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EASY PULSE SENSOR (VERSION 1.1) OVERVIEW (PART 1)

Posted on [April 20, 2013](#) | by [R-B](#) | [55 comments](#) |

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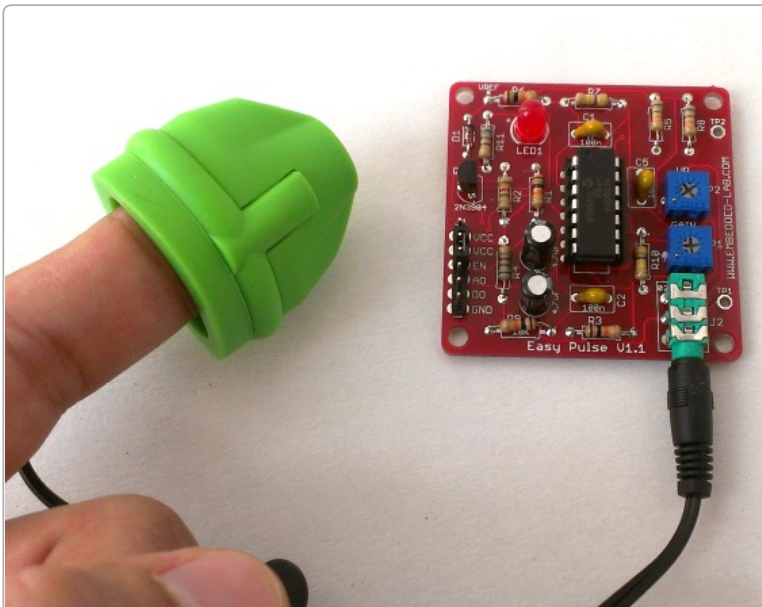
○ ○

The Easy Pulse sensor is designed for hobby and educational applications to illustrate the principle of photoplethysmography (PPG) as a non-invasive optical technique for detecting cardiovascular pulse wave from a fingertip. It uses an infrared light source to illuminate the finger on one side, and a photodetector placed on the other side measures the small variations in the transmitted light intensity. The variations in the photodetector signal are related to changes in blood volume inside the tissue. The signal is filtered and amplified to obtain a nice and clean PPG waveform, which is synchronous with the heart beat. The [original version of Easy Pulse](#) uses the TCRT1000 reflective optical sensor to sense the blood variation in the finger tissue and outputs a digital pulse which is synchronous with the heart beat. Today, we are pleased to announce the release of Easy Pulse Version 1.1, which has some improvements over the original design. The new version provides both analog PPG waveform as well as digital pulse signal as separate outputs. Easy Pulse Version 1.1 board is [available for purchase on Tindie](#). Recently, our Chinese distributor [Elecrow](#) has also started selling it for \$18.50, and they can ship it world-wide at lower cost.

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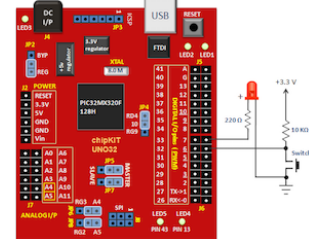
Easy Pulse version 1.1

Quick overview of Easy Pulse

The Easy Pulse sensor is based on the principle of photoplethysmography (PPG) which is a non-invasive method of measuring the variation in blood volume in tissues using a light source and a detector. Since the change in blood volume is synchronous to the heart beat, this technique can be used to calculate the heart rate. Transmittance and reflectance are two basic types of photoplethysmography. For the transmittance PPG, a light source is emitted in to the tissue and a light detector is placed in the opposite side of the tissue to measure the resultant light. Because of the limited penetration depth of the light through organ tissue, the transmittance PPG is applicable to a restricted body part, such as the finger or the ear lobe. However, in the reflectance PPG, the light source and the light detector are both placed on the same side of a body part. The light is emitted into the tissue and the reflected light is measured by the detector. As the light doesn't have to penetrate the body, the reflectance PPG can be applied to any parts of human body. In either case, the detected light reflected from or transmitted through the body part will fluctuate according to the pulsatile blood flow caused by the beating of the heart.

