Parts: MAX30102, MAX14595, MAX1921

Meta keywords: MAXREFDES117, heart rate, SpO2, heart rate algorithm, hr monitor, pulse rate, pulse oximeter, wearables, wearable devices, optical heart rate sensor, Arduino, mbed

Meta description: Learn about Maxim's optical heart rate and pulse oximetry reference design, MAXREFDES67#.

Abstract: *The MAXREFDES67# reference design is a photoplethysmogram (PPG - optical) based heart rate and SpO2 sensor. MBED and Arduino firmware and hardware design files as well as lab measurements are provided. Boards are available for purchase.*

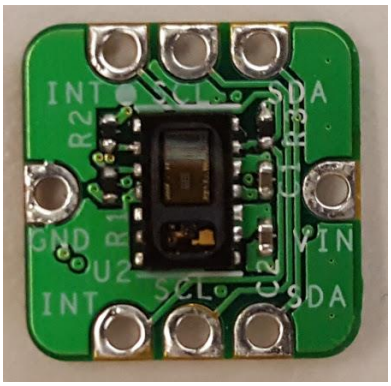
MAXREFDES117#: Heart Rate and Pulse Oximetry Monitor

<H1>Overview

The MAXREFDES117# reference design is a low power, optical heart rate module complete with integrated red and IR LEDs, and a power supply. This tiny board, perfect for wearable projects, may be placed on a finger or earlobe to accurately detect heart rate. This versatile module works with both Arduino and mbed platforms for quick testing, development and system integration. A basic, open source heart rate and SpO2 algorithm is included in the example firmware.

Comment [DA1]: I thought our algorithm only did HR?

The board features 8 sewing tap pads for attachment and quick electrical connection to a development platform. Refer to the Details tab for more information and performance data. Design files and firmware can be downloaded from the Design Resources tab. The board is available for purchase.



<<insert MAXREFDES117_Board.jpg>>

<H1>Introduction

Wearable devices hold the potential to transform health and medical monitoring. Heart rate, specifically, provides tremendous insight into heart function and health, during both activity and rest. Innovation and development of both optical semiconductors and lower power integrated circuits makes the transition to wearables possible. Until now, only large organizations, with deep development budgets, could deliver such advanced products.

MAXREFDES117# delivers the promise of wearable devices to all developers. This unique design measures both heart rate and pulse oximetry. MAXREFDES117# features the MAX30102 with integrated red and IR LEDs for heart rate and SpO2 detection. This configuration ideally detects heart rate and pulse ox on a person's fingertip, earlobe, or other fleshy extremity. The small board size of 0.5" x 0.5" is ideal for wearable applications and may be stitched into fabric for immediate prototyping. Firmware is available for both Arduino and mbed platforms, enabling users to develop with virtually any platform. User needs to provide a 2V to 5.5V supply at the power input, perfect for virtually any battery or Arduino form factor board.

The MAXREFDES117# design utilized the heart-rate/SpO2 sensor (MAX30102), an efficient, low power step-down converter (MAX1921), and an accurate level translator (MAX14595). The entire design typically operates at less than 5.5mW when using with the example firmware. A block diagram of the system is shown in **Figure 1**.

More detailed image (JPG, XXMB)
<< Insert board photo filename: MAXREFDES117_Board.JPG >>

