Working with Surface-Mount Technology

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Created for BSidesDFW 2020 HHV

This Slide Deck Is Available at https://altbier.us/SMT/

What is Surface-Mount Technology?

- Surface-mount technology (SMT) is a method in which the electrical components are mounted directly onto the surface of a printed circuit board (PCB). An electrical component mounted in this manner is referred to as a surface-mount device (SMD).
- An SMT component is usually smaller than its through-hole counterpart because it has either smaller leads or no leads at all
- In commercial applications, this approach has largely replaced the through-hole technology in large part because SMT allows for increased manufacturing automation reducing cost and improving quality.

Common Abbreviations

Different terms describe the components, technique, and machines used in manufacturing.

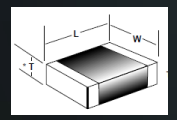
Abbreviation	Description
SMT	Surface-mount technology (assembling and mounting technology)
SMD	Surface-mount devices (active, passive and electromechanical components)
SMC	Surface-mount components (components for SMT)
SMP	Surface-mount packages (SMD case forms)
SMA	Surface-mount assembly (module assembled with SMT)
SME	Surface-mount equipment (SMT assembling machines)

Surface-Mount Packages

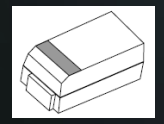
SMC come in many different sizes and shapes. Here are the categories of SMP.

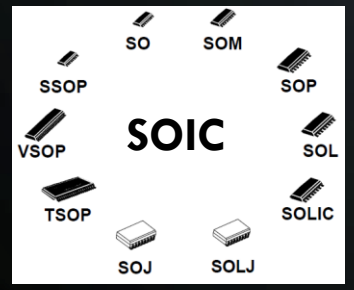
Note the term package(s) refers to the case forms and not delivery packaging.

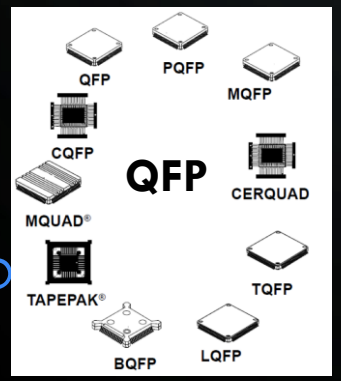
Flat Chip



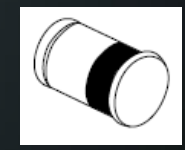
Tantalum



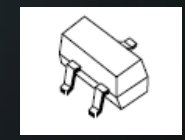




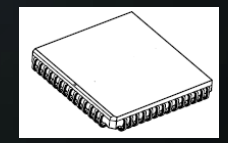
SMP Type	Description
Flat Chip	Simple flat chip components
MELF	Metal Electrode Face Bonded components
Tantalum	Tantalum molded capacitors
SOT	Small Outline Transistor
SOIC	Small Outline Integrated Circuit
PLCC	Plastic Leaded Chip Carrier
LCC	Leadless Chip Carrier
Flat Pack	Plastic Carriers with Flat leads
QFP	Quad Flat Pack
BGA	Ball Grid Array