The original **Easy Pulse** design was based on the reflectance approach and used TCRT1000 IR device as sensor. It could detect the pulse signal when an user places his/her fingertip on the top of the sensor. While this sensor performed well, it was susceptible to a very small movement of the finger. So, the user should keep the finger very steady to obtain the accurate pulse signal. Easy Pulse Version 1.1 uses a more robust sensor (HRM-2155E) that operates in transmission mode and fits tight around the fingertip, thereby it is less prone to motion.

environment that uses powerful 32-bit PIC processors for hardware. Check out these [free comprehensive tutorials and DIY projects](#) that are intended to facilitate the learning of chipKIT interfacing and programming.



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Pulse Sensor

Pulse Heart Rate Monitor

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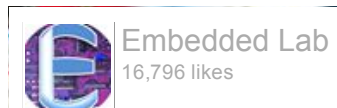
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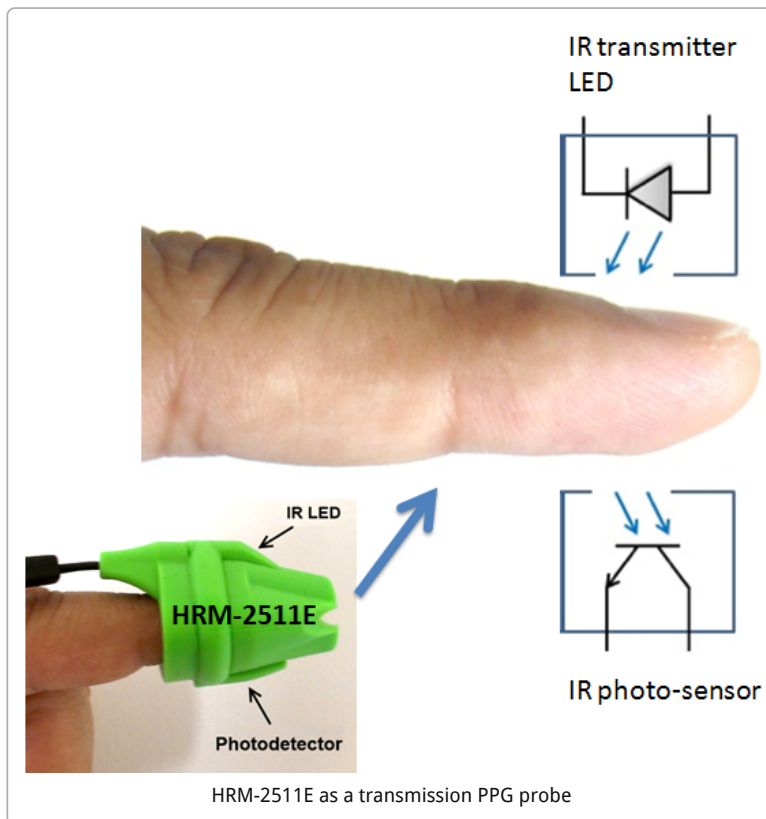
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The HRM-2511E sensor is manufactured by Kyoto Electronic Co., China, and operates in transmission mode. The sensor body is built with flexible Silicone rubber material that helps to keep the sensor tightly hold to the finger. Inside the sensor case, an IR LED and a photodetector are placed on two opposite sides and are facing each other. When a fingertip is plugged into the sensor, it is illuminated by the IR light coming from the LED. The photodetector diode receives the transmitted light through the tissue on other side. More or less light is transmitted depending on the tissue blood volume. Consequently, the transmitted light intensity varies with the pulsing of the blood with heart beat. A plot for this variation against time is referred to be a photoplethysmographic or PPG signal. The following picture shows a basic transmittance PPG probe setup to extract the pulse signal from the fingertip.



The PPG signal consists of a large DC component, which is attributed to the total blood volume of the examined tissue, and a pulsatile (AC) component, which is synchronous to the pumping action of the heart. The AC component, which carries vital information including the heart rate, is much smaller in magnitude than the DC component. A typical PPG waveform is shown in the figure below (not to scale).

