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Sparky: A Little Stick Welder with Big Features

By **Mr.RC-Cam,**
October 10, 2019 in Floobydust

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Mr.RC-Cam

Posted October 10, 2019 · IP

Like some of you, I'm a DiY maker. I enjoy modifying ordinary gadgets to personalize their functions or to completely change their intended use. Sometimes I hack to expand my hardware and firmware knowledge. This project is a mix of all these things.

My new project is called **Sparky**. It's a ESP32 based welding machine controller that enhances the features of a $60 USD Chinese stick welder. This adventure involves a color touchscreen, Bluetooth low energy (BLE) control, DAC voice playback, high current measurements, 3D printing, dangerous voltages, and so much more.

Below is a photo of Sparky the welder after the makeover. The photo shows the boot screen on the retrofitted display. Don't let the black and white image fool you because it's a full color TFT device. With touch entry to control all the new features.

I'll post some details to the build. Of course source code and schematics will be provided too. In the meantime, here's a demonstration video that shows Sparky's features. So loosen your welding jacket, flip back the visor, and enjoy the show.

UPDATE: Project files are available on Github: https://github.com/thomastech/Sparky

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- Thomas

Mr.RC-Cam

Posted October 10, 2019 · IP

There's a backstory to my welder project. For many years I relied on buddies that owned welders when metal repairs were needed. All along I planned to buy my own and learn to do it myself. So twenty years ago I installed a dedicated 220V (aka 240V) circuit in my workshop. Then I patiently waited for a good deal on a used Lincoln tombstone buzz box.

Occasionally I'd drive past a "yard sale" and see an old AC welder looking for a new home. But mostly abused and/or overpriced machines that I walked away from. So the 220V outlet has remained unused all these years. Until now.

The welder I purchased is the miniGB IGBT 200A ZX7-200 IGBT inverter welder. It was on sale for only $45 (normally $60), so not much to loose if it was a bad choice. It is indeed cheaply built; The 16A rated power switch failed on the third use, so I replaced it with a 30A switch. And its tiny form factor makes it look like a toy. But overall I would say that it is a decent machine for hobby and weekend warrior welding.

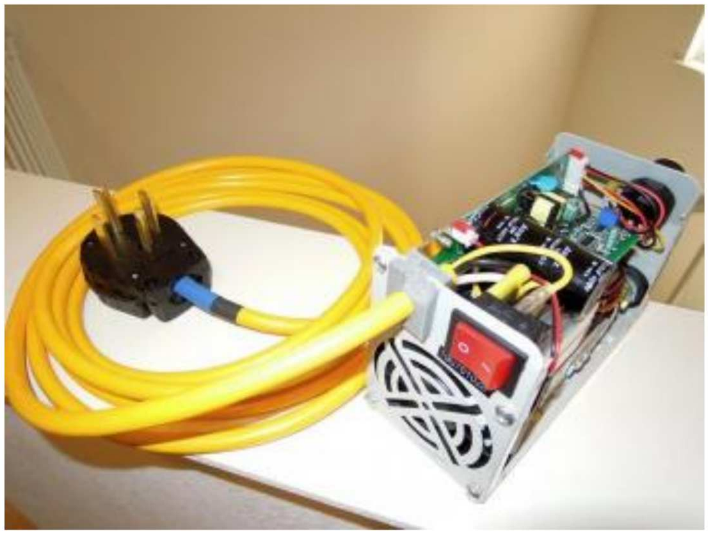
Thanks to its DC-DC inverter technology it is surprisingly small; About the size of a loaf of bread. But there are many different ZX7-200 labeled machines on the market and their packaging/internal circuitry vary. And despite the advertised

200A welding current, some designs deliver a fraction of that value. Fortunately this welder has sufficient current for the small welding projects that I have in mind.

I didn't prepare an unboxing video for the miniGB ZX7-200 welder. But I found one on Youtube that includes a tear down and some interesting comments.

Some economy priced Chinese welders include welding cables with a ground clamp and stinger (electrode holder). But you'll find that these bundled accessories are the lowest possible quality. So it's no big loss that this welder doesn't include them. I built my own by purchasing twenty feet of 2AWG welding cable, a Lincoln Electric KH525 ground clamp, and a Lenco AF-2 stinger. These DiY cables weigh more than the welder. And they cost about as much.

The welder includes a short ungrounded mains AC cord that has undersized wire (15AWG). So I replaced it with a fifteen foot long 12AWG three conductor (12/3 SJTO) power cord. The ground wire was connected to the metal chassis and a upgraded rear panel strain relief was 3D printed (ABS plastic). The cord was equipped with a North American NEMA 14/30P 30A "clothes dryer" plug with earthed ground.



- Thomas

Mr.RC-Cam

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So now I have a welder. Of course I'm a newbie and have a lot to learn. Welding school would be overkill so I've been relegated to binge watching Youtube how-to videos. There are many popular channels such as ChuckE2009, weldingtipsandtricks, weld.com, and others.

But learning means burning. I purchased a helmet, leather apron, and gloves. Plus 6011 and 7018 rods (3/32 and 1/8 inch) and a pile of metal remnants from the local metal shop. The metal is sold by the pound ($1.50 - $2.00 lb in my area) and a armful is surprisingly heavy. Here's a photo of the remnants I purchased for $30 USD:

Welding is a technical art that can take years to master. But my goals are less lofty; I'll be happy when I can reliably strike an arc and drag a rod without making a huge mess of things. I have a long ways to go, but it's been a blast so far. Sparks, smoke, and hot flying bits - what's not to love about that?

It is important to use the correct current when welding. Fortunately the training videos taught me how to identify low current arcs. This is how I discovered that the current setting knob was severely uncalibrated. Too bad, since using it for reference is a nice crutch for a newbie like me. That is to say, relying on my inexperience to set the current totally by eye was not a good idea.

So out came the clamp-on ammeter. That's when things fell apart. My ammeter can only handle AC current and this is a DC welder. Measuring AC mains current and using it to estimate welding amps is possible. Or I could have bought a DC ammeter. But I decided on a different strategy. Remember, I'm a hacker.

So it was during my welding practice that Sparky was born. It began with a simple idea; I'd make my own 200A DC ammeter and use it to calibrate the welder's current adjust knob. And then the list of my must-have features grew. It was an ambitious list but every box was checked-off in the final build.

Come back in a few days to read more about the project. The hacking adventure is about to begin.

