

Application Note

James Chen
EEC 134
3/25/2015

This document provides some tips for the PCB design process, from component selection to assembly.

Overview

- | | |
|----------------------------|-------|
| 1. Component Selection | p. 2 |
| 2. PCB Board Choices | p. 7 |
| 3. Schematics Design | p. 9 |
| 4. PCB Design Verification | p. 11 |
| 5. PCB Assembly | p. 12 |

1. Component Selection

Before actually starting the PCB design, you have the freedom to use any components you like, as long as they're readily accessible and affordable. It is then a good idea to use a big vendor such as **Digi-Key Electronics** and **Mouser Electronics**. They have a variety of components and you can place orders easily on OPS (Online Purchasing System, a system by the UC Davis College of Engineering).

The following tips are for using Digikey to look for components (such as a filter IC).

- Check the “In stock” box wherever possible to get common components and to avoid the delay in the future purchase.

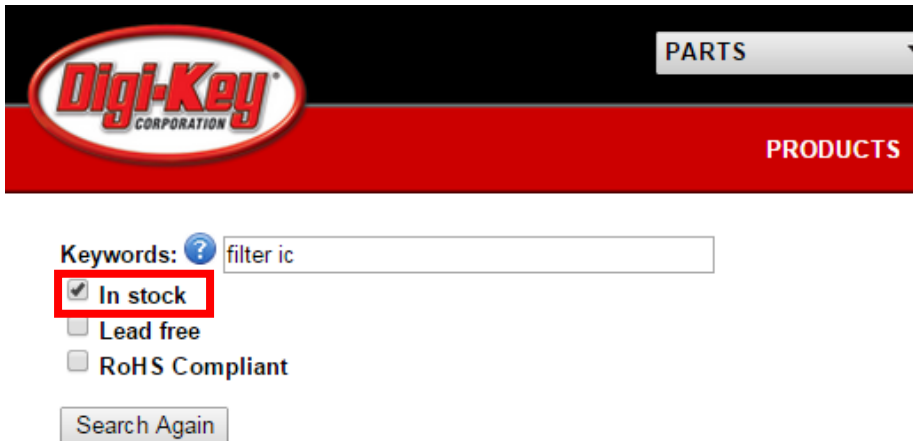


Fig 1. Check the box for “In stock”.

- If you're having trouble using keyword searching, look into the specific category of interest and use the sorting function to find components of desired specification (select multiple by holding Ctrl and clicking).