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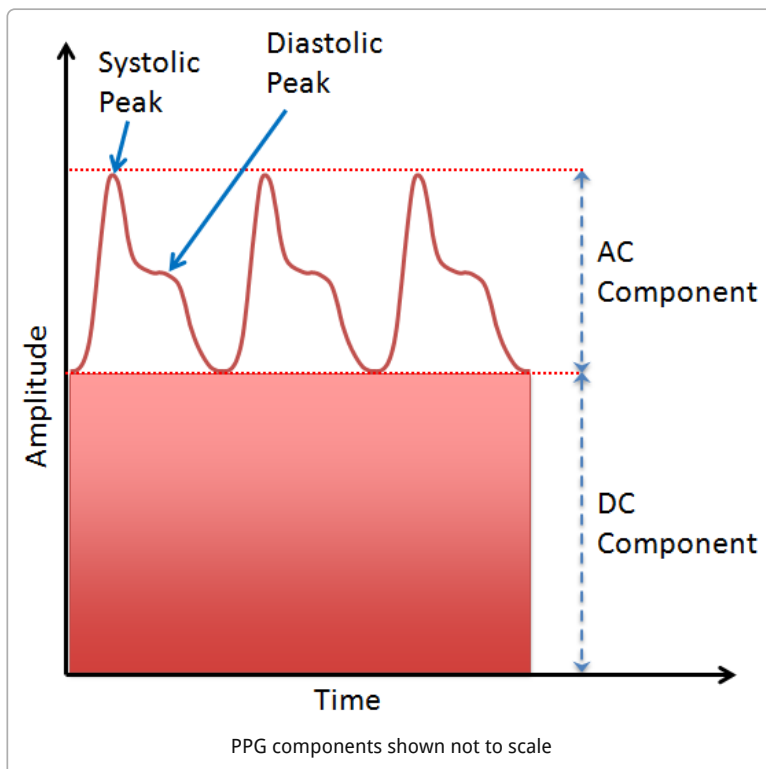
Infrared Sensor

Op Amp Sensor Circuit

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The two maxima observed in the PPG are called Systolic and Diastolic peaks, and they can provide valuable information about the cardiovascular system (this topic is outside the scope of this article). The time duration between two consecutive Systolic peaks gives the instantaneous heart rate.

Here are the features of Easy Pulse V1.1 sensor module.

- Uses HRM-2511E transmission PPG sensor for stable readings
- MCP6004 Opamp with rail-to-rail output capability for maximum signal swing
- Separate analog and digital outputs
- Potentiometer gain control for the analog output
- Pulse width control for the digital output
- Additional test points on board for analyzing signals at different stages of instrumentation

Circuit diagrams

The following circuit shows the ON/OFF control scheme for the infrared light source inside HRM-2511E. Note that the Enable signal must be pulled high in order to turn on the IR LED. The photodetector output (VSENSOR) contains the PPG signal that goes to a two-stage filter and amplifier circuit for further processing.

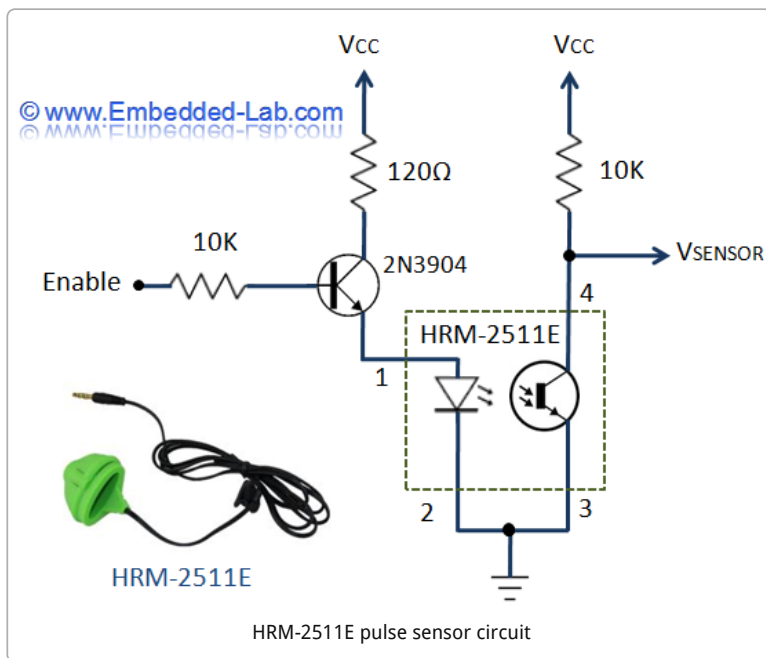
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IR Sensor

