



maxim
integrated™

MAX86176

Ultra-Low-Power, Optical PPG and Single-Lead ECG AFE



Enables HR, Afib Detection, and Pulse Transit-Time for Wearable Health

Maxim Integrated MAX86176 PPG and ECG Analog Front-End (AFE)

Maxim Integrated MAX86176 PPG and ECG Analog Front-End (AFE) is a complete photoplethysmogram (PPG) and electrocardiogram (ECG) solution for wearable applications. The ECG channel of the MAX86176 features EMI filtering, internal lead biasing, AC and DC lead-off detection, right-leg drive, ultra-low power DC lead-on detection during standby mode, and extensive calibration voltages for built-in self-test. The PPG data acquisition system supports up to 6 LEDs and 4 photodiode inputs, which are fully synchronized with the ECG signal path. The MAX86176 can operate with either an internal or external clock. The device is designed to meet IEC 60601-2-47 Ambulatory ECG Systems monitoring compliance for even the most challenging dry electrode applications.

The Maxim Integrated MAX86176 Analog Front-End is available in a 36-bump, 0.4mm pitch, 2.73mm x 2.71mm wafer-level package (WLP).

FEATURES

- System
 - 0.5 μ A shutdown current
 - 256-word FIFO for ECG and PPG
 - True synchronous ECG and PPG data from dedicated signal paths
 - Two fully configurable interrupts
 - High-speed SPI interface or I²C interface
 - LED driver with 128mA LED maximum current
 - -40°C to +85°C operating temperature range
 - 2.728mm x 2.708mm thin WLP36 package; 0.4mm pitch
- Photoplethysmogram (PPG)
 - Complete dual-channel optical data acquisition system
 - Ultra-low-power operation for wearable devices
 - Optical readout channel <11 μ A at 25fps
 - 14.6 μ s to 117.1 μ s ADC integration time
 - Low shutdown current <1 μ A (typical)
 - Signal to Noise Ratio (SNR) up to 110dB with average mode and off-chip filtering
 - Supports frame rates from 1fps to 2kfps
 - High-resolution 20-bit charge-integrating ADCs
 - Low dark-current noise of < 50pA_{RMS}
 - Excellent ambient range and rejection capability
 - > 100 μ A ambient photodiode current
 - > 90dB ambient rejection at 120Hz

- Electrocardiogram (ECG)
 - Clinical-grade ECG AFE with high-resolution ADC
 - 15.6 ENOB with $0.6\mu\text{V}_{\text{RMS}}$ noise over 0.05Hz to 40Hz
 - Very low input bias current
 - $233\text{fA}_{\text{RMS}}$ input-current noise (0.05Hz to 40Hz, $T_A = +25^\circ\text{C}$)
 - Fully differential input structure with Common-Mode Rejection Ratio (CMRR) > 110dB at power-line frequencies
 - High-input impedance > 1G Ω for extremely low common to differential-mode conversion
 - High DC-offset range of $\pm 1300\text{mV}$ (1.8V typical) allows a wide variety of electrodes to be used
 - High AC-dynamic range of > 90mV_{P-P} helps prevent saturation in the presence of motion
 - ECG biopotential channel can be used for some EEG applications
 - Higher-gain ranges available (480V/V, 960V/V)
 - Low input-referred voltage and current noise enables the use of small-area dry electrodes

APPLICATIONS

- Wearable devices for fitness, wellness, and medical applications with clinical accuracy
- Suitable for wrist, finger, ear, and other locations
- Optimized performance to detect heart rate, oxygen saturation (SpO₂), muscle and tissue oxygen saturation (SmO₂ and StO₂), and body hydration
- Single-lead event monitors for atrial fibrillation (AFib) and other arrhythmia detection
- Single-lead wireless patches for at-home and in-hospital monitoring
- Chest-band heart-rate monitors for fitness applications
- Biometric authentication and ECG-on-demand applications
- Fully synchronized PPG and ECG signal path for PTT measurements

The MAX86176 is a complete photoplethysmogram (PPG) and electrocardiogram (ECG) analog front-end (AFE) solution for wearable applications. The MAX30005 is a complete AFE solution for ECG only. Both AFEs offer high performance for fitness and clinical applications with ultra-low power for long battery life.