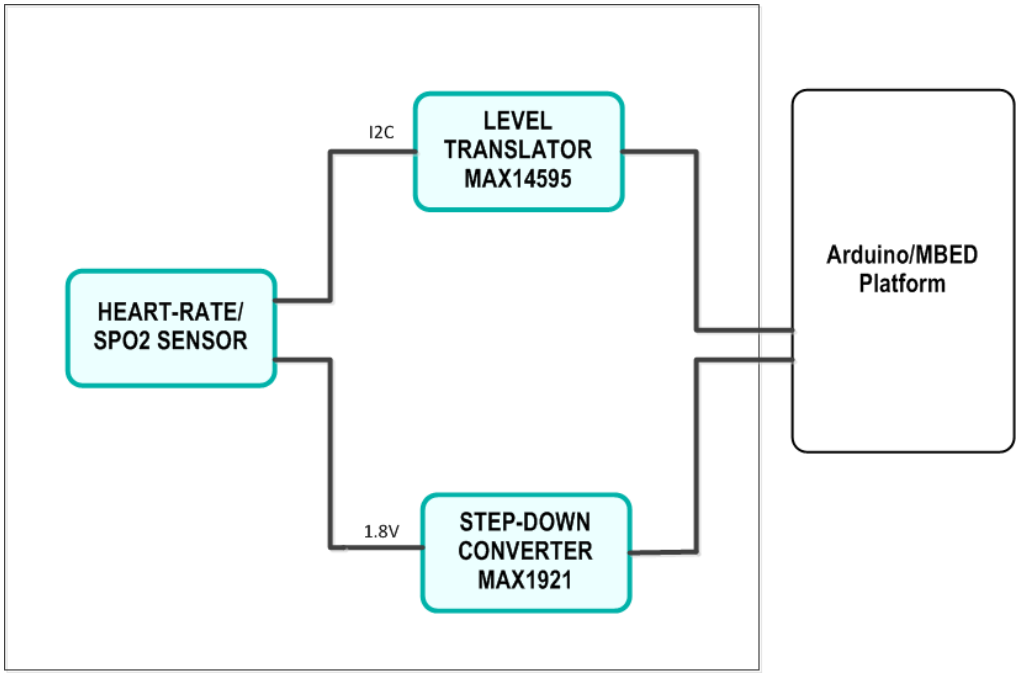


Figure 1.The MAXREFDES67# reference design block diagram.
<< Insert MAXREFDES117_block_diagram.vsd>>

<H1>Features

- Optical heart-rate monitor and pulse oximeter solution
- Tiny 0.5”x0.5” board size
- Low power
- Device drivers
- Free algorithm
- Example C source code for Arduino and mbed platforms
- Test data

Competitive Advantages

- Highly integrated, small size sensor
- Non-chest based heart rate/SpO2 detection
- Ultra-low power consumption

<H1>Applications

- Wearables
- Heart rate monitor
- Pulse oximeter

<H1>Detailed Description of Hardware

The power requirement is shown in **Table 1**.

Table 1. Power Requirement for the MAXREFDES117# Reference Design

Input Voltage (V)	Input Current (mA, typ)
2 to 5.5V	1.5mA (3.3V input)

Note: Controller board is powered separately

The MAXREFDES117# reference design is a photoplethysmopraphic (PPG) based heart rate and SpO2 monitor subsystem. The circuit utilizes the MAX30102 heart rate/SpO2 sensor with integrated red and IR LEDs. The step-down converter MAX1921 converts the 2V to 5.5V supply input and generates the 1.8V rail for the heart rate sensor. The MAX14595 level translator provides an interface between the heart rate/SpO2 sensor and the controller board, which generally use a different logic level.

<H1>Detailed Description of Firmware

The MAXREFDES117# can be used with virtually any microcontroller that has I2C interface. The Arduino and mbed example firmware have been tested on the following development platforms:

mbed:

- Maxim Integrated MAX32600MBED#
- Freescale FRDM-K64F
- Freescale FRDM-KL25Z

Arduino:

- Adafruit Flora
- Lilypad USB
- Arduino UNO

Users may read sampled data, calculated heart rate and SpO2 through a terminal program, allowing analysis on excel or any third-party software. The simple process flow is shown in **Figure 2**.