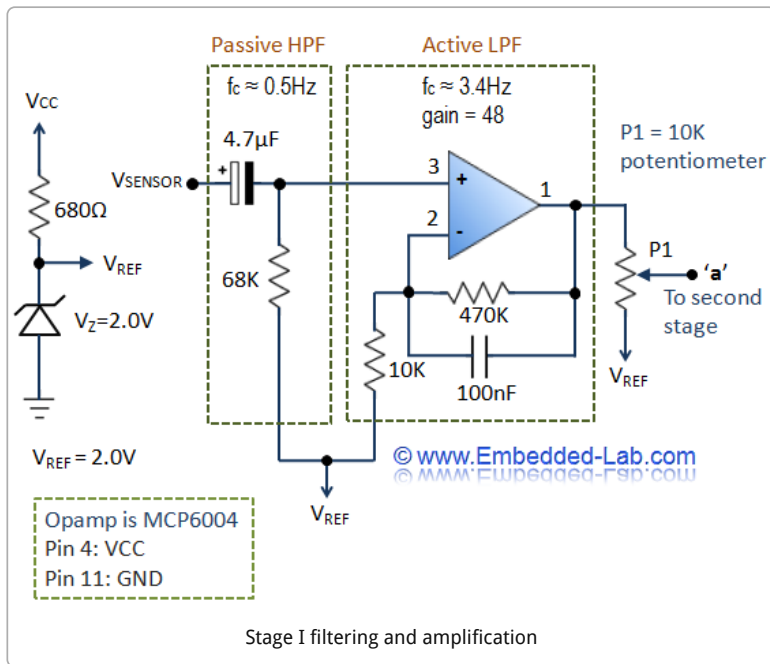
Sensor for Light

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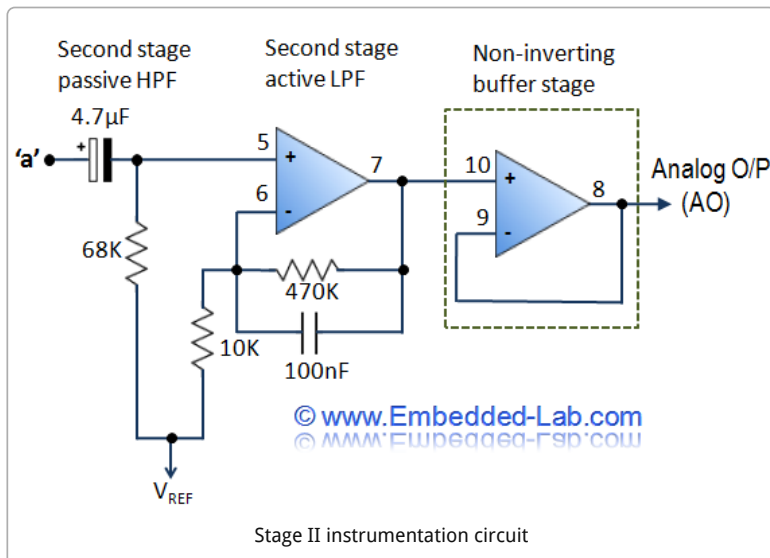
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The PPG signal coming from the photodetector is weak and noisy. So we need an amplifier and filter circuits to boost and clean the signal. In Stage I instrumentation, the signal is first passed through a passive (RC) high-pass filter (HPF) to block the DC component of the PPG signal. The cut-off frequency of the HPF is 0.5Hz, and is set by the values of R (=68K) and C (=4.7uF). The output from the HPF goes to an Opamp-based active low-pass filter (LPF). The Opamp operates in non-inverting mode and has gain and cut-off frequency set to 48 and 3.4Hz, respectively. In order to achieve a full swing of the PPG signal at the output, the negative input of the Opamp is tied to a reference voltage (Vref) of 2.0V. The Vref is generated using a zener diode. At the output is a potentiometer (P1) that acts as a manual gain control. The output from the active LPF now goes to Stage II instrumentation circuit, which is basically a replica of the Stage I circuit. Note that the amplitude of the signal going to the second stage is controlled by P1. The Opamp used in this project is MCP6004 from Microchip, which is a Quad-Opamp device and provides rail-to-rail output swing.

