TEXAS INSTRUMENTS

AFE4500 Ultra-Small, Integrated AFE for Bio-Impedance Analysis, Electrical Bio-sensing and Optical Bio-sensing

1 Features

- Integrated signal chains for Bio-Z, EDA, ECG, PPG
- Synchronized ECG, PPG enables PTT-based BP
- Bio-Z signal chain
  - Multi-frequency Body impedance Analysis (BIA) with frequency programmable up to 250 kHz
  - Low frequency excitation mode for EDA/GSR
  - Complex (I,Q) Tetrapolar impedance measurement
  - Sine-wave excitation with a 7-bit DAC
  - Calibration scheme compensates for electrode impedance to achieve accurate Bio-Z
  - State machine for Automatic Calibration
- ECG signal chain:
  - 1-lead ECG signal acquisition up to 2 kHz
  - INA gain programmable from 2-21
  - RLD output to set body bias through third electrode
  - Input noise (0.5-150 Hz): 0.75 µVrms at 1 kHz
  - ± 0.6 V differential DC offset and ± 0.3 V CM range
  - HPF with 0.4 Hz corner, quick saturation recovery
  - >1 GΩ input impedance, CMRR > 100 dB
  - Integrated 300 Hz anti-aliasing low pass filter
  - AC, DC lead-off detect: 1.6-nA to 100-nA
- PPG signal chain
  - Supports acquisition of up to 24 PPG signals
  - Flexible allocation of 8 LED, 4 PD in each phase
  - Supports PPG sensors at different data rates
  - Optical loopback SNR of 100-dB, extendable to 110-dB with on-chip filtering
  - Low Current for Continuous Operation with a Typical Value: 15-µA for an LED, 15-µA for the Receiver
- PPG Transmitter
  - 8-Bit Programmable LED Current with range adjustable from 25 mA to 250 mA
  - Programmable LED On-Time per-phase
  - Support of 8 LEDs in Common Anode
- PPG Receiver
  - Supports 4 PDs, 2 parallel receive paths
  - Noise filtering with programmable bandwidth
  - Trans-impedance Gain: 3.7 kΩ to 1 MΩ
  - 8-bit Ambient Offset Subtraction DAC with range from16-256 µA
  - 8-bit LED Offset Subtraction DAC with range from 32 to 64 µA
  - Automatic ambient & LED DC cancellation
  - Supports external clock and internal oscillator modes
  - FIFO with 256-sample Depth
  - SPI^{TM}, I^{2}C interfaces: Selectable by pin
  - Supplies: Rx:1.7-1.9V (LDO Bypass); 1.9 V to -3.6 V (LDO Enabled), Tx: 3 V to 5.5 V, IO:1.7-RX_SUP

2 Applications

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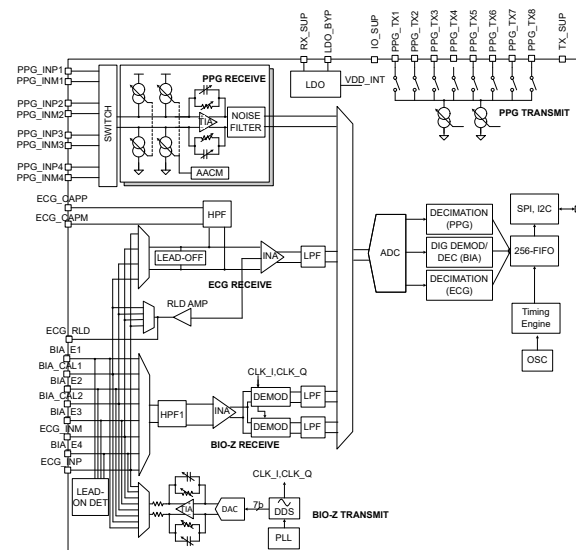- Current, voltage, impedance sensing

3 Description

The AFE4500 is a versatile signal acquisition system that supports three signal chains. An impedance measurement signal chain with integrated excitation and sense can be used for applications like Bio-impedance analysis (BIA), Electro-dermal analysis (EDA) and Impedance spectroscopy.

Device Information

PART NUMBER	PACKAGE[1]	BODY SIZE (NOM)
AFE4500	DSBGA	3 mm x 2.6 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Simplified Schematic

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4 Description (continued)

An ECG receiver with a Right-leg drive (RLD) can enable acquisition of a single-lead ECG from a pair of electrodes shared with the Bio-impedance measurement. A PPG signal chain comprises of a current driver for LEDs and a receiver that senses the signal from PDs. The outputs of the three signal chains are digitized by a common ADC and stored in a FIFO which can be read out using an SPI or I^{2}C interface

5 Revision History

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

DATE	REVISION	NOTES
April 2021	*	Initial release

6 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.

6.1 Documentation Support

Abbreviations used in this datasheet:

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*

6.1.1 Related Documentation

6.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* 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.

6.3 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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6.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.
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6.5 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.

6.6 Glossary

TI Glossary   This glossary lists and explains terms, acronyms, and definitions.

7 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
AFE4500YBGR	ACTIVE	DSBGA	YBG	42	3000	RoHS & Green	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4500	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

REEL DIMENSIONS

Reel Diameter

Reel Width (W1)

TAPE DIMENSIONS

K0 | P1

B0 | W

Cavity | A0

A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE

Sprocket Holes

Q1 | Q2   Q1 | Q2
Q3 | Q4   Q3 | Q4

User Direction of Feed

Pocket Quadrants

*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
AFE4500YBGR	DSBGA	YBG	42	3000	330.0	12.4	2.74	3.14	0.64	8.0	12.0	Q1

PACKAGE MATERIALS INFORMATION

TAPE AND REEL BOX DIMENSIONS

*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
AFE4500YBGR	DSBGA	YBG	42	3000	345.0	365.0	55.0

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