Blood Glucose Monitors

Features

- Optimized Power
- Lower Cost Designs
- Discrete/ Continuous Monitors
- Integrated Analog Front End
- Wireless Connectivity

With an ever-increasing number of older population segments and focused campaigns on disease-prevention awareness, manufacturers of blood glucose monitors are realizing consistent growth rates in the market. Rising obesity trends and technology advancements have accelerated the prevalence of monitors as well as insurance coverage of monitors to maintain healthy levels in patients, reducing risk and hospitalizations.

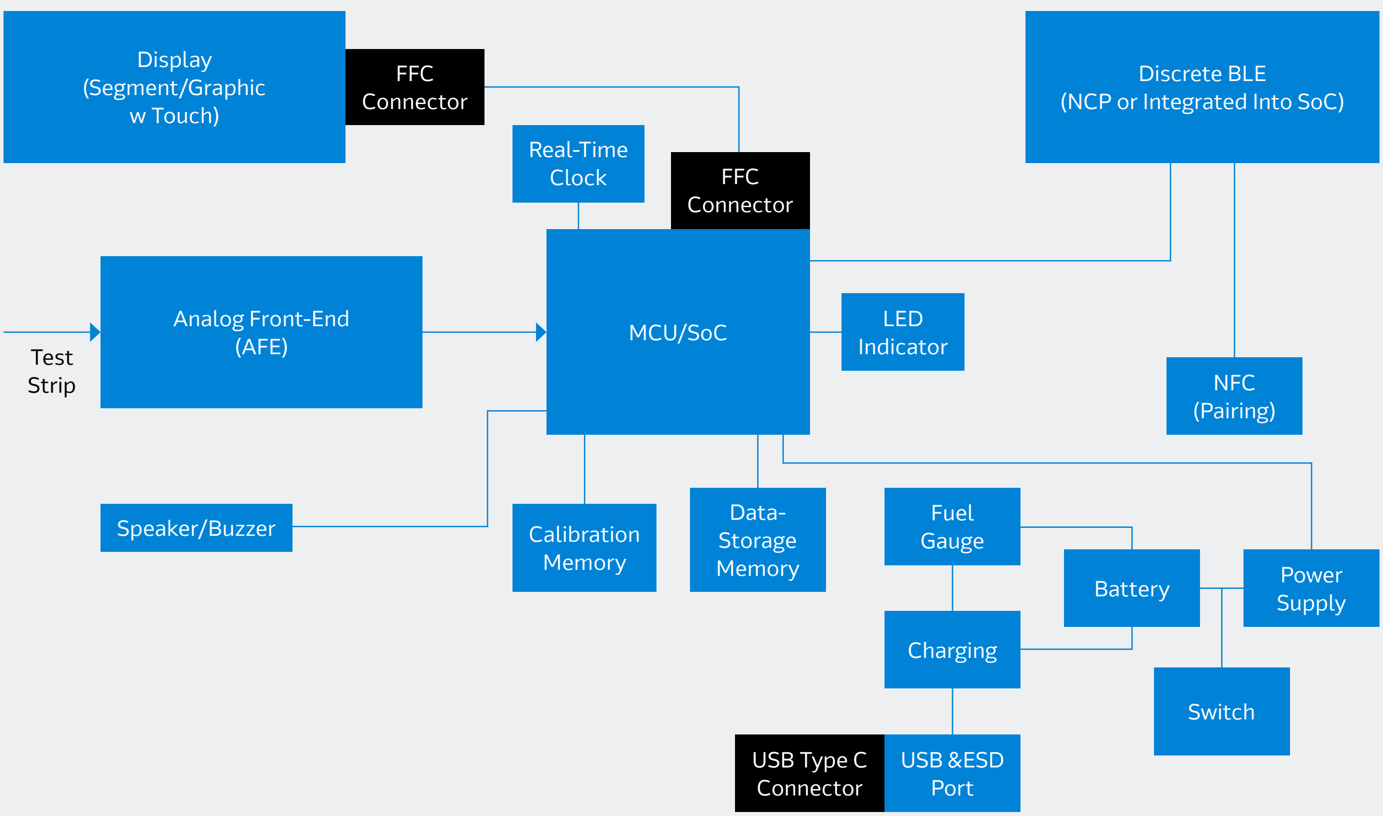
While monitors can take many forms, including continuous or discrete solutions, all rely on semiconductor-sensor-based front-ends, processors and an output user interface. In either form, yearly volumes of monitors are significant with a single OEM producing close to 1 million units per year. For years, the dominant monitor has been a self-monitoring discrete solution; this solution presents lifestyle hurdles in terms of daily finger pricks with lancets, blood drawings onto testing strips and tracking monitor readings. Continuous blood glucose monitors (CGM) afford the patient significant ease of use, eliminating the manual steps associated with self-monitoring discrete solutions. Additionally, CGM can take advantage of the manufacturers smartphone apps to provide a simple interface for both patient and physician, in many cases offering tele-health options in the form of record upload for physician review. Either architecture solution is focused on providing the user/