- Thomas

Mr.RC-Cam Posted October 15, 2019 · IP

It's time to get into the build. Let's start by summarizing the features:

- Color TFT Screen displays welding current, arc voltage, and menus.
- Touch Screen for selecting features. Built-in help screens display useful welding tips too.
- Programmable Pulse current mode for enhanced stick welding.
- Helmet mounted Bluetooth Low Energy (BLE) Button for remote Amps control.
- Audio for announcing Amps and over-temp alerts.
- Flash memory for saving power-up defaults.
- Low Cost hardware based on ESP32 (Lolin D32 Pro with 16MB Flash).
- Non invasive design, no permanent changes to the welder.

The last bulleted item is a safeguard. I prefer hacks that are easily reversible because sometimes a project hits a wall and needs to be abandoned. So there were no changes to the sheet metal or existing circuitry. Reverting it back to a stock unit would be a ten minute task. But I like what my little welder has become so there's no need to undo the makeover.

- Thomas

Mr.RC-Cam Posted October 15, 2019 · IP

This is a good time to talk about safety. An inverter welder is a potentially dangerous machine. Lethal primary voltages (>300 volts) are present inside the cabinet, even after power is turned off. There are bleeder resistors in the welder's power supply, but never rely on them. And don't forget that the involved currents have more than enough energy to vaporize misplaced wiring (and misguided hand tools) in a dangerously hot explosive flash.

This is NOT a beginner build! If you're not well versed in working with electronic designs that have hazardous circuitry then STOP, turn around, and walk away.

HARDWARE:

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The required hardware is summarized below. Estimated cost is about $40 USD.

Lolin D32 Pro ESP32 Microcontroller, V2.0.0 16MB Flash

Lolin 2.4-inch TFT Color Touchscreen Shield
SH1.0 Double Headed 10-Pin Cable for TFT
Microchip Technology MCP45HV51-502E 5K Ohm I2C Digital Potentiometer, TSSOP14
INA219 Current Sensor Module
PS2501-1 Optocoupler IC
PAM8403 3W Audio Amplifier
MP1584EN DC-DC Power Supply Module
TSSOP14 to DIP PCB Adapter
JST XH 2.54mm Wire-Cable with 7-Pin Female Plug, 30cm long
Ultra Thin profile (<13mm deep) 50mm diameter speaker, Qty 2
Bluetooth FOB Button Key Finder

You'll need a small (30 × 62mm) piece of Perfboard and a few resistors and capacitors (see schematic). I recommend having a variety of JST SH1.0 plugs/connectors on hand to connect things together.

Parts Photos: https://github.com/thomastech/Sparky/blob/master/PartsList.md

SCHEMATIC FILE:
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Schematic File: https://github.com/thomastech/Sparky/tree/master/Schematics

3D PRINTED PART FILES:
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There are several 3D Printed parts. The STL files are available on Github. You'll need some ABS Filament (PLA not recommended). Print time is about 15 hours. A 160mm or larger heated build plate is required. Small self-tapping screws are needed for assembly (7 pcs M2×6, 2 pcs M2×10, 1 pc M2×12).

STL Files: https://github.com/thomastech/Sparky/tree/master/stl

SOFTWARE FILES:
================

The software source code files are available on Github. For code development the VSCode/Platformio IDE is required. The custom modified Arduino libraries are provided in the download zip file. Please don't ask for a project package that works with the Arduino IDE since I have no plans to create that.

Software Files: https://github.com/thomastech/Sparky/tree/master/src

- Thomas

Mr.RC-Cam

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The Sparky project is intended for experienced electronic circuit builders. So step-by-step build instructions and "Heathkit" wire placement drawings will not be provided.

Along with the schematic I will be posting build photos that can be used for reference. I'll provide some written commentary to further explain what is shown in the images.

The two page schematic includes some useful notes. It also provides images of the various components to assist with your online purchases. To avoid compatibility issues you should confirm your component choices are EXACT matches to the images.

IMPORTANT: Fully test your new welding machine BEFORE you start the modifications. Burn as many rods as you can and confirm that it is working correctly. Do NOT start any disassembly until you are satisfied the welder is working. Immediately contact the seller if the Welder has problems.

- Thomas

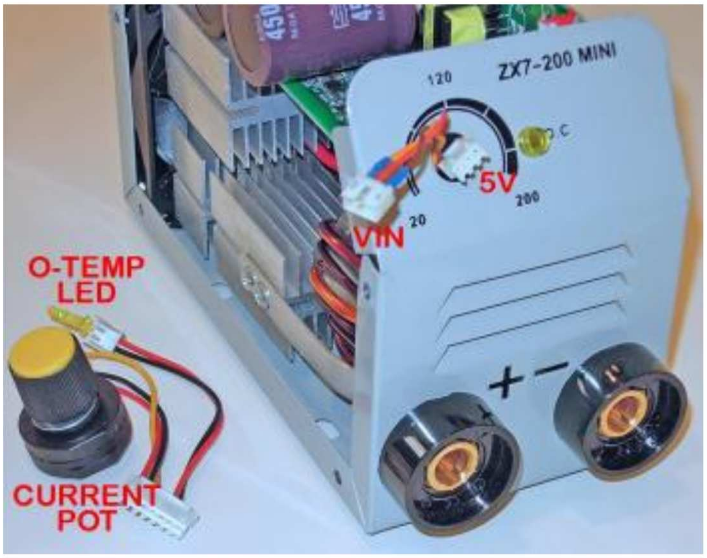
Mr.RC-Cam

Posted October 15, 2019 · IP

I originally intended to replace the front panel's current adjust POT with a big knob attached to a digital rotary encoder. Just like high-end welding machines use. But there wasn't room for it, so my "mechanical" control idea was abandoned.

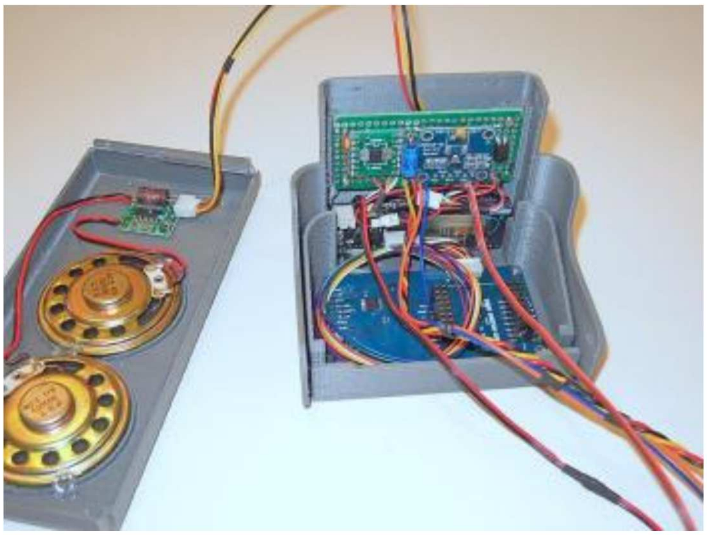
Instead, the current adjustment is on the touch screen. Which is too bad since I'm not a huge fan of touchscreens on tools. But throughout this project I had to remind myself that this hobby welder isn't going into the hands of a professional user. On a positive note, the touch screen looks nice and is small enough to fit within the Welder's front panel area. Touch entry is very reliable with bare fingers. Welding gloves can remain on if you touch it with a tablet stylus or eraser end of a pencil.