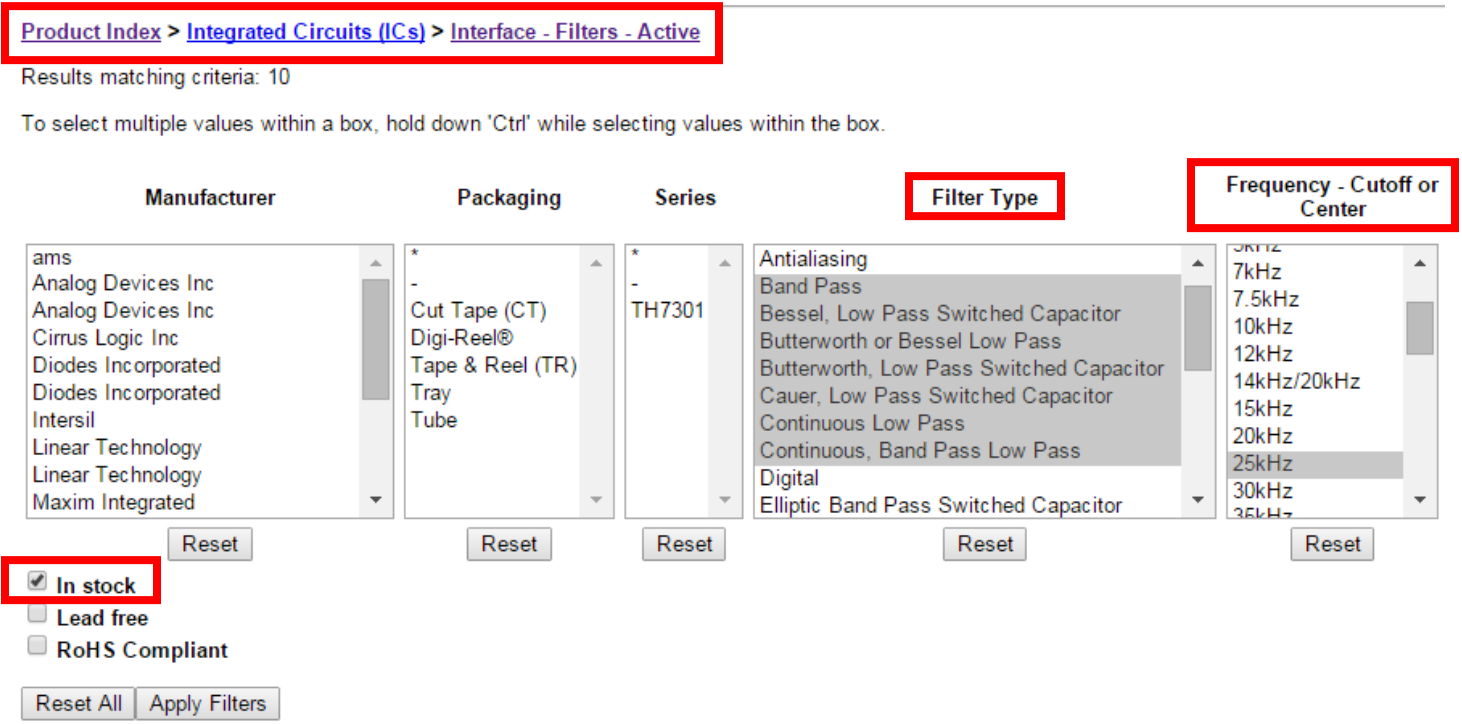


Fig 2. Sorting function in Digi-Key.

In the case of an IC filter, the filter type and cutoff frequency can be specified. If no results matched the criteria, select more criteria at a time.

- Read the component summary before checking the datasheet. It'll save you a lot of time.

In stock
 Lead free
 RoHS Compliant

[Search Again](#)

Product Index > [Integrated Circuits \(ICs\)](#) > [Interface - Filters - Active](#) > [Maxim Integrated MAX291CSA+](#)

All prices are in US dollars.

Digi-Key Part Number	MAX291CSA+-ND	Price Break	Unit Price	Extended Price
Quantity Available	Digi-Key Stock: 447 Can ship immediately	1	6.66000	6.66
	Factory Stock: 100	10	6.41300	64.13




Image shown is a representation only. Exact specifications should be obtained from the product data sheet.

When requested quantity exceeds displayed pricing table quantities, a lesser unit price may appear on your order. You may submit a [request for quotation](#) on quantities which are greater than those displayed in the pricing table.



Datasheets	MAX291,292,295,296	Customers Who Purchased This Product are also interested in:
Product Photos	8-SOIC	
Product Training Modules	Lead (SnPb) Finish for COTS Long-Term Supply Program	
Standard Package	100	MAX860MNCPE Texas Instruments IC REG MULTI CONFIG ADJ 8-SOIC Unit Price 1.65000
Category	Integrated Circuits (ICs)	2510-5002UB 3M SHROUDED HEADER 10 POS RT ANGLE Unit Price 2.85000
Family	Interface - Filters - Active	
Series	-	
Packaging	Tube	
Filter Type	Butterworth, Low Pass Switched Capacitor	
Frequency - Cutoff or Center	25kHz	
Number of Filters	1	
Filter Order	8th	
Voltage - Supply	4.75 V ~ 11 V, ±2.375 V ~ 5.5 V	
Mounting Type	Surface Mount	
Package / Case	8-SOIC (0.154", 3.90mm Width)	
Supplier Device Package	8-SOIC N	
Online Catalog	Filters	

Fig 3. Component summary section of the component.

- Check that the description is indeed what you're looking for, such as the voltage supply (3.3V or 5V), mounting type (Surface Mount or Through Hole).

Datasheets	MAX291,292,295,296
Product Photos	8-SOIC
Product Training Modules	Lead (SnPb) Finish for COTS Long-Term Supply Program
Standard Package	100
Category	Integrated Circuits (ICs)
Family	Interface - Filters - Active
Series	-
Packaging	Tube
Filter Type	Butterworth, Low Pass Switched Capacitor
Frequency - Cutoff or Center	25kHz
Number of Filters	1
Filter Order	8th
Voltage - Supply	4.75 V ~ 11 V, ±2.375 V ~ 5.5 V
Mounting Type	Surface Mount
Package / Case	8-SOIC (0.154", 3.90mm Width)
Supplier Device Package	8-SOIC N
Online Catalog	Filters

Fig 4. Individual items in the component summary.

