

AFE159x Low-Power, 4-Channel, 24-Bit Analog Front-Ends for Bio-Potential Measurements

1 Features

- Integrated Signal Chain for ECG, Pace Detection, and Respiration Measurement
- **ECG Receiver**
 - Four high resolution channels at low power of 0.42mW/channel
 - Flexible four leads selectable from six electrodes
 - Programmable gain: 1.25 to 9
 - Input-referred noise: $4\mu\text{V}_{\text{PP}}$ in 150Hz BW
 - Differential input range: $\pm 1\text{V}$ with Gain = 4
 - CMRR: -140dB
 - Data rate: 125SPS to 128kSPS
- **Pace Detection**
 - On-chip digital pace detection algorithm on programmable two leads
 - High-speed 128kSPS pace output on two channels for software pace detection
- **Respiration**
 - Low-noise of $24\text{m}\Omega_{\text{PP}}$ with $2\text{k}\Omega$ body impedance and $1\text{k}\Omega$ defibrillator protection resistor on each electrode
 - Supports Sine and Square wave excitation
- **Other Features**
 - Built-in right leg drive amplifier steerable to any electrode
 - DC lead-off detection, AC lead impedance detection, Wilson Center Terminal (WCT), Goldberger Central Terminals (GCT), test signals
 - Battery voltage monitoring
 - Flexible power-down and standby modes
 - Built-in oscillator, PLL, and reference
 - 1k sample main FIFO and 2k sample pace FIFO
 - SPI-compatible serial interface
 - Analog supply voltage 1: 3.15V to 5.25V
 - Analog supply voltage 2: 1.7V to 1.9V
 - I/O supply voltage: 1.65V to 3.6V
- Supports systems meeting AAMI EC11, AMI EC13, AMI EC38, IEC60601-1, IEC60601-2-25, IEC60601-2-27, and IEC60601-2-51 standards

2 Applications

- Medical instrumentation (ECG, EMG, and EEG):
 - Bedside patient monitoring and diagnostic ECG
 - Portable telemetry
 - Holter monitor and multi-lead patch
- Event, stress, and vital sign monitors:
 - ECGs
 - AEDs
 - Telemedicine Bispectral Index (BIS)
 - Evoked Audio Potential (EAP)
 - Sleep study monitor

3 Description

The AFE1594 is a family of multichannel, simultaneous sampling, 24-bit, delta-sigma ($\Delta\Sigma$) analog-to-digital converters (ADCs) with built-in programmable gain Instrumentation Amplifiers (INAs), internal reference, and an on-chip PLL. The AFE supports digital pace pulse detection, thoracic impedance measurement and incorporates all of the features that are commonly required in medical electrocardiogram (ECG) and electroencephalogram (EEG) applications. Multiple AFE159x devices can be cascaded in high channel count systems. With high levels of integration and exceptional performance, the AFE159x enables the development of scalable medical instrumentation systems at significantly reduced size, power, and overall cost.

Package Information

PART NUMBER	PACKAGE ⁽¹⁾	PACKAGE SIZE ⁽²⁾
AFE1594	QFN	7mm × 7mm
AFE1593/AFE1594	WCSP	3.7mm × 3.7mm

- (1) For all available packages, see Mechanical, Packaging, and Orderable Information.
- (2) The package size (length × width) is a nominal value and includes pins, where applicable.



Table of Contents

1 Features	1	5.2 Support Resources.....	4
2 Applications	1	5.3 Trademarks.....	4
3 Description	1	5.4 Electrostatic Discharge Caution.....	4
4 Device Comparison	3	5.5 Glossary.....	4
5 Device and Documentation Support	4	6 Revision History	4
5.1 Receiving Notification of Documentation Updates.....	4		

4 Device Comparison

Table 4-1. Comparison of the features between the AFE159x variants

	AFE159RP3	AFE159RP4	AFE159P4	AFE1594
Number of ECG electrode pins	6	6	6	6
Number of ECG channels	3	4	4	4
Number of Respiration electrode pins	4	3/4 ⁽¹⁾	3/4 ^{(1) (2)}	3/4 ^{(1) (2)}
Number of Respiration receiver channel	1	1	-	-
Number of internal Pace detect channels	1	2	2	-

(1) 4 electrodes supported in WCSP package.

(2) Only RESP_OUT pins available, RESP_IN pins are NC.

5 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.

5.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on 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.

5.2 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.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

5.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

5.4 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.

5.5 Glossary

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

6 Revision History

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

Changes from Revision * (June 2024) to Revision A (July 2024)	Page
• Updated device status to Production Data.....	1

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
AFE1594RGZR	Active	Production	VQFN (RGZ) 48	2500 LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-20 to 85	AFE1594
AFE1594YAFR	Active	Production	DSBGA (YAF) 49	6000 LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE1594
AFE1594YAFT	Active	Production	DSBGA (YAF) 49	250 SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE1594
AFE159P4RGZR	Active	Production	VQFN (RGZ) 48	2500 LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-20 to 85	AFE159P4
AFE159P4RGZT	Active	Production	VQFN (RGZ) 48	250 SMALL T&R	Yes	NIPDAU	Level-3-260C-168 HR	-20 to 85	AFE159P4
AFE159P4YAFR	Active	Production	DSBGA (YAF) 49	6000 LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE159P4
AFE159P4YAFT	Active	Production	DSBGA (YAF) 49	250 SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE159P4
AFE159RP3YAFR	Active	Production	DSBGA (YAF) 49	6000 LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE159RP3
AFE159RP3YAFT	Active	Production	DSBGA (YAF) 49	250 SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE159RP3
AFE159RP4RGZR	Active	Production	VQFN (RGZ) 48	2500 LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-20 to 85	AFE159RP4
AFE159RP4RGZT	Active	Production	VQFN (RGZ) 48	250 SMALL T&R	Yes	NIPDAU	Level-3-260C-168 HR	-20 to 85	AFE159RP4
AFE159RP4YAFR	Active	Production	DSBGA (YAF) 49	6000 LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE159RP4
AFE159RP4YAFT	Active	Production	DSBGA (YAF) 49	250 SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE159RP4
PAFE159RP4RGZR	Active	Preproduction	VQFN (RGZ) 48	2500 LARGE T&R	-	Call TI	Call TI	-20 to 85	