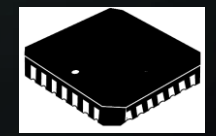
MELF



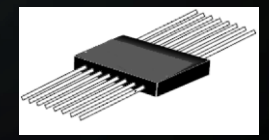
SOT



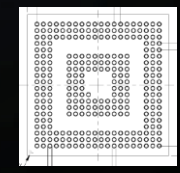
PLCC



LCC



Flat Pack



BGA

Surface-Mount Packaging

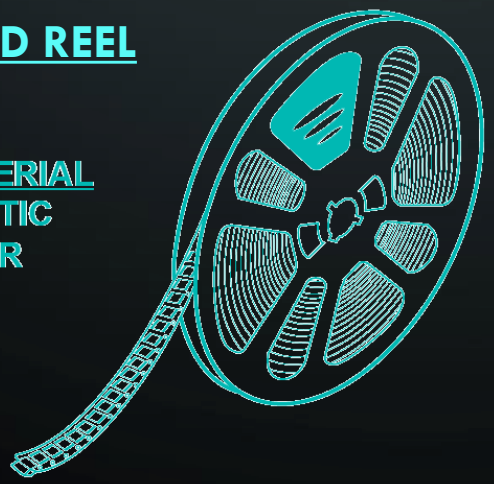
SMC come delivered in several different types of packaging. All of which are designed to allow for automation tools such as pick and place machines to make use of them with minimal human intervention.

Two of the most common packaging types:

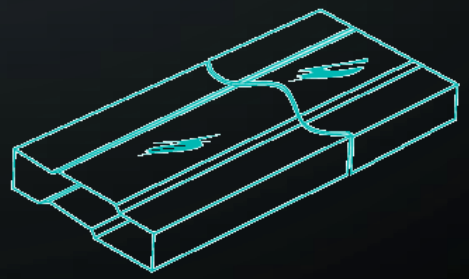
- Tape and Reel – SMC inside separation tape on a reel
- Tube – SMC inside a plastic slide tube

TAPE AND REEL

REEL MATERIAL
- PLASTIC
- PAPER



TUBE



Flat Chip SMP

Flat Chip components include ceramic capacitors, resistors, and diodes.

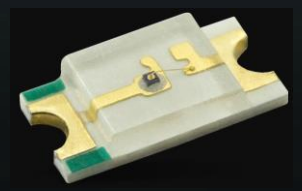
Flat capacitors tend not to have markings. Be careful not to mix them up!

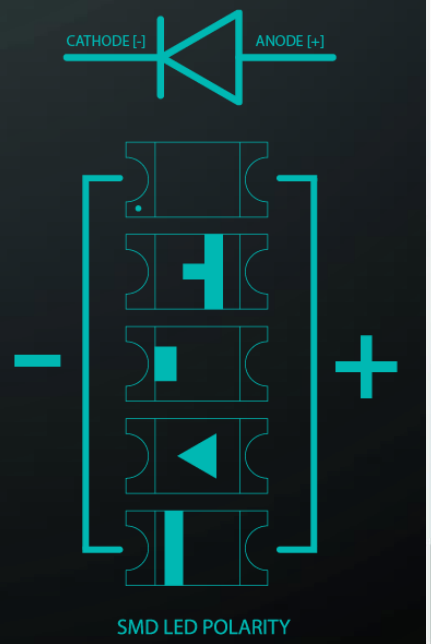
Flat resistors are marked with a number code that will tell you what resistance value it has. The letter R is used as a decimal place.

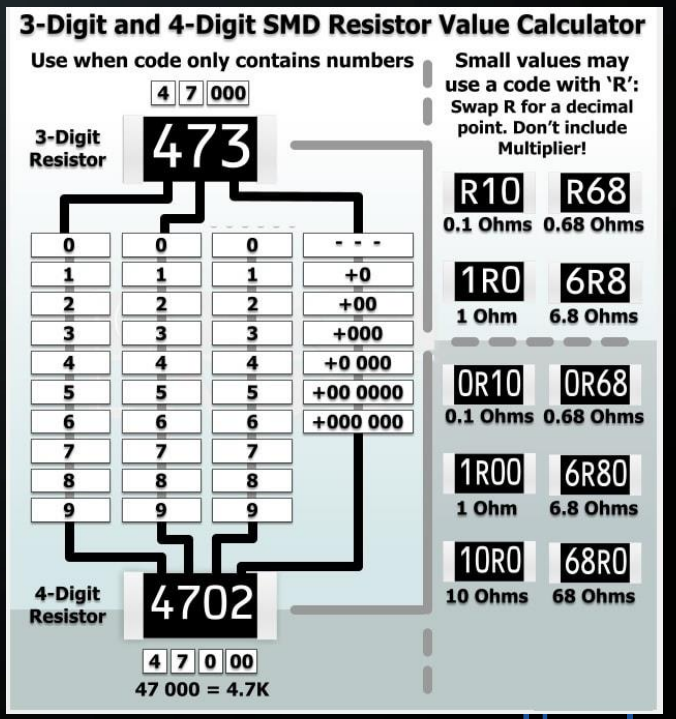
Diodes including LEDs tend to have makings indicating Anode and Cathode. These markings differ by product and manufacturer.