The original current adjust POT plugs into the Welder's motherboard via a 7-pin plug. The over-temperature LED is wired to this plug too. The POT is simply unplugged and an identical 7-pin plug (wired to a digital POT) goes in its place. Save the old POT assembly in case you need to restore the welder back to stock configuration.



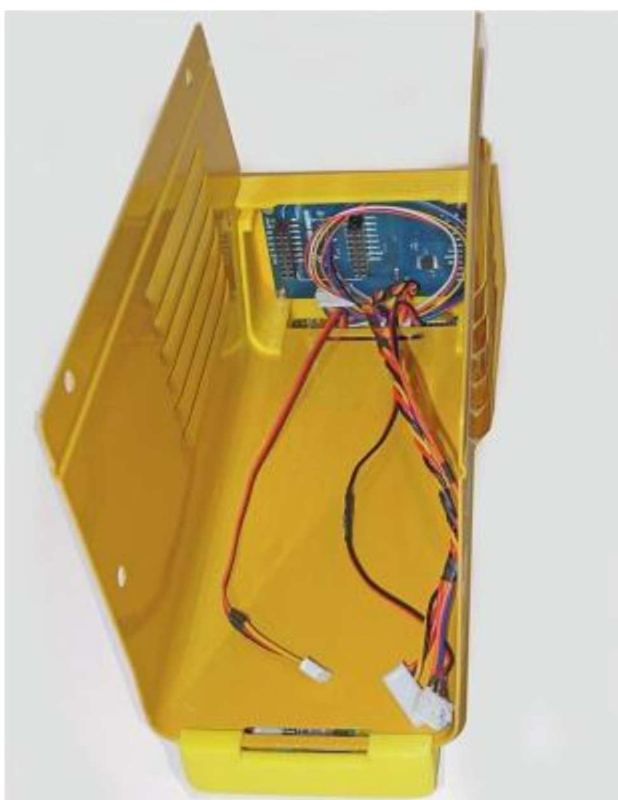
The discarded POT's empty mounting hole is a convenient place to pass wires into the Welder's interior. A new plastic bezel will cover it up.

All of the new components are mounted in the 3D Printed Bezel housing. Including two small speakers. It's a tight fit but with good cable management it all fits like a glove. Here's a photo of an early prototype.



Here's a front view photo of the final housing design (printed in yellow ABS). It slides into the Welder's metal cover and is securely attached by two *existing* screws.

This image below shows the snug fit of the new circuitry. The three cables are routed to the Welder's motherboard.



All the long cables will be passed into the Welder via the big hole that was exposed after the current adjustment POT was removed.

- Thomas

Mr.RC-Cam

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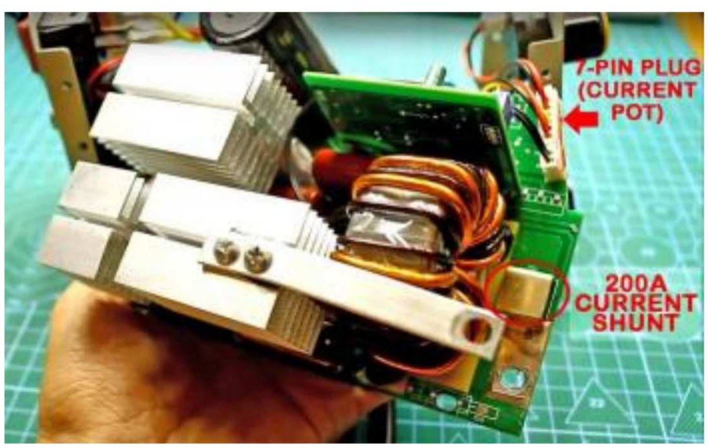
Sparky can measure the arc's welding current in real-time. It uses a low cost INA219 DC High Side Current Sensor module. The module is equipped with a 3A rated shunt resistor. But we need to measure up to 200A.

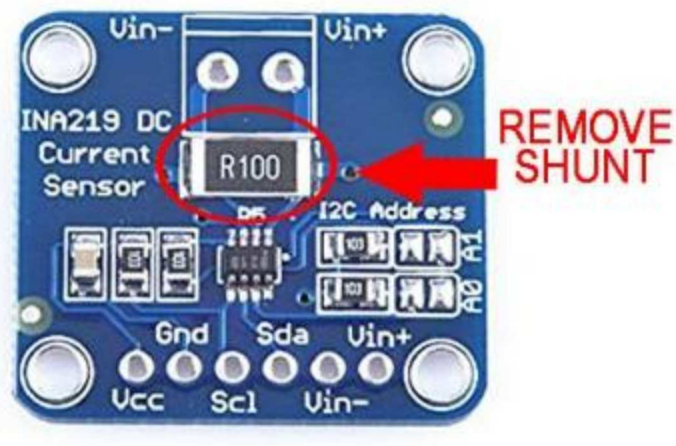
Fortunately there's already a 200A shunt inside the Welder. But it's a low side shunt and the INA219 is a high side sensor. After some datasheet spelunking, I convinced myself that it could be adapted for low side current measurements. I'm pleased to report full success with the unconventional configuration.

Here's a close-up photo of the shunt bar inside the Welder (images are screenshots from the video posted earlier).

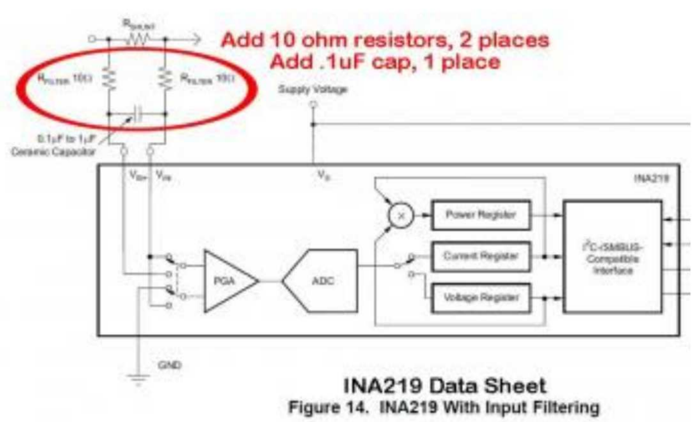
The shunt is on the motherboard. Here's another photo.