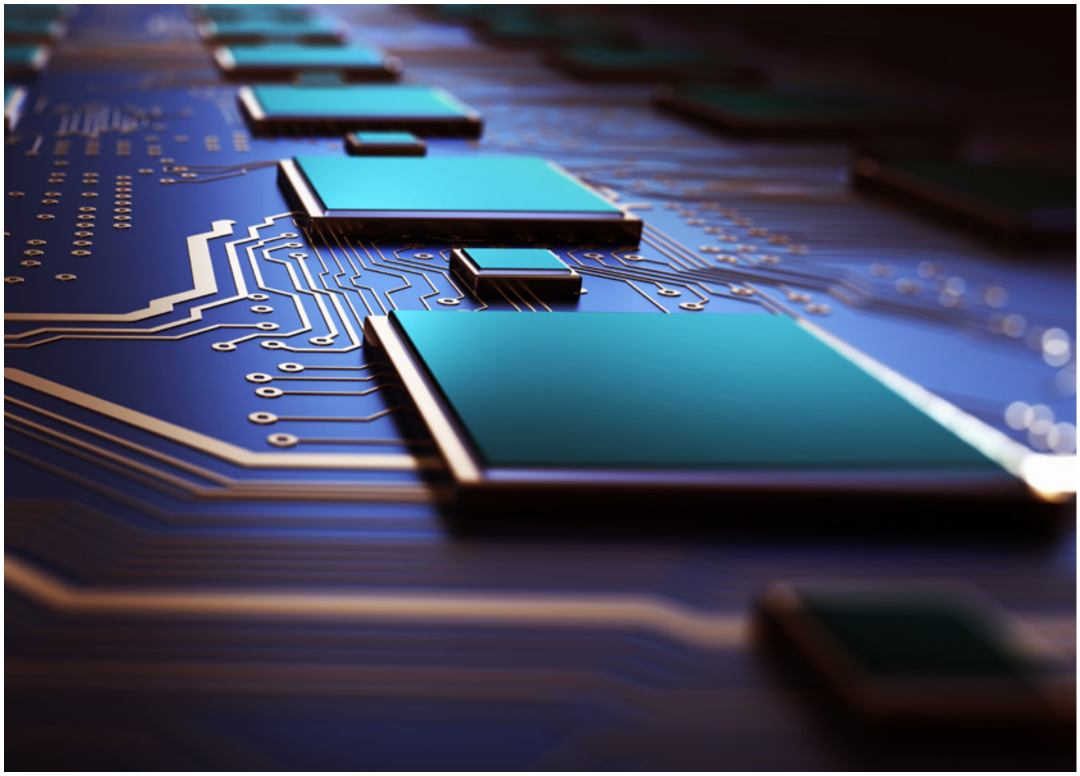
patient accurate glucose-level readings to prevent severe and/or life-threatening complications for diabetes patients.

Since volumes are high, previous design methodologies supporting multiple IC solutions quickly lost favor for integrated solutions. Today's targeted semiconductor solutions take a system-on-chip approach, eliminating as many external circuits and components as possible to drive down solution cost. Discrete blood glucose monitors utilize electromechanical test strips with electrodes excited by a digital-to-analog converter yielding a measured current proportional to the glucose in the blood. That proportional current is then passed through a transimpedance amplifier, producing a voltage which is sampled by an analog-to-digital converter and processed into a temperature-dependent reading for the user/patient. As noted, the system-on-chip devices incorporate these analog blocks and processing into a single device. Alternate system architectures can utilize an integrated analog front-end that passes the conditioned readings to a microcontroller that can incorporate additional functionality, including Bluetooth Low Energy. Continuous blood glucose monitors utilize an application-specific integrated circuit (ASIC) architecture comprised of an MCU, analog front-end and BLE transmitter.

System Block Diagram

The block diagram highlights the main architecture blocks for concern to the designer. Deciding on a solution typically involves integration levels such as a system-on-chip approach vs. traditional ICs, cost factors and overall size from an industrial design perspective. These architecture blocks include an input block for test-strip insertion followed by the analog front-end, responsible for signal conditioning of the electrical signal from the test strip. The analog front-end output is passed into a microcontroller or SoC block for processing the signal and converting to a glucose reading that can be displayed on the user screen as well as communicated via Bluetooth. Several memory blocks can exist for calibration data as well as user data with all blocks being supplied power via a battery and associated charging and gas-gauging circuits.