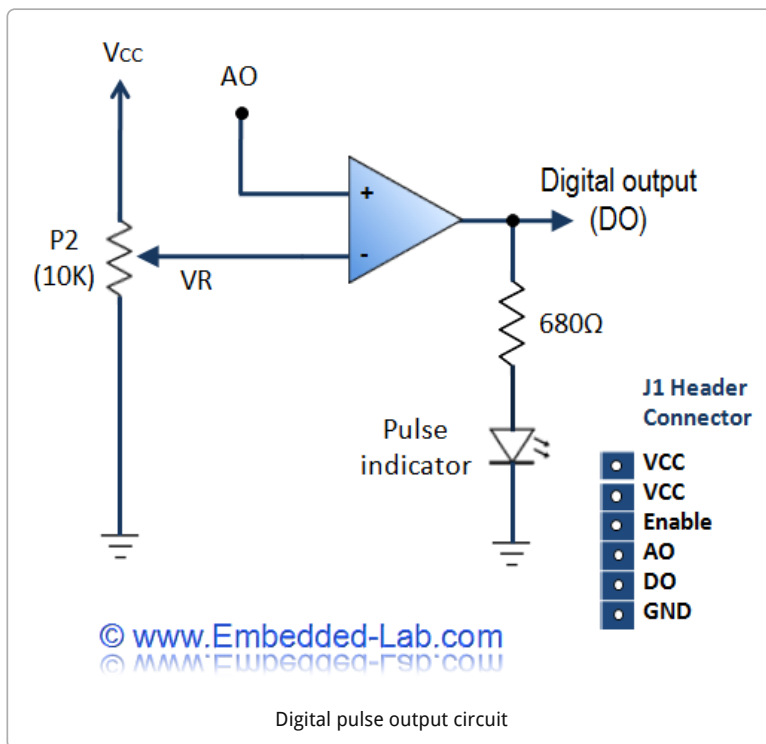


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The second stage also consists similar HPF and LPF circuits. The two-step amplified and filtered signal is now fed to a third Opamp, which is configured as a non-inverting buffer with unity gain. The output of the buffer provides the required analog PPG signal. The potentiometer P1 can be used to control the amplitude of the PPG signal appearing at the output of the buffer stage.

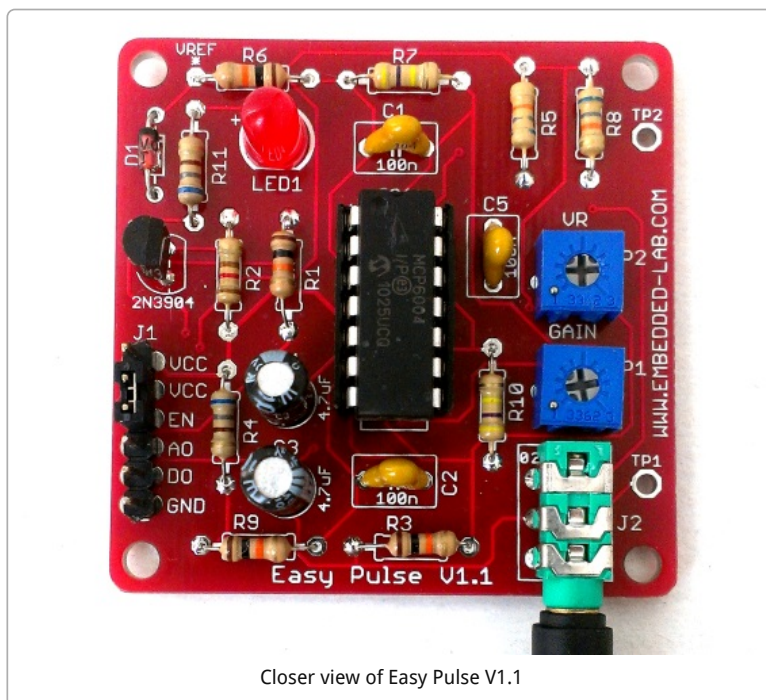


The fourth Opamp inside the MCP6004 device is used as a voltage comparator. The analog PPG signal is fed to the positive input and the negative input is tied to a reference voltage (VR). The magnitude of VR can be set anywhere between 0 and Vcc through potentiometer P2 (shown below). Every time the PPG pulse wave exceeds the threshold VR, the output of the comparator goes high. Thus, this arrangement provides an output digital pulse synchronous to heart beat. Note that the width of the pulse is also determined by VR. An LED connected to the digital output blinks accordingly.



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The following picture shows the Easy Pulse Version 1.1 board. The boards were manufactured by [Elecrow](http://www.elecrow.com), a company based in Shenzhen, China, which offers component sourcing, PCB manufacturing and assembly services. It turned out really good. The power supply, Enable, Analog PPG output (AO), and digital pulse output (DO) pins are accessible through the J1 headers. The HRM-2511E sensor connects to the board through a 3.5mm Audio Jack connector (J2). TP1 and TP2 are test pads on the circuit board that are connected to the raw PPG output signal (VSENSOR) and Stage I output ('a'), respectively.



