Maker Workbench | Volume 33

We get technical

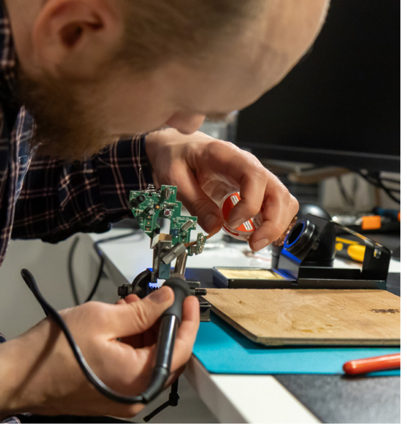
Cutting cable ties without cutting corners: HellermannTyton's EVO Cut hand tool

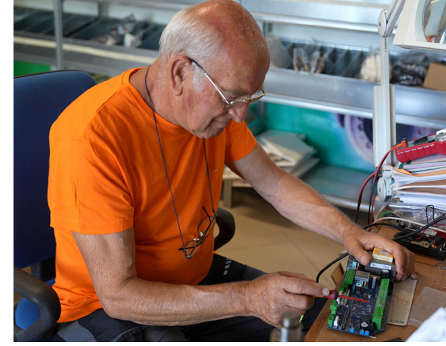
Recommended tooling for Bulgin's 400 Series power connectors

Making consistent and reliable crimped terminations is easy – with the right tool

A beginner's guide to oscilloscope basics

DigiKey



contents

Editor's note

Welcome to the DigiKey eMagazine Volume 33 – Maker Workbench.

As we present this latest volume of our eMagazine, we are excited to focus on a space where creativity, precision, and innovation come together.

Whether you are an experienced engineer, a hands-on hobbyist, or somewhere in between, the workbench is where ideas take shape and concepts become reality. In this issue, we explore the tools, techniques, and components that empower makers to build with confidence and consistency.

This volume is enriched by feature contributions from HellermannTyton and Bulgin, whose expertise underscores the importance of reliable connectivity and high-quality components in any successful build. Their insights highlight how even the smallest details on the bench can have a significant impact on performance in the field.

Complementing these perspectives, we explore a range of practical, skill-focused topics designed to enhance capabilities at the workbench. In "Making Consistent and Reliable Crimped Terminations is Easy – With the Right Tool," we demonstrate how proper tooling improves both repeatability and reliability. Our article, "Understanding, Selecting, and Using Passive Oscilloscope Probes," provides essential insight into achieving accurate measurements – an integral component of any effective diagnostic toolkit. In addition, "Recommended Soldering Techniques" reinforces best practices for creating strong, dependable connections at the core of every project. To further support foundational knowledge, we also recommend "A Beginner's Guide to Oscilloscope Basics."

Across each article, a clear theme emerges: a well-equipped and well-understood workbench is the foundation of successful making. The right tools, paired with the right knowledge, enable not only better results, but also a more enjoyable and efficient creative process.

We hope this issue inspires you to refine your workspace, sharpen your skills, and continue building with curiosity and purpose.

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HellermannTyton bulgin

Cutting cable ties without cutting corners: HellermannTyton's EVO Cut hand tool

HellermannTyton

If you have ever had to remove a cable tie from a dense wiring harness, you know the moment of hesitation that comes with reaching for a pair of side cutters. Slip by a millimeter and you risk nicking the insulation of the very wires you were trying to bundle, and, in some applications, that small mistake can translate into hours of rework or a costly field callback. HellermannTyton has designed its EVO Cut hand tool to take that risk off the table entirely, giving you a purpose-built way to remove cable ties quickly and safely.

A safer alternative to general-purpose cutters

The EVO Cut (part number 110-05105) (Figure 1) is a manual cutting tool developed by HellermannTyton for the specific job of removing plastic cable ties from various bundling applications. Unlike a standard pair of wire cutters, which rely on your judgment to position the blade away from the underlying wires, the EVO Cut uses a notched nosepiece that centers the tool directly on the cable tie strap or the tie head. This notch ensures that only the cable tie is cut, not the cables it was holding together. This design turns a task that used to require careful aim and a steady hand into a simple, repeatable operation.

Since the notch does the alignment work for you, the EVO Cut is the kind of tool you can hand to a newer technician without worrying about damaged wiring. On busy production lines or in a field service scenario, that predictability ensures fewer rework cycles and lower material waste.

Three nosepieces for different cable tie sizes

Cable ties come in a variety of widths and thicknesses, and a single cutting geometry cannot handle all of them cleanly. The EVO Cut ships with three nosepieces that can be swapped in, depending on the cable tie you are working with. Together, they cover cable ties from the 2.45 to 7.8 mm range, which covers most of the plastic ties you are likely to encounter in industrial, commercial, and light-duty applications. This flexibility is valuable in environments where you are servicing equipment assembled over several years. You may find a mix of tie widths on a single piece of legacy machinery, and the EVO Cut lets you work through all of them with one tool body.

One-handed operation and ergonomic design

The EVO Cut weighs just 0.317 kg and is designed to be used comfortably with one hand. That matters more than it might sound. When you are working overhead, inside a cabinet, or in any space where one hand needs to support or steady the harness while the other does the cutting, a heavy or awkward tool becomes a liability. The lightweight plastic housing

Figure 1: The HellermannTyton EVO Cut hand tool.
Image source: HellermannTyton

Figure 2: HellermannTyton released updated versions of its handheld cable tie application tools, the EVO 7 and 9. The new models, called the EVO 7i and 9i, offer visual and functional enhancements in line with the company's ongoing strategy to build the best industrial tools for customers that process wire, cable, and tubular bundles. Image source: HellermannTyton

also helps to keep operator fatigue low during repetitive use, and the shape fits naturally in the palm so you can position the nosepiece precisely without straining your wrist.

Where the EVO Cut fits in your workshop

The applications for a dedicated cable tie removal tool stretch across almost every industry that builds or maintains wired equipment. In automotive assembly and service work, harnesses are secured with dozens of cable ties that might need to be removed for diagnostics or component replacement. In industrial automation and control cabinets, wiring change during commissioning requires ties to be cut and re-applied several times before the final configuration is set. In data center and telecom installations, cables are bundled in tight, high-value runs, and the likelihood of damaging a conductor during removal is significant. The EVO Cut is suitable for all of these environments.

A complement to the EVO tensioning tools

The EVO Cut is part of a broader family of HellermannTyton hand tools that share the EVO name and design. On the installation side, EVO 7i and similar tensioning tools (Figure 2) are engineered for repetitive application of cable ties, combining durable construction with ergonomic shaping to reduce operator fatigue during long runs of harness assembly. Using the tensioning tool to install ties and the EVO Cut to remove them gives you a matched pair of purpose-built tools for the complete cable tie lifecycle, from the first bundle on a new build through every service visit that follows.

That pairing is worth considering whenever you are standardizing tooling for a production line, a service fleet, or training program. Technicians who learn on purpose-built tools tend to develop safer habits than those who improvise with general-purpose alternatives, and the quality of the finished work reflects that from the beginning.

A small tool with outsized value

It is easy to overlook a tool whose only job is to cut something that was already designed to be cut. But cable ties are almost always installed on cables that matter, whether they carry power, signals, or data that a whole system depends on. A tool that protects those cables every time you reach for it is worth having on the bench, in the service kit, and toolboxes of professionals who work with wiring for a living. The EVO Cut delivers value in a package that is light, simple, and ready to use from the moment you pick it up.

To see full specifications, purchase the EVO Cut, or explore HellermannTyton's complete EVO tooling family, please visit the EVO Cut product highlight page.

Recommended tooling for Bulgin's 400 Series power connectors

bulgin
an INFINITO brand

When you are specifying a sealed circular connector for a harsh-environment application, the part number on the bill of materials tells only part of the story. The long-term reliability of that connection depends just as much on how it is assembled, so the right tooling becomes crucial.

Bulgin designs its 400 Series Power Connectors to deliver IP68-rated performance across a wide range of industrial, marine, and outdoor applications, but achieving that level of protection in the field requires crimp terminations that are consistent, repeatable, and mechanically sound.

To help you get there, Bulgin recommends using a specific set of hand tools that work together with the 400 Series to ensure that every contact is seated, crimped, and retained exactly as the datasheet intends.

A quick look at the 400 Series

Before examining the tooling, it helps to understand what the 400 Series (Figure 1) is built to do. As the smallest member of the Buccaneer family, the 400 Series accommodates cable diameters from 3 to 7 mm and offers pole counts from 2 to 12. The current and voltage ratings scale with pole count: 2 and 3 pole versions handle 8 A at 250 V, while 4, 6, and 8 pole versions are rated for 5 A at 125 V, and 10 and 12 pole versions carry 1 A at 50 V. All variants are sealed to IP68 protection when mated, with the rating verified through immersion testing at roughly 1.054 kg per square cm, or a 10 meter depth for two weeks. Mounting options include front panel, rear panel, PCB, flex, and flex in-line styles, and connectors are available in plug and socket versions across all body styles.

Since the cable connectors ship without contacts pre-loaded, you need to crimp the appropriate pin or socket contacts onto your cable and insert them into the connector body. That two-step process is where the recommended tooling set comes in.

The crimp tool: getting your terminations right

The first and most critical tool in the recommended set is the crimp tool. Bulgin specifies the 14025 (Figure 2), an 8 indent crimp tool for use with 400 Series crimp contacts, which matters because the 8 indent geometry applies uniform pressure around the contact barrel, producing a gas-tight mechanical and electrical bond between the contact and the conductor. A poorly crimped contact can easily introduce resistance, heat, and eventual failure, so a tool that delivers repeatable crimps every time is a quiet but crucial contributor to long-term reliability. The crimp tool works in conjunction with a positioner, which is where the pole count matching begins.

The crimp positioner: matching the contact to the pole count

The 400 Series uses three different crimp contact sizes to accommodate various pole counts and current ratings. The 2 and 3 pole versions use the larger 8 A contacts (SA3349 sockets and SA3350 pins), the 4, 6, and 8 pole versions use 5 A contacts (SA3347 sockets and SA3348 pins), and the 10 and 12 pole versions use 1 A contacts (SA3179 sockets / SA3180 pins). Each contact size needs its own positioner to hold the contact correctly in the crimp tool during the operation.

Figure 1: Bulgin's 400 Series power connectors. *Image source: Bulgin*

Bulgin color codes the positioners to match the contact family, which makes it easy to identify the right positioner for the connector you are building. That simple visual cue helps reduce the risk of mismatching tooling on a busy assembly bench, and it pairs naturally with the similarly color coded insertion and extraction tool described next.

The insertion and extraction tool: seating and servicing contacts

Once a contact has been crimped to the wire, it needs to be seated into the connector body in the correct position. Bulgin offers a dedicated insertion and extraction tool for this purpose, and like the positioner it is color coded by pole count and contact rating. The 2 and 3 pole 8 A variant is the blue 13027/2, the 4, 6, and 8 pole 5 A variant is the red 13027/1 (Figure 3), and the 10 and 12 pole 1 A variant is the green 13027. Using the tool designed for the specific contact size ensures the contact is driven into the insert to the correct depth without damaging the seal or the retention mechanism.

The extraction side of the tool is equally valuable. If a contact needs to be replaced in the field, or a wire needs to be reworked during assembly, the same tool can safely remove the contact without cutting or destroying the connector body. For applications where downtime is costly, that level of serviceability is a practical advantage.

Figure 3: Insertion/extraction tool for use with 5 A connectors. Image source: Bulgin

Matching the tooling to your build

When you are planning a build around the 400 Series, your workflow becomes easier once you know your pole count. Start by selecting the connector body style and pole count that suit your mechanical and electrical requirements, then order the matching crimp contacts in pin or socket form as needed. From there, the tooling choices follow directly: the 8 indent crimp tool paired with the positioner that matches your contact size, and the insertion/extraction tool that shares the same color code. Keeping a full set on the bench means you can assemble any 400 Series variant without swapping base tools, which is helpful in mixed production environments where you might be building 2 pole power connections one hour and 12 pole signal connections the next.

Figure 2: The 14025, an 8 indent crimp tool for use with 12 Contact 400 Series Connectors. Image source: Bulgin

Why this matters for your end product

The 400 Series earned an IP68 rating in Bulgin's test lab, but the rating only carries over to your product if the field termination matches the design intent. A correctly crimped contact seated at the right depth maintains the integrity of the internal seal, preserves the contact retention force specified in the datasheet, and avoids the kind of intermittent failures that are almost impossible to diagnose once a product is deployed.

To see the entire range of Bulgin's 400 Series Power Connector body styles, pole counts, and accessories, as well as recommended tooling, visit the 400 Series Power Connectors product highlights page.

Video spotlight

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Digilent Analog Discovery Pro 2440/2450

The Analog Discovery Pro 2440 and Analog Discovery Pro 2450 deliver serious measurements for the engineer who knows what matters. Choose between four analog channels of either 100 MHz bandwidth at 12-bit resolution (ADP2440) or 200 MHz bandwidth at 8-bit resolution (ADP2450) with both featuring 16 independent digital I/O and seamless integration with the WaveForms software.

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Termination Technologies and Tools

Crimp termination, Screw termination, Han-Quick Lock®, Axial screw termination, Cage clamp termination, Han® ES Press, IDC termination technique.

Learn more

Video spotlight

DigiKey

Favorite Things 2025: Top Electronics Tools & Boards for Makers

In this video by @BeckyStern, we're showing off some of 2025's best electronics tools, parts, and boards that Becky has found useful recently and loves. If you're shopping for yourself or the maker in your life, these are her recommendations for great gift ideas. These tools make a great starter workbench!