- If you're using KiCad for PCB design, you can save some design time by choosing components that have footprints available in the built-in library (so you don't have to draw your own). Look for the "Package/Case" for common packaging types.

Voltage - Supply	4.75 V ~ 11 V, ±2.375 V ~ 5.5 V
Mounting Type	Surface Mount
Package / Case	8-SOIC (0.154", 3.90mm Width)
Supplier Device Package	8-SOIC N

Fig 5. Package / Case for the filter IC.

- After finding the corresponding footprint in KiCad (or other PCB software), check that the footprint dimensions match the values (and units) shown in the datasheet. Make sure the pad sizes have the correct separations and dimensions so that the components can be soldered on properly. If the footprint does not have the proper dimensions, you would have to go through the trouble of tweaking the component to make it work.

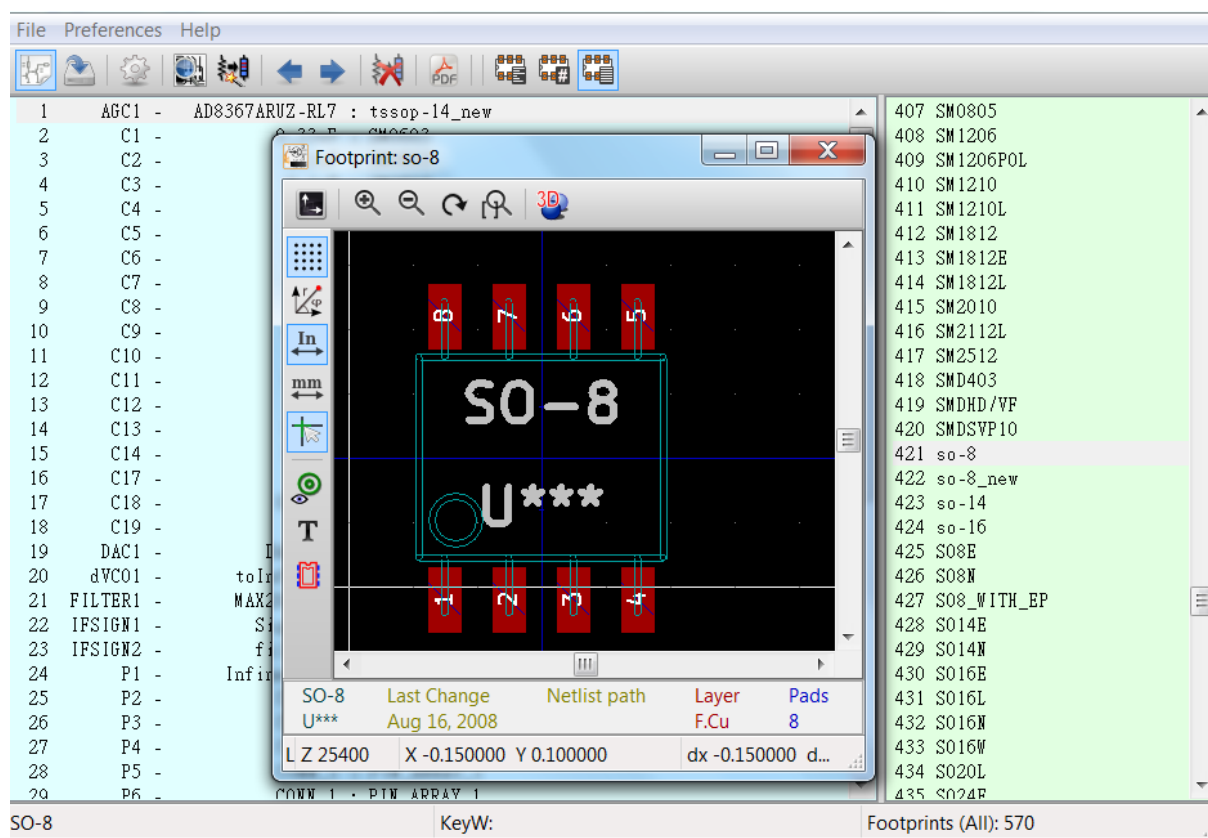


Fig 6. The corresponding footprint in KiCad for the 8-SOIC.