The sensor operation and output waveforms of Easy Pulse V1.1 are discussed in the second part of this article. [Click here to read Part 2 of this article.](#)

For US customers, [Click here to buy Easy Pulse Version 1.1](#)

Update (05/26/2013)

Easy Pulse version 1.1 boards are now also sold by [Elecrow](#), a China-based company, for \$18.50 and ships world-wide. Please visit the following link if you are interested on getting an assembled Easy Pulse V1.1 board at a cheap shipping cost world-wide.

Buy Easy Pulse online

Heart-rate monitor using Arduino and Easy Pulse

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R-B

Electronics enthusiast, hardware maker, and founder of Embedded Lab.



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Arunud

March 2, 2016 3:39 am



Is it possible to connect this device to matlab directly to get real-time data.? i have an icp12 device that i use to currently connect it to pc and to derive data through smartdaq software. please help.

[Reply](#)**Ukbrany**

February 3, 2016 1:47 am



A nice one, from all i have read about it, my main question basically is, that am confused on which is the main circuit diagram of the easy pulse detector?

[Reply](#)**NILESH THAKKAR**

November 22, 2015 12:46 am



i am a student working on PPG signal. i am using Easy Pulse sensor 1.1. It provides good results. Can you tell me why we required two stage OF SAME LOWPASS AND highpass filter.or can we change the cutoff frequency and gain???

[Reply](#)

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mubarak abubakar bello

November 7, 2015 7:13 am



sir, i wanted to make this your technology as my final year project, please how can you help me my ID: mbrktofa57@gmail.com

[Reply](#)**zarah**

November 5, 2015 3:39 pm



Can I use either matlab or labview using instrument control to display d pulse on a pc instead of ppg cos I want to work with it for my project

[Reply](#)**Fatemeh**

September 17, 2015 10:03 am



Will any 3.5 mm Audio Jack work for this board? I'm having difficulty picking a audio jack.

[Reply](#)**Rich Carthew**

June 10, 2015 6:32 am



Hi Rajenda,

Thanks so much for making your excellent project open source.

I bought an Easy Pulse Ver 1.1 and it works beautifully right out of the box – nice job!

I'm currently experimenting with recreating it on a breadboard (I tried that with the original version of Easy Pulse, but wasn't very

successful) but wanted to know if I could use the TCRT1000 sensor instead of the HRM-2511E ? for this new project? – I realize that it's not as stable as the HRM, but technically, I think if I swap the 10K for 1K on the enable & the 120 Ohm for a 150 Ohm resistor on the collector that should be OK for the wiring.

Would the Vsensor output be adequate enough to operate the remaining device? Maybe some adjustments on the 10K pots helps? – Big grey area for me!

Hope to hear your thoughts.

Thanks,

Rich.

[Reply](#)

Rich Carthew June 10, 2015 6:33 am



p.s. Sorry, I just realised I misspelt your name.

[Reply](#)

R-B June 10, 2015 4:05 pm



For TCRT1000, you can use the same circuit with some modifications that you have mentioned, like increasing the 120Ohm by 150 Ohm, and so. But the output would be less stable.

[Reply](#)

Rich June 12, 2015 2:14 pm



Excellent, thanks for the confirmation on that!

Thinking about it, if I wanted to by a couple of the HRM-2511E modules, are they available separately? – I've found them on Alibaba, but they need a min order of 1000 units.

I'm wanting to recreate your project into an artwork where the DIY etched circuit is aesthetically part of the work & will use the TCRT1000 for one of them, but may switch back to the HRM-2511E for more stability.

Also, would you happen to have the wavelength / specs / model number of both the LED and Photosensor in the HRM-2511E? – maybe I can get those on Mouser and create my own finger cup.

Again, many thanks for your help.

Rich.

[Reply](#)

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David Galvo June 1, 2015 1:50 pm



It is possible to connect this prototype to a myDAQ device in the VCC pin?

[Reply](#)

David Galvo June 1, 2015 1:47 pm



It would be possible to receive the PCB design of this Easy Pulse?

[Reply](#)

Fatemeh February 26, 2015 2:41 pm



Hi, Im trying to integrate the pulse sensor into a project I'm doing. Is there a schematic I can look at, I was hoping to create it with some modifications. Thanks!