The INA219 module's shunt resistor needs to be removed.



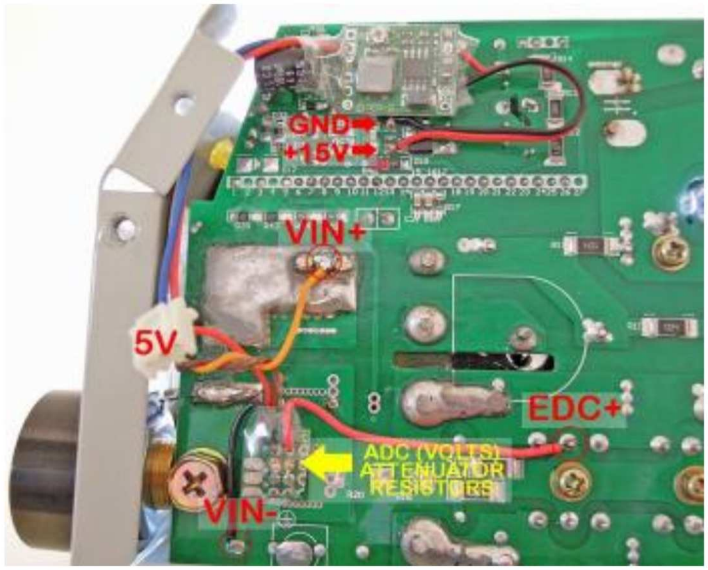
An input filter network MUST be added to the INA219 board. It requires cutting PCB copper traces, plus the installation of two 10 ohm resistors and a 0.1uF ceramic cap. These parts are soldered onto the INA219 board and must be near the current sensor IC. Input filter details are found on page 11 of the INA219 component datasheet. The basic filter diagram (circled in red) is shown below:



Small gauge (26AWG) twisted pair wiring was used to connect the sense signal pads (VIN+, VIN-) to the Welder's 200A shunt resistor. These are the Orange/Brown wire pair shown in the image below. Note: The Brown & Black wires are connected together at the EDC- side of the Perfboard mounted attenuator resistors.

The sense wires' solder locations at the Welder's motherboard are critical to ensure accurate measurements. That is because the full shunt resistance is comprised of the shunt bar *and* the adjacent PCB copper plane areas.

It is important to precisely copy the sense wire solder locations seen in the photo below. Also shown are other useful wiring locations used in the project.



Calibrating the INA219 with its upgraded shunt resistor would have been easy if I had a DC clamp-on ammeter. But let me remind you that I don't have one (and the reason this project began). Instead, I grabbed a household electric frying pan and a waffle maker. They provided a high wattage non-inductive load that I used to calibrate the current measurements. A Fluke 8040A milli-ohmmeter was used to measure the hot resistance and a DMM provided the Welder's loaded voltage. Apply basic math, done.

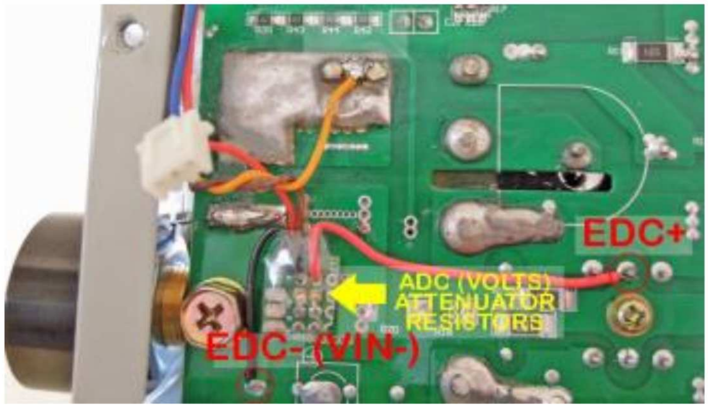
Here's a photo of my current sensor calibration test setup. Unsophisticated but effective.

- Thomas

Mr.RC-Cam

Posted October 17, 2019 · IP

As shown in the previous post, a pair of resistors are used to attenuate the welding voltage that is applied to PIN-3 of the ESP32 (see schematic). These are soldered on a piece of perfboard and protected with heatshrink. This assembly is mounted to the motherboard with double-sided foam tape. See image below.



The new circuitry is powered by a small adjustable DC-DC buck voltage regulator (VReg). A 100uF cap is added to its output and everything is protected in heatshrink. It's mounted on the Welder's motherboard with double-sided foam tape. The VReg's input is connected to the 15V supply, as shown below.

Important: Adjust the output to 5.25V BEFORE connecting any circuitry to it. Otherwise the factory set voltage will be too high and will destroy Sparky. During the voltage calibration I recommend temporarily loading the output with 1K ohms.