Learn more

DigiKey

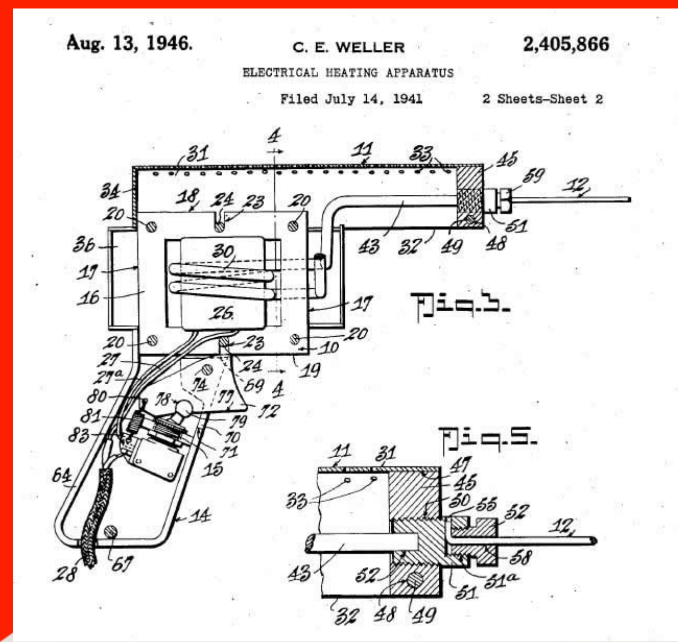
What is Auto vs. Ranging: Multimeters

Digital multimeters (DMMs) are capable of a wide variety of measurements including voltage, current, continuity and resistance. Some models also measure capacitance and temperature. This video explains the functions, features and operation of handheld manual and auto-ranging DMMs.

Learn more

Carl Weller: the man behind the soldering gun

Written by David Ray, Cyber City Circuits



Waiting...

There was a time when every radio repair began with waiting. Not diagnosing. Not probing. Not thinking. Waiting.

Waiting for the soldering iron to get hot, and when the repairman was finished, he would have to wait for the iron to cool off before he could pack it up and be on his way. Some accounts say that it could take half an hour for an iron to get hot enough to work correctly and just as long to cool off.

For a bench technician in a shop, this was tolerable because it would sit on the bench hot at all times, to avoid the delay of it heating up. For a field service technician, standing inside somebody's home, it was a problem.

The iron was built around a simple idea: heat a mass of metal and let that heat conduct to the tip. The resistance wire warmed the body, the body warmed the tip, and eventually, after enough time, you could do your work.

By the 1920s, radio had become a service industry in itself. Radio sets were everywhere. Storefronts, living rooms, kitchens, hospitals, and they constantly failed. Tubes burned out. Connections loosened. Solder joints cracked with constant heat from the vacuum tubes. Keeping the radio alive required a technician to go from house to house, fixing one solder joint at a time.

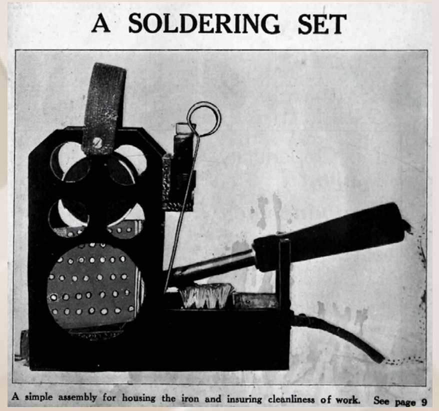
This was long before modern fiberglass circuit boards. Early radios were built on what were called "breadboards," flat wooden panels with components mounted in the open. Tube sockets, coils, and capacitors were fastened directly to the board, and connections were made point-to-point using wire and terminal posts. There were no printed traces, no standardized layouts, just physical connections you could see, follow, and repair by hand.

Soldering in the field was intermittent. Short bursts. A joint here, a joint there. The tool and the task were fundamentally mismatched, and for nearly every radio repairman of the time, that mismatch defined the pace of their work.

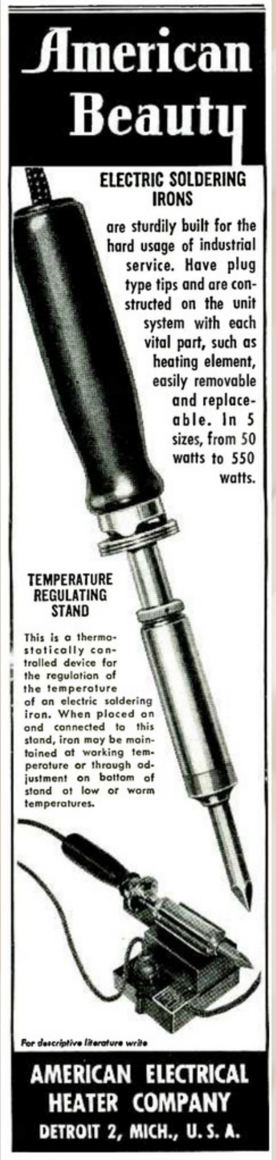
Carl E. Weller

Born in 1911 in rural Chalkhill, Pennsylvania, the youngest of seven children, Weller grew up in a household where formal education was limited, and work started early. At a young age, his father, a local minister, died in a hit-and-run while walking down the road. This left his family in a financial bind, and two of his older brothers moved to Easton, Pa., to start a radio repair shop. After some time, Carl left school early to join them at Weller Bros Radio.

Customers brought in their radios broken and had to be sent back



Example of a soldering station from 1932.



Advertisement for a pre-Weller soldering iron.

Example of the insides of a 1920s radio set.

working. This environment shaped how he thought. He didn't have any institutional training. He was self-taught and learned by doing. He would often say, *"You can learn everything you need to know from a book."* He learned electronics the way many technicians of that era did, through repetition, failure, and direct contact with the problem. Years later, his peers would describe him as "someone who thought with his hands." Weller's education came from repeatedly encountering the same issues, over and over, until his soldering iron stopped being just a tool and became a problem.

The problem that defined his career

The limitation Weller faced was not trivial. It appeared with every repair for every technician.

Carl Weller was the youngest of seven siblings. Here is a family photo of him in the center.

The iron had to heat. The work had to wait.

Time spent waiting was time not spent working. It limited the number of calls that could be made in a day, the number of repairs that could be completed, and the amount of income that could be earned. The tool set the pace of the job.

Electric soldering irons relied on indirect heating. Current passed through a resistance element, heating the body of the iron, which then conducted heat to the tip. Heat traveled through layers of material before it reached the point where it was needed most.

If electricity could generate heat, why not apply that heat directly at the tip? Why not pass current through the working end of the tool itself?

Many others encountered the same question before him. Connecting the tip directly to line voltage would make it live and dangerous for both the user and the work. Copper, the ideal material for a soldering tip, has very low electrical resistance. Connecting it directly to any power source would cause it to draw an enormous current and create a short circuit, making it a difficult problem for anybody to solve.

A solution found while wrapping altimeter coils

Weller did not serve in the military.

Carl with his mother and his older sisters in their western Pennsylvania home.

Church of the Brethren in Farmington, Pa, built in 1919, is the church where Weller's father ministered.

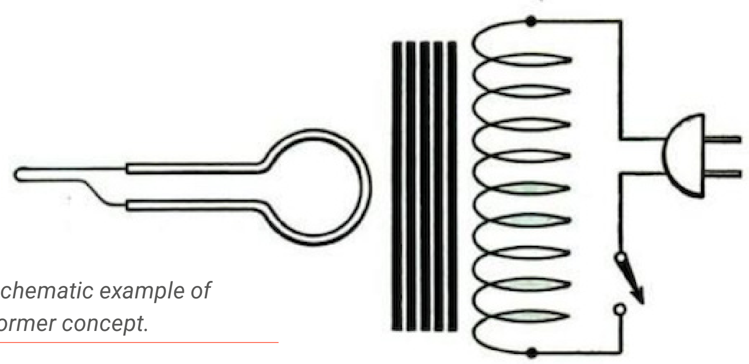
An eye injury kept him from qualifying. But like many small shops of the period, he found another way into the war effort, through production. During World War II, he picked up extra work making altimeter coils. This experience, wrapping coils, led to a breakthrough in 1941, when he reconsidered a new path for the energy. A transformer coil could reduce line voltage to a much lower level while allowing a corresponding increase in current. At very low voltage with a very high current, the electrical hazard would be minimized, and a conductor with low resistance would produce heat.

If current flows through a conductor of uniform size, it heats evenly. However, if part of the conductor becomes thinner, its resistance increases significantly at that specific point, concentrating energy at the soldering tip.

Weller's design incorporated a step-down transformer with a single-turn secondary directly connected to the tip, making the tip part of the circuit. When the trigger was pressed, current surged through the secondary loop, and the narrow tip heated to a soldering temperature within seconds. Releasing the trigger stopped the current, and the heat dissipated just as quickly.

The tool would no longer dictate the pace of the work.

Weller Bros Radio of Easton, Pa. This is the radio shop where Carl Weller first developed the modern soldering gun.



Fundamental schematic example of Weller's transformer concept.

The Weller Electric Corp.

In 1941, Weller filed for a patent on his design, "electrical heating apparatus." A *time-saving and money-making* marvel unlike anything before it.

He tried to sell it. The obvious path was to license the idea to an established manufacturer, like General Electric or Westinghouse. They already had factories, distribution, and sales channels. They knew how to make tools.

They weren't interested.

From their perspective, the idea did not fit an existing category. It did not look like a soldering iron. It did not behave like one. It introduced a transformer, a trigger, and a completely different heating method. It was unfamiliar, and unfamiliar things were risky during war.

Weller decided to start making them himself in the basement of the radio shop. Small batches.

The Weller home near Easton, Pennsylvania

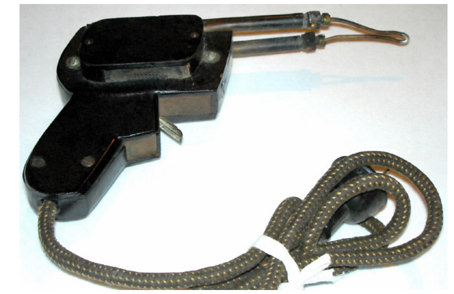
Parts were sourced where available and assembled by hand. Over the next few years, he made 274 soldering guns, using Bakelite and wood for the body. He went to competitors' radio shops, peddling soldering guns out of the back of his car. At first, it was a very tough sale, but soon they were selling so well that in 1945, he started a new company to manage this new venture.

By the time the war ended, Weller was no longer just a repairman with a clever tool. He was a manufacturer who understood how to build things that had to work, every time.

The company was formed as a family partnership, with a small workforce of around ten employees, and very limited automation. He started selling them for $15 a piece in magazine ads and took advantage of word-of-mouth among other repairmen. He went from selling 16,050 soldering guns in 1945 to selling over 32,000 units in 1947.

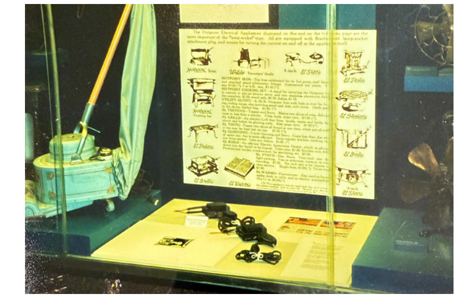
Weller Manufacturing Company

By 1950, the problem had changed. He was selling nearly 100,000 units a year. It was no longer about proving the tool worked. That issue had already been settled in repair shops, one solder joint at a time. The problem now was scale. Demand came faster than the company could respond. What had started as a basement operation had grown into a business that needed factories, planning, and structure.



So, Weller reorganized.

Manufacturing and sales were separated into two distinct operations. Weller Manufacturing Company would focus on building the tools. Weller Electric Corp. would handle distribution, sales, and the growing network of customers and dealers. Within the company, they began thinking in terms of numbers. Magazine reports were studied. Estimates were made. How many radio repairmen were there? How many guns would each one need? The soldering gun was becoming standard equipment across multiple industries.



One of the original prototype soldering guns is kept at the Smithsonian. Circa 1989

In 1952, they completed a large expansion of the factory, essentially doubling the size, and within a few more years, they would have manufacturing plants in North Carolina, the UK, Canada, Germany, and Puerto Rico.

Patent infringement

Competitors began to appear. Some copied the idea outright. Others tried to work around it, producing their own versions of instant-heat tools. What had once been a curiosity was now a product category.

Weller's 1941 filing, issued in 1946 as U.S. Patent 2405866, claimed a very specific way of achieving the 'instant heat' effect by using a low-voltage, high-current system with a transformer and the heating

Time Saving and Money Making

Early magazine advertisement for the Weller Soldering Gun. 1946

element integrated directly into the current path. Competitors were after a new way of creating the same 'instant heat' without violating this patent.

From a historical perspective, we've seen this before. Once a game-changing idea proves

Carl Weller and his wife, Emily, standing in front of Weller Manufacturing Company.

itself, it invites knock-offs and counterfeits. Companies look for ways around constraints. Marketing departments rename things that already existed.

One competitor's design crossed the line. Companies like Hexacon Electric began marketing their own "instant solder guns." Weller considered it an infringement of his patent, and the dispute moved to court. The case stretched on through appeals until, in 1956, a ruling was handed down in his favor. The competitor was required to compensate Weller for past sales and continue production only under a royalty agreement.

Weller advertisement for new line of power tools for Christmas, 1956.

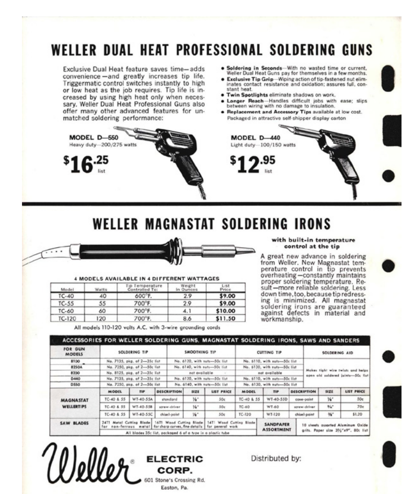
It wasn't a *total* victory. Competitors remained, and in some cases, he had to allow them to keep producing competing counterfeit units as long as they paid their court-ordered royalties.

Retro Electro fun fact: Reginald Fessenden created a patented part that replaced Marconi's detector in telegraph systems. His patent was so heavily counterfeited that when he performed the first voice broadcast on Christmas Eve 1906, it was an overwhelming success, with reports from as far away as Ireland, using a counterfeit Fessenden detector. Read that story in the Retro Electro article "Builder of Tomorrow: Reginald Fessenden's Legacy in Radio and Beyond."

Factory expansion leads to catalog expansion

With all of the new factory expansions, it opened up the opportunity to make more products than just soldering guns. If the company could build one successful electric tool, why not build others? Weller added many power tools to its catalog, such as sanders and saws, along with temperature-controlled soldering irons, and consumer-grade soldering guns.

Adding these new products to their catalog didn't actually go as well as they hoped. These tools did not benefit from some new underlying insight like what made the soldering gun successful. They were not built around a new way of delivering energy. They competed on features, price, and incremental improvements, the same playing field as every other tool manufacturer, and for these tools, Weller didn't have any particular advantage.