Flat Chip SMP nomenclature denotes the size of the SMD in inch or mm. (e.g. an 0805 SMD is 0.08 x 0.05 inches)

Size Code		Approximate Size (LxW)	
Inch	Metric	Inch	Metric
0402	1005*	.04" x .02"	1.0 x 0.5mm
0504	1210*	.05" x .04"	1.2 x 1.0mm
0603	1508	.06" x .03"	1.5 x 0.8mm
0805	2012	.08" x .05"	2.0 x 1.2mm
1005*	2512	.10" x .05"	2.5 x 1.2mm
1206	3216	.12" x .06"	3.2 x 1.6mm
1210*	3225	.12" x .10"	3.2 x 2.5mm
1812	4532	.18" x .12"	4.5 x 3.2mm
2225	5664	.22" x .25"	5.6 x 6.4mm







SOIC – Small Outline IC

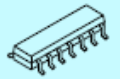
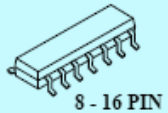
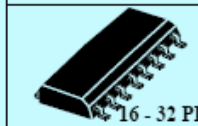
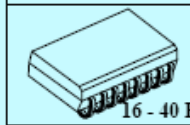
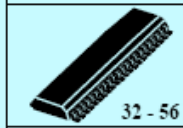
Small Outline IC's are a family of packages with a variety of lead styles and lead counts. Small outline packages are called by many different names. There are small differences between each type, and often they are called by the wrong name. The typical nomenclature is <SOIC_Package_Type><Number_of_Pins> (e.g. SOP16).

SOIC Package Type	Description
SO / SOP	Small Outline Package. It consists of a molded plastic case measuring approximately 156 mils (3.97mm) wide and has gull-wing leads with 50 mils (1.27mm) lead pitch.
SOM	SO Medium has a wider body measuring 220 mils (5.6mm) wide.
SOL	SO Large has the widest body measuring 300 mils (7.62mm) wide or larger.
SOJ / SOLJ	SO components with J leads
VSOP	Very Small Outline Package. Has high density 25 mil (.65mm) gull-wing leads and a 300 mil (7.62mm) wide body. Sometimes the term VSOP and SSOP (see below) are interchanged.
SSOP	Shrink Small Outline Package. Like VSOP has high density 25 mil (.65mm) gull-wing leads but has a smaller 208 mil (5.3mm) case.
QSOP	Quarter Small Outline Package. Same body as SOP and leads with 25 mils (0.635mm) lead pitch.
TSOP	Thin Small Outline Package. A low-profile body (1mm high) with a body width of 300 mils (7.62mm) or larger and fine pitch19.7 mils (0.5mm) leads
TSSOP	Thin Shrink Small Outline Package. A low-profile body (1mm high) with a body width of less than 300 mils (7.62mm) and fine pitch19.7 mils (0.5mm) leads

SOIC – Small Outline IC

As demonstrated by the table on the previous slide, we know that Small Outline IC's can come in a variety package sizes and lead pitches and densities.

When working with these components it is always important to RTFM the specifications sheets to ensure compatibility with your project.

