

## MAX32663A

## Ultra-Low Power ECG Biometric Sensor Hub

### General Description

The MAX32663A is a low-power sensor hub with embedded firmware and HeartKey® ECG algorithms from B-Secur for wearable and medical devices. It enables seamless communication with Maxim's low-power ECG sensors (e.g., the MAX30003), providing a complete solution that delivers health information and insights to an application.

Time to market is faster with this proven ECG solution that offers low power consumption, accurate and robust health data, and a tiny form factor, all while removing the licensing burden from the application.

### Applications

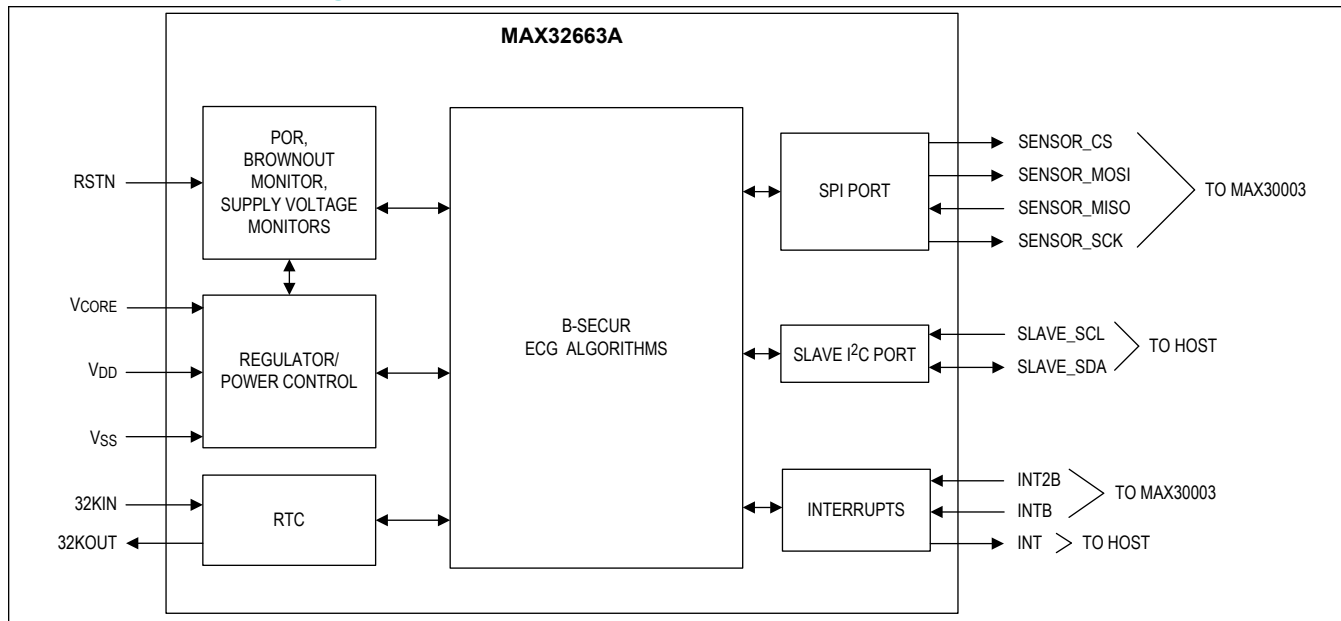
- Wearable Fitness
- Hearables
- Wearable Medical
- Portable Medical
- Mobile Devices

### Benefits and Features

- Three Different Versions
  - Version FS (Full HeartKey Suite)
    - Heart Rate, Heart Rate Variability, Stress Level Index, Energy Expenditure and User Identification
  - Version W (Health and Wellness)
    - Heart Rate, Heart Rate Variability, Stress Level Index and Energy Expenditure
  - Version UI (User Identification)
    - User Identification
- Biometric Sensor Hub Enables Faster Time to Market
- Removes Software Licensing Burden
- One Slave I<sup>2</sup>C for Communication with a Host Microcontroller
- One Master I<sup>2</sup>C for Communication with Sensors
- Manages the Ultra-Low Power-Hardware for Increased Efficiency
- First-In First-Out (FIFO) Provides Minimal Host Interaction
- Easily Integrate with Maxim's Low-Power ECG AFEs (e.g., MAX30003)
- Tiny Form Factors for Footprint-Constrained Designs
  - 3mm x 3mm TQFN
  - 1.6mm x 1.6mm WLP

[Ordering Information](#) appears at end of data sheet.

