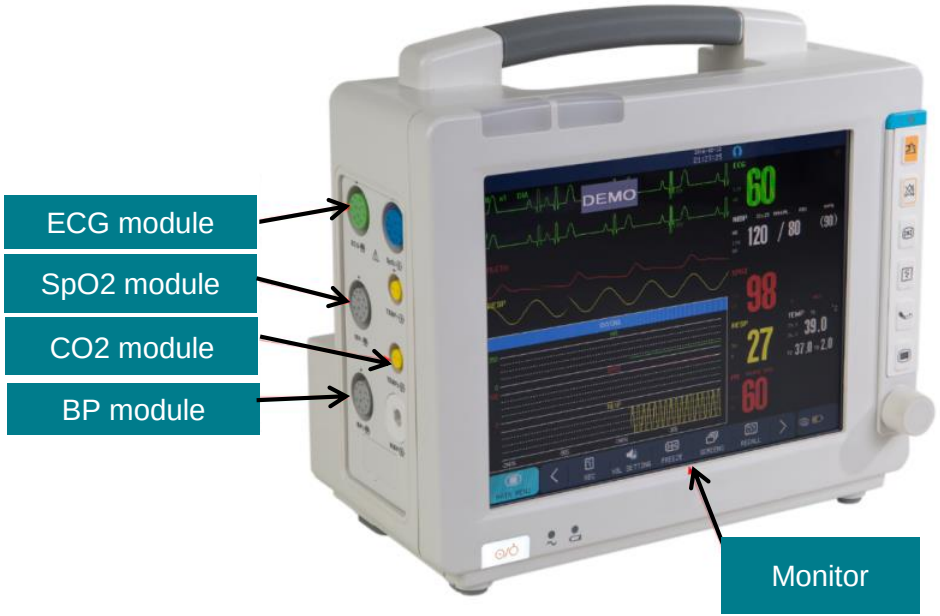
Patient monitoring 101: Part-1

Multiparameter patient monitor and sensor patch for remote monitoring

Multiparameter patient monitor



Example Image

https://www.ti.com/solution/multiparameter-patient-monitor

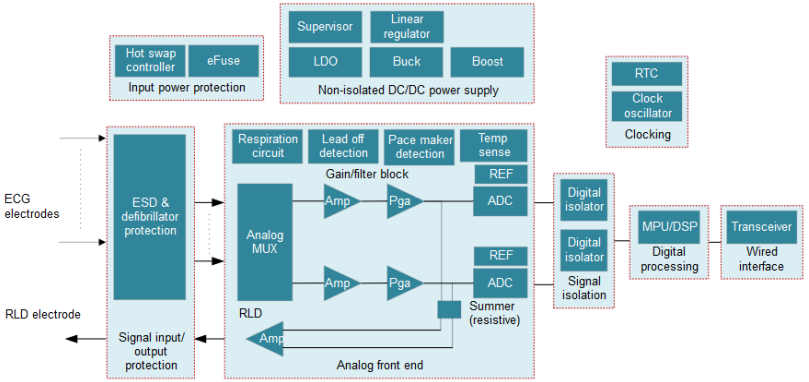
Multiparameter patient monitor – ECG module

What does this module do?

- Allows users to monitor the heart activity in real-time, by recording the electrical signals of the heart muscles using electrodes placed over the skin.
- Many ECG modules can detect arrhythmia and diseases using algorithms. Few machines also provide pacemaker detection signal.

Key system requirements

- **High Signal-to-Noise-Ratio(SNR)** to accurately detect the small electrical changes and minimize the noise for proper reproduction of the heart activity
- **Right Leg Driver (RLD) circuitry** to reduce common-mode interference and to bias the patient to proper voltage range of the ADC
- **Lead-off detection circuitry** to determine electrode contact quality and thus prevent erroneous data
- **Ultra-low power consumption** for longer operation
- **Good circuit design and post-processing** to overcome common sources of irregular ECG readings