- Thomas

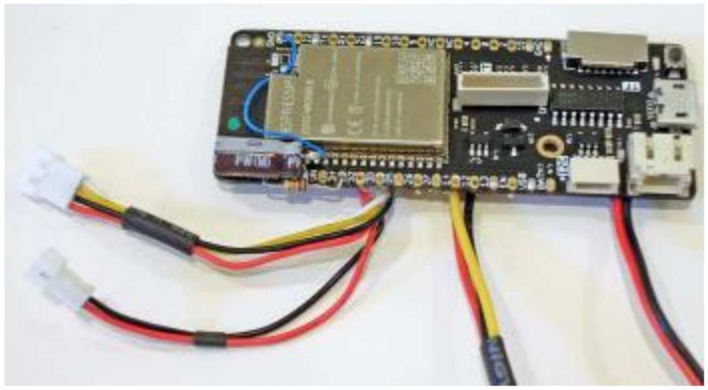
Mr.RC-Cam

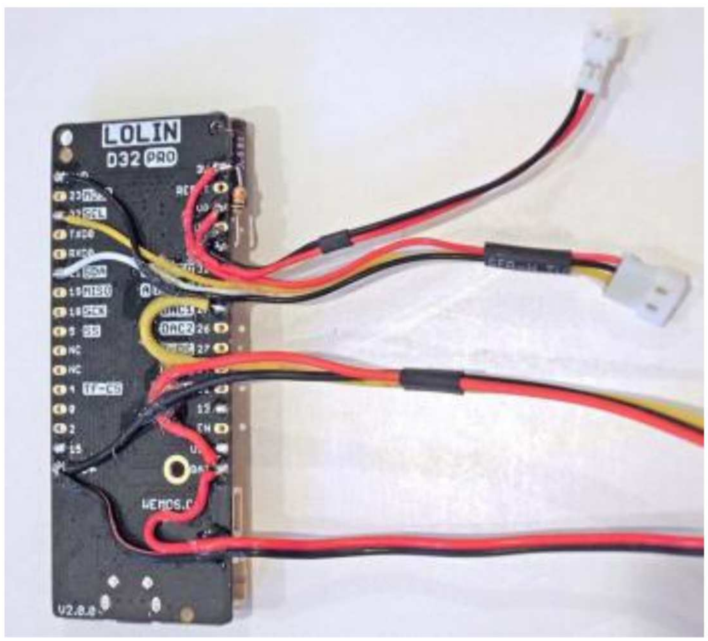
Posted October 17, 2019 · IP

The ESP32 microcontroller is a [Lolin D32 Pro](). It has 16MB FLASH and 4MB PSRAM.

It saves us from some tedious wiring by including a TFT port connector. Attaching the TFT color touchscreen is as simple as plugging in a 10-Pin cable.

But there's some soldering needed on the ESP32. A 0.47uF cap (C1) is added to Pin-3 and a 10K ohm resistor (R3) is installed on Pin-5. Caps C2, C3, C4 are omitted (not needed). Then all the I/O wiring is added, per the schematic. See photos below.



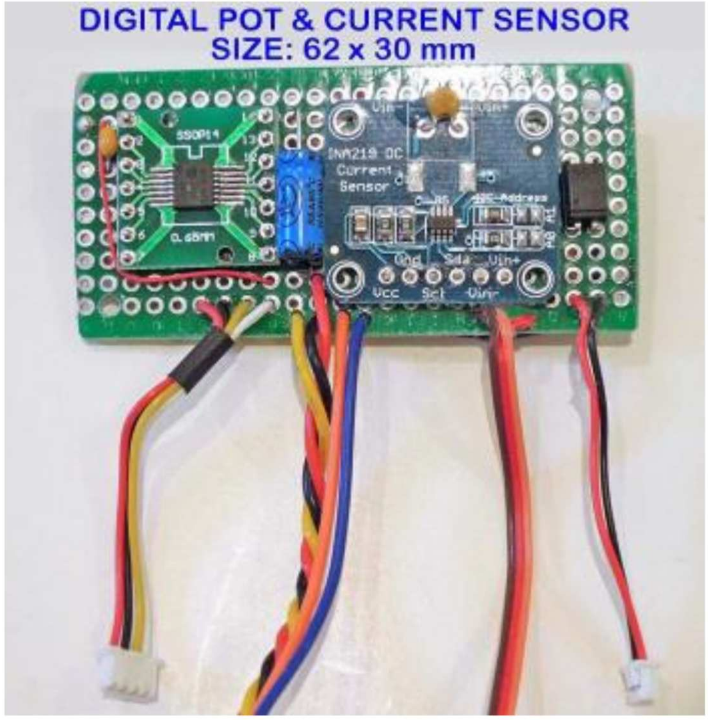


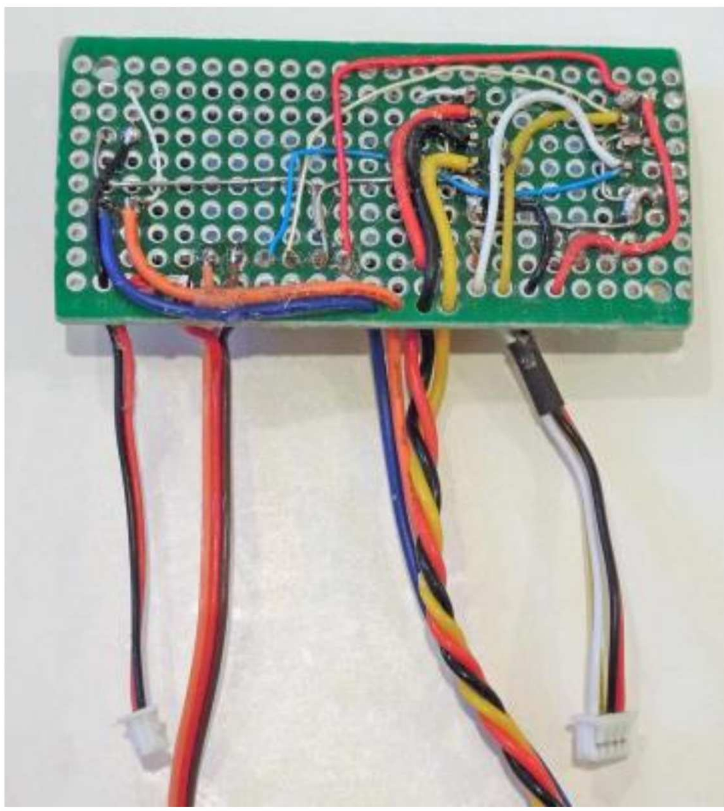
- Thomas

Mr.RC-Cam

Posted October 17, 2019 · IP

The MCP45HV51 digital pot IC is a tiny TSSOP14 SMD component. A 14-Pin DIP adapter board is used to make installation a bit easier. The INA219 module, MCP45HV51 (with DIP adapter), and PS2501 optocoupler are installed on a piece of Perfboard. See images below.





IMPORTANT: A previous post mentioned that the INA219 module requires shunt resistor removal and the installation of a filter network. So be sure to do that BEFORE soldering the module to the Perfboard.

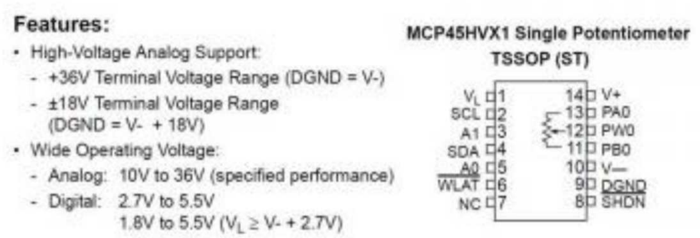
- Thomas

Mr.RC-Cam

Posted October 17, 2019 · IP

This is a good place to stop and talk about the digital POT chip that is controlled by the ESP32. In case it wasn't obvious, it replaces the front panel mounted Welding Current POT that was removed earlier. But this I2C Bus controlled component is no ordinary digital POT.