- Go through the datasheet to make sure the specifications are compatible with your design and other components. Items to look out for are the required supply voltage, input/out impedance, maximum operating frequency, maximum input voltage/current/power. Make sure that the specifications are either matched or within the tolerance to avoid damaging the components or degrading its performance.

- Look for free samples on the manufacturer’s official site. Companies such as Maxim Integrated, Texas Instruments, Mini-Circuits, Analog Devices, and Avago Technologies have free sample programs where you can simply sign up to get a limited number of components for free, including shipping. For example, the above filter IC is made by Maxim Integrated, so you can check whether or not it has free samples by looking at their component information.

maxim integrated. 中文 | 日本語 Share

ANALOG
INTERFACE
COMMUNICATIONS
DIGITAL
INDUSTRIES
ALL
WHAT'S NEW
SOLUTIONS
DESIGN
ORDER
SUPPORT
ABOUT US

MAX291

8th-Order, Lowpass, Switched-Capacitor Filters

Also See MAX7401/5 8th-Order, Low-Power Bessel Filters

[Data Sheet](#) [Subscribe](#) [Active: In Production. But some versions of the family are Not Recommended for New Designs.](#)

OVERVIEW KEY SPECS DESIGN RESOURCES **ORDER**

Part Number	Free Sample	Buy	My Maxim Subscriptions	Status	Recommended Replacement	Package: TYPE PINS FOOTPRINT DRAWING CODE/VAR *	Temp
MAX291C/D		Buy	<input type="checkbox"/> PCN	NRND	MAX291ESA+	DICE SALES,;NA pin;DICE; Package Details	
MAX291CPA		Buy	<input type="checkbox"/> PCN	Active		PDIP(N),;8 pin;79.7 mm ² Package Details	0°C to
MAX291CPA+	Sample	Buy	<input type="checkbox"/> PCN	Active		PDIP(N),;8 pin;79.7 mm ² Package Details	0°C to
MAX291CSA		Buy	<input type="checkbox"/> PCN	Active		SOIC(N),;8 pin;30.9 mm ² Package Details	0°C to
MAX291CSA+	Sample	Buy	<input type="checkbox"/> PCN	Active		SOIC(N),;8 pin;30.9 mm ² Package Details	0°C to

Fig 7. The component information for the MAX291 filter IC.

- For more sophisticated ICs, there may be evaluation boards available, which are essentially PCB's with the IC, necessary components, and connections made already. Check the datasheet for the availability. For example, ADI's VGA (variable gain amplifier) AD8367 has evaluation boards and the PCB layout is included in the datasheet. Unfortunately the listing price is \$99 and does not have free sampling at the time this application note was written. However, generally it doesn't hurt to looking up the boards to see if free samples are available.

EVALUATION BOARD

Figure 42 shows the schematic of the AD8367 evaluation board. The board is powered by a single supply of 2.7 V to 5.5 V.

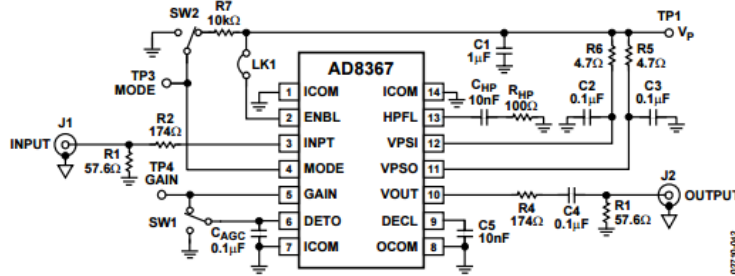


Figure 42. Evaluation Board Schematic

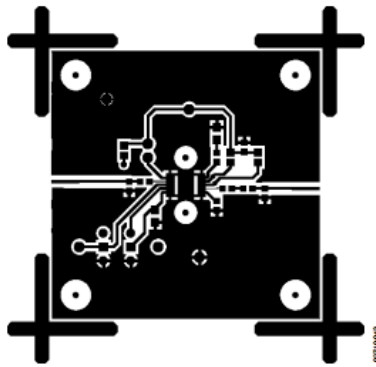


Figure 43. Layout of Component Side

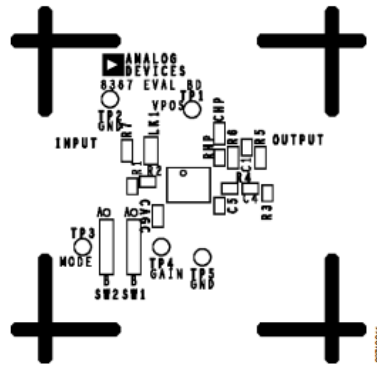


Figure 44. Silkscreen of Component Side

Fig 8. Evaluation board information for the AD8367 VGA.