DRAWING	NOMENCLATURE	BODY WIDTH	LEAD TYPE
 8 - 16 PIN	SO = Small Outline	156 mil	Gull 50 mil Pitch
 8 - 16 PIN	SOM = Medium Outline	220 mil*	
 16 - 32 PIN	SOL = "Large" Outline SOP = "Small" Outline Package	300 mil	
 16 - 40 PIN	SOJ or SOL-J = "J" - Lead Large Outline	300 mil*	J-Lead 50 mil
 32 - 56 PIN	VSOP = Very Small Outline Package	300 mil	Gull Wing 25 mil
 8 - 30 PIN	SSOP = Shrink Small Outline Package	208 mil	Gull Wing 25 mil
 20 - 56 PIN	QSOP = Quarter Small Outline Package	156 mil	Gull Wing 25 mil

*Up to 440 mils

SOT – Small Outline Transistor

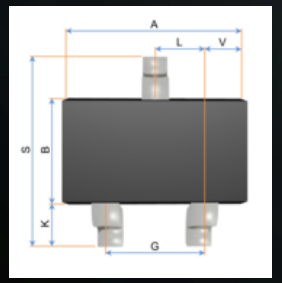
A small outline transistor (SOT) is a family of small footprint, discrete surface mount transistor.

The most common are the SOT23 variations.

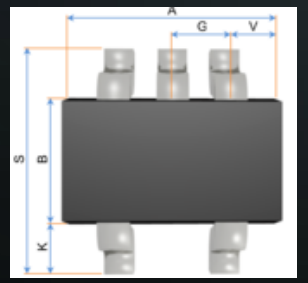
The nomenclature for SOT components is SOT<serial>[-<variant>] where serial is the JEDEC SOT specification number and variant is an accepted variation (e.g. SOT23-3).

Note: Several different SOT specification may use the same basic body shape but with slightly different dimensions.

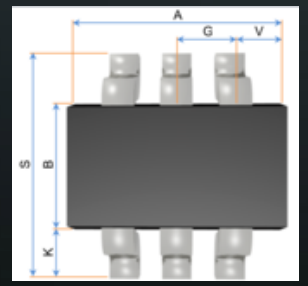
Here are a few examples of SOT packages.



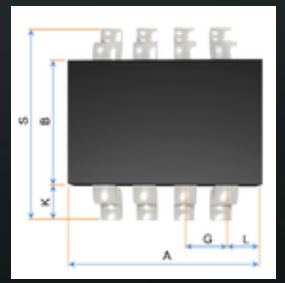
SOT23-3
SOT323
SOT416



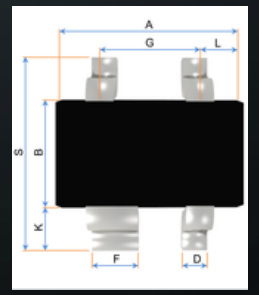
SOT23-5
SOT353



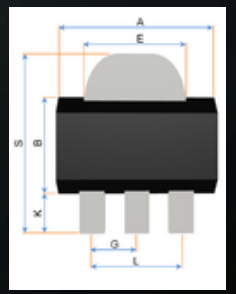
SOT23-6
SOT363



SOT23-8



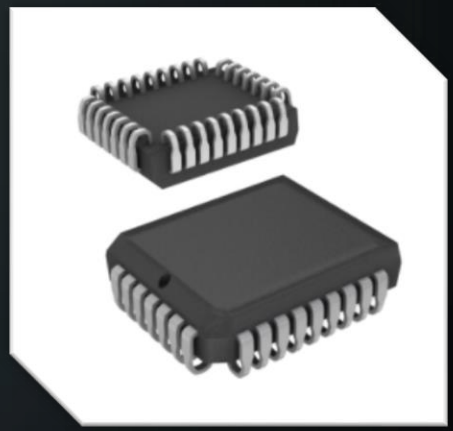
SOT143
SOT343



SOT89-3

PLCC – Plastic Leaded Chip Carrier

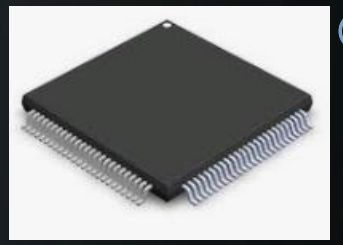
- The plastic body PLCC is the most popular leaded chip carrier.
- Its J leads are always 50 mils (1.27mm) pitch.
- They are commonly available from 18 to 100 leads.
- As an alternative to the plastic case, leaded chip carriers are available in other materials
  - Ceramic (known as CLCC)
  - Metal (known as MLCC)
- These components are designed to fit into IC sockets.