Simplified Block Diagram



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### Absolute Maximum Ratings

V <sub>DD</sub> .....	-0.3V to +3.63V	Output Current (source) by Any Digital Pin.....	-25mA
32KIN, 32KOUT .....	-0.3V to V <sub>DD</sub> + 0.3V	Continuous Package Power Dissipation 24 TQFN-EP (multilayer board) T <sub>A</sub> = +70°C (derate 16.3mW/°C above +70°C)...	1305mW
All Digital Pins .....	-0.3V to V <sub>DD</sub> + 0.3V	Operating Temperature Range .....	-40°C to +105°C
Total Current into All Digital Pins Combined (sink) .....	100mA	Storage Temperature Range .....	-65°C to +150°C
V <sub>SS</sub> .....	100mA	Soldering Temperature (reflow) .....	+260°C
Output Current (sink) by Any Digital Pin.....	25mA		

**Note:** All voltages with respect to V<sub>SS</sub>, unless otherwise noted.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

### Package Information

#### 24 TQFN-EP

Package Code	T2433+2C
Outline Number	<a href="#">21-100264</a>
Land Pattern Number	<a href="#">90-100089</a>
<b>Thermal Resistance, Four-Layer Board:</b>	
Junction to Ambient (θ <sub>JA</sub> )	61.3°C/W
Junction to Case (θ <sub>JC</sub> )	2.2°C/W

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://www.maximintegrated.com/packages). Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to [www.maximintegrated.com/thermal-tutorial](http://www.maximintegrated.com/thermal-tutorial).

### Electrical Characteristics

(Limits are 100% tested at T<sub>A</sub> = +25°C and T<sub>A</sub> = +105°C. Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Specifications marked GBD are guaranteed by design and not production tested. Specifications to the minimum operating temperature are guaranteed by design and are not production tested.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>POWER SUPPLIES</b>						
Supply Voltage	V <sub>DD</sub>		1.71	1.8	3.63	V
Power-Fail Reset Voltage	V <sub>RST</sub>	Monitors V <sub>DD</sub>	1.63		1.71	V
Power-On Reset Voltage	V <sub>POR</sub>	Monitors V <sub>DD</sub>		1.4		V
<b>DIGITAL I/O</b>						
Input Low Voltage for RSTN, SLAVE_SCL, SLAVE_SDA, SENSOR_MISO, INTB, INT2B	V <sub>IL</sub>				0.3 × V <sub>DD</sub>	V
Input High Voltage for RSTN, SLAVE_SCL, SLAVE_SDA, SENSOR_MISO, INTB, INT2B	V <sub>IH</sub>		0.7 × V <sub>DD</sub>			V