Competition intensified, margins tightened, and the products became harder to justify, so one by one, they were dropped from the catalog, returning focus to soldering equipment.

Where is the market saturation?

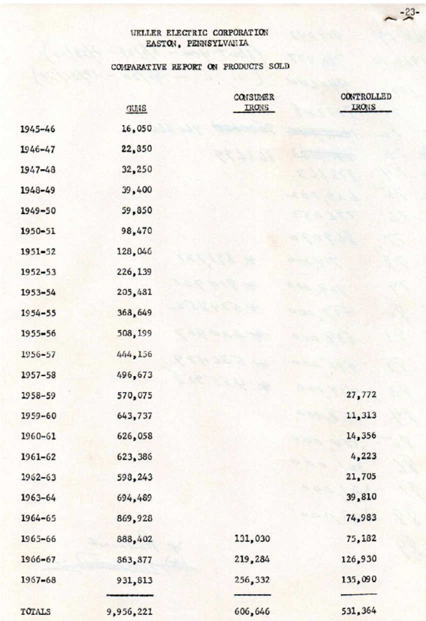
By the early 1960s, the market should have been full. Every radio repairman who needed a soldering gun likely already had one. The initial wave of adoption had passed. By conventional thinking, growth should have slowed, then leveled, or declined, but it never did. Demand continued to rise. The proliferation of television in the home grew the market base of repairmen dramatically, but not enough to account for these sales.

The product had outgrown its original market. New users were appearing, quietly at first, then in increasing numbers. Hobbyists building their own equipment at home. Manufacturers assembling radios, televisions, and new kinds of electronic devices. Entire industries are beginning to rely on soldered connections as a primary means of construction. The soldering gun was no longer tied to radio repair. It was used for so many things it was never intended for.

Cooper Industries

Cooper Industries was founded in 1833 as C&E Cooper by brothers Charles and Elias Cooper. The two grew up digging and hauling coal. Dissatisfied with the business of the coal trade, Charles thought to start his own blacksmith shop and foundry. Charles and Elias, along with a horse to turn the machines, ran the shop themselves. The pair would produce between 500 and 700 pounds of castings a day.

The brothers' early success came from focusing on the local agricultural and food service markets. They produced high-quality plows, stoves, mill irons, wagons, and animal feed troughs. In 1836, they replaced the horsepower with a small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WELLER ELECTRIC CORPORATION
EASTON, PENNSYLVANIA

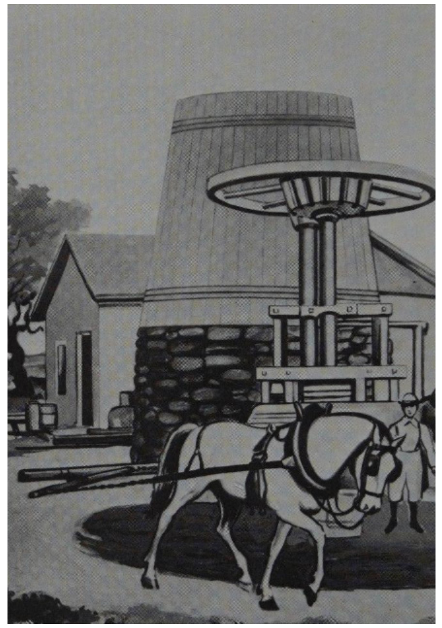
COMPARATIVE REPORT ON PRODUCTS SOLD

	GUNS	CONSUMER IRONS	CONTROLLED IRONS
1945-46	16,050		
1946-47	22,850		
1947-48	32,250		
1948-49	39,400		
1949-50	59,850		
1950-51	98,470		
1951-52	128,046		
1952-53	226,139		
1953-54	205,481		
1954-55	368,649		
1955-56	508,199		
1956-57	444,156		
1957-58	496,673		
1958-59	570,075		27,772
1959-60	643,737		11,313
1960-61	626,058		14,356
1961-62	623,386		4,223
1962-63	598,243		21,705
1963-64	694,489		39,810
1964-65	869,928		74,983
1965-66	888,402	131,030	75,182
1966-67	863,877	219,284	126,930
1967-68	931,813	256,332	135,090
TOTALS	9,956,221	606,646	531,364

Weller Electric Corp sales report for 1945-1968. Over 11 million units sold.

steam engine, which tripled their production capacity. Eventually, turning to making powered machinery for industry, while still supporting the farming industry. In 1848 Elias Cooper died from "Painter's Colic" (lead poisoning from using lead-based paints).

Following his brother's death, Charles sold an interest in the company to a man named T.L. Clark, renaming the business to Cooper & Clark. In 1853, Clark retired, and the company was renamed again to C&J Cooper, after Charles' younger brother, John Cooper. The company, taking advantage of railroad expansion, started building wood-burning locomotives. By 1870, Cooper was manufacturing huge engines that were used to push the Second Industrial Revolution across America.



A drawing of the horse that worked at the first Cooper foundry.

The company would go on to make the first self-propelled tractor in the US. Over fifteen years, they produced nearly 5,000 traction engines, making 500 units a year by 1880. Charles was very active in the company until his death in 1901 at age 90.

At the turn of the twentieth century, Cooper faced a problem. Steam had built the company, but steam was no longer the future. Natural gas and oil were beginning to reshape every industry. New fields in Pennsylvania, West Virginia, and the Midwest were producing fuel that did not need to be shoveled, hauled, or burned in boilers. It could be piped. It could be controlled and, most importantly, used in entirely different kinds of engines. Gas engines.

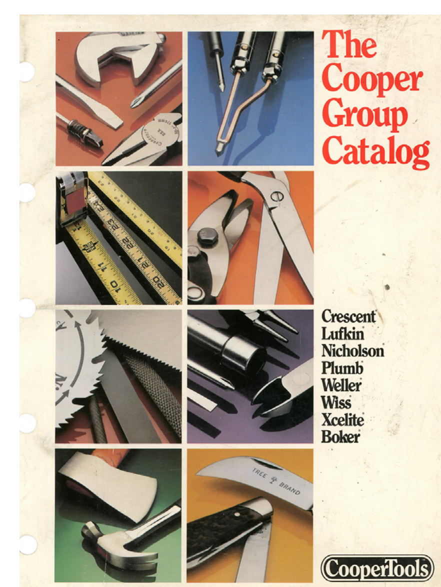
The decision was not to copy an existing gas engine but to build their own by combining the best available ideas. To do that, they hired a German-born engineer, Martin A. Thiel, and began developing large gas engine systems. In 1909, they installed their first unit on a short natural gas pipeline in West Virginia.

By the 1910s and 1920s, Cooper was no longer primarily a steam engine builder. It was becoming a specialist in pipeline compression for oil and natural gas fields. These were not small machines. They were massive, slow-moving engines designed to run continuously, pushing gas across hundreds of miles of pipe. Installation often required teams of field engineers working for months in remote locations. It was difficult, unglamorous work, but it placed Cooper at the center of a new industry.

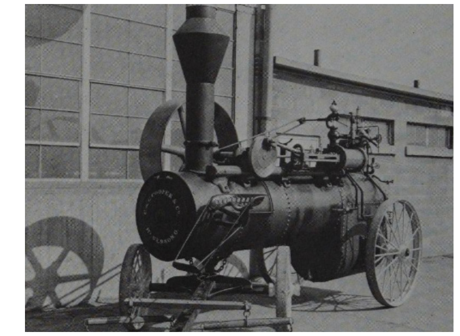
In 1920, Cooper shipped its last major steam engine. The Corliss Engine era, which had defined the company for decades, came to an end. Through the 1920s and into the 1930s, Cooper expanded its role in gas pipeline transmission, becoming one of the dominant suppliers of equipment in the United States.

Vertical integration

Eventually, Cooper was no longer a manufacturer of products in the traditional sense. It was becoming a system integration company. Once a company begins to think in systems, its growth strategy changes. It stops asking, "What can we build?" and starts asking, "What belongs together?"



The 1982 CooperTools catalog includes brands like Crescent, Wiss, Lufkin, and Weller.



A Cooper Portable Steam Engine, manufactured in 1870.

The answer was not always a new or better engine.

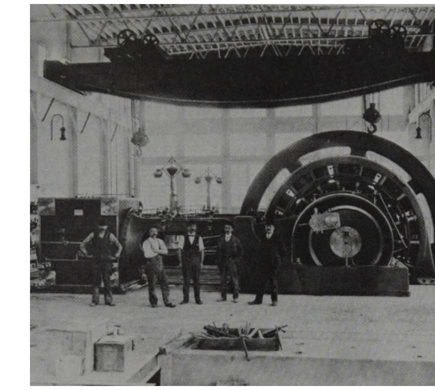
Sometimes it was a component.

Sometimes it was a tool.

Sometimes it was an entire company.

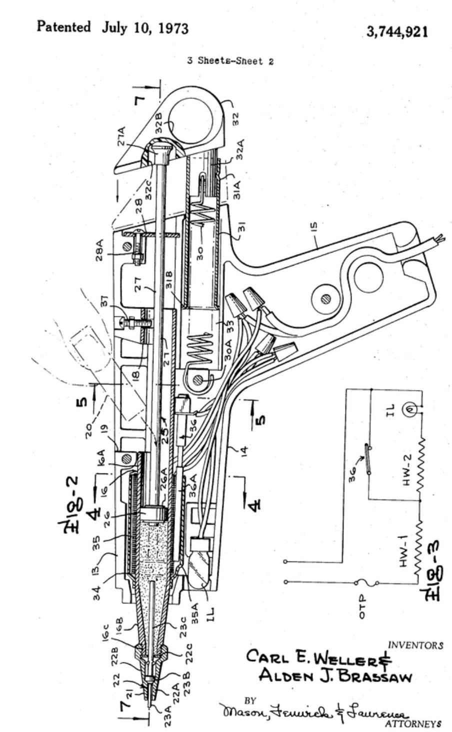
Cooper began to answer that question through acquisition. Rather than inventing every new product internally, the company began acquiring other companies. Each business came with its own specialty, its own market, and its own history. Each carried adjacent capabilities: tools, components, and equipment that fit into the broader industrial ecosystem Cooper was supplying.

By the 1960s, Cooper Industries had become something very different from the small foundry in Ohio.



This Corliss engine ran continuously for fifty years at the National Cash Register Plant in Dayton, Ohio. At the end of the nineteenth century, the Corliss Engine was the flagship product of the ***C. & G. Cooper & Company.***

In 1969, that process reached a point that matters for our story. Cooper Industries acquired the Weller Electric Corporation. Carl Weller worked for Cooper for a handful of years after the purchase.



US Patent 3744921, Glue Gun Construction

Carl and his wife Emily at their 50th wedding anniversary. Early 1990s

Carl Weller and his 635-pound catch in Cabo Blanco, Peru, in 1956.

During this time, he worked within the company to develop new tools and new ideas. One of those tools that became as prolific as the soldering gun is the hot glue gun.

After the acquisition

While working in Puerto Rico he took up boating and fishing. He would go fish off of Cabo Blanco, Peru each year. After a few years with Cooper, Weller moved to Florida in a form of semi-retirement.

Since there was nowhere to dock his large fishing boat, he started his own full-service marina, Venice Marine Center, in 1974. It included docks, a hotel, and even a restaurant. Carl would live for another twenty years, passing in 1994 at the age of 83. His wife's and his ashes were spread across their Pennsylvania estate when they passed. Carl was a philanthropist who gifted 50 acres of the family's land to the town in Pennsylvania. It now houses the town's municipal buildings, fire department, and a public park.

In 2010, Cooper Industries 'spun-off' their tools division into Cooper Tools. Soon, they merged with another large tool group named Danaher, rebranding into Apex Tool Group, the modern holder of the Weller product line.

Today's Weller Soldering Gun still works the same way it did in 1941. Current flows. Resistance concentrates. Heat appears exactly where it is needed instantly.

DigiKey is a leading distributor for the Apex Tools Group catalog.

The writer has a lot of gratitude to Jeff Weller and Craig Grossenbacher, grandsons of Carl Weller. Their help was invaluable. They were very kind to provide many family photos that have never been published before. Thank you.

Suggested reading

1. "The Weller Speedy Iron Model B Soldering Gun" from Steve's Antique Technology
2. "Have Gun – Will Solder" by Hubert Luckett – Popular Science – May, 1963
3. "Weller Electric Corp." by Vintage Machinery
4. "Cooper Industries 1833-1983" by David N Keller
5. "A Weapon of Technology: The Soldering Gun" by Kenneth Segal for Pennsylvania Center for the Book
6. "Carl Weller was inventor, industrialist and altruist." By Ferrara, Katherine for the Sarasota Herald-Tribune 5 Oct. 1994
7. Patent US3744921A "Glue Gun Construction"
8. Patent US2405866 "Electrical Heating Apparatus"

1911
Carl Weller born

Born in Chalkhill, Pennsylvania, into a working family shaped by necessity and limited formal education.

1920s-1930s
Radio repair work

Weller works at Weller Bros Radio, where repeated exposure to slow, inefficient soldering tools defines the problem that will shape his career

1941
Transformer-based soldering gun concept

While wrapping altimeter coils, Weller realizes that low-voltage, high-current transformer design can localize heat directly at the tip, eliminating thermal delay.

Weller files for his "electrical heating apparatus," redefining how heat can be delivered in soldering.

1945
Weller Electric Corp. formed

After early sales success, Weller formalizes production and begins scaling manufacturing.

1945–1947
Rapid adoption

Sales double from ~16,000 to over 32,000 units, driven by word-of-mouth among technicians.

1950
Manufacturing reorganization

Weller separates production and sales operations, creating **Weller Manufacturing Company** to manage scale, marking the transition from invention to industrial enterprise.

1956
Patent litigation victory

Weller successfully defends his core concept in court, forcing competitors into licensing agreements and cementing the design as industry standard.

1969
Cooper Industries acquires Weller Electric

1970s
Weller semi-retires

Carl Weller transitions out of active industry work, founding a marina business in Florida.

1994
Death of Carl Weller

Weller dies at age 83, leaving behind a tool that fundamentally changed how electrical work is performed.

2010
Cooper Tools spin-off becomes Apex Tool Group

Cooper reorganizes its tool division, eventually forming Apex Tool Group, the modern holder of the Weller brand.

