Exposure rules. This equipment should be installed and operated keeping the radiator at least 20cm or more away from person's body.

Cet équipement est conforme aux limites d'exposition aux rayonnements énoncées pour un environnement non contrôlé et respecte les règles les radioélectriques (RF) de la FCC lignes directrices d'exposition dans et d'exposition aux fréquences radioélectriques (RF) CNR-102 de l'IC. Cet équipement doitêtre installé et utilisé en gardant une distance de 20 cm ou plus entre le dispositif rayonnant et le corps

9. OPERATING ENVIRONMENT

The operating environment excludes special environments (extreme temperatures, dust, humidity, vibrations, flammable gases, corrosive or explosive atmosphere, etc.).

10. DISCLAIMERS

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