**Electrical Characteristics (continued)**

(Limits are 100% tested at  $T_A = +25^\circ\text{C}$  and  $T_A = +105^\circ\text{C}$ . Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Specifications marked GBD are guaranteed by design and not production tested. Specifications to the minimum operating temperature are guaranteed by design and are not production tested.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output Low Voltage for SENSOR_MOSI, SENSOR_SCK, INT	$V_{OL}$	$V_{DD} = 1.71\text{V}$ , $I_{OL} = 1\text{mA}$		0.2	0.4	V
Output High Voltage for SENSOR_MOSI, SENSOR_SCK, INT	$V_{OH}$	$V_{DD} = 1.71\text{V}$ , $I_{OH} = 1\text{mA}$	$V_{DD} - 0.4$			V
Output Low Voltage for SLAVE_SDA	$V_{OL}$	$V_{DD} = 1.71\text{V}$ , $I_{OL} = 2\text{mA}$		0.2	0.4	V
Input Hysteresis (Schmitt)	$V_{IHYS}$			300		mV
Input/Output Pin Capacitance for All Pins	$C_{IO}$			4		pF
Input Leakage Current Low	$I_{IL}$	$V_{IN} = 0\text{V}$	-500		+500	nA
Input Leakage Current High	$I_{IH}$	$V_{IN} = 3.6\text{V}$	-500		+500	nA
Input Pullup Resistor to RSTN	$R_{PU\_VDD}$	Pullup to $V_{DD} = 3.63\text{V}$		10.5		k $\Omega$
<b>CLOCKS</b>						
System Clock Frequency	$f_{SYS\_CLK}$			96		MHz
RTC Input Frequency	$f_{32KIN}$	32.768kHz watch crystal, $C_L = 6\text{pF}$ , $ESR < 90\text{k}\Omega$ , $C_0 < 2\text{pF}$		32.768		kHz
RTC Operating Current	$I_{RTC}$	All power modes, RTC enabled		0.45		$\mu\text{A}$
RTC Power-Up Time	$t_{RTC\_ON}$			250		ms

**Electrical Characteristics— $I^2\text{C}$** 

(Limits are 100% tested at  $T_A = +25^\circ\text{C}$  and  $T_A = +105^\circ\text{C}$ . Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Specifications marked GBD are guaranteed by design and not production tested. Specifications to the minimum operating temperature are guaranteed by design and are not production tested.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>FAST MODE</b>						
Output Fall Time	$t_{OF}$	From $V_{OH(MIN)}$ to $V_{OL(MAX)}$		150		ns
Pulse Width Suppressed by Input Filter	$t_{SP}$			75		ns
SCL Clock Frequency	$f_{SCL}$		0		400	kHz
Low Period SCL Clock	$t_{LOW}$		1.3			$\mu\text{s}$
High Time SCL Clock	$t_{HIGH}$		0.6			$\mu\text{s}$
Setup Time for Repeated Start Condition	$t_{SU;STA}$		0.6			$\mu\text{s}$

**Electrical Characteristics—I<sup>2</sup>C (continued)**

(Limits are 100% tested at  $T_A = +25^\circ\text{C}$  and  $T_A = +105^\circ\text{C}$ . Limits over the operating temperature range and relevant supply voltage range are guaranteed by design and characterization. Specifications marked GBD are guaranteed by design and not production tested. Specifications to the minimum operating temperature are guaranteed by design and are not production tested.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Hold Time for Repeated Start Condition	$t_{HD;STA}$		0.6			$\mu\text{s}$
Data Setup Time	$t_{SU;DAT}$			125		ns
Data Hold Time	$t_{HD;DAT}$			10		ns
Rise Time for SDA and SCL	$t_R$			30		ns
Fall Time for SDA and SCL	$t_F$			30		ns
Setup Time for a Stop Condition	$t_{SU;STO}$		0.6			$\mu\text{s}$
Bus Free Time Between a Stop and Start Condition	$t_{BUS}$		1.3			$\mu\text{s}$
Data Valid Time	$t_{VD;DAT}$		0.9			$\mu\text{s}$
Data Valid Acknowledge Time	$t_{VD;ACK}$		0.9			$\mu\text{s}$

**Electrical Characteristics—SPI**

(Timing specifications are guaranteed by design and not production tested.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
<b>MASTER MODE</b>						
SPI Master Operating Frequency	$f_{MCK}$				48	MHz
SPI Master SCK Period	$t_{MCK}$			$1/f_{MCK}$		ns
SCK Output Pulse-Width High/Low	$t_{MCH}, t_{MCL}$		$t_{MCK}/2$			ns
MOSI Output Hold Time After SCK Sample Edge	$t_{MOH}$		$t_{MCK}/2$			ns
MOSI Output Valid to Sample Edge	$t_{MOV}$		$t_{MCK}/2$			ns
MISO Input Valid to SCK Sample Edge Setup	$t_{MIS}$			5		ns
MISO Input to SCK Sample Edge Hold	$t_{MIH}$			$t_{MCK}/2$		ns