Making consistent and reliable crimped terminations is easy – with the right tool

Written by Bill Schweber

As much as I enjoy soldering and producing a quality, attractive solder joint, I also recognize that there are times when soldering is not the right way to join wires to each other or their terminations. I was recently reminded of this reality when I helped a friend upgrade his home's three-zone heating system from one with basic, unpowered, dumb thermostats to smart, Wi-Fi-enabled units.

My original installation plan was to simply solder uninsulated spade lugs to the ends of the various wire connections, including the signal and power-interface relays, then attach the lugs to a standard screw terminal barrier strip (Figure 1). This would simplify the physical connections, allow for disconnection if required for troubleshooting or maintenance, and provide a nice, clean way to organize the arrangement for the long term.

While there were some wires and lugs I could conveniently pre-solder off-site at my bench, many would have to be done on-site in the basement at the heating system electrical panel (which was a large piece of plywood). Upon further thought, I realized this was a bad idea, as properly soldering the several dozen wires to their spade lugs in an awkward, cramped basement setting is never easy, neat, or consistent.

Figure 1: A screw terminal barrier strip provides ease of wiring, access, and connection swapping (if needed for test purposes).
Image source: You-Do-It Electronics

From soldering to crimping

That's when I remembered an alternative. I had a basic manual crimping tool in my toolbox, which offered another solution (Figure 2). You may be familiar with this one. It looks like a large pair of pliers with a designated area at the tip of the jaws for crimp barrels of three sizes, along with other wire-stripping and screw-shearing functions.

What is crimping? Crimping is a joining method that connects two components using a defined pressing procedure. The method forms a secure connection between the conductor and contact and has replaced the soldering process in many cases. Crimping can be used with many types of connectors, including wire-end ferrules, which are then inserted into mating receptacles or connector bodies (Figure 3). This crimped wire-end ferrule is available in many sizes and has a plastic collar (offered in many colors) as an additional insertion aid due to the conical shape in the inner diameter of the collar. It also prevents the angular edges of the conductor insulation from getting caught in the insertion funnel of the contact point.

Figure 2: My crimper was part of a multifunctional tool that could also strip wires and shear small screws. Image source: Harbor Freight Tools

Even if you are an admirer of a well-done solder joint (as I am), there are many reasons to use crimping. A good crimp is mechanically rugged, electrically consistent, and forms a gas-tight contact between the wire and termination, which prevents the ingress of moisture and subsequent corrosion. It is quick and easy to set up, interrupt temporarily, or stop entirely; there are no hazardous fumes or materials, and there's no heat to distort insulation or even cause ignition and fire.

So I bought a box of spade lugs with insulated barrels, practiced crimping on about ten of them to make sure I could do it right, and then did the actual installation (Figure 4). It went fairly smoothly, and the system was up and running after resolving some minor wire-routing problems. Despite the haphazard appearance of the loop entry feeds (beyond my control), the actual relay and interconnection wiring, with its crimped spade lugs and barrier strips, is clean, organized, crisp, and reliable.

However, while crimping the spade lugs, I found that it was tricky to make consistent crimps, as my tool was manual and uncalibrated and relied upon the user (myself, in this instance) to place the spade lug correctly in the jaws and apply the correct amount of pressure. It was easy for me to be off target in the final crimp position and to also apply more pressure than necessary. For example, some spade lug barrels were crimped too little, some too much, and some had insulation partially under the crimp zone.

What I now wish I had was a crimping tool like the Weidmülle PZ 6 ROTO ADJ (Figure 5). It reliably and consistently crimps wire-end ferrules over a wide ran of wire cross-sectional areas fro 0.14 square millimeters (mm2) tc mm2 (roughly 26 AWG to 10 AWG). It works with wire-end ferrules, with and without plastic collars. Its ratchet guarantees precise crimping and a release option in the event of incorrect operation.

Among its other features are the adjustable handle width for optimum ergonomics and fatigue-free work, a weight of just 425 grams (15 ounces), and a rotatable crimp die for adapting it to a wide range of installation situations.

Getting technical

Due to its versatility, convenience, and potential performance, the physics and mechanics of crimping have been extensively studied. For example, Weidmüller's 17-page white paper 'Crimping: A permanent connection' begins with a discussion of wire types, stranding, and gauges; contact types; ferrules; and tools.

Figure 3: This crimped wire-end ferrule is available in many sizes and has a plastic collar as an additional insertion aid due to the conical shape in the inner diameter of the collar.
Image source: Weidmüller Interface GmbH & Co.

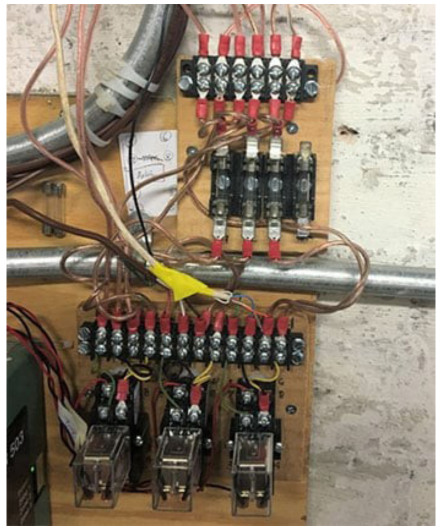


Figure 4: Despite the haphazard appearance of the loop entry feeds, the actual relay and interconnection wiring, with its crimped spade lugs and barrier strips, is clean, organized, crisp, and reliable. Image source: Bill Schweber

It examines the relative pros and cons of different press shapes such as trapezoid, square, and hexagon. It looks at preparing the wire, showing the problems, which can occur if the wire is not cut properly (Figure 6) or the insulation is not stripped properly (Figure 7).

The white paper also calls out the many DIN and IEC standards related to crimping, such as conductor (wire) classes, stripping errors, tool lifetimes (in cycles), die connector compartment sizes versus wire size, and crimp actuating force.

Then there's testing

One of the challenges with crimped connections is that there is no easy way to non-destructively test them. This is the same dilemma designers face when using many other components, such as standard, thermally activated fuses: you can't test them, so they have to be perfect by design and manufacturing. As crimping is widely used in countless mission-critical applications, this testing limitation poses a quality assurance challenge.

Recognizing this, NASA has developed a patented ultrasonic-based, non-destructive evaluation method that operates in real-time at the crimp installation location. In this approach, the quality of the contact between the connector and the wire is determined by sending an acoustic wave through the crimp assembly (Figure 8). As the applied pressure increases and the crimp terminal deforms around the wire, the ultrasonic signature passing through the crimp is altered.

Figure 5: The Weidmüller PZ 6 ROTO ADJ is an adjustable crimping tool that provides consistent results, is comfortable to use, and handles a range of wire sizes and types. Image source: Weidmüller Interface GmbH & Co.

The system analyzes the changes in the signal signature, including the amplitude and frequency content, as an indication of the quality of both the electrical and mechanical connection between the wire and terminal (Figure 9).

Crimp-related issues such as under-crimping, missing wire strands, incomplete wire insertion, partial insulation removal, and incorrect wire gauge have been tested using this system. The results demonstrate that the instrument consistently distinguishes between good and poor crimps for these issues, among others.

Figure 6: Shown are the three ways a wire can be improperly cut, as well as the appearance of one done correctly. Image source: Weidmüller Interface GmbH & Co.

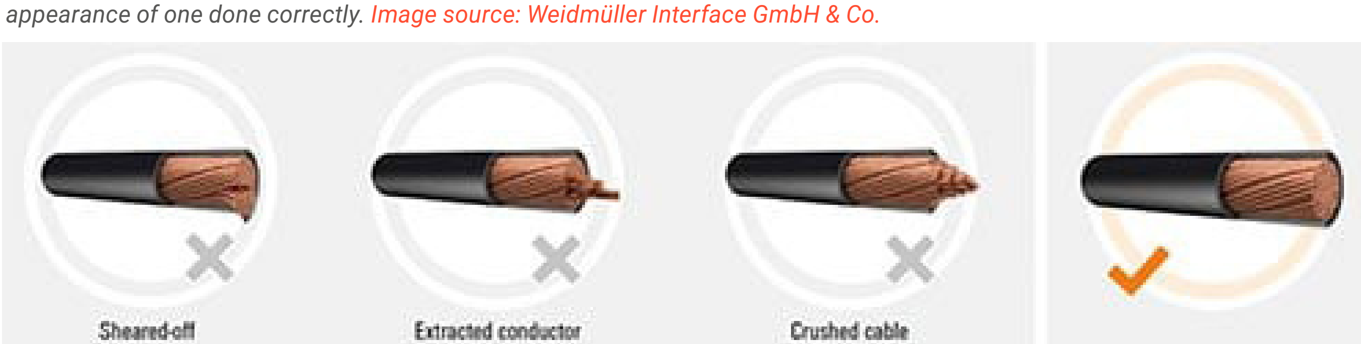


Figure 7: Shown are three examples of insulation stripping errors as well as a properly stripped wire. Image source: Weidmüller Interface GmbH & Co.

Conclusion

In the end, I redid a few of my crimps, which did not meet my admittedly subjective standards, and the three-zone, smart-thermostat control system has worked without any issues for three winters. Using the uncalibrated crimp tool, with its user-dependent variations in squeeze pressure, made me realize yet again, that having the right tool is a very important part of delivering consistent, properly made results. If I ever have to do a similar job, I'll beg, borrow, or buy the needed tool.

Figure 8: This portable instrument developed by NASA can non-destructively identify both good crimps and the many types of bad crimps in real-time. Image source: NASA

Related Content

1. Weidmüller, "PZ 6 ROTO ADJ Data Sheet"
2. Weidmüller, "Super individual: PZ 6 ROTO ADJ" (video)
3. Weidmüller, "Crimping: A permanent connection"
4. NASA, "Rapid and Verified Crimping for Critical Wiring Needs"

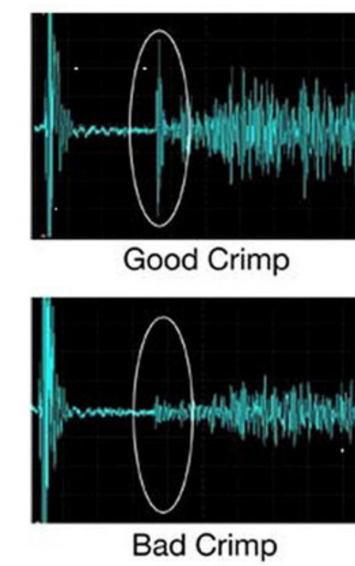


Figure 9: The NASA system uses ultrasound-derived signatures to identify crimp quality and problems. Image source: NASA

Understanding, selecting, and using passive oscilloscope probes

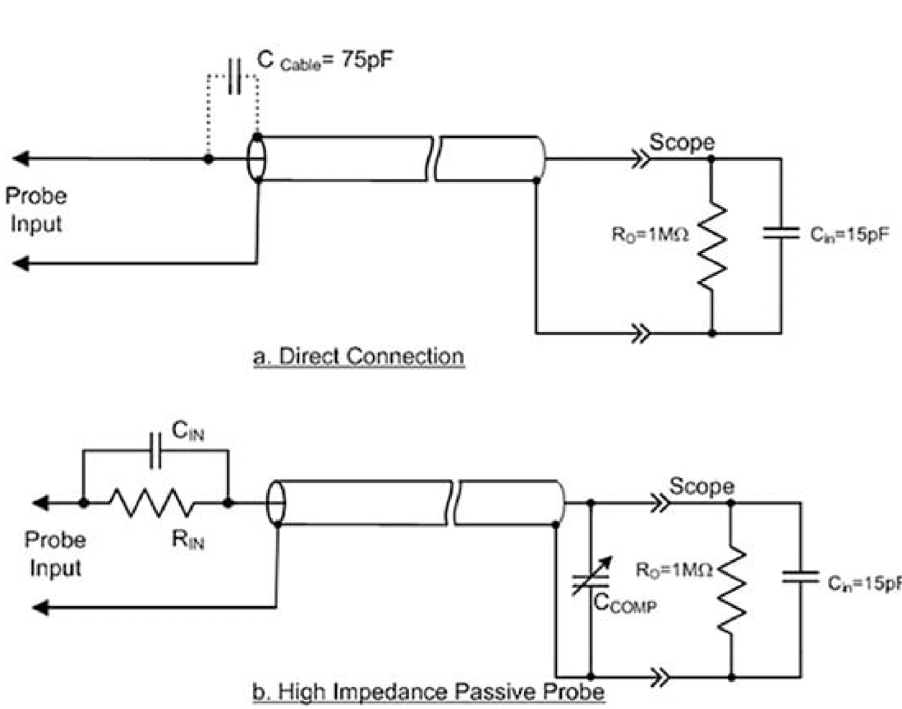
Written by Art Pini

Editor's note: probes connect the input of the oscilloscope to test points on the device under test (DUT). There are many types, including: high impedance passive, low capacitance, single-ended active, differential active, high voltage, and current probes. This is the first in a series of three articles on probe selection and application and will focus on passive probes. Part 2 and part 3 will address active probes and current probes, respectively.

Passive probes offer a good way of connecting an oscilloscope to the device or circuit under test. They are low cost, reliable, and offer reasonable signal integrity when used knowledgably. This article will explore passive probes from the theory of operation through basic adjustments and use. The characteristics of passive probes that affect proper measurement are presented with an eye toward understanding the most effective application of these devices.

Oscilloscopes commonly offer either a 50 W or 1 MW input termination. The 50 W termination is generally used with matching coaxial cables to connect to circuit elements with 50 W sourcing. This results in a high-quality interconnection with minimum signal distortion. Use the 1 MW input termination to connect to circuits with a higher source impedance. This connection can be made in a couple of ways, directly using a cable or an X1 probe, or

Figure 1: Simplified circuit comparing a direct connection (a) and the use of a high impedance probe (b) to connect a signal to an oscilloscope's 1 MW input.
Image source: DigiKey



by using a high impedance probe (Figure 1).

The 1 MW input also includes a shunt capacitance of from 15 to 25 pF. With a direct connection, the unmatched cable adds an additional 10 to 30 picofarads (pF) per foot of cable length. In a typical situation with a three-foot-long cable, the load at the probe end of the cable is 1 MW with a parallel capacitance of approximately 90 pF (Figure 1a). For low-frequency measurements, the capacitive loading is negligible. For instance, at 1 kHz the capacitive reactance is about 1.8 MW. However, for higher frequency signals, the effects can be very bad. At 100 MHz, the capacitive reactance is reduced to about 18 W, which will attenuate the signal significantly.