QFP – Quad Flat Pack

- The QFP is a very popular IC package.
- It has gull wing leads that vary in pitch from 12 mils (0.3mm) to 50 mils (1.27mm).
- They are commonly available from 32 to 304 leads.
- They come in several sizes and body materials. Here are a few examples.

QFP Package Type	Description
QFP	Quad Flat Pack
PQFP	Plastic Quad Flat Pack
CQFP / CERQUAD	Ceramic Quad Flat Pack
MQUAD	Metal Quad Flat Pack
BQFP	Bumpered Quad Flat Pack (bumpered corners protect leads)



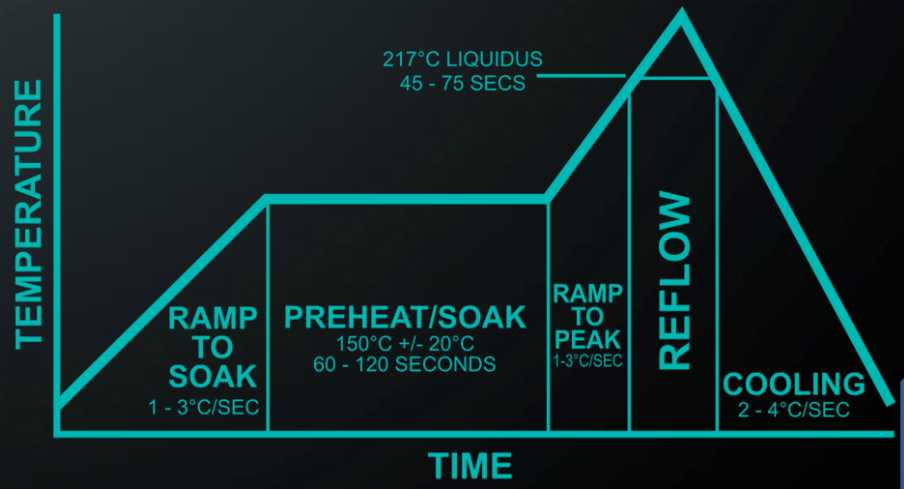
Reflow Soldering SMT

Reflow soldering is the most widely used method of attaching surface-mount components to a printed circuit board.

This process involves applying a solder paste (a sticky mixture of powdered solder and flux) to the PCB component contact pads, placing the SMD components onto the pads, and evenly heating to controlled temperatures that cause the solder paste to reflow into a molten state creating permanent solder joints.

While the heating process usually takes place in a specialized oven, it can be accomplished with any heat source that can have temperature predictably controlled in short time frames.

It is also possible to use a hot air solder rework tool to apply heat to a specific area of a PCB or to a specific SMD component to reflow it for individual component assembly or replacement.



Traditional Soldering SMT

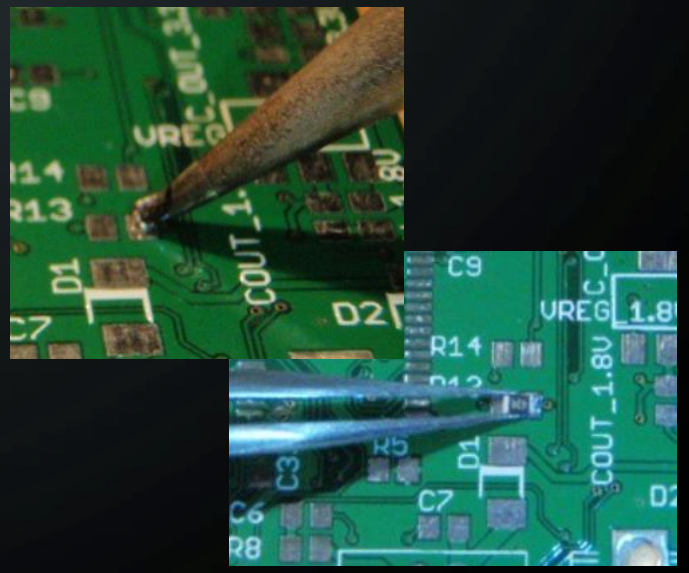
Based on the size of the SMD and its lead pitch it may be possible to use traditional soldering methods.