- Once all the parts are chosen and checked, order them as soon as possible. If you receive them before the PCB design submission, you may check the footprints in your design against the actual components (see PCB Design Verification).

2. PCB Board Choices

You most likely have the option to use either a 2-layer board or a 4-layer board. While 4-layer boards give you more design flexibility, it complicates the design somewhat and increases the fabrication cost.

The standard 2 layer order

\$5 per square inch, which includes three copies of your design. For example, a 2 square inch board would cost \$10 and you'd get three copies of your board. You can order as many copies as you want, as long as they're in multiples of three.

Orders go to the fab every business day, and have a turn time of about 12 calendar days. They can be ordered on [OSH Park](#).

The standard 4 layer order

\$10 per square inch, which includes three copies of your design. For example, a 2 square inch board would cost \$20 and you'd get three copies of your board. You can order as many copies as you want, as long as they're in multiples of three.

Orders are weekly and have a turn time from the fab of about two weeks. They can be ordered on [OSH Park](#).

Fig 9. OSH Park price comparison.

- If possible, use a simple 2-layer board since it is easier to debug. If a 4-layer board is used and something is not working, you cannot modify or test the circuitry of the inner two layers.
- For low frequency boards, the board thickness and material is usually not too important. But for a board with RF components and microstrip/CPW lines, definitely look into the board thickness and material. Although getting a special or customized board may cost more, it will help improve the performance.

Materials

Double-Sided Boards > Standard Temp FR-4.

Multi-Layer Boards (more than 2 layers) > High Temp FR-4.

Standard Thickness is .062". Other available thicknesses include .093", .125", .031" & more.

A wide variety of materials are available for use. Contact us to discuss any specific requirements.

Fig 10. Bay Area Circuits materials options.

- To design a microstrip/CPW line, use calculators online or ADS LineCalc to find the proper line width that gives the desired characteristic impedance ($50\ \Omega$, or other values specified in the datasheet).

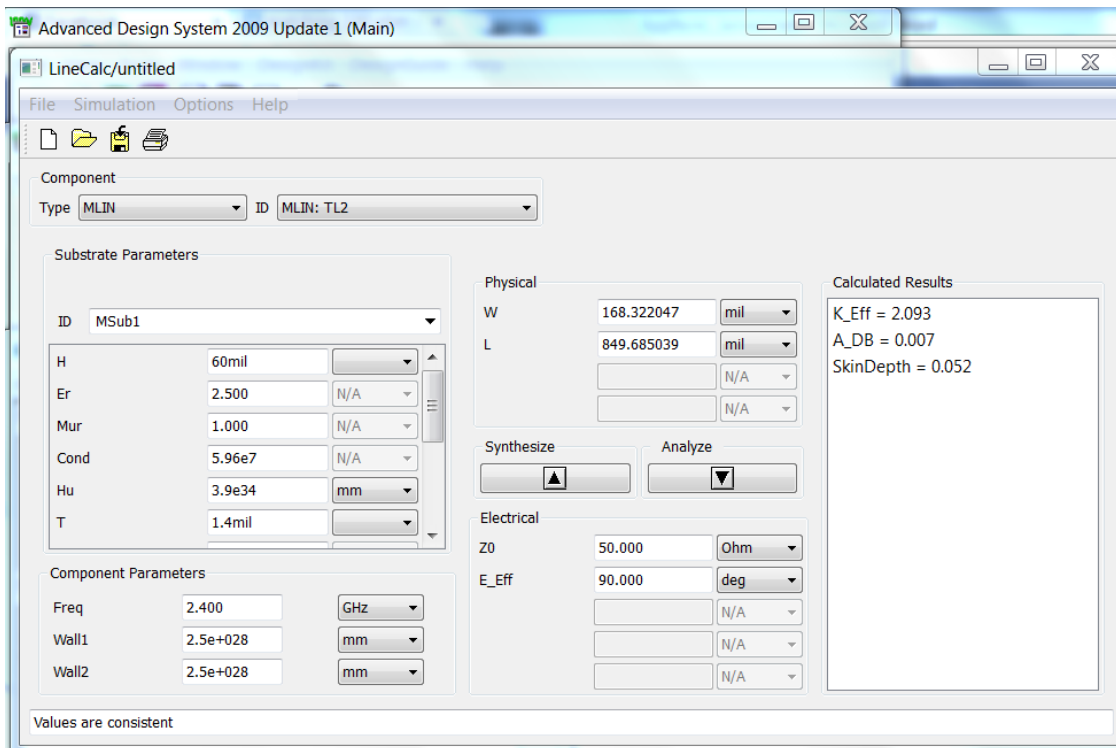


Fig 11. LineCalc function in ADS.