[Reply](#)

Adeboye January 29, 2015 10:32 am



i can simulate the output with labview using DAQ simulation circuit

[Reply](#)

julien January 28, 2015 9:01 pm



Hi, i received the sensor and it's work!
i have a question about the sensor, it is possible to connect VCC heart sensor to I/O arduino digital as a an ouput? because i need to stop the sensor after 1

hour...

thanks for your help

[Reply](#)

R-B January 28, 2015 9:31 pm



Hi Julien,
No you can't power the sensor with Arduino output pin. The sensor requires ~130 mA current for operation, which cannot be delivered by an output pin. There is a EN pin on the board which can be connected to Arduino pin to activate/deactivate the pulse sensor.

[Reply](#)

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julien January 29, 2015 11:15 am



thanks for answer and explication, yes 130ma exceeds the limit of the ouput...
If i understand i remove the jumper between vcc and en and i connect en to i/o digital

ouput...thanks

[Reply](#)

R-B February 3, 2015 8:39 pm



True.

[Reply](#)

Manu December 4, 2014 1:18 am



Hi, i am thinking to buy this board... I would like to add some other circuit to make the hearthbeat audible; to a mini jack female connector. It's an easy job with this board? Or it only makes like not audible digital pulses or trigs?. I can use an Arduino or maybe a Raspberry Pi if it's needed... Thanks!

[Reply](#)

R-B December 4, 2014 9:24 pm



The output will require a current amplifier to drive a speaker for audio sound.

[Reply](#)

Alan Medina October 30, 2014 1:07 am



Hi! my name is Alan can you tell me, What is the zener diode model you use?

thanks

[Reply](#)

Dhananjay October 28, 2014 1:02 pm



Can I use Lth 1550-01 in place of the sender shown???
Why are v using Vref using zener?? Can Vref be grounded??

[Reply](#)

archana September 4, 2014 2:56 am

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Hi can i use this circuit for transmission mode of operation. i want to find the arterial pulse to detect stiffness of artery

[Reply](#)

Tim

August 14, 2014 11:25 am



Does anyone know how to get this wired up to a Rasp Pi?

[Reply](#)

Pingback: [مازول سنسورایزی پالس - سنسور ضربان قلب](#)

rahul

June 18, 2014 1:18 pm



Awesome article sir...
it worked in first attempt...
thank you very much..

[Reply](#)

christine

June 17, 2014 3:29 am



currently trying to make a smaller version of this circuit. the SMD packages for zener diodes (from what I've seen) have a voltage of 2.4V instead of 2V. Will this make a different to the reference voltage?

[Reply](#)

Hoang Ha

June 3, 2014 10:59 pm



would you mind to explain – why you need 2 stage filter the signal while only one can do , why the stage 2 is exactly the same with stage 1

[Reply](#)

Muhammad Maaz Siddiqui

April 17, 2014 1:45 pm



Can u give only green sensor please?

[Reply](#)

Muhammad Maaz Siddiqui

April 9, 2014 1:52 pm

Please tell me, Can i use Lm358 instead of MCP 6004, this is not available , or any other suitable amplifier.
Please reply soon as possible,

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[Reply](#)**Muhammad Maaz Siddiqui**

May 14, 2014 4:37 am



Can u tell me the referred amp instead of MCP 6004

[Reply](#)**rahul**

June 18, 2014 1:20 pm



Mine worked perfectly with LM 324...
Go ahead as circuit will work with any oppamp as it does not involve very high frequencies...

[Reply](#)**Alan Medina**

October 30, 2014 1:08 am



Hi! im Alan, can you tell me, What is the zener diode model you use?

[Reply](#)**Marc**

April 2, 2014 7:25 am



Hi! Would you mind writing the software for pic microcontroller? thank you very much! 😊
Have a good day!

[Reply](#)**biq**

March 27, 2014 5:20 am



Hi, I would like to get the CAD file to check if the PPG Sensor can be used for a project that I'm developing. How can I contact the author?

[Reply](#)**Adam Evenson**

March 24, 2014 7:40 pm



I'd like to post a comment on the Easy Pulse. I can't locate any product review page, so this will have to serve. I liked the device, it is quite professionally constructed, and is easy on the pocketbook. I can use the device, and found the inventor, Raj., to be top-notch for

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customer service and satisfaction. He is quite personal about helping the customer and goes "the extra mile" to do it. I've not see this very often.