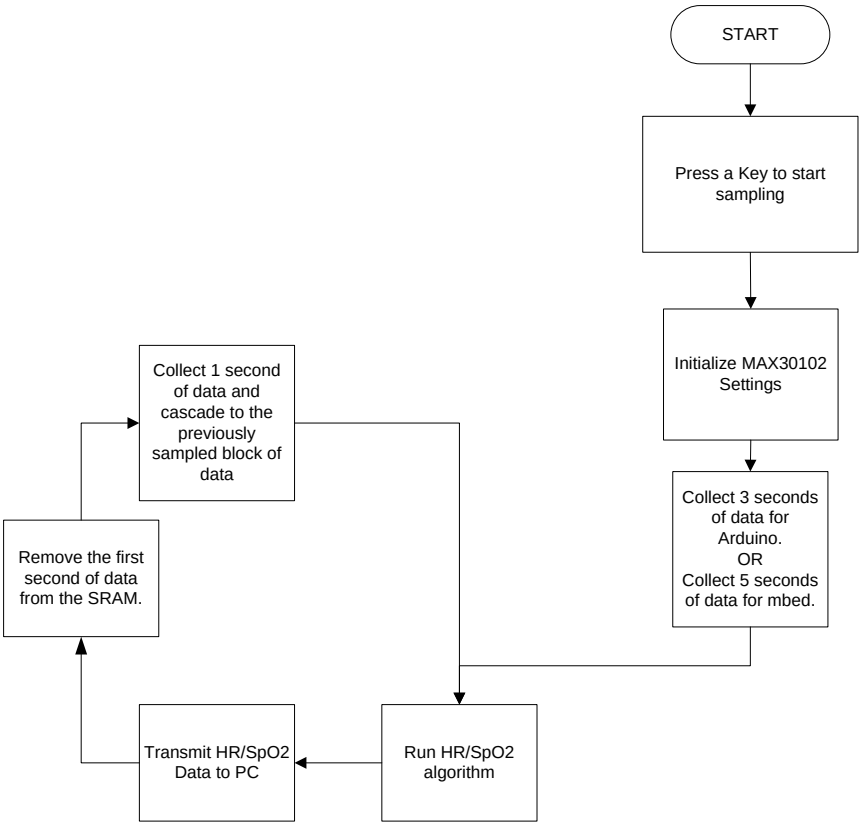


Figure 2. The MAXREFDES67# firmware flowchart.
<<Insert MAXREFDES67_Firmware_Flowchart.vsd >>

The complete source code is provided to speed up customer development. Code documentation can be found in the corresponding firmware platform files.

mbed platforms give more accurate heart rate/SpO2 calculations than the Arduino platforms because the mbed platform controllers have higher SRAM than the Arduino platform controllers. For the example firmware, mbed platforms store 5 seconds of samples collected at 100sps for calculation while the Arduino platforms only have enough memory to store 3 seconds of samples collected at 25sps.

SpO2 calculation is based on the equation shown below. However to determine the constants (C_1, C_2, and C_3) requires calibration and clinical study that involves lots of resources and analysis for population study. The clinical study was not done for this design, therefore the calculated SpO2 value may have error.

$$SpO2 = c_1 * AverageRatio^2 + c_2 * AverageRation + c_3$$

Where AverageRatio is the average ratio of IR and red LED readings. C_1, C_2, and C_3 are constants.

<H1>Quick Start

Required equipment:

- Windows PC with a USB port
- MAXREFDES117# board
- 5 cables that can be used to connect the MAXREFDES117# with the controller board
- One of the supported mbed or Arduino controller boards listed above
- One USB cable that is compatible with the selected controller board

Download, read, and carefully follow each step in the appropriate MAXREFDES117# quick Start Guide:
MAXREFDES117# mbed Quick Start Guide <<insert: Arduino Quick Start.pdf>>
MAXREFDES117# Arduino Quick Start Guide <<insert: MBED Quick Start.pdf>>

<H1>Lab Measurements

Equipment used:

- MAX32600MBED#
- Adafruit Flora
- Adafruit BlueFruit
- Polar H7 Bluetooth Smart Heart Rate Sensor
- Android tablet

Figure 3 and **Figure 4** show how the MAXREFDES117 calculated heart rate compared to the Polar H7 chest strap.