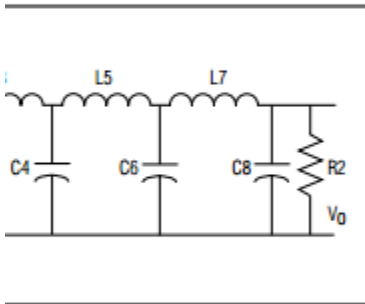
3. Schematics Design

The schematics part of the PCB design is just as important as the layout part. If you wire something wrong incorrectly, you may not catch it in the later PCB design stage. It is therefore important to double check and triple check your design before proceeding.

- Look for suggested schematic connection in the datasheet. Many of them show where and how to connect the pins. You can then simply translate the diagram into your schematics.

MAX291/MAX292/MAX295/MAX296

8th-Order, Lowpass, Switched-Capacitor Filters



Filter Network

les, while the same mismatch in a read its error over all poles.

AX295/MAX296 input impedance switched-capacitor resistor (see e 1), and it is inversely proportion-ut impedance values determined Fig 12. Suggested pin configuration for the filter IC shown in the datasheet.

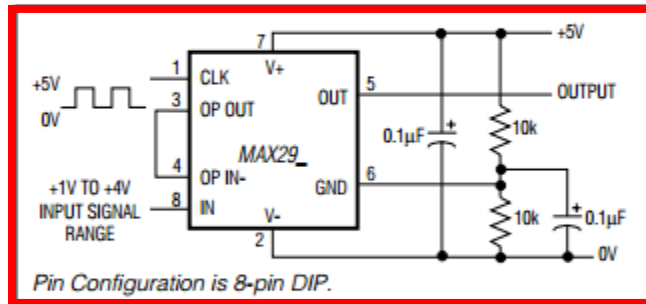


Figure 3. +5V Single-Supply Operation

clock frequency over the clock range 100kHz to 1MHz. Varying the rate of an external clock will dynamically adjust the corner frequency of the filter.

Ideally, the MAX291/MAX292/MAX295/MAX296 should be clocked symmetrically (50% duty cycle). MAX291/MAX292/MAX295/MAX296 can be operated with clock

- For low frequency circuits, put test pins at the connection between every active component. It allows you to test the output after every component for debugging. In the case that one of your active component fails to work, you can simply bypass it by using a wire for external connection. It also gives you the freedom to use the pin to output the signal at any part of your system. You can even use your PCB as a steady power supply by using the test point at the output of your voltage regulator!

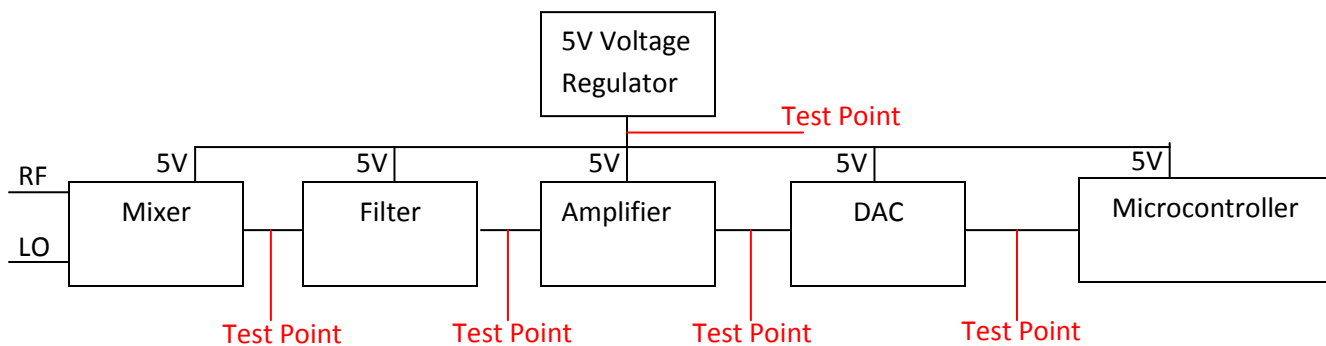


Fig 13. Block diagram for the baseband circuit.

