The CC2650 device is a wireless MCU targeting *Bluetooth*, ZigBee® and 6LoWPAN, and ZigBee RF4CE remote control applications.

The device is a member of the CC26xx family of cost-effective, ultralow power, 2.4-GHz RF devices. Very low active RF and MCU current and low-power mode current consumption provide excellent battery lifetime and allow for operation on small coin cell batteries and in energy-harvesting applications.

The CC2650 device contains a 32-bit ARM Cortex-M3 processor that runs at 48 MHz as the main processor and a rich peripheral feature set that includes a unique ultralow power sensor controller. This sensor controller is ideal for interfacing external sensors and for collecting analog and digital data autonomously while the rest of the system is in sleep mode. Thus, the CC2650 device is ideal for applications within a whole range of products including industrial, consumer electronics, and medical.

The *Bluetooth* Low Energy controller and the IEEE 802.15.4 MAC are embedded into ROM and are partly running on a separate ARM Cortex-M0 processor. This architecture improves overall system performance and power consumption and frees up flash memory for the application.

The SimpleLink CC2650 Wireless MCU contains an ARM Cortex-M3 (CM3) 32-bit CPU, which runs the application and the higher layers of the protocol stack.

The CM3 processor provides a high-performance, low-cost platform that meets the system requirements of minimal memory implementation, and low-power consumption, while delivering outstanding computational performance and exceptional system response to interrupts.

CM3 features include the following:

• 32-bit ARM Cortex-M3 architecture optimized for small-footprint embedded applications

• Outstanding processing performance combined with fast interrupt handling

• ARM Thumb®-2 mixed 16- and 32-bit instruction set delivers the high performance expected of a 32-bit ARM core in a compact memory size usually associated with 8- and 16-bit devices, typically in the range of a few kilobytes of memory for microcontroller-class applications:

– Single-cycle multiply instruction and hardware divide

– Atomic bit manipulation (bit-banding), delivering maximum memory use and streamlined peripheral control

– Unaligned data access, enabling data to be efficiently packed into memory

• Fast code execution permits slower processor clock or increases sleep mode time

• Harvard architecture characterized by separate buses for instruction and data

• Efficient processor core, system, and memories

• Hardware division and fast digital-signal-processing oriented multiply accumulate

• Saturating arithmetic for signal processing

• Deterministic, high-performance interrupt handling for time-critical applications

• Enhanced system debug with extensive breakpoint and trace capabilities

• Serial wire trace reduces the number of pins required for debugging and tracing

• Migration from the ARM7™ processor family for better performance and power efficiency

• Optimized for single-cycle flash memory use

• Ultralow-power consumption with integrated sleep modes

• 1.25 DMIPS per MHz

The RF Core contains an ARM Cortex-M0 processor that interfaces the analog RF and base-band circuitries, handles data to and from the system side, and assembles the information bits in a given packet structure. The RF core offers a high level, command-based API to the main CPU.

The RF core is capable of autonomously handling the time-critical aspects of the radio protocols (802.15.4 RF4CE and ZigBee, *Bluetooth* Low Energy) thus offloading the main CPU and leaving more resources for the user application.

The RF core has a dedicated 4-KB SRAM block and runs initially from separate ROM memory. The ARM Cortex-M0 processor is not programmable by customers.

The Sensor Controller contains circuitry that can be selectively enabled in standby mode. The peripherals in this domain may be controlled by the Sensor Controller Engine which is a proprietary power-optimized CPU. This CPU can read and monitor sensors or perform other tasks autonomously, thereby significantly reducing power consumption and offloading the main CM3 CPU.

The Sensor Controller is set up using a PC-based configuration tool, called Sensor Controller Studio, and potential use cases may be (but are not limited to):

• Analog sensors using integrated ADC

• Digital sensors using GPIOs, bit-banged I2C, and SPI

• UART communication for sensor reading or debugging

• Capacitive sensing

• Waveform generation

• Pulse counting

• Keyboard scan

• Quadrature decoder for polling rotation sensors

• Oscillator calibration

The peripherals in the Sensor Controller include the following:

• The low-power clocked comparator can be used to wake the device from any state in which the comparator is active. A configurable internal reference can be used in conjunction with the comparator. The output of the comparator can also be used to trigger an interrupt or the ADC.