Unlike common digital POTs, Microchip Technology's MCP45HV51 can handle the higher voltages used in the Welder's closed-loop PWM current control circuitry. That is to say, the feedback signal voltages are high enough to damage a typical digital POT. So don't attempt to go rogue and substitute it.



And you may have noticed that the original front panel mounted POT was 1K ohms and the digital POT is 5K. In a perfect world we would use a 1K digital POT. But that value is not offered by the chip maker. Fortunately there's no harm in using the 5K substitute.

BTW, during design validation I installed a "mechanical" 5K POT on the Welder. Testing confirmed that the wiper voltages were correct and welding operation was not affected. I rarely experience a lucky break like this one, so please join me in thanking the silicon gods for their mercy.

- Thomas

Mr.RC-Cam

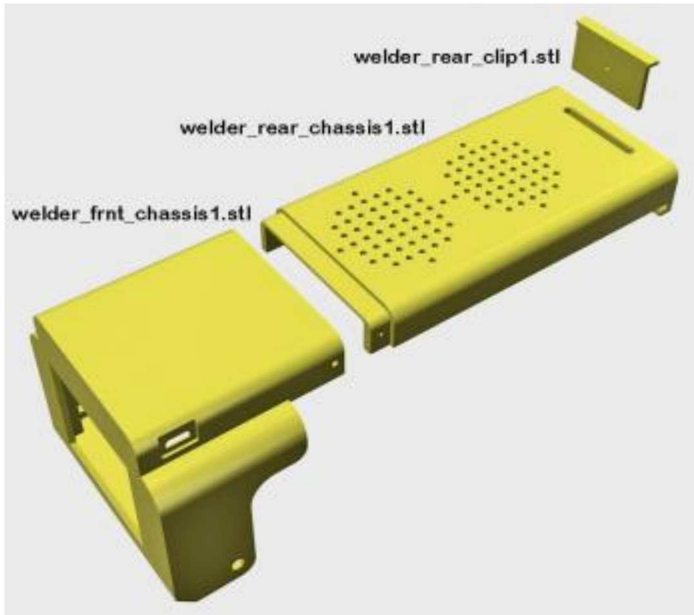
Posted October 17, 2019 · IP

IMPORTANT: The provided STL files must be re-scaled to account for filament shrinkage; 101% works well for typical ABS filaments.

Sparky is housed in two 3D printed parts. The Front Chassis holds the TFT, ESP32, and Perfboard assembly. Seven M2×6 self-tapping screws are used to hold these in place.

The Rear Chassis holds the two speakers and PAM8403 audio amplifier. Hot Melt glue is used to mount them. Don't forget to add the two resistors and two capacitors to the audio amp (see schematic).

The Front and Rear Chassis are held together by two self-tapping M2×10 screws. A 3D printed Clip slides into the slot at the far-end of the Rear Chassis. It locks the plastic housing to the metal cabinet. A single M2×12 screw holds it in place.



The 3D printed strain relief can be used if the power cord is upgraded to 12/3 (12AWG) SJTO cable. See image below. Apply rubber adhesive (shoe glue), plus cinch zip tie wraps around the cable on the front and back sides of the strain relief.

- Thomas

Mr.RC-Cam

Posted October 18, 2019 · IP

Sparky's remote Amps Adjust feature requires a Bluetooth Low Energy "lost key finder." This device is officially named iTAG, but I refer to it as a FOB since it can attach to a key chain. It was intended to be used to find lost keys and has a button for taking smart phone selfie photos.

The FOB device is sold by online Chinese retailers for about $1. That's about the same price as the CR2032 coin cell that powers it. Although it is a low energy device, I've burned through three batteries playing with it. OK, not all of button presses were fun and games; Hundreds of presses occurred during code development.

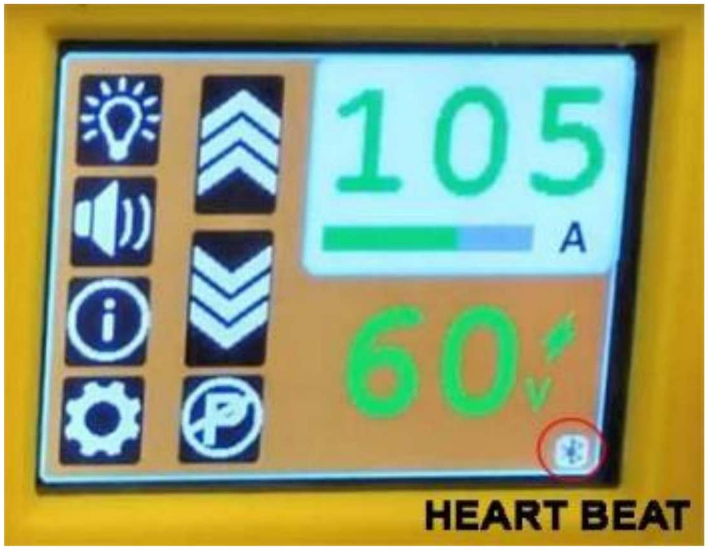
Besides automatic low-battery shutdown, the FOB has a manual On/Off function. To turn it On, press and hold the button until you hear two short beeps. To turn it Off, press the button until a single long beep is heard. If it is paired with a smart phone the pairing must be disabled before it can be used with Sparky.

During power-up (boot) Sparky will scan-search for the FOB button. If it is found a pairing will be performed. If not found during the boot scan the Bluetooth function will be disabled and no further scans will be attempted. But you can use Sparky's *Settings* menu to perform a manual scan.

The Bluetooth connection can become unpaired (disconnected) during use. Especially if the FOB is moved too far away from the Welder. When this occurs several periodic connection retries will be attempted before giving up; If pairing is not successful a manual scan will be required to reconnect the FOB.

