

# 适用于生物阻抗分析、电生物传感和光学生物传感的 AFE4500 超小型、集成式 AFE

## 1 特性

- 集成的 Bio-Z、EDA、ECG 和 PPG 信号链
- 同步 ECG 和 ECG 可实现基于 PTT 的 BP
- Bio-Z 信号链
  - 多频人体阻抗分析 (BIA), 可编程频率高达 250kHz
  - 适用于 EDA/GSR 的低频激励模式
  - 复合 (I,Q) 四极阻抗测量
  - 具有 7 位 DAC 的正弦波激励
  - 校准方案可补偿电极阻抗, 实现准确的 Bio-Z
  - 自动校准状态机
- ECG 信号链:
  - 频率高达 2kHz 的单引线 ECG 信号采集
  - INA 增益在 2 至 21 的范围内可进行编程
  - RLD 输出通过第三电极设置人体偏置
  - 输入噪声 (0.5Hz 至 150Hz): 1kHz 时为 0.75 $\mu$ Vrms
  - $\pm 0.6$ V 差分直流失调电压和  $\pm 0.3$ V 共模范围
  - 具有 0.4Hz 拐角频率的高通滤波器, 可实现快速饱和恢复
  - $>1$ G $\Omega$  输入阻抗, CMRR  $> 100$ dB
  - 集成式 300Hz 抗混叠低通滤波器
  - 交流、直流导联脱落检测: 1.6nA 至 100nA
- PPG 信号链
  - 支持采集多达 24 个 PPG 信号
  - 在每个相位内均可实现灵活的 8 个 LED、4 个 PD 分配
  - 支持采用不同数据速率的 PPG 传感器
  - 光学回送 SNR 为 100dB, 可通过片上滤波扩展至 110dB
  - 实现持续运行的低电流, 其典型值为: LED 为 15  $\mu$ A, 接收器为 15  $\mu$ A
- PPG 发送器
  - 8 位可编程 LED 电流, 可调范围为 25mA 至 250mA
  - 每相位可编程 LED 导通时间
  - 支持 8 个采用共阳极配置的 LED
- PPG 接收器
  - 支持 4 个 PD、2 个并行接收路径
  - 具有可编程带宽的噪声滤波功能
  - 跨阻增益: 3.7k $\Omega$  至 1M $\Omega$
  - 8 位环境失调电压减法 DAC (范围为 16 $\mu$ A 至 256 $\mu$ A)
  - 8 位 LED 失调电压减法 DAC (范围为 32 $\mu$ A 至 64 $\mu$ A)
  - 自动环境消除和 LED 直流消除

- 支持外部时钟和内部振荡器模式
- 采样深度为 256 的 FIFO
- SPI™, I<sup>2</sup>C 接口: 可通过引脚进行选择
- 电源: Rx: 1.7V 至 1.9V (LDO 旁路), 1.9V 至 3.6V (LDO 使能); Tx: 3V 至 5.5V, IO:1.7-RX\_SUP

## 2 应用

- 可穿戴设备上的 Bio-Z、ECG、PPG、EDA 和 BP
- 阻抗谱分析
- 可进行人体成分测量的体重秤
- 电流、电压和电阻感应

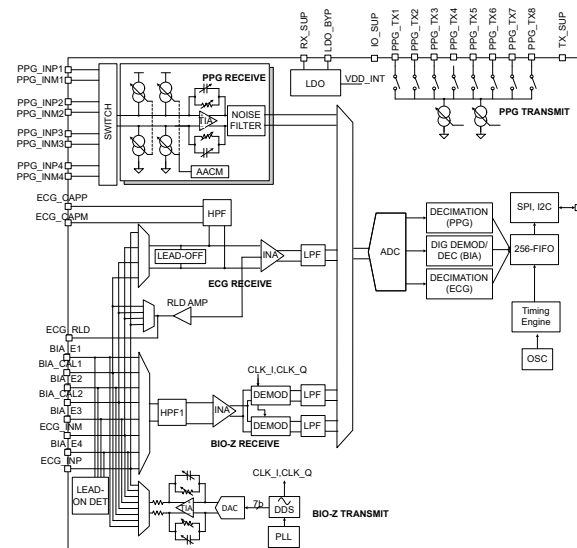
## 3 说明

AFE4500 是一种多功能信号采集系统, 支持三种信号链。具有集成激励和感应功能的阻抗测量信号链可用于生物阻抗分析 (BIA)、皮肤电反应分析 (EDA) 和阻抗谱分析等应用。

### 器件信息

器件型号	封装 <sup>(1)</sup>	封装尺寸 (标称值)
AFE4500	DSBGA	3mm x 2.6mm

(1) 如需了解所有可用封装, 请参阅数据表末尾的可订购产品附录。



简化版原理图



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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<sup>2</sup>C interface

## 5 Revision History

注：以前版本的页码可能与当前版本的页码不同

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 接收文档更新通知

要接收文档更新通知，请导航至 [ti.com](http://ti.com) 上的器件产品文件夹。点击 [订阅更新](#) 进行注册，即可每周接收产品信息更改摘要。有关更改的详细信息，请查看任何已修订文档中包含的修订历史记录。

### 6.3 支持资源

**TI E2E™ 支持论坛** 是工程师的重要参考资料，可直接从专家获得快速、经过验证的解答和设计帮助。搜索现有解答或提出自己的问题可获得所需的快速设计帮助。

链接的内容由各个贡献者“按原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的《[使用条款](#)》。

### 6.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.

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### 6.5 静电放电警告



静电放电 (ESD) 会损坏这个集成电路。德州仪器 (TI) 建议通过适当的预防措施处理所有集成电路。如果不遵守正确的处理和安装程序，可能会损坏集成电路。

ESD 的损坏小至导致微小的性能降级，大至整个器件故障。精密的集成电路可能更容易受到损坏，这是因为非常细微的参数更改都可能会导致器件与其发布的规格不相符。

## 6.6 术语表

[TI 术语表](#) 本术语表列出并解释了术语、首字母缩略词和定义。

## 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	<a href="#">Samples</a>
AFE4500YBGT	ACTIVE	DSBGA	YBG	42	250	RoHS & Green	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4500	<a href="#">Samples</a>

(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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