When the SMD size and/or lead pitch is too small then the traditional soldering method is likely to bridge connections causing shorts.

The choice of how small is too small comes down to an individual's soldering skill.

When soldering SMD components with an iron and rosin core solder, I find it easier to accomplish by first applying solder to the PCB contact pads.

Then you can hold the SMD with tweezers onto those contact pads with one hand while you use the iron in your other to reheat those pads allowing the molten solder to affix to the SMD.



SURFACE-MOUNT PROJECT

This next section will outline a simple surface-mount project using the Arduino.

This project will use a single circuit with two SMD components: a resistor and an LED.

Each of the two SMD components will be attached to the PCB using a different method, the first using traditional soldering, and the second using reflow soldering via a hot air rework tool.

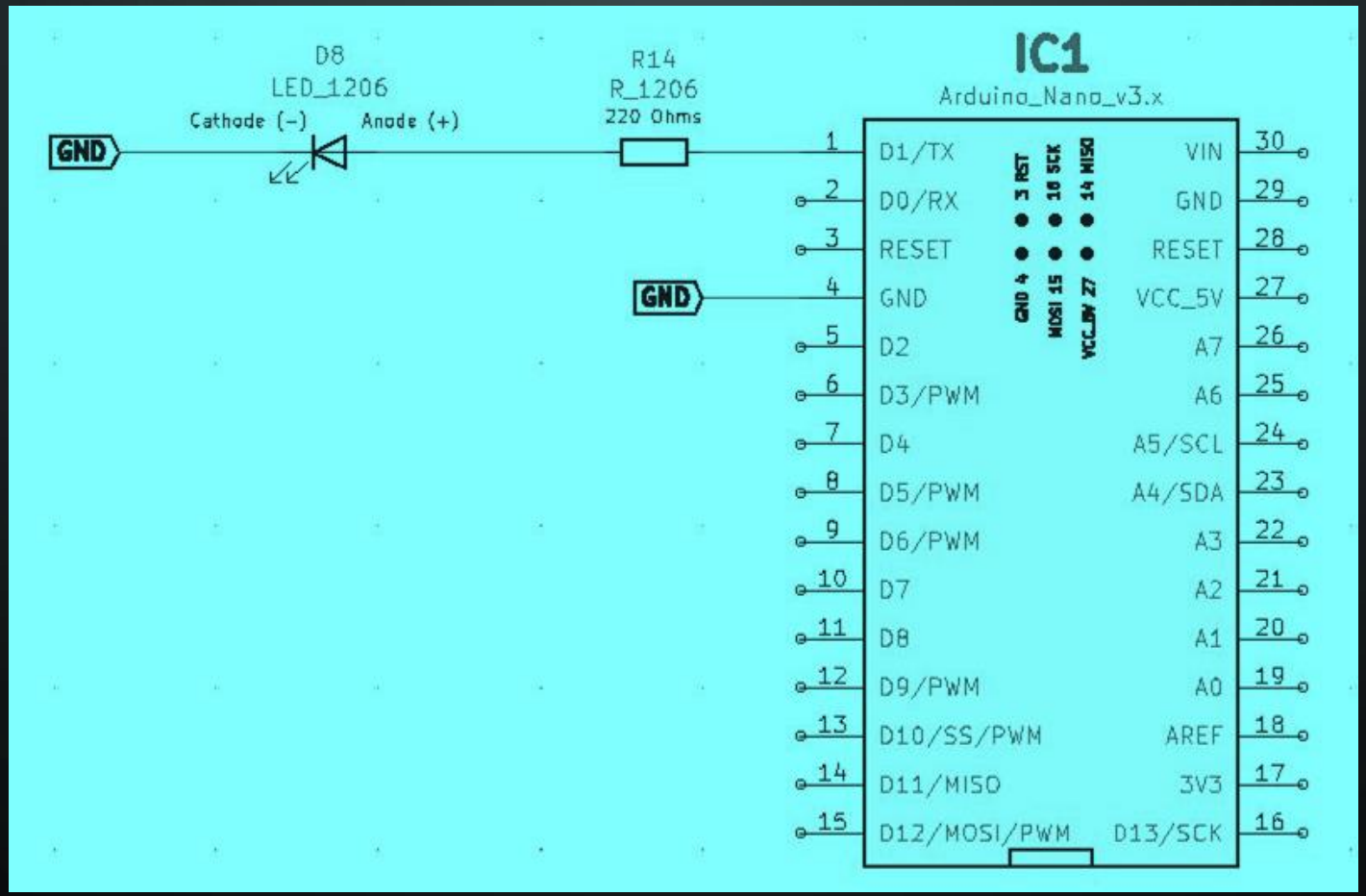
Since the focus of this lab is the SMD soldering, we will just use a simple LED blink code to demonstrate its functionality.