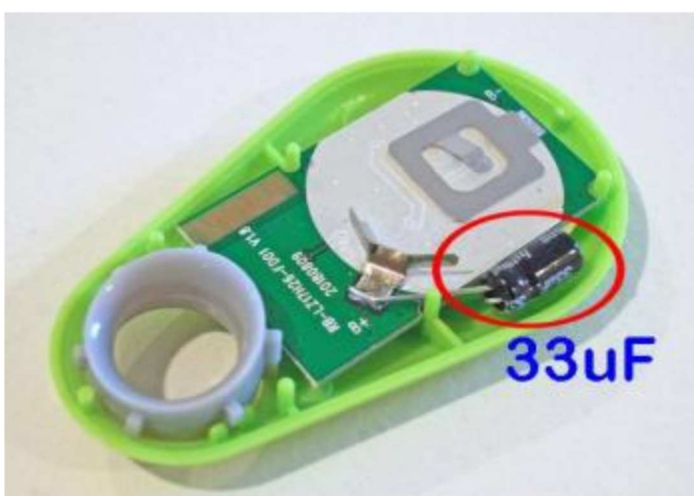
The Lolin D32 Pro ESP32 microcontroller includes all necessary Bluetooth Low Energy (BLE) hardware. The "ESP32 BLE for Arduino" software library is used in the firmware. I have customized this library to improve reliability (the updated lib files are included in the source code package). Be aware that the ESP32 may occasionally lockup (hang forever) during a BLE device scan / connect.

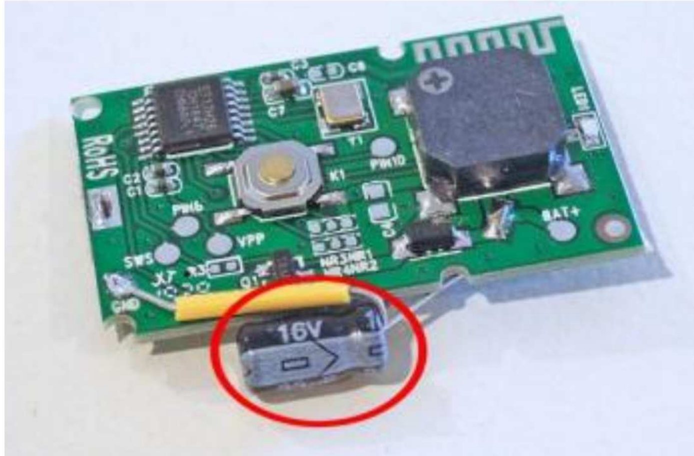
Sparky's heart-beat icon is located in the lower right corner of the screen. When the FOB is connected it will appear as a blinking Bluetooth icon. Otherwise it will be a blinking red heart. It will stop blinking when the CPU is locked-up. Do NOT attempt to weld if the Bluetooth or heart icon is frozen (not blinking). A power cycle reboot is required to restore full operation.



Before we end our FOB discussion I have a word of warning on choosing a CR2032 replacement battery. I made the mistake of ordering a 50 piece pack from Amazon. At $10 it seemed like a bargain. But these Chinese made coin cells have high internal resistance. So they are unable to supply the peak current needed when the FOB's button is pressed. This results in it randomly shutting off during use.

A partial workaround requires hacking the FOB. I added a tiny 33uF cap across the battery supply (see photos below). The cap provides an energy boost during the button press. This simple trick keeps the FOB from shutting off due to low power. But the cheap coin cells still have short life compared to name brands.





- Thomas

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Sparky's real-time current measurements confirmed that the actual welding current is 45A to 100A. It's certainly not the advertised 20A to 200A range, but the findings are not a huge surprise. That's because the measured min/max currents match the information reported in the unboxing video shown earlier.

I noticed the DC-DC inverter circuit's primary side filter has insufficient capacitance for a "200A" welder. It could be a partial explanation for the under-performing welding current. While searching for IGBT inverter welder schematics I found the patent to what may be the original Chinese designed ZX7 IGBT inverter stick welder. The reference schematic has four 470uF/400V caps, whereas my welder has a single 680uF.

There's not enough room in the primary circuit region to install enough caps (high voltage electrolytics are big beasts). But I was able to squeeze in a 330uF/450V next to the factory installed cap. Unfortunately this small increase in capacitance was wasted effort; There was no noticeable improvement.

So welding current is half what it should be. How does this impact Sparky's design? Software has been updated so that the available current settings match the welder's actual capabilities. Looking forward, it would be ideal to investigate the inverter power supply to see if the current can be increased. But digging deeper into this can wait since the welder has been useful to me as-is. And since this is an open source design, perhaps another project builder will tackle this hardware challenge and share their improvements.

EDIT: See Nov-01-2019 Post, Bus Bar upgrade.

- Thomas

Mr.RC-Cam

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Time to wrap things up. The welding controller was an interesting project. However it took more time to complete than I dare admit. But I learned some new tricks, so that is all the reward I need.

Epilogue:
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Sparky introduced me to client side Bluetooth Low Energy (BLE) communication. This has a lot of potential for my battery operated IoT projects. The BLE library isn't perfect but the developers have obviously put enormous effort into creating it.

I learned how to play wav files using the ESP32's DAC pin. All of Sparky's tones and voices are handled by the ESP32 XT DAC Audio 4.1.0 library. This lib was created by Steve at www.xtronical.com. His work deserves to be officially integrated into the Arduino library ecosystem.

I found that a INA219 "high side" sensor module can be used as a low side current sensor. And measuring 200 Amps is possible from this $2 module by swapping out its 3A rated shunt resistor. Tricks like this are a hacker's delight.

And best of all, I finally have a DC stick welder with custom features. Cost was about $200 US for everything, including helmet and leather protection. My setup isn't something that a serious metalworker would dare own. But it's a good match for my hobby/household projects. Of course I need more practice before I try to build something. So please pardon the sparks and smoke while I burn some rods.

Project files are available on Github: https://github.com/thomastech/Sparky

- Thomas

pseddon

Posted October 20, 2019 · IP

Very interesting - thanks for publishing it.

Peter

2 weeks later...

Mr.RC-Cam

Posted November 1, 2019 · IP

Project Update:

I upgraded the bus bar that bridges the inverter's output to the positive Dinse style connector. The original aluminum bar stock piece was replaced with copper.

Maximum short circuit current increased to 121 Amps (was 102A before mod). I also performed a test weld with some 1/8" (3.2mm) 7018 rod. Peak current increased to 115 Amps (was 96A before mod).

The new copper busbar is larger than the original. It's 2mm thick and overall size is 24mm x 100mm. The copper surface that directly contacts the aluminum heatsink was tinned with tin-lead solder. A third mounting screw was added too. See photo above.

I highly recommended doing the copper mod to any mini-sized welder that was factory assembled with cheap aluminum bus bars. It's a simple hack with a big reward.

No doubt there are more opportunities to improve the welding current. It would be fantastic to find a way to push it to 150 Amps. That seems achievable, especially with some help from the community.

