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: 4μV_{PP} in 150Hz BW
  - Differential input range: ±1V 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 24mΩ_{PP} with 2kΩ body impedance and 1kΩ 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 (ΔΣ) 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

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.

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5.3 Trademarks

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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
AFE1594RGZR.A	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
AFE1594YAFR.A	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
AFE1594YAFT.A	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
AFE159P4RGZR.A	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
AFE159P4RGZT.A	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
AFE159P4YAFR.A	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
AFE159P4YAFT.A	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
AFE159RP3YAFR.A	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
AFE159RP3YAFT.A	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
AFE159RP4RGZR.A	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
AFE159RP4RGZT.A	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
AFE159RP4YAFR.A	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
AFE159RP4YAFT.A	Active	Production	DSBGA (YAF) | 49	250 | SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-20 to 85	AFE159RP4
PAFE159RP4RGZR.A	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.

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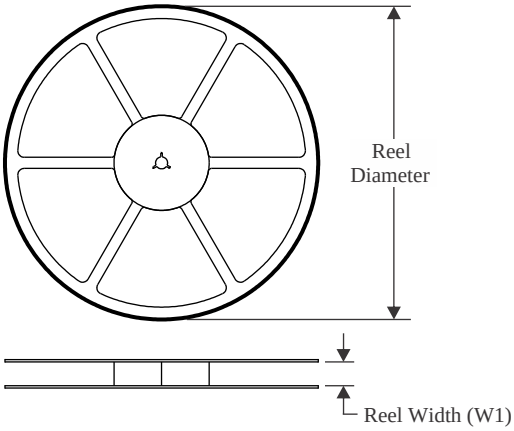
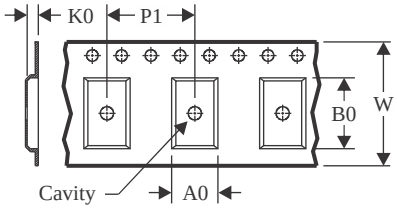
TAPE AND REEL INFORMATION

REEL DIMENSIONS

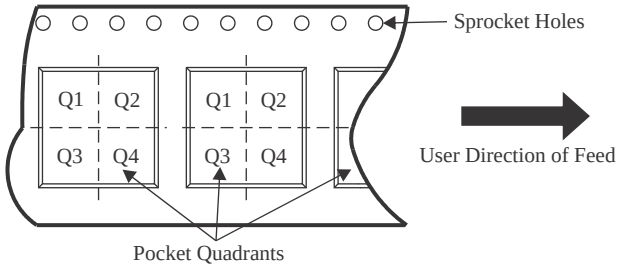


TAPE DIMENSIONS



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

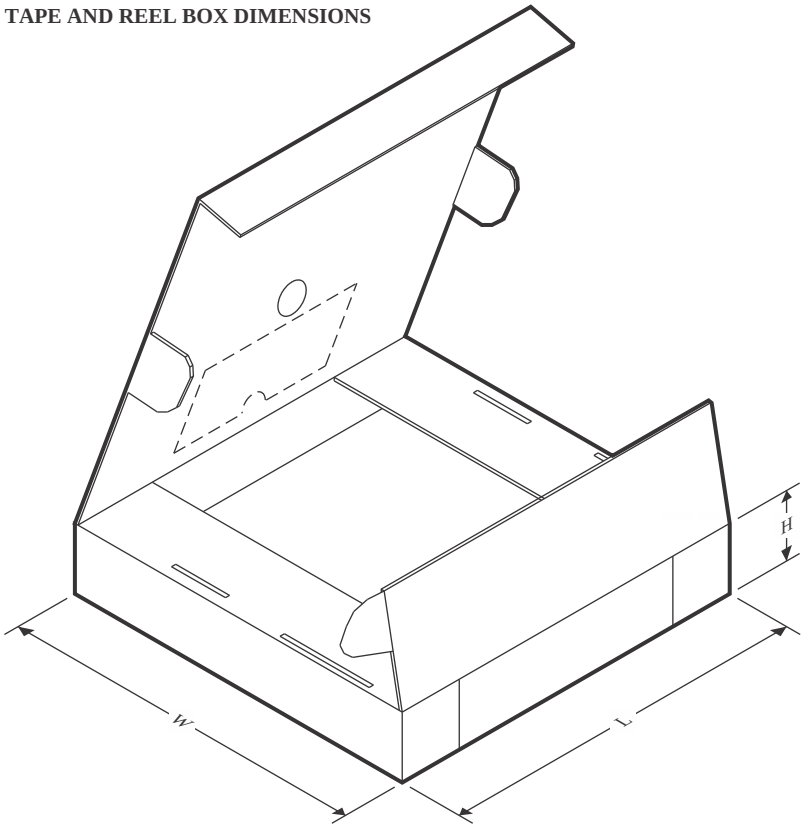
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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

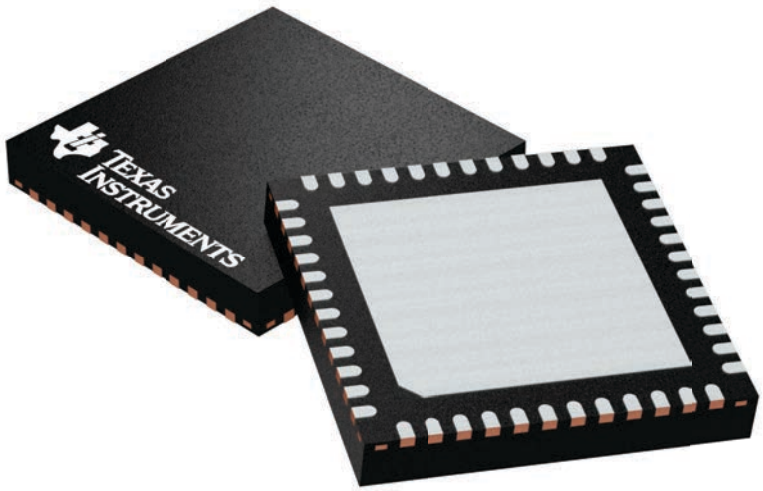
GENERIC PACKAGE VIEW

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.

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