Reply

Jeff Dege

March 15, 2014 8:50 pm



I was wondering if I could extract pulse wave velocity from the waveform of the Easy Pulse 1.1. There is literature describing ways in which that can be done:

<http://m.qjmed.oxfordjournals.org/content/95/2/67.1>

ng

<http://hyper.ahajournals.org/content/51/1/112>

<http://www.pulsecor.com/augmentation-index.html>

Which does not mean that the signal is present clearly enough in the peripheral capillaries to be measured.

I've had no problem in extracting a double-peaked signal from the Easy Pulse 1.1, but I have nothing to validate it against.

I also bought two Easy Pulse 1.0's - which have the advantage of being reflective, rather than transmissive, so I had thought I might be able to use it at the carotid and femoral. With two signals at two locations, calculating the velocity would be simple, and I could use that to validate the calculations I was extracting from the Easy Pulse 1.1's waveform.

Unfortunately, I've not been able to get a signal out of the 1.0's, except at the fingertip. At the fingertip, I get a signal, if I'm careful. I've been unable to get a clean signal anywhere else on the body.

Anyone have any ideas? Either in how to make the 1.0's, work, or how to make the 1.1's work on the trunk, or of some other way of detecting the pulse?

Thanks would be appreciated.

Reply

Lux

June 8, 2014 2:47 pm



Hi Jeff,

Did you manage to get the pulse wave velocity using easy pulse? We are working on a design project which involves the calculation of the pulse wave velocity in order to determine if the user has peripheral arterial disease.

Let me know. 😊

The favor will be returned 😊

Reply

Adam Evenson

March 7, 2014 9:30 pm

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Could anybody that is monitoring this website advise me regarding the Easy Pulse 1.1 circuit I just bought and received today? I need to know exactly which pins I should hook the 9v battery to. I'm not quite an intermediate electronics student and I need to be certain I am hooking the battery wires correctly. Could anyone assist me please, and if not, give me contact information on who can help?

Thank you,

Adam

[Reply](#)

tommy

February 4, 2014 11:13 am



sorry, i purchased the easy pulse device, but didnt get a data sheet with it , i need to knw the equivalent heart beat to the voltage e.g dose 60bpm equal to 5V?

[Reply](#)

Muhammad Maaz Siddiqui

February 4, 2014 3:31 am



Can i send the o/p signal to GSM module?

[Reply](#)

Gerard O Brien

January 22, 2014 10:13 am



hey everyone I am using the easypulseV1.1 to interface with the c8051f020 microcontroller. I connected the digital output from the sensor to the T1 pin with timer 1 configured as an external counter.

The problem I have is the microcontroller is counting up to 800 high to low transistions in a 1 minute test. Is it possible to clean up this signal?? any help would be greatly appreciated?

[Reply](#)

R-B

January 28, 2014 4:40 pm



Hi Gerard,
Try something like this: Once you detect low-to-high or high-to-low transition, wait for 50 ms before counting another transition. This should clean up the transient behavior if there exists any.

[Reply](#)

Patrick Fairclough

January 14, 2014 11:11 am

Can you use this in reflection rather than transmission. I would like to use it for an undergraduate project but it needs to work in

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reflection. I guess this is similar to Patryk's question.

thanks

[Reply](#)

Terence

November 28, 2013 5:15 am



Can i replace HRM2511E sensor to TCRT1000?

[Reply](#)

Kim Do yup

November 20, 2013 1:34 pm



Hi, Could I buy only IR sensor parts? (green module and dc-jack(?) line)

[Reply](#)

shirly

October 13, 2013 1:07 am



May i know whether this easy pulse v1.1 can be connected to Netduino Plus?

[Reply](#)

shirly

October 13, 2013 1:04 am



may i know whether this easy pulse version 1.1 can be connected to Netduino plus?

[Reply](#)

Pingback: [BLOG | Introducing Easy Pulse Version 1.1 Sensor](#)

keerthi

May 17, 2013 2:50 am



hiii Mr. ROjbex i need to discuss with you regarding this technology as i trying to develop this kind of technology with few more modifications i hope u can help me so please contact me sir.

my id : ramya.kirthe@gmail.com

[Reply](#)

Patryk Grabowski

May 11, 2013 3:37 am

It would be great if you could put this green part into wrist. Maybe you can convert it to run on the wrist? I need this stuff for running:)

Share

[Reply](#)**kelly**

April 28, 2013 10:06 pm



hi, may i know do you provide any programming code on PIC for this project? can i change to pic18f4550? as i need to interface this system with laptop using USB later.

[Reply](#)

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