- Thomas

Jumbo

Posted November 6, 2019 · IP (edited)

I'm currently into the same Electrical Engineering "power conversion" related to welding mode. :>)

The EE specs of the currently available Silicon power devices (IGBT's and MOSFETs) are simply amazing.

- Am I missing something, or does this "version" of a super-low cost IGBT-based AC-DC converter (in this case a Stick/TIG power supply) **NOT** have a ferrite, AC line-isolating switch mode step-down transformer?

The "reference design" you post a link of is a nice schematic of a full-bridge (primary switching topology) IGBT-based step-down welding supply **WITH** said isolation transformer. This is a "standard" (and clearly much safer) design.

In looking at the unit you are hacking, it basically looks like the design is an IGBT "buck-mode" DC-DC step down converter (the AC line is just bulk rectified with that full wave bridge) without **ANY** AC line isolation.

- Is this correct?

This would also explain why in the other videos on these welders that they are tripping the AC circuit breakers feeding power to these units (although the unit's closed loop current regulation should somehow prevent this).

It would also make me wonder why they would **NOT** have earth-grounded the chassis of this unit.

Nice work.

It makes me feel a little less stupid for playing with all of these things as you do, when I can easily go out and just buy a nice TIG machine.

...where is the fun in that though?

Mr.RC-Cam

Posted November 6, 2019 · IP

> **Quote**
>
> Am I missing something, or does this "version" of a super-low cost IGBT-based AC-DC converter (in this case a Stick/TIG power supply) **NOT** have a ferrite, AC line-isolating switch mode step-down transformer?

In this design, a SG325 PWM controller chip and the IGBT transistors are used to switch (at 30 to 50 KHz) the rectified line voltage for the step-down voltage conversion. These drive the primary of a large Toroidal transformer (seen in the image in my previous post). The transformer's low voltage secondary is DC rectified. The reference patent claims the toroid's ferrite material is a special microcrystalline alloy.

> **Quote**
>
> In looking at the unit you are hacking, it basically looks like the design is an IGBT "buck-mode" DC-DC step down converter (the AC line is just bulk rectified with that full wave bridge) without **ANY** AC line isolation.

The toroidal transformer has independent primary and secondary windings. So the AC input and DC output are galvanically isolated.

BTW, the low voltage controller supply (15VDC) is also isolated. It uses a TNY275P series chip and bobbin type transformer.

> **Quote**
>
> This would also explain why in the other videos on these welders that they are tripping the AC circuit breakers feeding power to these units

> (although the unit's closed loop current regulation should somehow prevent this).

I too have watched YouTube videos where the welder was tripping breakers. But they were using 115VAC outlets (versus 230VAC). A 80A welding current will trip a North American 115VAC / 20A circuit (80A x 26VDC / 0.85% = ~2450W). A dedicated 230VAC 30A-50A outlet is is recommended for common welding machines.

> **Quote**
>
> It makes me feel a little less stupid for playing with all of these things as you do, when I can easily go out and just buy a nice TIG machine.

The market is flooded with very capable Stick, TIG, MIG machines. So I could have bought my way into welder ownership. But I'm also drawn to interesting challenges and I like to hack.

So I took a chance on a insanely cheap Chinese Inverter machine. Despite all its shortcomings, it seems to satisfy my needs. And it has given me the chance to finally try my hand at stick welding, something I've been wanting to do for many years.

> **Quote**
>
> ...where is the fun in that though?

Exactly! Creating Sparky was interesting and a fun challenge. That's a reward of hacking. Even my failed hacks are a win, since something is usually learned along the way.

- Thomas

Jumbo

Posted November 7, 2019 · IP (edited)

Aha... I see the light now.

The smallish wire-gauge of the enameled magnet wire of the toroidal step-down transformer is so insanely small, that I thought it to be an inductor that isn't directly in the welding current path. The torroidal transformer-core is surely any one of the "standard" "power-materials" from the various ferrite-core suppliers. The core size itself is amazingly undersized (even at a 50 KHz switching frequency), but it obviously works!

This unit, as with many similar units, probably have a 5% maximum duty-cycle so as not to allow all of these "undersized elements" (heat-sinks, silicon, and copper/aluminum windings etc...) to begin to glow red before permanently cooking themselves :>)).

I agree with your assessment of the root-cause of the 15A 120VAC breaker tripping in that video. that concept crossed my mind after already having posted.....

Also, I believe you meant to say SG3524 PWM controller. That is still one of my favorite ICs from way back....

Thanks for the reply.

Keep on learning. I like your philosophy,

Mr.RC-Cam

Posted November 7, 2019 · IP

> **Quote**
>
> This unit, as with many similar units, probably have a 5% maximum duty-cycle so as not to allow all of these "undersized elements" (heat-sinks, silicon, and copper/aluminum windings etc...) to begin to glow red before permanently cooking themselves :>)).

Surprisingly, this welder runs cool. As a test I burned a half-dozen 7018 rods uninterrupted at 85A and temperature rise was minimal. So I'd say that the IGBT transistors and oversized fan are helping out.

In case of overheated silicon this welder has a thermal sensor to shut it down. And Sparky will voice announce the overheat alarm condition. But I have a feeling that this audio alert may never be needed.

> **Quote**
>
> Also, I believe you meant to say SG3524 PWM controller.

Oops, indeed I am guilty of a typo. This welder's PWM controller uses a SG3525A, not the SG325 nonsense I typed.

- Thomas

- Thomas

2 weeks later...

digitalether

Posted November 20, 2019 · IP

Just want to say, found this project through the Hackaday podcast and think it is genius. For one thing it give some much needed safety aspect to the original design but for another it is a great update with flexible scope for upgrades and other features.

I have been arc welding for years but these little inverter welders I have never really used and the addion of pulsewelding is very interesting indeed. So I have bought one of this welders and will be working on converting it to a sparky over the next few months. Thanks for the inspiration.

Mr.RC-Cam

Posted November 20, 2019 · IP

> **Quote**
>
> I have bought one of this welders and will be working on converting it to a sparky over the next few months.

Welcome aboard the Sparky project.

- Thomas

Kaitsu

Posted November 23, 2019 · IP

Wonderful project and design! In fact I had almost exactly the same idea when I ordered the small yellow thing, it arrived today. I found this blog by searching the ZX7 combined with SG3525AP :-), trying to find a schematics, I guess you have not found them either? The high voltage digital pot is a good find. I planned to use an opto with PWM to control the current. Is the potentiometer just a constant voltage divider or is it driven with some sensing feedback?

My goal is to build a lift arc TIG controller, let's see how it goes :-).

Many thanks for sharing all the information!

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