The effects of the input capacitance of the oscilloscope and that of the connecting cable can be reduced as shown in the high impedance probe (Figure 1b). This probe is basically a compensated attenuator. The input resistor, nominally 9 MW, forms a 10:1 attenuator with the 1 MW input termination of the scope. The capacitors Cin and Ccomp are used to compensate the attenuator and form an all pass network. Compensation is ideal when the RC products of Cin and Rin equal those of Ro and the sum of the cable capacitance Cin and Ccomp. Ccomp is used to adjust compensation. The capacitance at the input is dominated by Cin, which is about one tenth that of the sum of the other capacitors in the circuit. For this, example it will be about 10 pF.

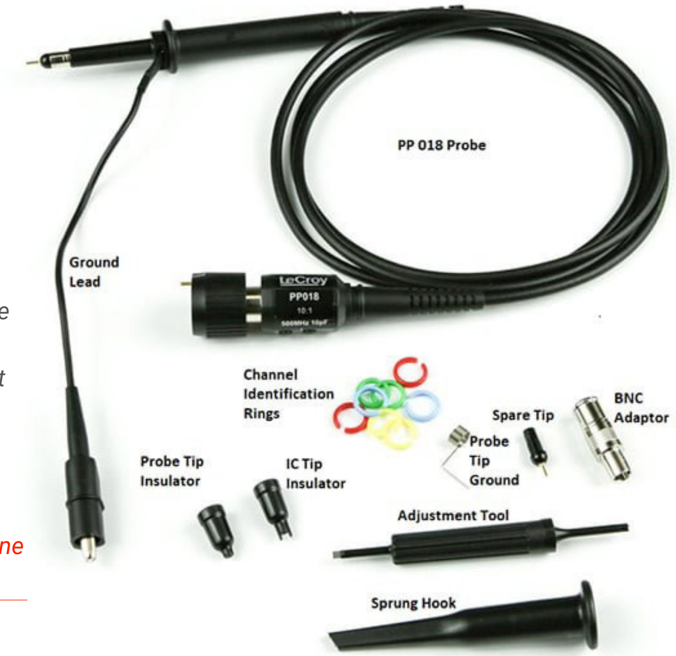
High impedance passive probes

Almost every major oscilloscope supplier includes a set of high impedance probes with their instruments. Teledyne LeCroy's HDO4104A four channel, 1 GHz oscilloscope comes with four PP018-1 probes. These are 10:1 high impedance passive probes with a bandwidth of 500 MHz and an input capacitance of 10 pF. The probes are designed to handle input voltages of at least 350 Vrms.

Most passive probes use an attenuation sense pin that tells the oscilloscope to scale the waveforms automatically, requiring no user input.

Many high impedance probes also include a high frequency compensation adjustment. This adjustment does not commonly have to be performed. The probe manual will supply details of this test.

Figure 2: The PP018 high impedance probe has a bandwidth of 500 MHz and an input capacitance of 10 pF. It is shown here along with supplied accessories.
Image source: Teledyne LeCroy



Low frequency compensation of a high impedance probe

High impedance probes are matched to the channel they are connected to by the process of low frequency compensation. For this process, all oscilloscopes provide a low-frequency square wave, typically 1 kHz, usually called the CAL output. To make use of this feature, first connect the probe to the desired channel and then connect the probe tip to the CAL output. Trigger the scope and view the selected channel trace on the screen. Use the adjustment tool to vary the compensation adjustment in the probe connector box to obtain a square corner on the square wave trace as shown in the center trace (Figure 3).

Compensation should be done whenever the probe is connected to a different channel, and especially before any critical measurement. Many high impedance probes also include a high frequency compensation adjustment. This adjustment does not commonly have to be performed. The probe manual will supply details of this test.

Smart probing

Applying high impedance probes correctly requires attention to fundamentals so that they don't distort the measured waveform. For example, how will the input capacitance of the probe affect the measurement?

To find out, compute the capacitive reactance (1/2πfCin) for the probe at the highest frequency component of the signal. Does the circuit under test support that load? If it does go ahead. If not, look for a different probing solution, such as an active probe (Part 2 of this

Figure 3: Low frequency compensate the probe by adjusting the compensation adjustment to obtain a square corner on the CAL square wave, as shown in the center trace. Image source: DigiKey

series). A good rule of thumb is to restrict the use of high impedance probes to signals under 25 MHz. The probe manual will commonly provide a graph of the probe input impedance versus frequency to help assess the usefulness of the probe at any given frequency.

Probe accessories can also lead to problems, again mostly at high frequencies. A case in point is the ground lead inductance. The ground lead shown in Figure 2 is about 4.3 inches (11 cm) long. It has significant inductance. When the probe is connected, any voltage across that inductance will be in series with the signal. It pays to keep the ground path length as short as possible. To that end, there are a number of accessories included with the probe. The probe tip ground and the BNC adaptor are included for this purpose. Figure 4 compares the results of using different ground accessories to measure a step signal with a 3 nanosecond (ns) rise time.

The yellow trace in Figure 4 is the signal coming from the generator measured using the 50 W input termination, it serves as a reference to signal quality. The red trace shows the result of using the 11 cm ground lead. High-frequency components from the signal developed across the lead inductance have caused the observed overshoot. The probe tip ground and BNC adaptor have about the same response with a much smaller overshoot because the ground path length is much shorter with respectively lower series inductance.

As mentioned, this effect only occurs where the signal has significant high-frequency content. If the same measurement were made with a sine wave, the difference would not be at all apparent. These are effects to keep in mind when using a probe.

Probe accessories and their purpose

Table 1 lists the accessories

Accessory Component	Use
Sprung Hook	Attaches to the probe tip to clip onto circuit test points or components
Ground lead with alligator clip	Attaches to probe ground rin to provide return connection for the probe
BNC adapter	Fitted onto the probe tip, it allows the probe to be attached to a BNC jack, providing both signal and ground connections
Probe tip ground	Fitted around probe tip ground sleeve to provide a short ground connection to the circuit under test
IC tip insulator	Fitted over the probe tip, provides insulation and is intended to go between the pins of an IC, allowing the probe to contact one pin while insulating it from adjacent pins
Tip insulator	Fitted over the probe tip, insulates the probe tip except for the very end. Used for probing on circuit boards with closely spaced components to prevent short circuits
Channel identifier rings	Slipped into slots on the probe and the probe connector box. Color should match the trace color of the channel the probe is connected to
Adjustment tool	Used to adjust the low frequency and high frequency compensation trimmers
Replacement tip	Spare tip for the probe in case the original tip is damaged

Table 1: Probe accessories supplied with the PP018 probes and their purpose (refer to Figure 2). Information source: DigiKey

supplied with the PP018-1-ND probe and their purpose.

Selecting alternative probes for an oscilloscope

Sometimes, the measurement application may require a different oscilloscope probe. For instance, a test of a power supply requires both a direct connection for ripple measurement, and an x10 high impedance probe for measuring the voltage rails. Having to change between two probes is time consuming, but DigiKey lists several x1/x10 switchable probes. This means no need to change probes, but how is an appropriate substitute specified?

The first step is to determine the bandwidth required for the measurement. In this example a probe bandwidth of under 100 MHz would do. Check the maximum voltage rating of the probe to insure that it meets the measurement requirements. Finally, make sure that the oscilloscope's input capacitance is within the compensation range of the probe x10 specification.

A good probe to go with the 15 pF input capacitance of the HDO 4104A oscilloscope is the SP300B x1/x10 switchable probe with a 300 MHz bandwidth, 300 volts maximum input, and a compensation range of 10 to 35 pF.

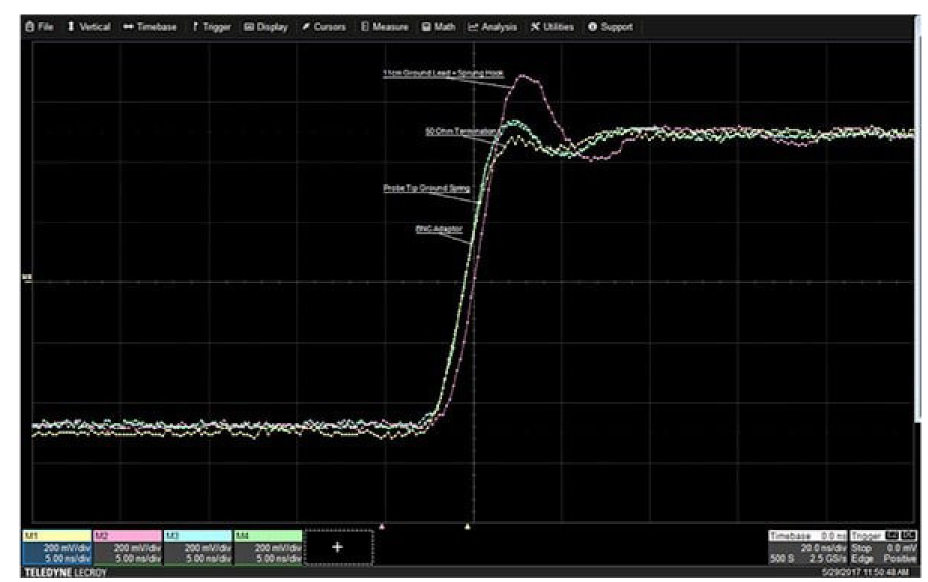


Figure 4: Showing the effects of ground lead inductance on a signal: it pays to keep the ground lead as short as possible as it presents an inductance in series with the signal. Image source: DigiKey

Conclusion

High impedance passive probes, applied with fundamental knowledge of test issues and techniques and some experience, are a good general purpose tool for connecting an oscilloscope to a test circuit. Keep in mind that they are not the only solution to probing issues, but they are a cost-effective starting point.

Recommended soldering techniques

Written by Diodes Incorporated

The soldering process is the means by which electronic components are mechanically and electrically connected into the circuit assembly. Adhering to good soldering practices will preserve the inherent reliability of the original components and ensure a good, reliable connection of the component into the circuit assembly.

Soldering considerations

Substrates

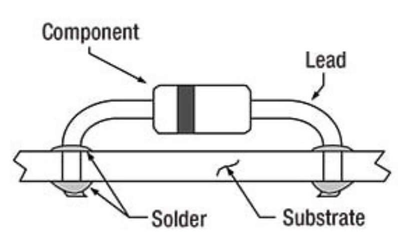
A substrate is a material which constitutes a printed circuit board, commonly called a PCB.

To select the most appropriate substrate material for the application, the designer of the circuit assembly must weigh these five factors:

1. Coefficients of expansion for all the components which will be soldered onto the PCB
2. Coefficient of expansion for the substrate
3. Cost of the substrate
4. Cost of any secondary operations to the substrate, such as the drilling of *"through-holes"*
5. Application-specific issues, such as vibration resistance and weight

It is important to match the coefficients of expansion for the components to those for the PC board. When a PCB assembly is soldered and the coefficients of expansion for the components and the PC board are not matched, the solder joints may crack or the bodies of the parts may crack or shatter as the assembly cools.

Figure 1: Axial-leaded components.



There are many different types of PCB substrate materials. Among the most common are the following:

Substrate	Advantages	Disadvantages
Phenolic	Very inexpensive, easy to punch and drill.	Poor resistance to vibration and mechanical shock.
FR-4	Inexpensive, moderately easy to drill.	Cannot be punched, heavy components need mechanical support.
Alumina	Good resistance to mechanical shock.	Expensive, poor coefficient of expansion match to glass.

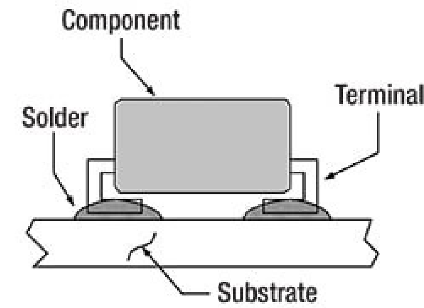
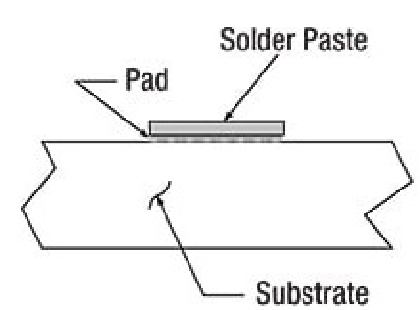


Figure 2: Surface-mount components.

PCB pad layout and solder paste thickness

It is important to use proper layout patterns in order to ensure good solder connections, especially for surface-mount components soldered by a reflow process. Many surface-mount components have more than three terminals which form the "footprint" for the devices. Ideally, every terminal of the device would be formed to create a perfect mounting plane. In the real world, there is a tolerance associated with how close each lead comes to meeting the intended plane. A measure of this characteristic is called coplanarity. In most cases, some of the terminals of a device will not be perfectly aligned with the intended mounting plane. In an infrared reflow solder process, the PCB pads are coated with a solder paste (Figure 3). When the assembly is heated in an oven, the solder paste warms and reflows. As the solder paste liquefies, it forms an apex at the center of the PCB pad. This apex must contact the terminal of the device in order to make contact. When using an IR reflow process, the solder process engineer must take into account the pad layout and the coplanarity of the devices when determining the solder paste thickness. Figure 4 shows a failure mode where the device has poor coplanarity and the solder paste thickness is insufficient for the apex of the liquefied solder to contact the poorly formed terminal.

Figure 3: PCB with solder paste before component insertion and reflow.



Care must also be taken not to use too much solder paste. Excessive solder paste will result in too much solder on the pad. The terminals of many surface-mount components are designed to flex, which allows the terminals of the component to withstand mechanical and thermal stress without fracturing. When excessive solder is applied, the terminals become captivated within the solder and force is transferred away from the terminals and into the internal structure of the device. This can lead to immediate or latent failures. Figure 5 shows a solder connection with the proper amount of solder and Figure 6 shows excessive solder.

Fluxing and cleaning

Another major consideration in soldering is fluxing. Flux, used in conjunction with solder during the soldering process, is the material that aids the solder in flowing. The selection of the proper flux and its correct application are essential to proper soldering. Fluxes have differing levels of activity, or abilities to remove contaminants from the device terminals and PCB pads.

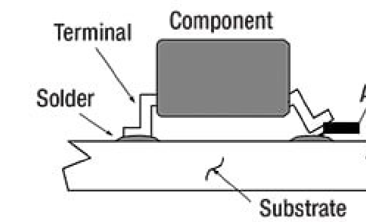


Figure 4: Device exhibiting poor coplanarity.