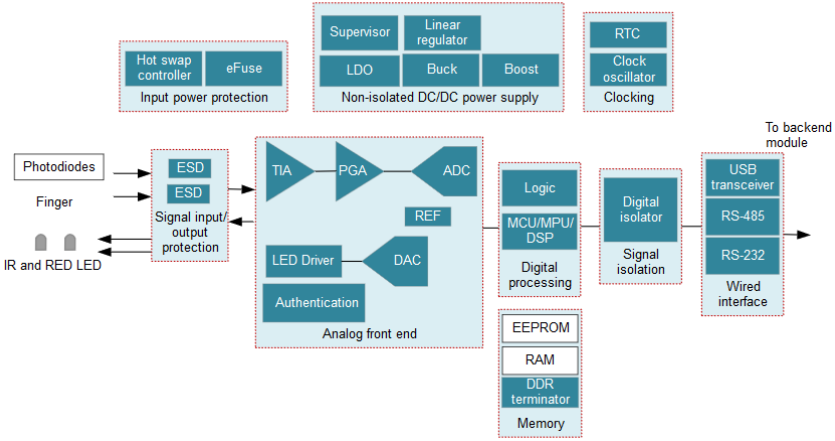
More details on:
https://www.ti.com/solution/multiparameter-patient-monitor?variantid=26674&subsystemid=26675

Multiparameter patient monitor – SpO2 module

* Deoxygenated Hemoglobin
** Oxygenated Hemoglobin
# Trans-impedance amplifier

What does this module do?

- Uses an optical setup to monitor the heart rate and peripheral oxygen saturation (SpO2 %) of blood.
- Monitoring by driving Red and IR LEDs alternately through an analog switch.
- Depending on the concentration of Hb* and HbO2**, the absorption of these two wavelengths vary. These changes in light intensity are converted into electrical signal by a photodiode. The received signals are then signal conditioned (using TIA#, filters and ADC) and processed by the MCU to derive the SpO2 % using algorithms.



Key system requirements

- **Ambient noise cancellation & DC offset correction** to subtract the noise introduced due to ambient light in order to improve the signal-to-noise ratio (SNR).
- **Temperature compensation** for eliminating effects of temperature drift on LED driver and photodiode sensing
- **Motion compensation** to prevent artifacts due to motion

More details on:
https://www.ti.com/solution/multiparameter-patient-monitor?variantid=26674&subsystemid=26675

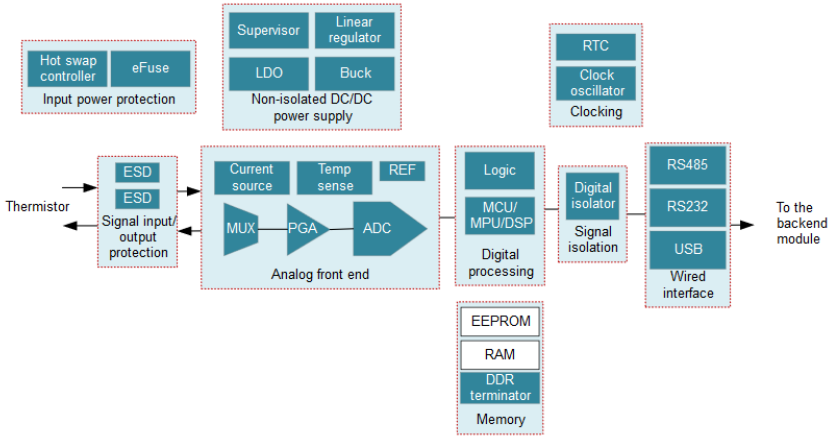
Multiparameter patient monitor – Temperature module

What does this module do?

- Allow users to effortlessly monitor the body temperature in real-time.
- Mainly used for patient diagnostics.
- A thermistor (or similar temperature sensor) is placed in contact with the body, whose resistance changes with temperature variations.
- The Analog Front-End (AFE) converts the signal picked-up by the sensors into equivalent voltage, amplifies it, and sends it to processor for temperature calculations.