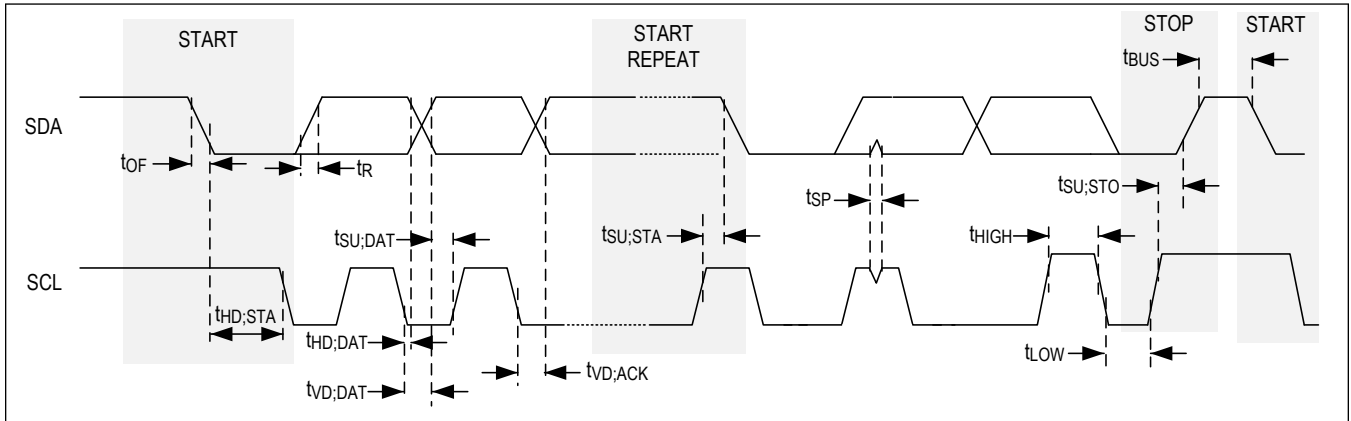


Figure 1. I<sup>2</sup>C Timing Diagram