A key characteristic of fluxes is their solubility. The solubility of the flux determines which wash processes can be used to remove the flux. In the past, many circuit assembly facilities used active, non-water soluble fluxes. Active fluxes are able to remove surface oxides from the leads or terminals of the devices and result in even, smooth solder joints with excellent wettability. However, active fluxes are highly corrosive. When active fluxes are not completely removed, the solder joints are more likely to corrode and the long-term reliability of the assembly may be degraded. Active fluxes must be removed from the PCB. The removal process is called cleaning or washing. Many

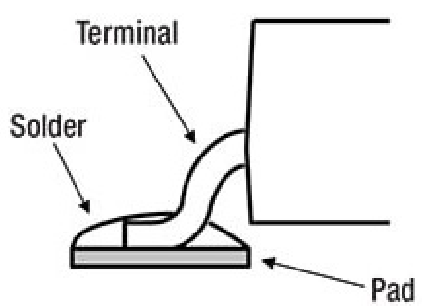
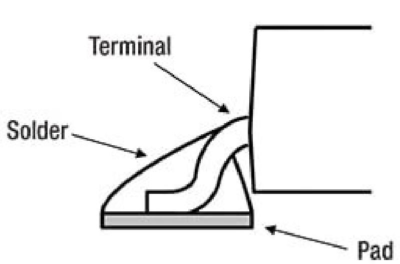


Figure 5: A good solder connection.

materials which are highly effective at removing flux (such as freon and trichloroethane) became subject to environmental legislation several years ago, and they are now illegal in environmentally conscious countries. As a result of these concerns, the following two trends have emerged:

1. Some circuit assemblers have migrated to low activity fluxes. Fluxes are available now which have such low activity levels that it is not necessary to remove them from the PCB. Such fluxes are commonly referred to as "no-wash" "leave-on" fluxes. However, low activity fluxes frequently lead to wettability problems. Wettability is a measure of how well the solder joins the device lead or terminal to the PC board (Figure 7).

Figure 6: Excessive solder.



Two important factors in a low-activity flux process are the cleanliness of the device leads or terminals, and the plating thickness of the leads or terminals. If the terminals of a device are not sufficiently clean, de-wetting can occur. If the plating thickness of the device terminals is insufficient, non-wetting can occur.

- *De-wetting:* Fluxes with low activity levels are not as effective at removing oxides and contaminants from device leads or terminals as active fluxes. When contaminants are not properly removed from the pads and/or the leads of the devices, de-wetting can occur. De-wetting is characterized by irregular and dispersed solder droplets on the joint surface, often separated by a thin layer of solder between them.
- *Non-wetting:* Solder may not adhere to the leads or terminals of a device if the plating thickness is too thin. This problem especially applies to axial-leaded devices since the solder must bridge across the through-hole from the pad to the lead (Figure 8).

2. Due to the aforementioned concerns pertaining to low activity fluxes, the electronics industry has developed highly active fluxes which are water soluble. These new types of fluxes offer the effectiveness of a highly active flux in conjunction with water-solubility for ease of cleaning.

Plating composition

The leads or terminals of components usually consist of either copper, a copper alloy, or other alloys such as dumet. The leads are plated with one or more other metals. Three common plating materials are tin, lead, and silver. The composition of the plating material directly affects the solderability of the device. When an alloy is used for plating, the temperature at which it transitions from its solid to liquid state is called the eutectic temperature. Many axial-leaded components are plated with either 100% Tin (Sn), or 90% Tin (Sn)/10% Lead (Pb). The melting point of 100% Tin is approximately 232°C, and 90 Sn/10 Pb has a eutectic temperature of approximately 216°C. Many surface-mount components are plated with an alloy of 60% Tin, 40% Lead (Pb), which is eutectic at approximately 190°C. The eutectic temperature of the plating alloy determines the minimum limit of the soldering process temperature in order to reflow the plating on the device's leads or terminals.

Body composition

The body composition of the devices is also pertinent to the soldering process. The body material of many components consists of plastic epoxies, which can be grouped into two main

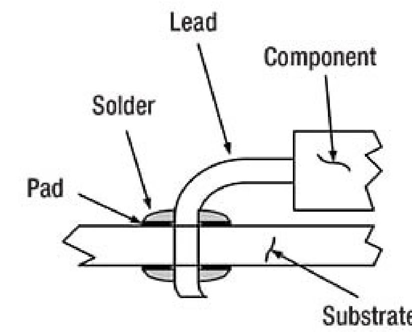


Figure 7: A solder joint exhibiting good wetting.

categories:

- *Thermoplastics:* Thermoplastics can be melted and remolded more than once. One such body material is called Thermoplast, which melts at around 280°C. Thermoplast has a melting temperature which is relatively close to the eutectic point of the plating on their leads or terminals. Solder process engineers should make sure that the peak soldering temperature does not exceed the melting temperature of any thermoplastic-bodied devices.
- *Thermosetting plastics:* In contrast to thermoplastics, thermosetting plastics, such as Duroplast, are formed only once. Subsequent exposures to high temperatures (such as those in the range of most solder processes) cause the material to harden instead of soften. Exposure to excessively high heat causes a thermosetting plastic to crack or crumble.

Soldering methods and process stages

Soldering methods commonly used today include:

- *Wave soldering:* Wave soldering is still widely employed for axial leaded devices and for mixed technology boards. Surface-mount components can be wave soldered successfully if the recommendations in this document are followed. Surface-mount components must first be mounted to the PCB with an adhesive before they can pass through the solder wave.
- *Reflow soldering:* Most surface-mount components are reflow soldered. The two major types of reflow processes are:

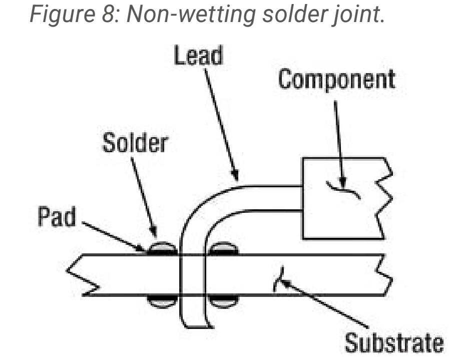
1. *Infrared reflow* - the most common type of reflow process.
2. *Vapor phase reflow* - rapidly disappearing due to environmental restrictions on fluorocarbons.

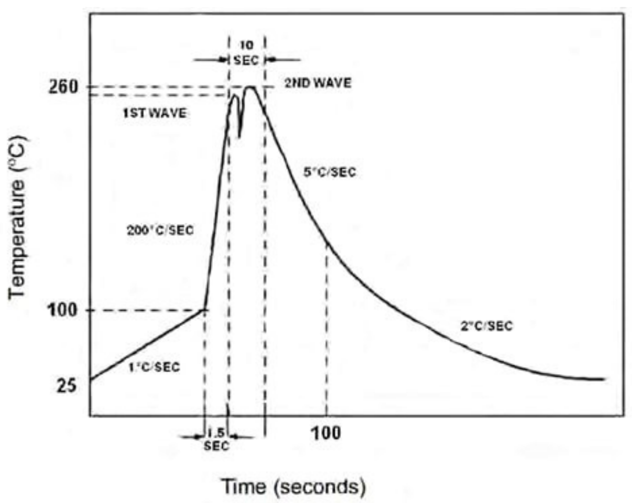
There are four process stages in soldering:

1. *Preheat:* The preheat process is very important in any kind of soldering process. To avoid thermally shocking the components, PCB assemblies must be preheated. Immediate or latent damage can occur to the components if they are not preheated properly.
2. *Soak:* A soak period is advisable so that components of differing thermal mass will approach a similar temperature prior to the peak stage. During reflow soldering, this is the period where the flux begins to break down the oxides which would inhibit solder adhesion.
3. *Peak/Reflow:*

- Temperature: The range of the peak soldering temperature depends on several factors, two of which have been described in previous sections: plating and body compositions. The minimum soldering temperature range should be at least 5-10°C higher than the eutectic temperature of the plating alloy. The maximum soldering temperature should be at least 5-10°C lower than the melting temperature of any thermoplastic components (if used).
- Time: The devices must be held at the peak soldering temperature long enough to ensure the proper wetting

Figure 8: Non-wetting solder joint.





Profile Feature	Pb-Free System
Average Ramp-Up Rate	~200 °C/second
Heating Rate during Preheat	Typical 1–2, max 4 °C/sec
Final Preheat Temperature	Within 125 °C of solder temp.
Peak Temperature	260 °C
Time within +0 -5 °C of actual Peak	10 seconds
Ramp-Down Rate	5 °C/second max.

Figure 9: Suggested wave solder profile (For devices with Pb-free terminal plating using Pb-free solder).

of the solder connections. However, keeping the peak soldering time to a minimum to avoid the possibility of damage to the devices and to increase throughput, is recommended.

4. *Cool down:* After the devices are exposed to the peak soldering temperature, they go through a cool-down process. Although some manufacturers cool their PCB assemblies in free air, it is better to use a controlled temperature chamber for superior control of the thermal gradient.

Suggested thermal profiles for soldering processes

Diodes Incorporated presents the following general thermal profiles for soldering processes (Figures 9 and 10) as examples only. The solder process engineer should always optimize the thermal profile for each circuit assembly based on its specific requirements.

Soldering process suggestions

1. One of the first surface-mount packages that was introduced to and accepted by the manufacturing community was the plastic MELF (metalized electrode face) package. Although plastic MELF products are often used in wave-solder applications, their long-term reliability may be adversely affected if they are used in a non-optimized wave-solder process. Superior surface-mount packages have been developed since their introduction that have proven to be more rugged and more reliable in wave solder processes. In particular, we recommend our SMA, SMB, SMC, POWERDI 123 and POWERDI 5 style devices. Please review our suggested pad layout document for converting PCB layouts from MELF to SMA, SMB or POWERDI 5.

2. Due to the differing thermal capacities of large and small components and equipment wear, localized "hot spots" and "cold spots" may be generated during reflow soldering. Special care should be taken to avoid the damage of small components in "hot spots" and de-wetting or non-wetting of larger components in "cold spots". A good practice is to mount miniature thermocouples in several locations on the PCB which are suspected to be hot and cold spots. The reflow solder profile can then be adjusted accordingly to result in optimal soldering. A good practice is to place the PCB assemblies at regular, repeated positions on the conveyor system to achieve uniform soldering on successive assemblies.

3. The leads on most Diodes Inc. RoHS compliant (Pb-free) devices have a Matte Tin (Sn) plating finish over an ALLOY 42 Lead frame. Some devices have silver (Ag) plating. The Matte Tin finish requires a higher solder temperature (235-255°C) than our standard products (217-235°C), which have a tin/lead (Sn-Pb) finish.

4. IPC/JEDEC document J-STD-020C provides a reflow profile applicable to both Sn-Pb and Pb-free devices. This profile is not a recommendation for reflow soldering. Rather, it is a temperature vs. time profile that a device must withstand without failure in order to maintain a desired moisture sensitivity level. In that sense, it represents the maximum stress to which a device should be subjected.

5. Diodes Inc. soldering recommendations are within the JEDEC profile and should be considered a reasonable starting point in developing a profile for reflow soldering. Actual temperatures will depend on your soldering alloy, PCB layout, weight of copper, pad sizes, and other variables. In any event, temperatures in excess of 260°C violate Diodes Inc. specifications.

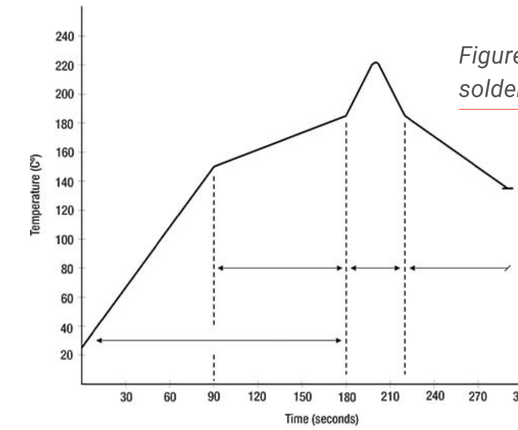
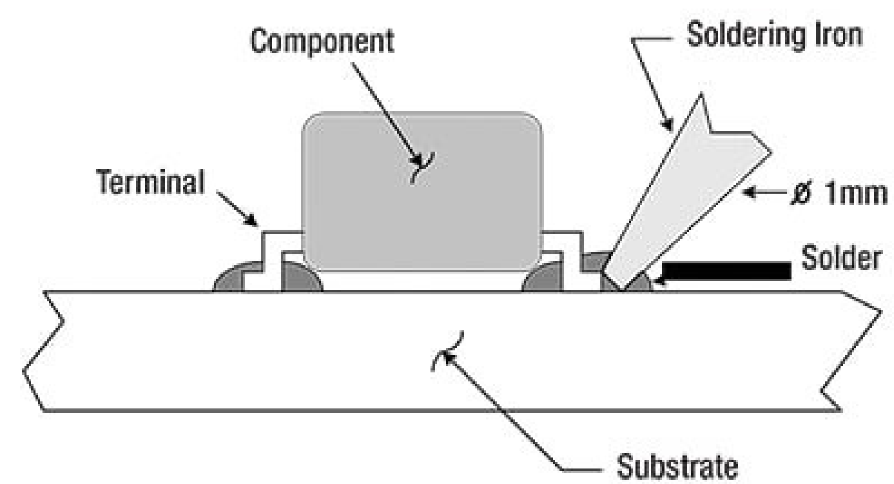


Figure 10: Typical IR reflow soldering thermal profile.

Figure 11: Rework by soldering iron.



Recommendations for rework

Hot gas pencils

Hot gas pencils should be set up to limit the gas temperature to a maximum of 300°C at a distance of 3 mm from the nozzle tip.

Soldering Irons:

1. Only thermostatically-controlled irons should be used. The bit should have a diameter not exceeding 1 mm and should be set so that its maximum temperature never exceeds 300°C.

2. The bit must not touch the component body. Contact should only be with the component leads or the land pads on the printed circuit board (Figure 11).