Key system requirements

- **Highly accurate sensor** for correct temperature measurements within the specified body temperature range – the sensing data can be used for calculating core body temperatures also
- **Quick calibration** to yield correct readings without much delay



More details on:
https://www.ti.com/solution/multiparameter-patient-monitor?variantid=26674&subsystemid=26675

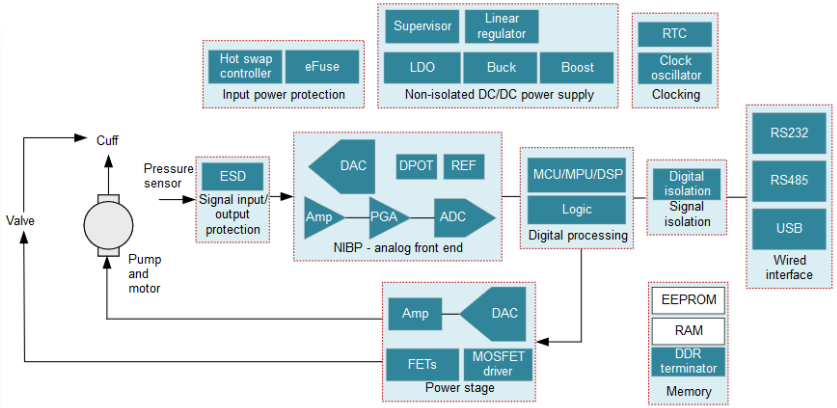
Multiparameter patient monitor – Non-Invasive BP module

What does this module do?

- Non-invasive blood pressure (NIBP) module easily captures blood pressure data over long sampling periods.
- An automatic blood pressure monitor inflates or deflates a cuff (wrapped around the arm) to regulate the blood flow in the artery. A pressure sensor is used to capture the exact instances when blood just begins to flow through the artery and when the blood flow is no longer restricted, the measurement of which gives the systolic and diastolic pressure respectively. The picked-up signal is conditioned and digitized by the Analog Front-End (AFE) and processed further by the MCU.

Key system requirements

- **Precise and efficient control of the pump and valve** to regulate the cuff's inflation/deflation and prevent any discomfort since continuous operation might be desired
- **Sensitive analog signal conditioning** to efficiently detect the small pressure changes and avoid errors in measurements



More details on:
https://www.ti.com/solution/multiparameter-patient-monitor?variantid=26674&subsystemid=26675

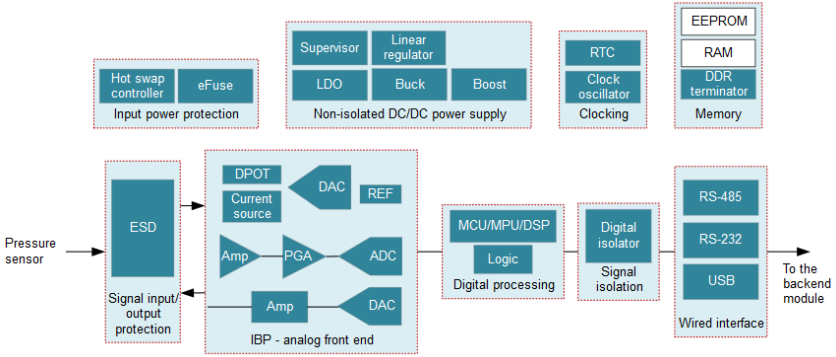
Multiparameter patient monitor – Invasive BP module

What does this module do?

- Invasive (intra-arterial) blood pressure (IBP) is a form of continuous monitoring useful in Incentive care unit (ICU) for patients who are likely to display sudden changes in blood pressure or in patients receiving drugs to maintain the blood pressure.
- The technique involves the insertion of a catheter into a suitable artery, which is connected to a tubing filled with fluid. This fluid moves whenever there is any change in the pressure. A pressure transducer is connected to the tubing which detects these pressure changes and converts them into corresponding electrical signals.

Key system requirements

- **High Signal-to-Noise-Ratio(SNR)** to accurately detect the small electrical changes and minimize the noise for proper reproduction of the pulsing blood
- **Safety features** such as high and low mean blood pressure alarms and tachycardia/ bradycardia alerts



More details on:
https://www.ti.com/solution/multiparameter-patient-monitor?variantid=26674&subsystemid=26675