• Capacitive sensing functionality is implemented through the use of a constant current source, a timeto- digital converter, and a comparator. The continuous time comparator in this block can also be used as a higher-accuracy alternative to the low-power clocked comparator. The Sensor Controller will take care of baseline tracking, hysteresis, filtering and other related functions.

• The ADC is a 12-bit, 200-ksamples/s ADC with eight inputs and a built-in voltage reference. The ADC can be triggered by many different sources, including timers, I/O pins, software, the analog comparator, and the RTC.

• The Sensor Controller also includes a SPI–I2C digital interface.

• The analog modules can be connected to up to eight different GPIOs.

The peripherals in the Sensor Controller can also be controlled from the main application processor.

The flash memory provides nonvolatile storage for code and data. The flash memory is in-system programmable.

The SRAM (static RAM) can be used for both storage of data and execution of code and is split into two 4-KB blocks and two 6-KB blocks. Retention of the RAM contents in standby mode can be enabled or disabled individually for each block to minimize power consumption. In addition, if flash cache is disabled, the 8-KB cache can be used as a general-purpose RAM.

The ROM provides preprogrammed embedded TI RTOS kernel, Driverlib and lower layer protocol stack software (802.15.4 MAC and *Bluetooth* Low Energy Controller). It also contains a bootloader that can be used to reprogram the device using SPI or UART.

The on-chip debug support is done through a dedicated cJTAG (IEEE 1149.7) or JTAG (IEEE 1149.1) Interface.

The CC2650 supports two external and two internal clock sources.

A 24-MHz crystal is required as the frequency reference for the radio. This signal is doubled internally to create a 48-MHz clock.

The 32-kHz crystal is optional. *Bluetooth* low energy requires a slow-speed clock with better than ±500 ppm accuracy if the device is to enter any sleep mode while maintaining a connection. The internal 32-kHz RC oscillator can in some use cases be compensated to meet the requirements. The low-speed crystal oscillator is designed for use with a 32-kHz watch-type crystal.

The internal high-speed oscillator (48-MHz) can be used as a clock source for the CPU subsystem.

The internal low-speed oscillator (32.768-kHz) can be used as a reference if the low-power crystal oscillator is not used.

The 32-kHz clock source can be used as external clocking reference through GPIO.

Federal Communication Commission Interference Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation.

This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:
. Reorient or relocate the receiving antenna.
. Increase the separation between the equipment and receiver.
. Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
. Consult the dealer or an experienced radio/TV technician for help.

FCC Caution: To assure continued compliance, any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment. (Example - use only shielded interface cables when connecting to computer or peripheral devices).

End Product Labeling

This transmitter module is authorized only for use in devices where the antenna may be installed such that 20 cm may be maintained between the antenna and users. The final end product must be labeled in visible area with the following: "Contains FCC ID: GX9ZBH-LE   "
  "

End Product Manual Information

The user manual for end users must include the following information in a prominent location "IMPORTANT NOTE: To comply with FCC RF exposure compliance requirements, the antenna used for this transmitter must be installed to provide a separation distance of at least 20cm from all persons and must not be colocated or operating in conjunction with any other antenna or transmitter." This device complies with part 15 of the FCC 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.

IMPORTANT NOTE: In the event that these conditions can not be met (for example certain laptop configurations or colocation with another transmitter), then the

FCC authorization is no longer considered valid and the FCC ID can not be used on the final product. In these circumstances, the OEM integrator will be responsible for reevaluating the end product (including the transmitter) and obtaining a separate FCC authorization.   This device is intended only for OEM integrators under the following conditions: The antenna must be installed such that 20 cm is maintained between the antenna and users. As long as a condition above is met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end product for any   additional compliance requirements required with this module installed   (for example, digital device emissions, PC peripheral requirements, etc.).