3. The maximum permitted temperature-time combination on the component lead is 300°C for 10 seconds.

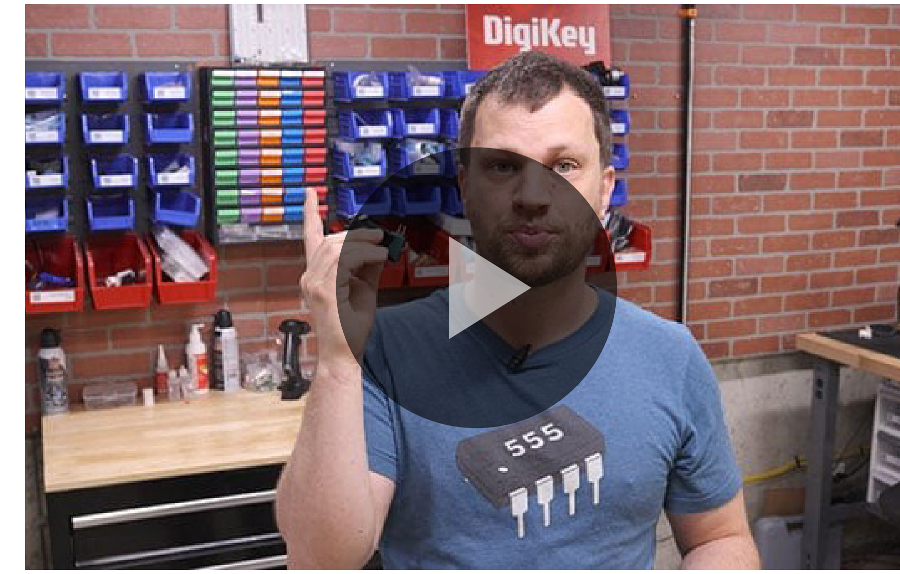
A beginner's guide to oscilloscope basics

Written by [Zach Hipps]

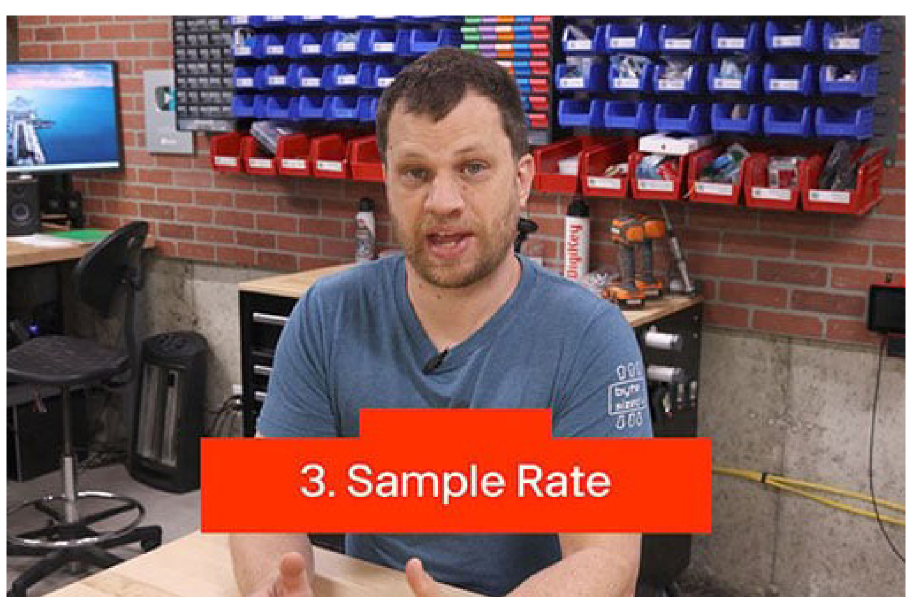
One of the most frustrating aspects of being an electrical engineer is wrestling with invisible problems. These can be incredibly difficult to pinpoint and resolve. Imagine trying to read a push button with your microcontroller, and every time you press it, your microcontroller registers five presses instead of one. Why? That's precisely the kind of invisible problem an oscilloscope helps you identify and fix.

Before we dive deeper, let's talk about why an oscilloscope is such a vital tool. If you work with electronics, chances are you own a digital multimeter. These are great for measuring voltages that remain constant over time. But what about signals that just won't sit still? They're like a toddler during a family photo – constantly in motion. That's where oscilloscopes shine. They excel at visualizing voltages that change over time. So, if you're dealing with a constant voltage, stick to your multimeter. But if your voltage is dynamic, an oscilloscope is your go-to device.

Now, not all oscilloscopes are created equal. If you're in the market for one or simply want to better understand the one you already own, there are three key features you need to know. The first is the number of channels. This refers to the number of signals the oscilloscope can measure simultaneously. Next up is bandwidth. The bandwidth rating of an oscilloscope tells you the maximum frequency it can faithfully reproduce. As a general rule of thumb, you want a scope with about 3 to 5 times the bandwidth of the highest frequency you plan to measure. Therefore, if you're looking to measure a 25MHz signal, you'll need a scope with a bandwidth of at least 100MHz. Finally, there's the sample rate. This indicates how many times per second the oscilloscope measures and digitizes the signal. A similar rule of thumb applies here: your scope will need a minimum of 2x



If you're looking to get your first oscilloscope, you don't need to go overboard on these features.



the sample rate of your highest frequency. However, in practice, it's much better to have a sample rate of 5x to 10x the frequency of your signal. For a deeper dive into this, you can read about the Nyquist theorem. In short, more oscilloscope channels mean you can measure more signals at once. Higher bandwidth enables the measurement of higher frequencies, and a higher sampling rate ensures that those signals are digitized with much greater clarity.

If you're looking to get your first oscilloscope, you don't need to go overboard on these features. Honestly, a two-channel, 50MHz scope with a 1gigasample per second sampling rate is more than sufficient. There are numerous excellent beginner scopes available on the market that fit this description. I personally use the Rigol DS1054Z. It's a fantastic scope for its price point, offering four channels (allowing you to measure up to four signals simultaneously), a 50MHz bandwidth (upgradable with a key), and a sampling rate of 1 gigasamples per second.

At first glance, the front panel might seem a bit overwhelming – it looks a bit like a spaceship control panel with all those buttons. But once you break it down, it's not so bad. You can categorize the knobs and buttons into three main groups: those that control the horizontal display, those that control the vertical display, and those that control how you trigger the signal.

Let's start simple. I'm going to measure the 1-kilohertz square wave that's present on the front panel of the oscilloscope. Most scopes have this for testing and calibration purposes. The simplest way to begin measuring on an oscilloscope is to hit the Auto button. This automatically adjusts both the vertical and horizontal scale. Let's see how the scope adjusted for this signal. Down here, I can see that my vertical resolution is 500 millivolts per division. This means every horizontal grid line across the screen represents 500 millivolts. I'll locate the ground reference and count the divisions to determine the square wave's voltage. We have 500, 1000, 1500, 2000, 2500, and 3000 millivolts. So, that's a 3-volt square wave.

On this scope, all the vertical controls are outlined in this area. I can adjust the vertical resolution by turning this knob, and you'll see the number change on the screen. Now it's 1 volt per division. Our 1 kilohertz signal remains unchanged; it's still 3 volts, but our resolution has changed. We count one, two, three horizontal lines, which confirms our square wave is 3 volts. Depending on your signal's voltage, you'll want to adjust the vertical resolution to ensure the entire signal fits within the screen's real estate.

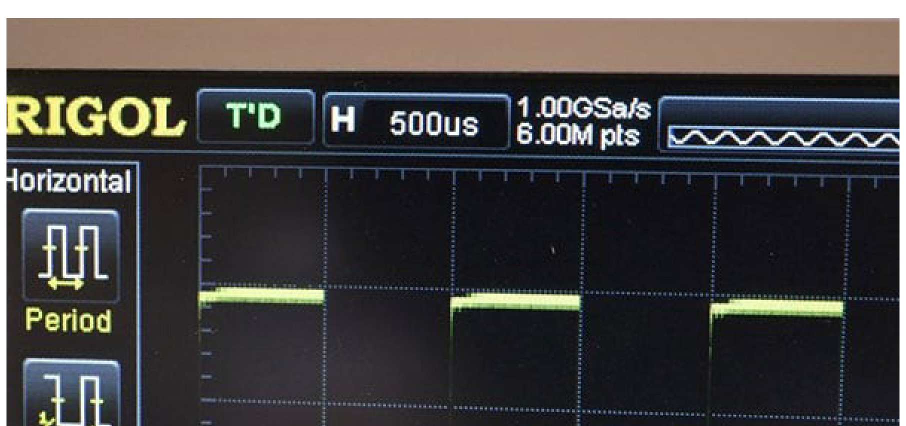
Now, let's move on to the horizontal controls. On this scope, they're

It's a fantastic scope for its price point, offering four channels (allowing you to measure up to four signals simultaneously), a 50MHz bandwidth (upgradable with a key), and a sampling rate of 1 gigasamples per second.

If I want to shift the rising edge left or right, I can simply adjust the horizontal position by turning the knob.

outlined in the gray area. I can change the horizontal resolution by turning this knob. We start at 200 microseconds per division. Let's count the vertical grid lines from rising edge to rising edge to determine our signal's frequency. I'll start with this rising edge because it aligns with one of our vertical grid lines. So, we have 200, 400, 600, 800, and 1000 microseconds. That's 1 millisecond. This makes sense because I know this is a 1-kilohertz square wave. To change the horizontal resolution, I just turn the knob. Now it's 500 microseconds per division. This is how you adjust the vertical and horizontal resolution based on your signal. A great way to start is by hitting the Auto button and then fine-tuning from there.

Finally, we'll move to the trigger control section. Adjusting the trigger settings helps you achieve a stable signal on your oscilloscope.



The first thing to check is which channel your trigger is set to. In my case, the probe is plugged into channel one, so I have selected that as the source. You can trigger on a variety of things, but as you're starting out, you'll probably want to stick to triggering on a rising or falling edge. I can select the type of edge by clicking the button: rising edge, falling edge, or any change in edge. If I select Rising Edge, that will place the rising edge of my square wave right in the middle of our display. If I want to shift the rising edge left or right, I can simply adjust the horizontal position by turning the knob. To reset it back to the middle, all I have to do is press that button in, and it centers it.

The next setting you'll want to know how to use is the trigger voltage, which is controlled by the knob. I know I have a 3-volt square wave, and I'm looking for a rising edge, so I'll pick a voltage between 0V and 3V to trigger on. I'll just pick something in the middle, like 1.5V, because I know I have a nice, clean square wave.

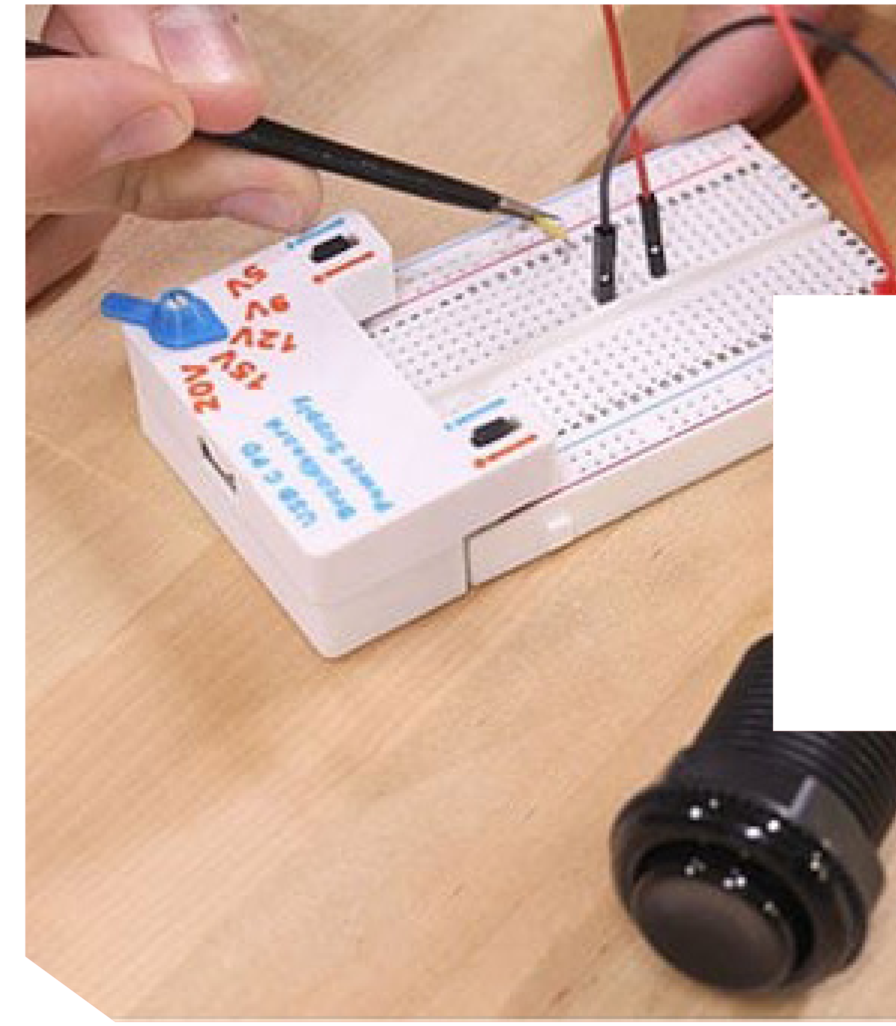
And that's basically it! There are really only three types of controls on an oscilloscope: vertical controls, horizontal controls, and triggering controls. So, while it might look like a spaceship control panel at first, once you break it down into vertical, horizontal, and triggering controls, it starts to make a lot more sense.

Now that you're armed with this knowledge, let's try a real-world example. Earlier, I had a push button in my project, and I was reading it with a microcontroller. But every time I pressed the button, the microcontroller would register multiple button presses. The reason is that mechanical switches don't make a clean contact when pressed. It's like dropping a bouncy ball; it will make several bounces before making full contact and staying closed.

Let's connect it up to the breadboard. I'll connect one end to ground, and the other end I'll pull up to 12V using a 10K resistor. Now that the push button is connected to the breadboard, let's measure it using the oscilloscope. I've connected my USB-C breadboard power supply, which I built in a previous video, and I've set it to 12V. Let's see if we can see that on the oscilloscope.

Channel one should just be reading a constant 12V because it's being pulled up by the resistor. So, I'm going to hit auto and see what the scope does. You know what? It didn't do a good job. It set the vertical resolution to 20 millivolts per division. Let's adjust that to 5 volts per division using the knob, and then I'll center it by pressing the button.