Full system: Multiparameter patient monitor + wireless sensors

Nurse's station / Doctor's office

Wi Fi CERTIFIED

Bluetooth

Patch #4

Bluetooth

Patch #3

Bluetooth

Patch #2

Patch #1

Full system: Multiparameter patient monitor + wireless sensors

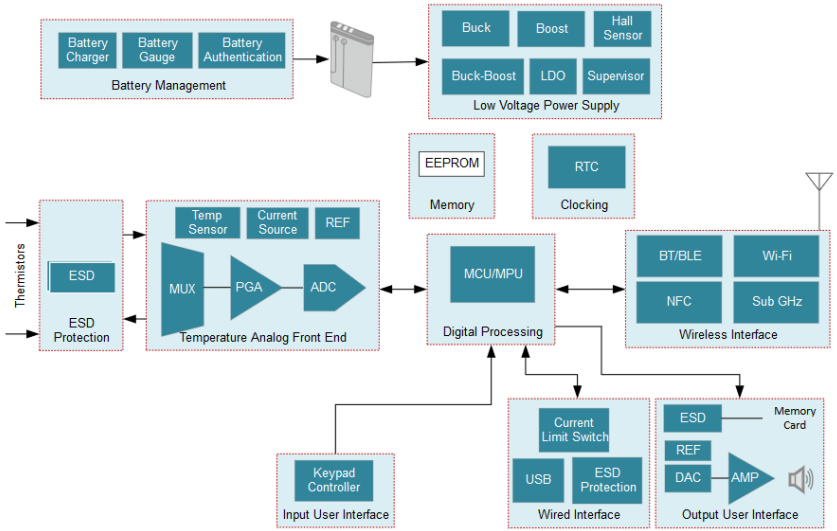
Medical sensor patches: Temperature sensor patch

What does this patch do?

- A monitoring unit which allow users to effortlessly (by sticking it on the body) monitor the body temperature in real-time. It is mainly used for patient diagnostics.
- Temperature sensors detect the temperature of the body and depending on the type of temperature sensor (analog or digital), this signal is conditioned by an Front-End before getting processed by the MCU.
- The processed temperature data can be displayed on a computer or mobile phone, typically through a wireless interface.

Key system requirements

- **Low cost** for disposable patches
- **Highly accurate sensor** for correct temperature measurements within the specified body temperature range
- **Small form factor** for easy incorporation to wearable applications
- **Efficient, low power and battery management** to provide longer battery life for continuous operation
- **Quick data transfer** to allow real-time monitoring
- **Wireless connectivity** to remotely monitor temperature changes



More details on:
https://www.ti.com/solution/multiparameter-patient-monitor?variantid=26674&subsystemid=26675

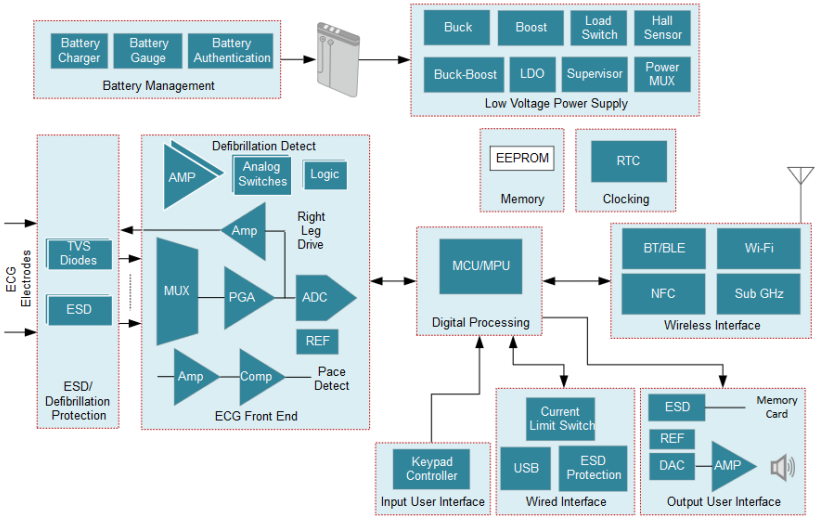
Medical sensor patches: Electrocardiograph (ECG) patch

What does this patch do?

- An ECG patch allow users to effortlessly monitor the heart activity in real-time. It is an independent unit with power and wireless modules and allows the person to be completely mobile by eliminating the use of long cables. Typical configurations use 1-lead or 2-leads.
- The Analog front-end (AFE) amplifies the ECG signals and converts it into digital data for further processing and analysis. A right-leg drive (RLD) circuit helps in cancelling common-mode (ac line) interference. The patches are powered using batteries with typical run-time of 7 days (for coin cell) or 24 hours (for rechargeable 1S battery).
- The resultant data can be transferred (via BLE or Wi-Fi) to a computer or smart phone, and the waveform and attributes can be displayed.

