

# AFE4510 Ultra Small, Integrated AFE for Bio Impedance Analysis, Electrical Bio Sensing & Optical Bio Sensing

## 1 Features

- Integrated signal chains for Bio-Z, EDA, ECG, PPG
- Synchronized ECG, PPG enables PTT-based BP
- **Bio-Z signal acquisition:**
  - Multi-frequency Body impedance Analysis with frequency programmable up to 250kHz
  - Low frequency excitation mode for EDA/GSR
  - Complex (I, Q). Tetrapolar impedance measurement
  - Sine-wave excitation with a 7-bit DAC
  - Calibration scheme to compensate for electrode impedance and achieve accurate BioZ
- **ECG signal acquisition:**
  - 1-lead ECG signal acquisition up to 4kHz
  - Mode to configure as 2-channel ECG
  - INA gain programmable from 1.27 - 12.23
  - RLD output to set body bias through the third electrode
  - Input noise (0.5-150Hz): 0.5 $\mu$ Vrms at gain of 12.23
  - >1G $\Omega$  input impedance, CMRR>100dB
  - Integrated 370 Hz anti-aliasing low pass filter
  - AC, DC lead-off detect: 1.6nA to 1 $\mu$ A
- **PPG signal acquisition:**
  - Acquisition of 24 PPG signal sets (LED, AMB)
  - Supports PPG sensors at different data rates
  - Peak system SNR of 115 dB in 0.5-10Hz band enables high-accuracy SpO<sub>2</sub> measurement
  - Low Current for Continuous Operation with a Typical Value: 19 $\mu$ A for the Receiver
- **PPG Transmitter:**
  - 8-Bit Programmable LED Current with a range adjustable from 50mA to 300mA
  - LED Short Detection
  - Support of 16 LEDs in Common Anode configuration for SpO<sub>2</sub>, OHRM, Spectroscopy
- **PPG Receiver:**
  - Supports 5 PDs, 4 parallel receive paths
  - Noise filtering with programmable bandwidth
  - Trans-impedance Gain: 3.7k $\Omega$  to 1M $\Omega$
  - 8-bit Ambient Offset Subtraction DAC up to 256 $\mu$ A
  - 9-bit LED Offset Subtraction DAC up to 64 $\mu$ A
  - Digital Ambient Subtraction at ADC Output

### • EDA Signal Acquisition:

- Low-power continuous EDA and PPG acquisition using the ECG receiver
- Independent data rates for EDA and PPG acquisition with optimized power cycling
- High-accuracy EDA signal chain for spot-check EDA using the BIA signal chain
- Supports external clock and internal oscillator
- Option to operate 2 AFEs in parallel
- Option to configure the 5th PD input as a general purpose voltage measurement channel
- FIFO with 384-sample Depth, SPI™
- Supplies: RX, :1.7-1.9V, I/O: 1.15-1.9V, TX:3-5.5V

## 2 Applications

- Bio-Z, ECG, PPG, EDA on wearable devices
- Impedance spectroscopy
- Weight scales with body composition
- Current, voltage, impedance sensing

## 3 Description

The AFE4510 is a versatile signal acquisition system that supports acquiring PPG, EDA, ECG, and Bio-impedance signals. A PPG signal chain comprises a current driver for LEDs and a receiver that senses the signal from PDs. An ECG receiver with a Right-leg drive (RLD) can acquire a single-lead ECG from a pair of electrodes. An impedance measurement signal chain with integrated excitation & sense can be used for applications like BIA, EDA, and Impedance spectroscopy. The outputs of the various signal chains are digitized by a common ADC and stored in a FIFO which can be read out using an SPI interface