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts 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.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

Important Information and Disclaimer:The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

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
AFE1594RGZR	VQFN	RGZ	48	2500	330.0	16.4	7.3	7.3	1.1	12.0	16.0	Q2
AFE1594YAFR	DSBGA	YAF	49	6000	330.0	12.4	3.91	3.96	0.81	8.0	12.0	Q1
AFE1594YAFT	DSBGA	YAF	49	250	180.0	12.4	3.91	3.96	0.81	8.0	12.0	Q1
AFE159P4RGZR	VQFN	RGZ	48	2500	330.0	16.4	7.3	7.3	1.1	12.0	16.0	Q2
AFE159P4RGZT	VQFN	RGZ	48	250	180.0	16.4	7.3	7.3	1.1	12.0	16.0	Q2
AFE159P4YAFR	DSBGA	YAF	49	6000	330.0	12.4	3.91	3.96	0.81	8.0	12.0	Q1
AFE159P4YAFT	DSBGA	YAF	49	250	180.0	12.4	3.91	3.96	0.81	8.0	12.0	Q1
AFE159RP3YAFR	DSBGA	YAF	49	6000	330.0	12.4	3.91	3.96	0.81	8.0	12.0	Q1
AFE159RP3YAFT	DSBGA	YAF	49	250	180.0	12.4	3.91	3.96	0.81	8.0	12.0	Q1
AFE159RP4RGZR	VQFN	RGZ	48	2500	330.0	16.4	7.3	7.3	1.1	12.0	16.0	Q2
AFE159RP4RGZT	VQFN	RGZ	48	250	180.0	16.4	7.3	7.3	1.1	12.0	16.0	Q2
AFE159RP4YAFR	DSBGA	YAF	49	6000	330.0	12.4	3.91	3.96	0.81	8.0	12.0	Q1
AFE159RP4YAFT	DSBGA	YAF	49	250	180.0	12.4	3.91	3.96	0.81	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)
AFE1594RGZR	VQFN	RGZ	48	2500	367.0	367.0	35.0
AFE1594YAFR	DSBGA	YAF	49	6000	335.0	335.0	25.0
AFE1594YAFT	DSBGA	YAF	49	250	182.0	182.0	20.0
AFE159P4RGZR	VQFN	RGZ	48	2500	367.0	367.0	35.0
AFE159P4RGZT	VQFN	RGZ	48	250	210.0	185.0	35.0
AFE159P4YAFR	DSBGA	YAF	49	6000	335.0	335.0	25.0
AFE159P4YAFT	DSBGA	YAF	49	250	182.0	182.0	20.0
AFE159RP3YAFR	DSBGA	YAF	49	6000	335.0	335.0	25.0
AFE159RP3YAFT	DSBGA	YAF	49	250	182.0	182.0	20.0
AFE159RP4RGZR	VQFN	RGZ	48	2500	367.0	367.0	35.0
AFE159RP4RGZT	VQFN	RGZ	48	250	210.0	185.0	35.0
AFE159RP4YAFR	DSBGA	YAF	49	6000	335.0	335.0	25.0
AFE159RP4YAFT	DSBGA	YAF	49	250	182.0	182.0	20.0

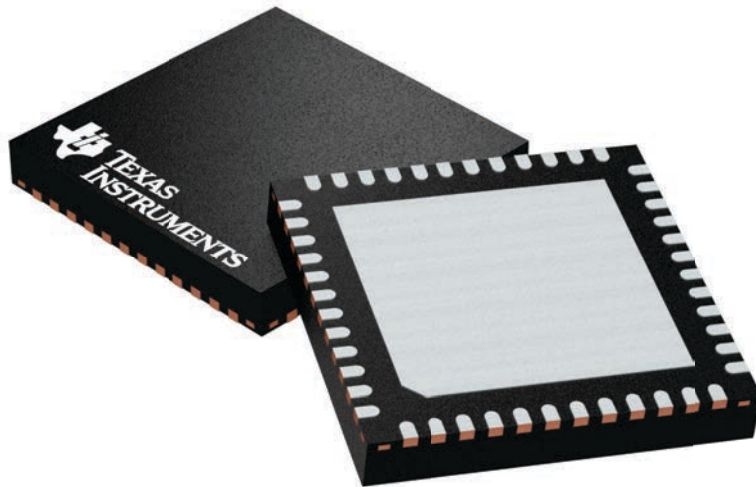
GENERIC PACKAGE VIEW

RGZ 48

VQFN - 1 mm max height

7 x 7, 0.5 mm pitch

PLASTIC QUADFLAT PACK- NO LEAD



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

4224671/A

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2025, Texas Instruments Incorporated