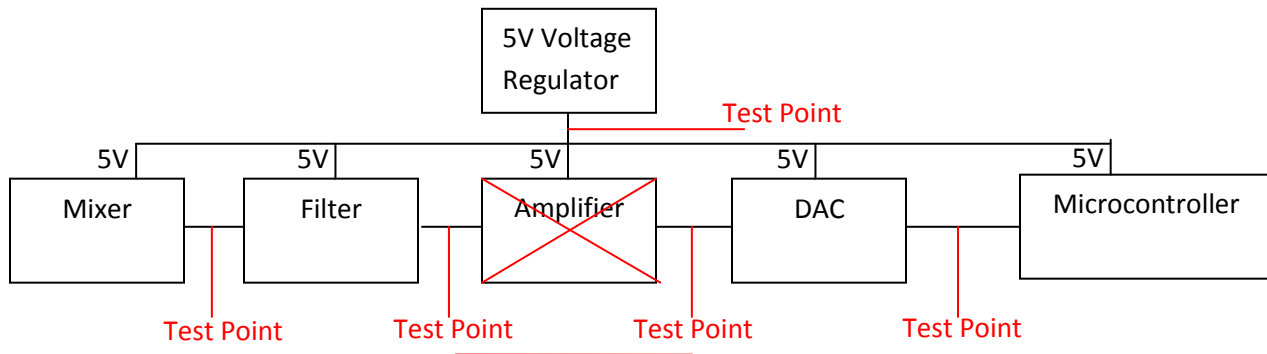


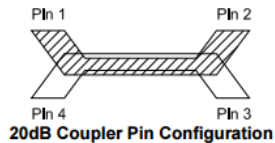
Fig 14. Test points allow one to bypass a malfunctioning component of a low frequency circuit.

- For RF circuits, test pins cannot be placed easily because of impedance matching. Therefore, test points would only be placed at crucial connections, such as the output of a mixer to monitor the frequency. An option to implement a test point is by using a 20 dB (or 30 dB) directional coupler. A small portion of the signal is coupled out, which can be connected to an SMA connector for testing. As convenient as it sounds, the coupler does introduce some insertion loss, which reduces the power of the original signal by a small fraction that depends on the design of the coupler.



Directional Coupler Pin Configuration

The X3C19E2-20S has an orientation marker to denote Pin 1. Once port one has been identified the other ports are known automatically. Please see the chart below for clarification:



Pin 1	Pin 2	Pin 3	Pin 4
Input	Direct	Isolated	Coupled
Direct	Input	Coupled	Isolated

Fig 15. An illustration of the directional coupler found in the datasheet of Anaren X3C19E2-20S.

4. PCB Design Verification

After spending hours designing the schematics and the layout, you should ask others to take a look at your design to catch possible mistakes.

- Print out your layout with 1:1 scale to see its physical size. If you have the components already, place it on top of the printout to see if your footprints are correct. It also helps you to see if components are too closely placed to avoid overcrowding or possibly placement problems.