Key system requirements

- **Low cost** for disposable patches
- **Small form factor** for easy incorporation in wearable applications
- **Efficient battery management and ultra-low power consumption** for longer operation
- **High Signal-to-Noise-Ratio(SNR)** to accurately capture the low amplitude and low frequency electrical signals of the heart and minimize the noise
- **Quick data transfer** to allow real-time monitoring



More details on:
https://www.ti.com/solution/multiparameter-patient-monitor?variantid=26674&subsystemid=26675

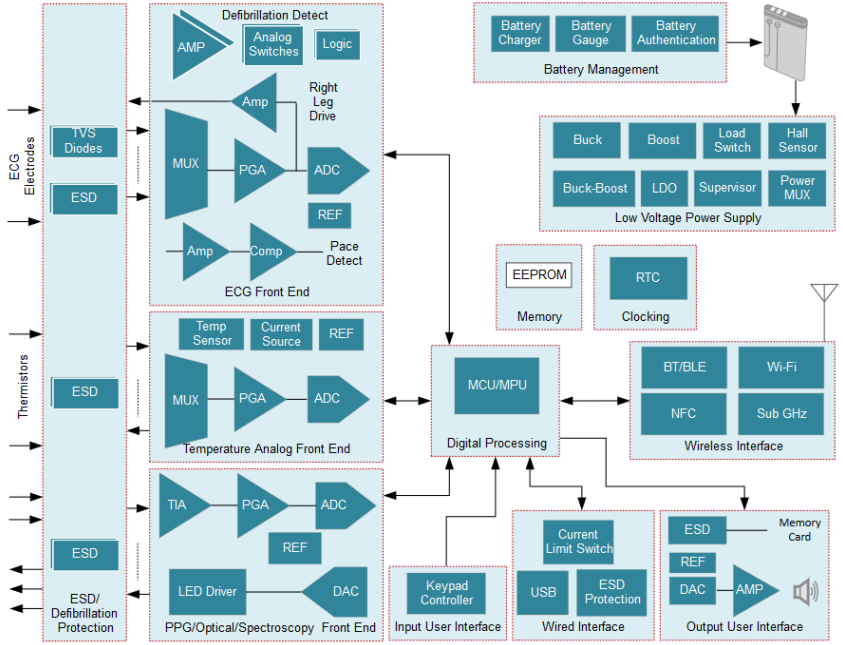
Medical sensor patches: Multi-parameter patch

What does this patch do?

- A multi-parameter sensor patch can monitor the heart activity, body temperature and blood oxygen saturation to provide a holistic view of the well-being of the person.
- The patch has multiple sensors (ECG electrodes, temp sensor and optical sensors) placed on the body. These sensors pick-up their respective signal and send them to their respective Front-Ends for signal conditioning and digitization. The MCU gathers all the data, processes them individually and sends out the measurements to a remote terminal (typically through a wireless interface).
- With the advancements in technology, measurement of more parameters like breathing rate, blood glucose, galvanic skin resistance etc. are being incorporated in these patches.

Key system requirements

- **Low cost** for disposable patches
- **Small form factor** to incorporate all these functionalities without drastically increasing the device dimensions
- **Efficient battery management and ultra-low power consumption** for longer operation
- **High SNR and noise cancellation** to accurately capture the signals and prevent them from getting corrupted by noise
- **Quick data transfer and Wireless connectivity** to remotely monitor all the data



More details on:
https://www.ti.com/solution/multiparameter-patient-monitor?variantid=26674&subsystemid=26675

What to expect in this video series?

- Understanding ECG basics and lead derivation
- Key considerations for designing ECG front-end circuit (discrete & integrated)
- Choosing right ECG front-end for your design
- Electrode configurations and Interface circuitry for ECG in Wearable devices
- Understanding PPG measurement basics (transmissive vs. reflective type)
- Analog and digital temperature sensing
- Invasive & non-invasive blood pressure monitoring
- Achieve isolation and help ensure safety with power and data architectures
- Power supply design challenges for medical sensor patches
- Medical alarm (tone) generation
- Industrial interfaces in multi-parameter patient monitors
- So on…