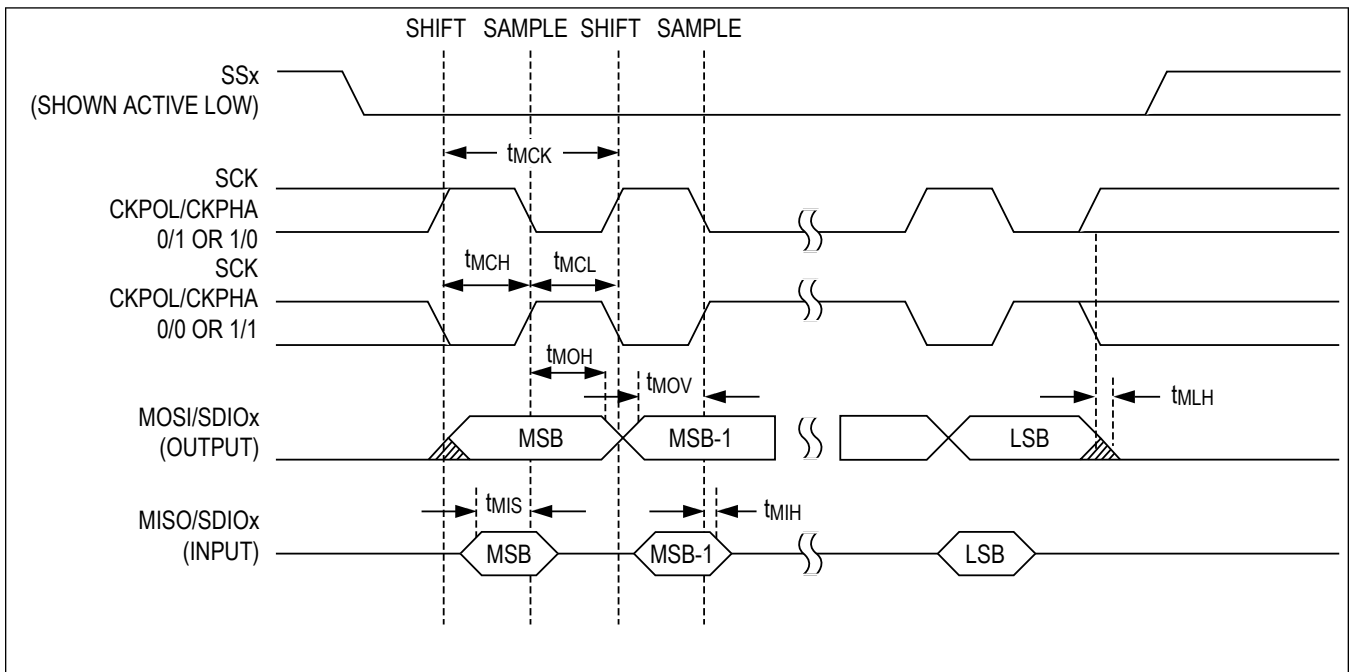
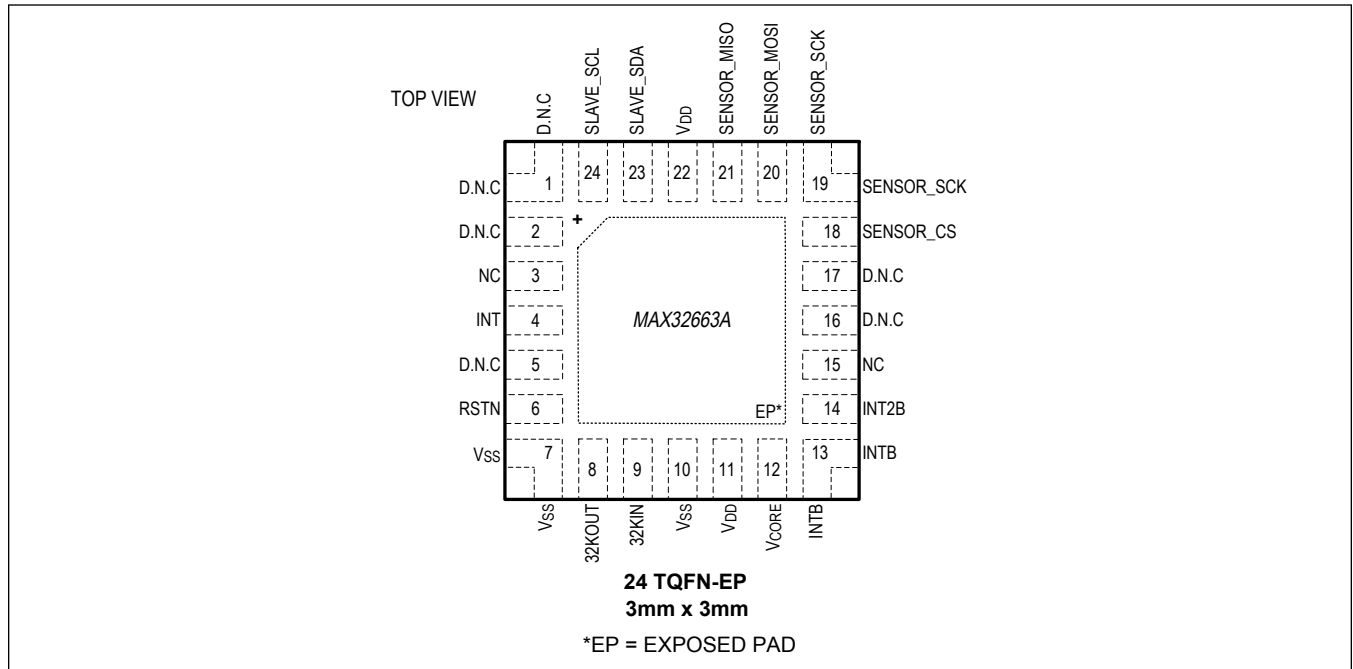