Both MAX86176 and MAX30005 feature an ECG channel, EMI filtering, internal-lead biasing, AC and DC lead-off detection, right-leg drive, ultra-low power DC lead-on detection during standby mode, and extensive calibration voltages for built in self-test. In addition, the MAX86176 has a PPG data acquisition system supporting up to 6 LEDs and 4 photodiode inputs, which is fully synchronized with the ECG signal path. The MAX86176/MAX30005 can operate with either internal or external clock. The MAX86176/MAX30005 are designed to meet IEC 60601-2-47 Ambulatory ECG Systems monitoring compliance for even the most challenging dry electrode applications.

The MAX86176/MAX30005 are available in a 6x6 36-bump wafer-level packages (WLP), operating over the -40°C to +85°C temperature range.

Key Features

PPG (MAX86176)

- Complete Dual-Channel Optical-Data Acquisition System
- Ultra-Low-Power Operation for Wearable Devices
 - Optical Readout Channel < 11 μ A (typ) at 25fps
 - 14.6 μ s to 117.1 μ s ADC Integration Time
 - Low Shutdown Current < 1 μ A (typ)
- Signal to Noise Ratio (SNR) up to 110dB with Average (Avg) Mode and Off-Chip Filtering
- Supports Frame Rates from 1fps to 2kfps
- High-Resolution 20-bit Charge-Integrating ADCs
- Low Dark-Current Noise of < 50pA_{RMS}
- Excellent Ambient Range and Rejection Capability
 - > 100 μ A Ambient Photodiode Current
 - > 90dB Ambient Rejection at 120Hz (Avg > 2)

ECG (MAX86176/MAX30005)

- Clinical-Grade ECG AFE with High-Resolution ADC
 - 15.6 ENOB with 0.6 μ V_{RMS} Noise over 0.05Hz to 40Hz
- Very Low Input-Bias Current (-40°C to +85°C)
 - 233fA_{RMS} Input-Current Noise (0.05Hz to 40Hz, T_A = +25°C)
- Fully Differential Input Structure with CMRR > 110dB at Power-Line Frequencies
- High-Input Impedance > 1G Ω for Extremely Low Common to Differential-Mode Conversion
- High DC-Offset Range of \pm 1300mV (typ 1.8V) Allows a Wide Variety of Electrodes to be Used
- High AC-Dynamic Range of > 90mV_{P-P} Helps Prevent Saturation in the Presence of Motion
- ECG Biopotential Channel Can Be Used for Some EEG Applications
 - Higher-Gain Ranges Available (480V/V, 960V/V)
 - Low Input-Referred Voltage and Current Noise Enables Use of Small-Area Dry Electrodes

SYSTEM

- Shutdown Current of 0.5 μ A (typ)
- 256-Word FIFO for ECG and PPG
- True Synchronous ECG and PPG Data from Dedicated Signal Paths
- Two Fully Configurable Interrupts
- High-Speed SPI Interface or I²C Interface
- Small 2.728mm x 2.708mm WLP Package

- **PPG (MAX86176):** Wearable Devices for Fitness, Wellness and Medical Applications with Clinical Accuracy
- **PPG (MAX86176):** Suitable for Wrist, Finger, Ear and Other Locations
- **PPG (MAX86176):** Optimized Performance to Detect Heart Rate, Oxygen Saturation (SpO₂), Muscle and Tissue Oxygen Saturation (SmO₂ and StO₂), and Body Hydration
- **ECG (MAX86176/MAX30005):** Single-Lead Event Monitors for Atrial Fibrillation (AFib) and other Arrhythmia Detection
- **ECG (MAX86176/MAX30005):** Single-Lead Wireless Patches for At-Home/In-Hospital Monitoring
- **ECG (MAX86176/MAX30005):** Chest-Band Heart-Rate Monitors for Fitness Applications
- **ECG (MAX86176/MAX30005):** Biometric Authentication and ECG-on-Demand Applications
- **PPG-ECG SYNC (MAX86176):** Fully Synchronized PPG and ECG Signal Path for PTT Measurements

Parametric specs for Bio-Sensors

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|---|-------------|
| I_{SUPPLY} (μA) (typ) | 11 |
| V_{SUPPLY} (V) (min) | 1.7 |
| V_{SUPPLY} (V) (max) | 2 |
| Resolution (bits) (ADC) | 19 |
| SNR (dB) | 109 |
| Package/Pins | THIN WLP/36 |
| Budgetary | 5.25 |
| Price (See Notes) | |