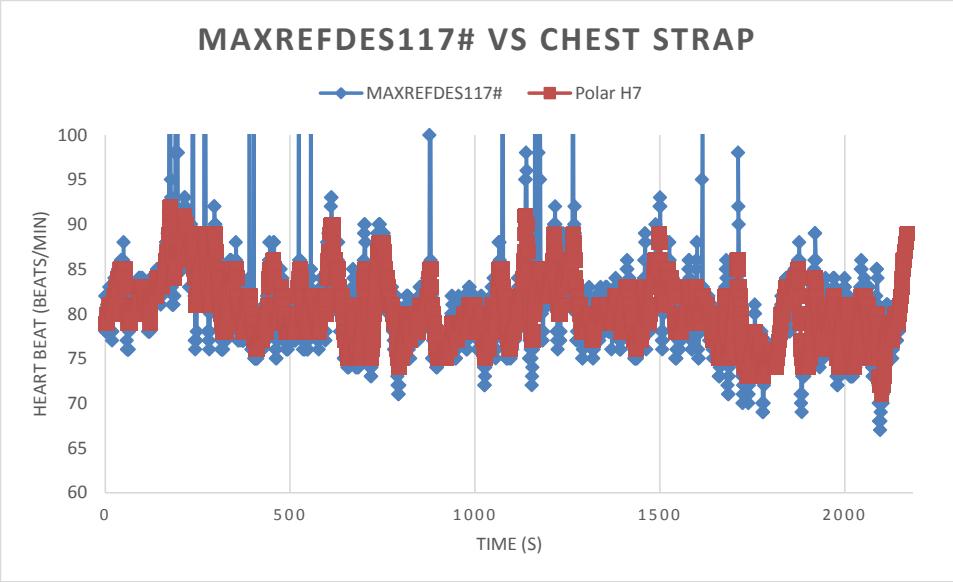


Figure 3. For sedentary test, over 96% of the mbed+MAXREFDES117 heart rate data are less than 5 beats/min delta from the Polar H7 chest strap

<< insert MAXREFDES117_test1.bmp >>

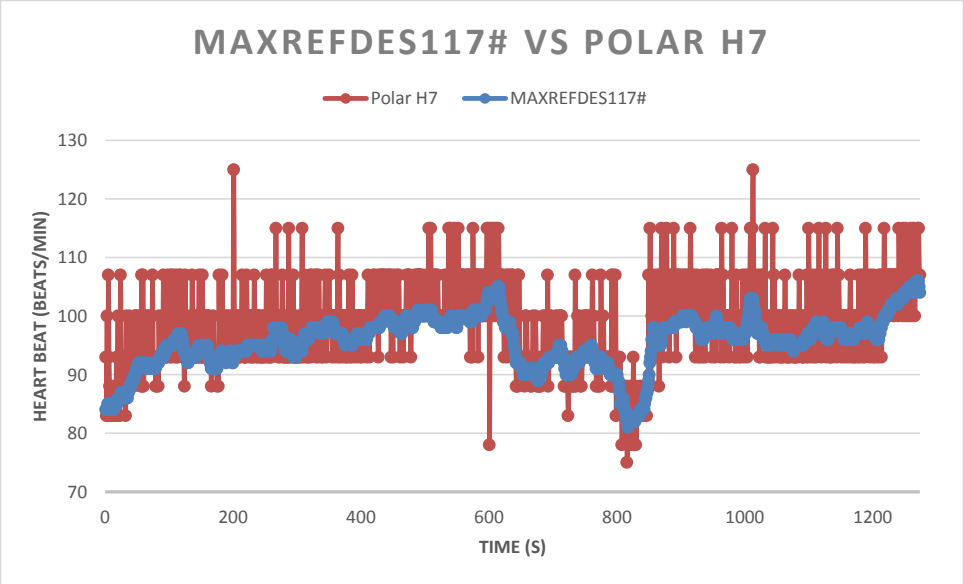


Figure 3. For moving test, over 92% of the Arduino+MAXREFDES117 heart rate data are less than 10 beats/min delta from the Polar H7 chest strap

<< insert MAXREFDES117_test2.bmp >>

<H1>All Design Files

Download All Design Files <<hyperlink to filename: RD117V01_00.zip>>

<H2>Hardware Files

<H3>Schematic <<hyperlink to filename: MAXREFDES117_SCH_RA.PDF>>

<H3>Bill of materials (BOM) <<hyperlink to filename MAXREFDES117_BOM_RA.PDF>>

<H3>PCB layout <<hyperlink to filename MAXREFDES117_LAYOUT_RA.PDF>>

<H3>PCB Gerber <<hyperlink to filenameMAXREFDES117_FAB_PACKAGE_RA.ZIP>>

<H3>PCB CAD (PADS 9.0) <<hyperlink to filename MAXREFDES117_CAD_RA.ZIP>>

<H2>Firmware Files

<H3>Arduino Platform <<hyperlink to filename RD117_ARDUINO_V01_00.zip>>

<H3>mbed Platform <<hyperlink to filename RD117_MBED_V01_00.zip>>

<H1>Buy Reference Design

MAXREFDES117#