Figure 2. SPI Master Mode Timing Diagram

Pin Configuration



Pin Description

PIN	NAME	FUNCTION MODE	FUNCTION
		Signal Name	
<b>POWER</b>			
11, 22	V <sub>DD</sub>	Digital Supply Voltage	This pin must be bypassed to V <sub>SS</sub> with a 1.0µF capacitor as close as possible to the package. The device operates solely from this one power supply pin.
12	V <sub>CORE</sub>	Core Supply Voltage	V <sub>CORE</sub> must always be bypassed to V <sub>SS</sub> with a 1.0µF capacitor as close as possible to the package. Do not connect this device pin to any other circuits.
7, 10	V <sub>SS</sub>	Digital Ground	—
EP	EP	Exposed Pad	Exposed Pad (TQFN Only). This pad must be connected to V <sub>SS</sub> . Refer to <a href="#">Application Note 3273: Exposed Pads: A Brief Introduction</a> for additional information.
<b>CLOCK</b>			
9	32KIN	32.768kHz Crystal Oscillator Input	Connect a 32.768kHz crystal between 32KIN and 32KOUT for RTC operation. Optionally, an external clock source can be driven on 32KIN if the 32KOUT pin is left unconnected.
8	32KOUT	32.768kHz Crystal Oscillator Output	—

PIN	NAME	FUNCTION MODE	FUNCTION
		Signal Name	
<b>RESET</b>			
6	RSTN	Reset	External System Reset (Active-Low) Input. The device remains in reset while this pin is in its active state. When the pin transitions to its inactive state, the device performs a reset (resetting all logic on all supplies except for real-time clock circuitry) and begins execution. This pin is internally connected with an internal pullup to the $V_{DD}$ supply as indicated in the <i>Electrical Characteristics</i> table. Add and place a noise snubber circuit as close as possible to the device with component values shown in the <i>Typical Application Circuit</i> .
<b>SPI</b>			
19	SENSOR_SCK	SPI Master Clock for Sensors	This is the SPI master clock output that should be connected to the MAX30003 SCLK input.
21	SENSOR_MISO	SPI Master In Slave Out	This is the SPI master-in, slave-out that should be connected to the MAX30003 SDO pin.
20	SENSOR_MOSI	SPI Master Out Slave In	This is the SPI master-out, slave-in that should be connected to the MAX30003 SDI pin.
18	SENSOR_CS	Sensor Chip Select	This is the SPI master chip select output that should be connected to the MAX30003 CSB input.
<b>I<sup>2</sup>C</b>			
24	SLAVE_SCL	I <sup>2</sup> C Slave Clock	This is the I <sup>2</sup> C slave SCL that should be connected to the host I <sup>2</sup> C master SCL.
23	SLAVE_SDA	I <sup>2</sup> C Slave Data	This is the I <sup>2</sup> C slave SDA that should be connected to the host I <sup>2</sup> C master SDA.
<b>INTERRUPTS</b>			
14	INT2B	MAX30003 INT2B	This pin is an active-low interrupt input. It connects to the INT2B interrupt output of the MAX30003.
13	INTB	MAX30003 INTB	This pin is an active-low interrupt input. It connects to the INTB interrupt output of the MAX30003.
4	INT	Interrupt Output	This pin is asserted low by the MAX32663A when the device requires servicing through the I <sup>2</sup> C interface.
<b>DO NOT CONNECT</b>			
1, 2, 5, 16, 17	D.N.C.	Do Not Connect	This pin is internally connected. Do not make any electrical connection, including $V_{SS}$ , to this pin.
<b>NOT CONNECTED</b>			
3, 15	NC	Not Connected. This pin is not connected to the die and can be used to route any signal.	This pin is not connected to the die and can be used to route any signal.