System Benefits

As discussed, several architecture implementations can offer solutions to the block diagram presented leveraging integrated solutions, reducing overall component costs and space savings. These optimizations also cross over into reduced-weight realizations and smaller-sized batteries or longer life with the same-sized battery offering a better end user experience.

One such solution offers an analog front-end in support of a discrete monitor solution combining DAC, TIA and ADC presented to the system microcontroller. Advantages of a modular approach allow for easy upgrades as sensor technology advances. The use of an integrated analog front-end provides a high level of integration, thereby reducing complexity in overall board space and optimized power consumption vs. discrete ICs

Temperature measurement is also a critical parameter for ambient temperature readings near the test strip. Typical measurement accuracies are +/-1C to +/-2C. Measurement is typically performed with a stand-alone temperature sensor IC or via remote thermistor into the ADC of the MCU.

At the heart of the monitor is an MCU used to control and manage the operation of the glucose monitor. The MCU provides the necessary processing power to perform signal processing from the analog front-end block, data storage management, and various I/O and communications interfaces. Various manufacturers offer MCU solutions targeted for blood glucose monitoring applications that incorporate at some level the tasks of an analog-front-end approach. These include on board operational amplifiers and analog-to-digital converters for converting the analog signals from the glucose-sensing electrodes for processing by the MCU. This approach offers cost optimization and size efficiencies.

Power management within a typical portable blood glucose monitor takes the form of either primary or secondary batteries married to a fuel gauge for user status on the display, as well as battery charger communication via MCU I/O pins. Rechargeable or secondary batteries are typically single-cell Li-ion interfaced to the appropriate battery charger and fuel gauge. Typical external charging in modern day monitors is accomplished via USB. If there is a removable battery that is charged in a dock, authentication can be added to ensure only authorized batteries are used per the manufacturer's requirements.

The display and user interface typically comprise an LCD segment or graphic dot matrix solution. While the graphic dot matrix affords the developer more flexibility in creating custom icons and display information, these displays require additional memory, typically along with bias voltages and drivers if not incorporated into the LCD module from the manufacturer. Some MCUs targeted for the blood glucose monitor space include the LCD-driving capability on the MCU, typically for segment-based displays in most cases.

In addition to the LCD interface, which patients could have difficulty reading depending upon their age and eyesight capabilities, an audible indicator is typically included in the form of a buzzer and in some cases a voice assist to guide the patient without dependency on the display. In it's simplest form, a buzzer can be pulse-width modulated via available I/O pins on the MCU, thereby limiting additional circuit costs.

I/O and data interfaces were provided in the early days for uploading test results to a computer. Monitor designs today leverage standard interfaces such as USB and more recently Bluetooth wireless solutions. While there are additional cost factors by adding these standards into blood glucose monitors, various health alliances are driving the industry for more convenient avenues to upload patient data to a health care provider.

Overall, system architectures for the core circuitry of the monitor design are utilized as a building block such that when another feature is needed, a complete redesign is not needed, thereby negating risk, reducing regulatory approvals and yielding a faster time to market for the manufacturer.

Training/Resources

MICROCONTROLLERS/SOC
ST Microelectronics
MCU-STM32Lxx series

Analog Devices
MCU/SoC-ADUCM355

NXP Semiconductors
MCU-K53 Kinetis Series

Silicon Labs
MCU-EFM32PG22

Infineon Technologies
MCU/SoC-PSoC 61/62

Microchip
MCU-PIC24F Series

MEMORY/DATA LOGGING
Infineon Technologies
F-RAM-CY15x104/108

LCD DISPLAY DRIVER
NXP Semiconductors
LCD Driver-PCF8551

BUZZER/AUDIO INDICATOR
CUI Devices
Audio Indicator

ANALOG + FRONT-END
Analog Devices
AFE-MAX30131

Analog Devices
AFE-AD5941

onsemi
CEM102

SENSORS
Amphenol Sensors
NTC Thermistors-MA Series

Honeywell
NTC Thermistors-192 Series

POWER MANAGEMENT
NXP Semiconductors
Single Cell Charger-MC34673

ST Microelectronics
Single Cell Charger-STBC08

onsemi
Single Cell Charger- FAN54120

Silicon Labs
PMIC/Charger-EFP01

BATTERY
NuEnergy Storage Technologies
Li-ion Battery

WIRELESS SOC
Silicon Labs
SoC-EFR32BG22

Nordic Semiconductor
SoC-nrf52832 w NFC

ST Microelectronics
SoC: STM32WB10

Infineon Technologies
SoC-PSoC 63

Analog Devices
SoC-MAX32690

IP & E
Amphenol Commercial Solutions
USB Charging Port-GMCB05 Series

Molex
Display Flex Cables/Connectors

Littelfuse
USB ESD Protection

C&K
Tactile Switches

Samtec
Board-to-Board

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