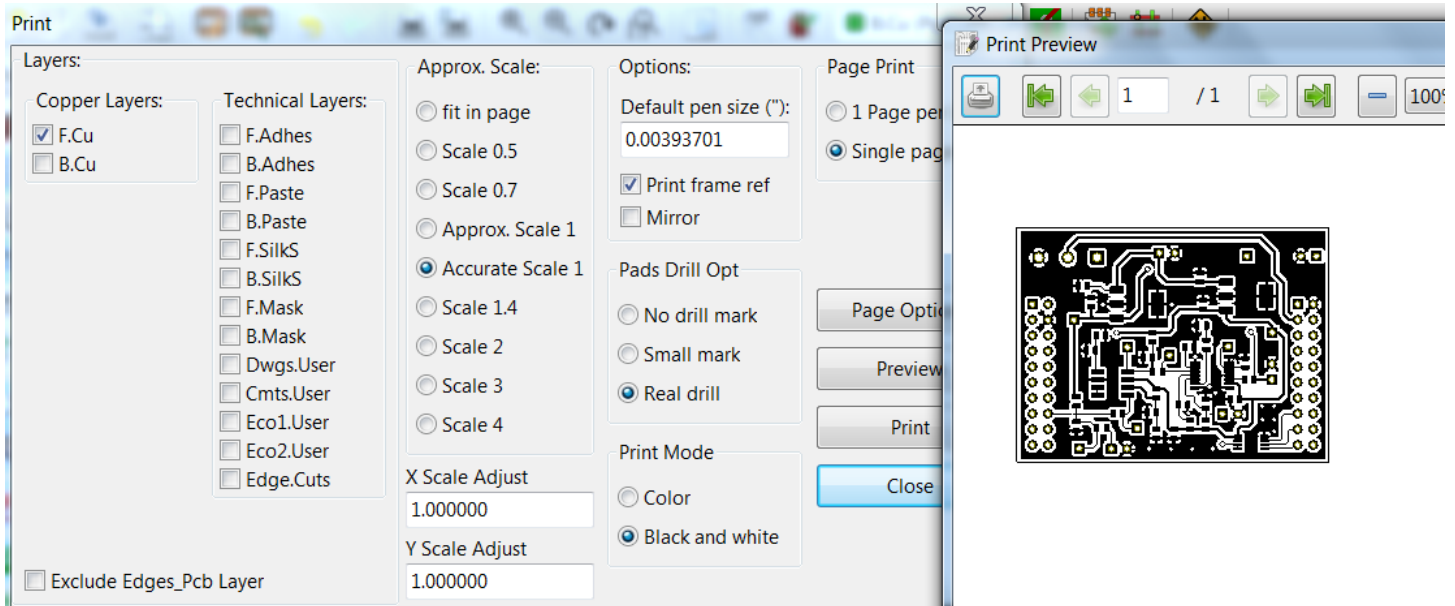


Fig 16. Print preview in KiCad.

- Export the gerber files and upload it to PCB fabrication websites (such as OSH Park) to see how their program interprets the files.

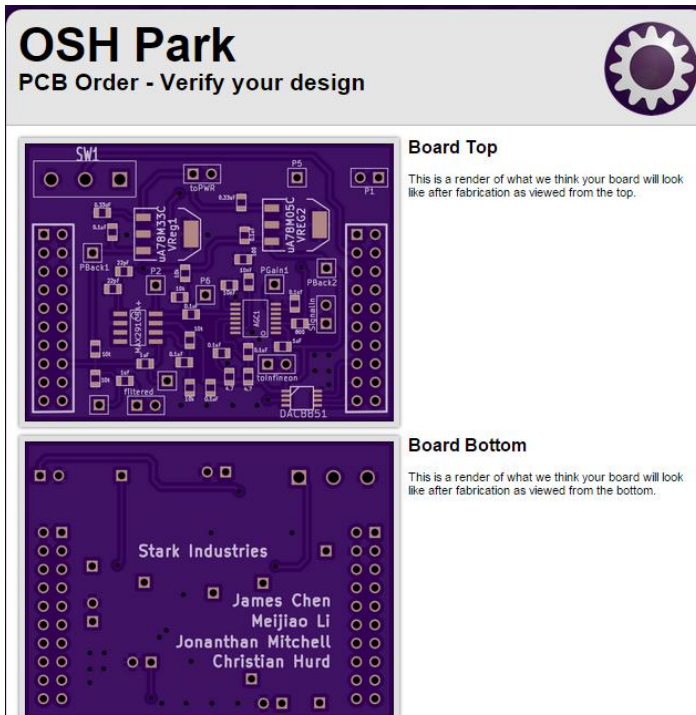


Fig 17. OSH Park preview of the design.

5. PCB Assembly

You have your boards and you're ready to solder the components. There are three options to solder it:

- Use a soldering iron and solder it directly (with a magnifier for small components).
- Use solder paste and use an oven for reflow.
- Use solder paste and use a hot plate for reflow.

Generally reflow soldering is good for large quantity of small components (such as 0603 and 0402 resistors/capacitors/inductors). Because there are many soldering tutorials available online, this document will not go through the step-by-step process and instead will just list a few helpful tips.

- Solder a few components at a time. If you solder everything in one go, debugging is going to be very difficult because components interact with each other and you may not be able to pin down the source of the problem.
- Usually start with the power supply (voltage regulator) parts. You want to make sure your power lines are not shorted anywhere. If your power is shorting, you can easily damage your ICs.
- Soldering and testing a few components at a time may take longer time, but it'll help you debug a lot easier.