## Detailed Description

### Three Different Versions of the MAX32663A

- Version FS (Full HeartKey Suite) includes all available ECG measurements in a single sensor hub.
  - Heart Rate, Heart Rate Variability, Stress Level Index, Energy Expenditure, and User Identification
- Version W (Health and Wellness) excludes the security portion to aim applications where the security portion of a design is not needed, and instead focuses on the health and wellness measurements.
  - Heart Rate, Heart Rate Variability, Stress Level Index, and Energy Expenditure
- Version UI (User Identification) is ideal when you need a method of identifying users before giving access to your end product.
  - User Identification

### Heart Rate (HR)

Heart rate provides one of the most common base insights into your body's health. The HeartKey Heart Rate algorithm is as accurate on dry electrodes as a medical Holter monitor using wet electrodes. When the signal quality is sufficient, an estimated heart rate is displayed after three intervals with medical-grade accuracy available after nine intervals.

### Heart Rate Variability (HRV)

HRV is a key indicator of heart health and is increasingly used as a metric for wellness as well. By calculating a quantitative measurement into the autonomous nervous system (ANS), it can provide insight into a user's health, including overtraining in athletes and as an input into stress measurements.

### Physiological Stress

In the U.S. alone, stress is estimated to cost 2.6% of the US GDP, which is equivalent to \$300 billion. The Stress algorithm allows a user to monitor their state in real time and take appropriate action. The Stress algorithm calculates a stress score between 0 to 100 on 30 interval windows, updating every 15 intervals.

### Energy Expenditure (EE)

Obesity is a leading contributor to health issues in a variety of areas. In 2015/2016 it was estimated that one in three adults in the USA were obese. One of the most effective ways of weight loss is through the tracking and management of calories. The EE algorithm uses physiological metadata and the ECG to calculate the amount of energy a user is using in real time.

### HeartKey User ID

The HeartKey User ID uses your ECG to identify you, give early insight of cardiac conditions, protecting your physiological data and personalizing wellness insights. Accuracy in real-world applications is 1:1000 and can be used as part of a multimodal approach to improve system security. Subjects can be identified in less than five beats where there is sufficient quality signal capture.

### Interface to Host

The interface to the host is the I<sup>2</sup>C interface. The devices support one slave interface with an address of 0x55. The features for this interface are as follows:

- One slave for communication with a host
- RESTART condition
- Fast mode: 400kbps
- Internal filter to reject noise spikes
- Receiver FIFO depth of 8 bytes
- Transmitter FIFO depth of 8 bytes

- Firmware bootloader

### **Interface to the Sensor**

The interface to the MAX30003 is a master SPI.

### **Device Selection**

See the *Ordering Information* table at the end of this data sheet for device selection by interface type.