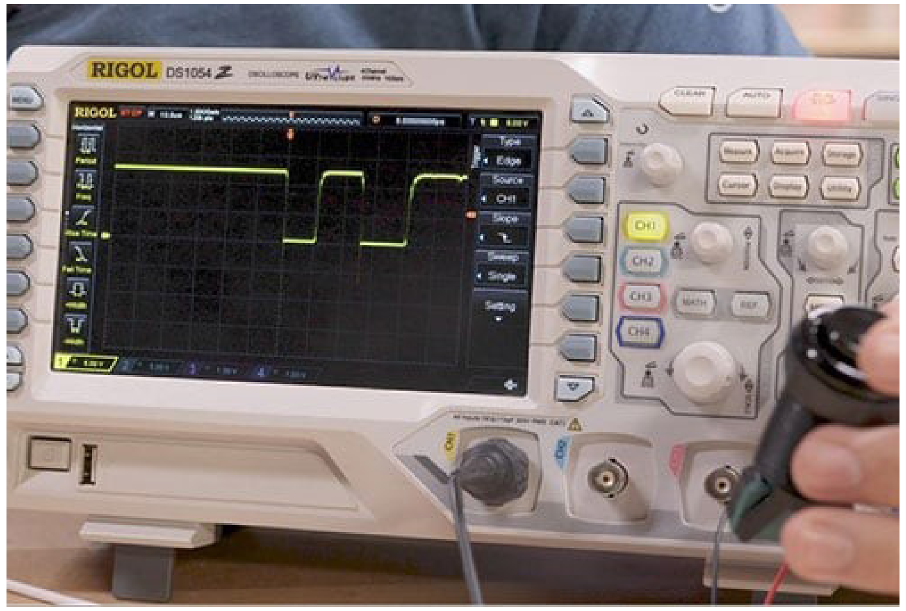
Right now, the scope is reading a constant 12V, but as I press it down, it reads a constant 0V. Then, when I let it go, it goes back to 12V. But I'm interested in the transition between



Now I can take advantage of having more than one channel to measure both with the filter and without the filter.

12V and ground, so I'm going to be looking for a falling edge. Remember when we discussed the trigger controls earlier? I need to set those to trigger on the falling edge. Now that I have that set, I'm going to put the scope into single capture mode by pressing that button. So, when I press the button, we should see the falling edge.

Okay, I've got a problem. It's not triggering. I just noticed that my trigger voltage level is set to 24V. If I have a 12-volt signal connected to ground, the oscilloscope will never find a falling edge at 24V. So, let's fix that problem by bringing the triggering voltage down to 6V, below 12V. The scope is still in



single capture mode, and I'm going to press the button, and there we go. We've got a falling edge!

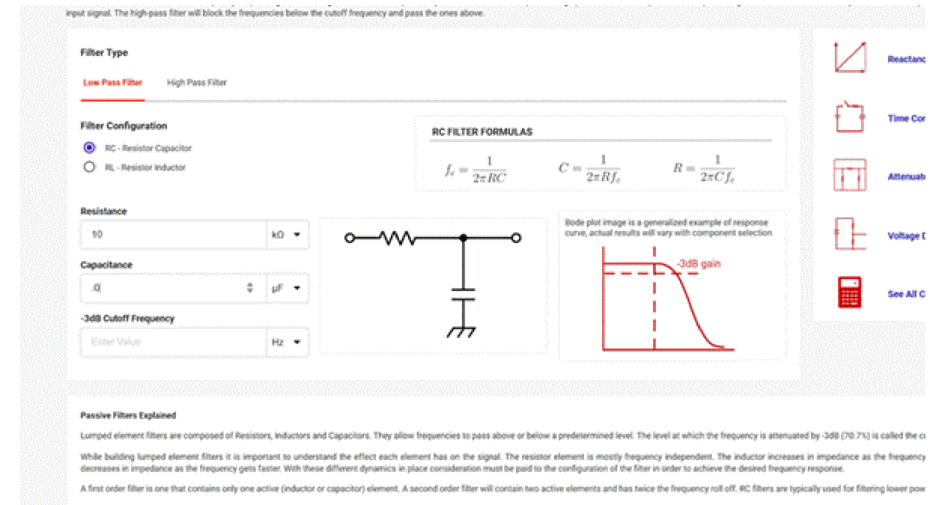
As I described, we have bouncing going on because this is a mechanical switch. It appears to be still bouncing beyond the edge of my screen, so I need to adjust the horizontal resolution to see everything. Now I've set my horizontal resolution to 1 millisecond per division, which means that every vertical line is 1 millisecond long. Let's see what our switch bounce looks like. We can see that it lasts for approximately 1.5 milliseconds, and then it finally settles down to ground. That explains why my microcontroller was reading multiple button presses – it was detecting all those edges.

What's the solution to this problem?

We need to add a low-pass filter. I'm actually going to use the low-pass filter calculator on DigiKey's website. I can enter my resistance and capacitance, and it will calculate the cutoff frequency. If I enter 10k and 0.01 microfarad, that tells me my cutoff frequency is around 1600 hertz. Anything faster than that will get attenuated. So, let's go ahead and wire that up on the breadboard. Now I can take advantage of having more than one channel to measure both with the filter and without the filter.

The blue signal now is that filtered signal, and I can see that it's doing something. It is slowing down those high-frequency pulses, but by the looks of this, it's not enough. So, let's change the value of our capacitor to 0.1 microfarad and see what that does. Alright, that looks so much better! You can see how the low-pass filter effectively attenuates those high-frequency signals and smooths them out. Now we have a continuous falling edge, which should be much better for the microcontroller to read.

Let's say I have a couple of



different measurements that I want to compare. The cool thing about oscilloscopes is that you can actually save screenshots to a flash drive. So let me plug that into the USB port here. Now I can hit the print button, and it's capturing a PNG file to the flash drive. I can take that into my computer, write a report, compare, and do all sorts of things.

And that's not the end of it. Oscilloscopes have a ton of other features that I haven't talked about yet. For example, this scope features a USB port on the back, allowing me to connect it to my computer and run software to control the oscilloscope. It also features an Ethernet jack in the back, allowing you to connect to your network for remote monitoring, testing, and configuration, among other functions. Some oscilloscopes even come with the ability to analyze logic signals. So, if you have SPI or I2C signals, you can measure them and decode them right on your oscilloscope.

Why is an oscilloscope such a valuable tool in your workshop?

Because it lets you see what your circuit is actually doing, rather than what you expect it to do. Whether you're chasing down a glitch, verifying timing, or just learning how your signal behaves, this tool can give you insight that no other tool can. Although an oscilloscope might look complex at first, once you get the hang of it, it can become the most powerful tool in your toolkit.

This month in history

1866

July 27

Completion of the 1866 Transatlantic Cable

The successful completion of the 1866 transatlantic cable enabled reliable, continuous telegraph communication between North America and Europe. Earlier attempts, including the 1858 cable, had failed after a short few weeks of operation. The 1866 cable marked the beginning of sustained global telecommunications.

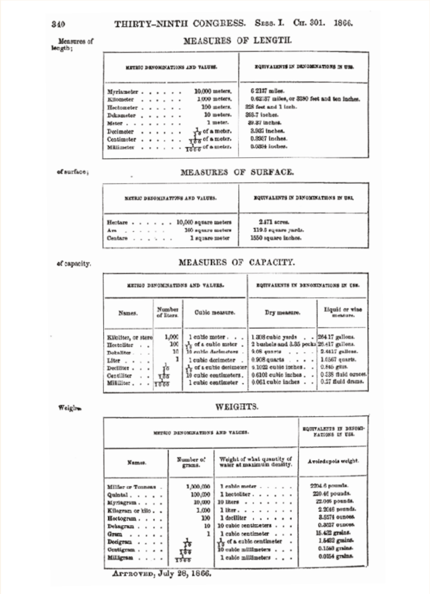
The cable-laying ship, Great Eastern, is entering Newfoundland to lay the final end of the 1866 cable.

1866

July 28

Congress passes the Metric Act of 1866

The Metric Act of 1866 authorized the use of the metric system in the United States and provided official conversion tables for commerce. While not mandatory, it legalized metric measurements alongside customary units. The act supported scientific and industrial standardization in an increasingly international economy.



340 THIRTY-NINTH CONGRESS. Sess. I. Ch. 301. 1866.

Measures of length;

MEASURES OF LENGTH.

Metric denominations and values.		Equivalents in denominations in use.
Myriameter	10,000 meters.	6.2137 miles.
Kilometer	1,000 meters.	0.62137 miles, or 3280 feet and ten inches.
Hectometer	100 meters.	328 feet and 1 inch.
Dekameter	10 meters.	393.7 inches.
Meter	1 meter.	39.37 inches.
Decimeter	1/10 of a meter.	3.937 inches.
Centimeter	1/100 of a meter.	0.3937 inches.
Millimeter	1/1000 of a meter.	0.0394 inches.

of surface;

MEASURES OF SURFACE.

Metric denominations and values.		Equivalents in denominations in use.
Hectare	10,000 square meters	2.471 acres.
Are	100 square meters	119.6 square yards.
Centare	1 square meter	1550 square inches.

of capacity.

MEASURES OF CAPACITY.

Metric denominations and values.			Equivalents in denominations in use.	
Names.	Number of liters.	Cubic measure.	Dry measure.	Liquid or wine measure.
Kiloliter, or stere	1,000	1 cubic meter	1.308 cubic yards	264.17 gallons.
Hectoliter	100	1/10 of a cubic meter	2 bushels and 3.35 pecks	26.417 gallons.
Dekaliter	10	10 cubic decimeters	9.08 quarts	2.6417 gallons.
Liter	1	1 cubic decimeter	0.908 quarts	1.0567 quarts.
Deciliter	1/10	1/10 of a cubic decimeter	6.1022 cubic inches	0.845 gills.
Centiliter	1/100	10 cubic centimeters	0.6102 cubic inches	0.338 fluid ounces.
Milliliter	1/1000	1 cubic centimeter	0.061 cubic inches	0.27 fluid drams.

Weights.

WEIGHTS.

Metric denominations and values.			Equivalents in denominations in use.
Names.	Number of grams.	Weight of what quantity of water at maximum density.	Avoirdupois weight.
Millier or Tonneau	1,000,000	1 cubic meter	2204.6 pounds.
Quintal	100,000	1 hectoliter	220.46 pounds.
Myriagram	10,000	10 liters	22.046 pounds.
Kilogram or kilo	1,000	1 liter	2.2046 pounds.
Hectogram	100	1 deciliter	3.5274 ounces.
Dekagram	10	10 cubic centimeters	0.3527 ounces.
Gram	1	1 cubic centimeter	15.432 grains.
Decigram	1/10	1/10 of a cubic centimeter	1.5432 grains.
Centigram	1/100	10 cubic millimeters	0.1543 grains.
Milligram	1/1000	1 cubic millimeter	0.0154 grains.

Approved, July 28, 1866.

Table of accepted metric units as passed by Congress in 1866.

1928

July 15

German army adopts Enigma cipher machine for communications

The German military's adoption of the Enigma machine institutionalized electromechanical encryption at scale. The system used rotating cipher rotors to encode messages, significantly increasing communication security. Its eventual decryption by Allied cryptanalysts influenced early computing development.

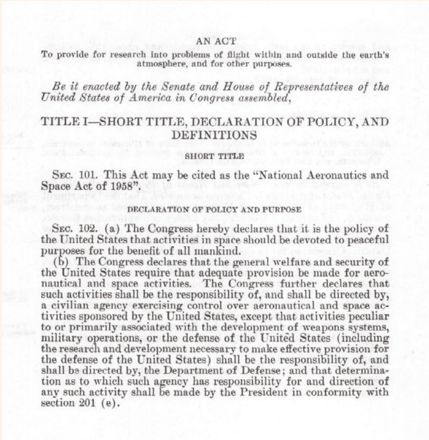
Early Enigma cipher machine used by German military forces, an electromechanical device that encrypted communications using rotating cipher rotors.

1958

July 29

National Aeronautics and Space Act of 1958

The National Aeronautics and Space Act was signed into law on July 29, 1958, establishing the National Aeronautics and Space Administration (NASA). The act transferred responsibilities from the National Advisory Committee for Aeronautics (NACA) and created a civilian agency to oversee U.S. space exploration and aeronautics research. It defined space activity as being conducted for peaceful purposes.



AN ACT

To provide for research into problems of flight within and outside the earth's atmosphere, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

TITLE I—SHORT TITLE, DECLARATION OF POLICY, AND DEFINITIONS

SHORT TITLE

Sec. 101. This Act may be cited as the "National Aeronautics and Space Act of 1958".

DECLARATION OF POLICY AND PURPOSE

Sec. 102. (a) The Congress hereby declares that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind.

(b) The Congress declares that the general welfare and security of the United States require that adequate provision be made for aeronautical and space activities. The Congress further declares that such activities shall be the responsibility of, and shall be directed by, a civilian agency exercising control over aeronautical and space activities sponsored by the United States, except that activities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States) shall be the responsibility of, and shall be directed by, the Department of Defense; and that determination as to which such agency has responsibility for and direction of any such activity shall be made by the President in conformity with section 201 (e).

First page of the National Aeronautics and Space Act of 1958, which established NASA as a civilian agency to oversee U.S. space exploration and aeronautics research.

1982

July 9

TRON premiers, popularizing computer graphics in film

TRON was among the first major films to extensively use computer-generated imagery and digital effects. Its production required early CGI pipelines, including vector graphics and rendered environments. The film is often cited in computing history for advancing interest in computer graphics and digital visualization.

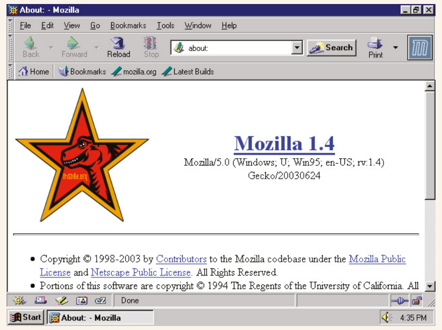
Original movie theater poster for the movie TRON.

2003

July 15

Mozilla Foundation launched to support open web

The Mozilla Foundation was established to support the development of open-source internet software, including the Mozilla browser suite. It formalized efforts to promote open web standards and community-driven software development. The organization later oversaw the development of Firefox, which influenced browser competition and standards compliance.



Mozilla 1.4 "About" screen, reflecting early 2000s open-source browser development under the newly formed Mozilla Foundation.