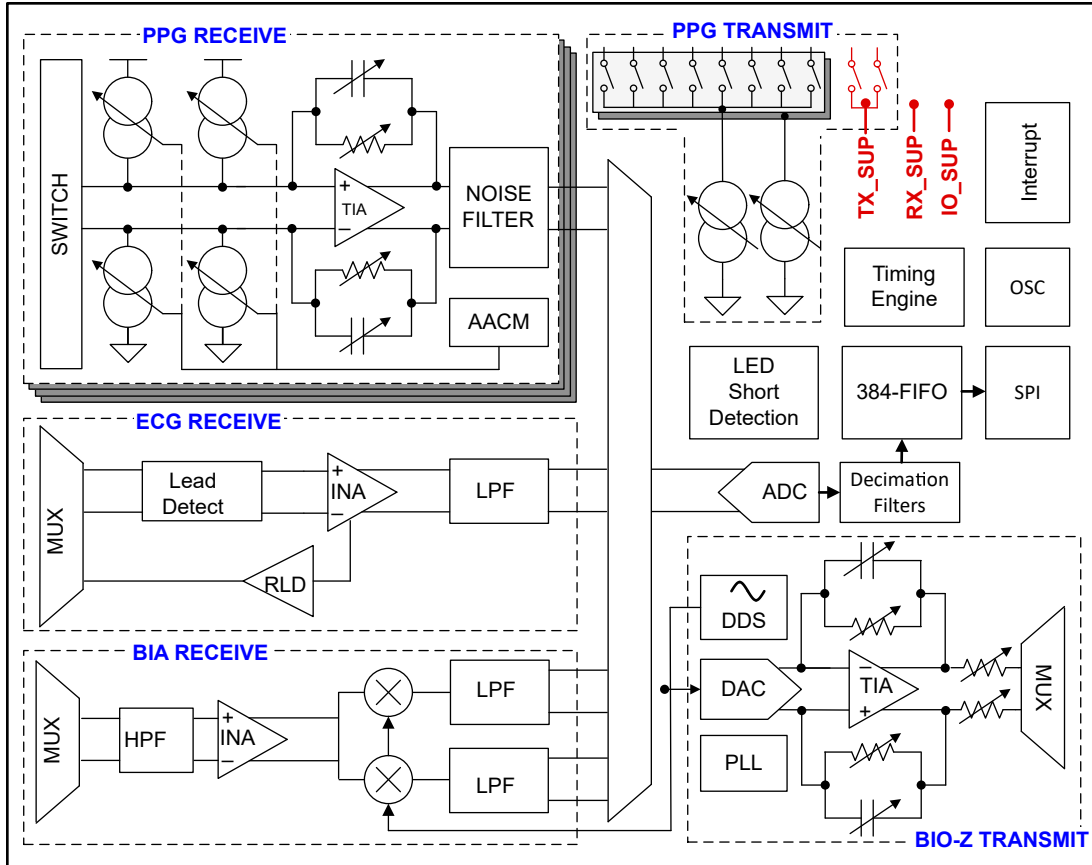
### Device Information

PART NUMBER	PACKAGE <sup>(1)</sup>	PACKAGE SIZE <sup>(2)</sup>
AFE4510	DSBGA (42)	2.9mm × 2.6mm

(1) For all available packages, see [Section 6](#).

(2) The package size (length × width) is a nominal value and includes pins, where applicable.





**Simplified Schematic**

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## 4 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

### 4.1 Abbreviations Used in this data sheet

**Bio-Z:** Bio-impedance. *Can be substituted with any other impedance that needs to be measured*

**BIA:** Bioelectrical Impedance analysis/ Bio-impedance analysis. *Refers to the measurement and analysis of Bio-impedance at one or more excitation frequencies. In this datasheet, the abbreviations BIA and Bio-Z are used interchangeably.*

**ECG:** Electrocardiography

**EDA:** Electro-dermal activity

**GSR:** Galvanic Skin response. Used interchangeably with EDA.

**HF-BIA:** High frequency Bio-impedance analysis.

**LF-BIA:** Low frequency Bio-impedance analysis

**MF-BIA:** Medium frequency Bio-impedance analysis

**OHRM:** Optical Heart-rate monitoring

**PPG:** Photoplethysmography

**PRF:** Pulse repetition frequency. *Derived from the PPG terminology which refers to the rate at which the LEDs are turned on (pulsed). Extended to denote the frequency of a periodically repetitive set of operations involving signal acquisition of PPG, ECG and/or Bio-Z signals.*

**RLD:** Right leg drive. *Derived from the clinical ECG terminology where the right leg is driven to set the DC bias of the body.*

### 4.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 4.3 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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### 4.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.

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### 4.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 4.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 5 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
March 2024	*	Initial Release

## 6 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
AFE4510YBGT	ACTIVE	DSBGA	YBG	42	250	RoHS & Green	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4510	Samples

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
AFE4510YBGT	DSBGA	YBG	42	250	330.0	12.4	2.74	3.14	0.64	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
AFE4510YBGT	DSBGA	YBG	42	250	345.0	365.0	55.0



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