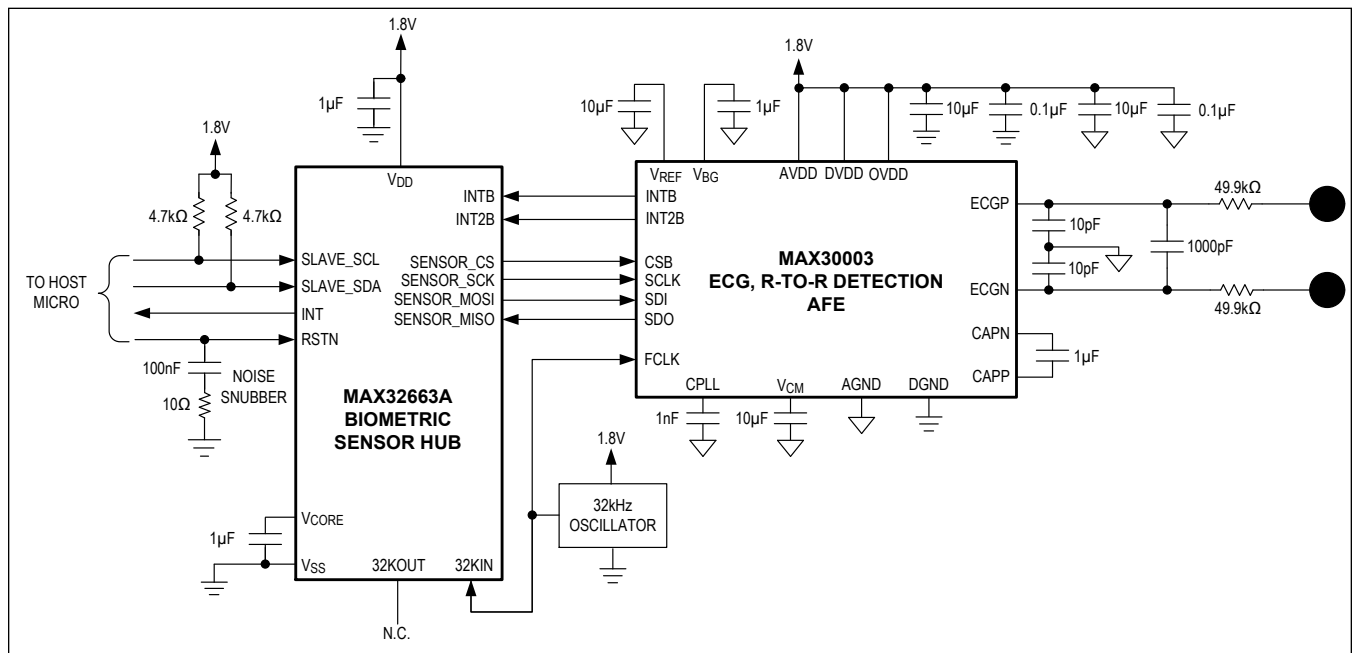
Applications Information

Table 1. Evaluation Platforms

DEVICE	PLATFORM
MAX32663A	MAX30003WING2#

Typical Application Circuits

MAX32663A and MAX30003 ECG Patch



## Ordering Information

PART	VERSION	PIN-PACKAGE
MAX32663AGTGFS+	FS (Full HeartKey Suite)	24 TQFN-EP (3mm x 3mm x 0.75mm, 0.4mm pitch)
MAX32663AGTGFS+T	FS (Full HeartKey Suite)	24 TQFN-EP (3mm x 3mm x 0.75mm, 0.4mm pitch)
MAX32663AGTGW+*	W (Health and Wellness)	24 TQFN-EP (3mm x 3mm x 0.75mm, 0.4mm pitch)
MAX32663AGTGW+T*	W (Health and Wellness)	24 TQFN-EP (3mm x 3mm x 0.75mm, 0.4mm pitch)
MAX32663AGTGUI+*	UI (User Identification)	24 TQFN-EP (3mm x 3mm x 0.75mm, 0.4mm pitch)
MAX32663AGTGUI+T*	UI (User Identification)	24 TQFN-EP (3mm x 3mm x 0.75mm, 0.4mm pitch)

+Denotes a lead(Pb)-free/RoHS-compliant package.

T = Tape and reel. Full reel.

\*Future product—contact factory for availability.

**Revision History**

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	11/20	Initial release	—

For pricing, delivery, and ordering information, please visit Maxim Integrated's online storefront at <https://www.maximintegrated.com/en/storefront/storefront.html>.

*Maxim Integrated cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim Integrated product. No circuit patent licenses are implied. Maxim Integrated reserves the right to change the circuitry and specifications without notice at any time. The parametric values (min and max limits) shown in the Electrical Characteristics table are guaranteed. Other parametric values quoted in this data sheet are provided for guidance.*

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