- Arduino Nano SMD LED – Lab HHV2020_08
  - Blink an SMD LED

The Lab reference number refers to the BSidesDFW Hardware Hacking Village Videos which can be accessed here: **https://altbier.us/bsidesdfwHHV2020/**

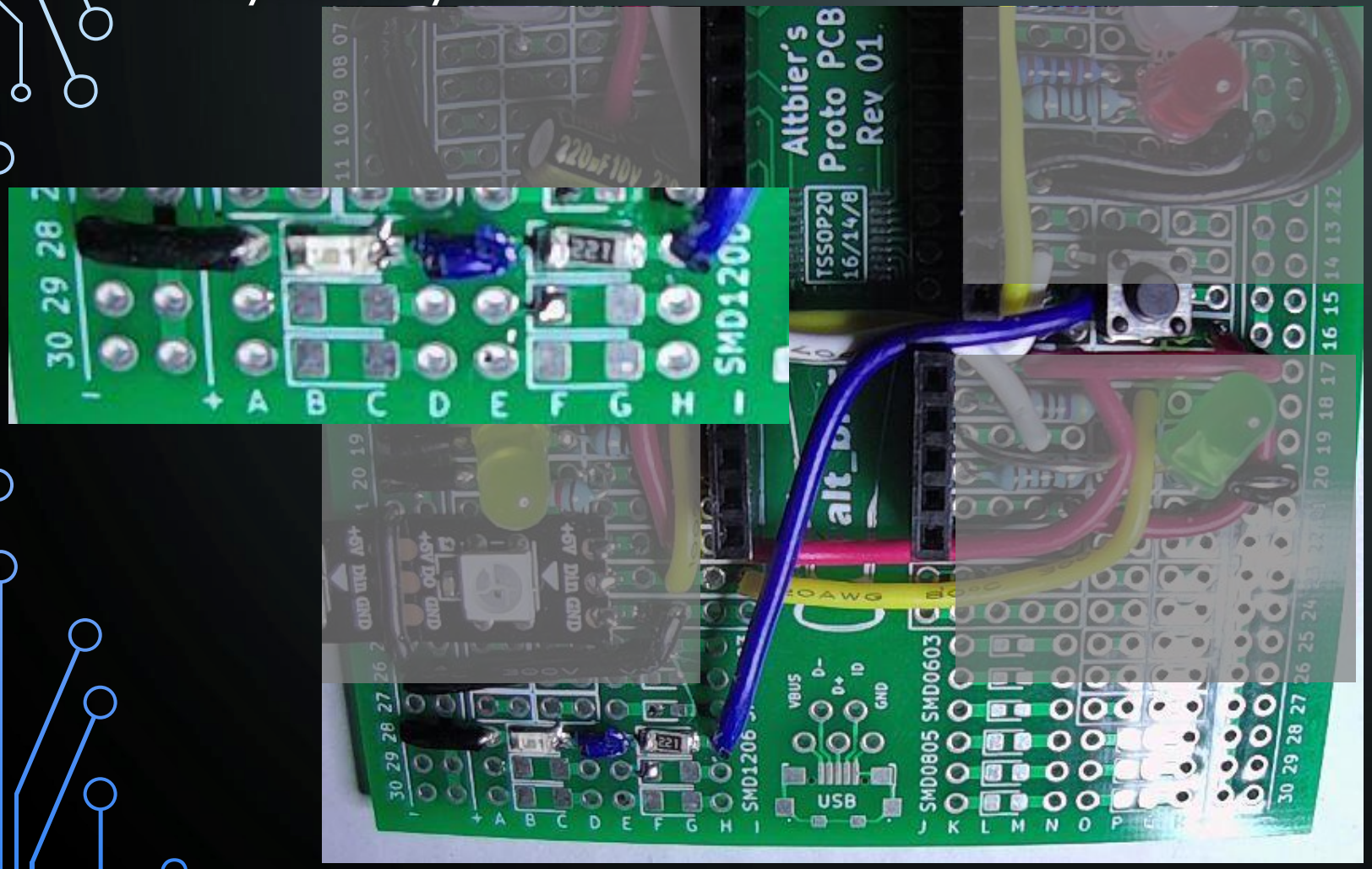
ARDUINO NANO SMD LED

Schematic



ARDUINO NANO SMD LED

Physical Layout



Wire up a circuit as shown in the schematic and physical layout.

Strip Board Connection Details

- Nano – **I1-15** and **K1-15**
- Resistor 220 Ohm 1206 – **G28** and **F28**
- LED 1206 – **C28** (Anode) and **B28** (Cathode)
- Wire – **N15** and **H28**
- Wire – **E28** and **D28**
- Wire – **A28** and **VCC28**

Note: The Resistor and LED are SMD 1206 components.

Components:

- 1x Resistor 220 Ohm SMD 1206
- 1x LED SMD 1206

ARDUINO NANO SMD LED

Blink a single SMD LED

This code will blink an external SMD 1206 LED.

This is just a slight modification of the standard Blink LED Arduino example code.

The purpose of this is to ensure that our SMD components are working.

If the SMD LED does not blink, then you will need to troubleshoot the SMD component solder joints.

Be careful when re-soldering SMD components as they are much more heat sensitive that THT components and can be burned into little bricks that do nothing.

Arduino_Nano_Single_LED_Blink.ino

```
/* ************************
 *  Arduino Nano SMD LED Blink
 *
 *  Use digitalWrite to Blink an LED
 *
 *  Written by @alt_bier
 * ************************ */

// Define Pins
#define LED8 1

void setup() {
  // Initialize LED Pins As Output
  pinMode(LED8, OUTPUT);
}

// Main Loop
void loop() {
  digitalWrite(LED8, HIGH);  // turn the LED on
  delay(500);                // wait for 1/2 second
  digitalWrite(LED8, LOW);   // turn the LED off
  delay(500);                // wait for 1/2 second
}
```

This Code Is Available Here: https://github.com/gowenrw/BSidesDFW_2020_HHV/

THANK YOU

I hope you enjoyed this presentation and learned something from it.

-- @alt_bier

This Slide Deck – https://altbier.us/SMT/

Code – https://github.com/gowenrw/BSidesDFW_2020_HHV/