 Contact tonyjag@comcast.net

ABSTRACT

Hard-wiring and mounting a Radar Detector (RD) in a Tesla Model 3, more challenging than with most ICE (Internal Combustion Engine) cars, is addressed. A rationale for deciding where to mount the RD is presented and mounting under the rear-view mirror selected for further work. A prototype novel Quick Mount was constructed and the following advantages demonstrated:

- Very easy to remove/replace the RD by simply sliding it in or out with one hand.
- No RJ-11 connection to fuss with.
- The RD can be removed without even looking at it.
- Amenable to constant power since hiding the RD also shuts it off in one action.
- Not connected to the mirror, so its adjustment won't be disturbed.
- Entire mount easily removable without tools, e.g. for autocross.
- Built using readily-available parts and materials.

Two methods to connect 12 Volt power, one constant and the other switched, were implemented and demonstrated. Several goals for the paper were established:

- Build upon the applicable work of others published in forums, videos, Tesla documentation, etc. References are therefore cited throughout.
- Make measurements or run mini-experiments as needed.
- Facilitate others constructing and installing their own mount, using all or just a portion of the concepts presented. Thus, photos showing details of construction and installation, together with sources for parts and materials, are included.
- Identify ideas specific to the Tesla Model 3 and the Valentine One Gen2 because many concepts may also be helpful to those with other vehicles or other RD.

Radar Detector (RD) Mounting Location

The first decision to make is where to mount the RD. The Model 3 has some constraints on mount locations, particularly because of the small, high rear window and very-few places to connect 12V power, especially switched power so that the RD turns off when the car is not being driven. Figure 1. shows a comparison of locations inside the car based on criteria important given individual driving characteristics and the threat environment here in central MA… your requirements may differ. Remote mounts, e.g. behind the front bumper, are not included, but would score well on Forward Radar and Sun & Theft Temptation Tolerance. Jamming is also not considered.

Location	**Concept Source**	**For-ward Radar**	**For-ward Laser**	**Rear-ward Radar**	**Rear-ward Laser**	**Sun &Theft Temptation Tolerance**	**Nearest 12V source**	**Comments**
Windshield Suction cup	Multiple	Good	Good	OK if central, high	OK if central, high	Poor	Console Outlet S	-Against some laws -Annoyingly drops - Ugly
Left Visor Clip-on	Multiple	Good	Good	Fair to the right	Fair to the right	Fair	Console Outlet S	-Hard to aim -Constrains visor
Left corner above dash	Multiple	Good	Good	Poor	Poor	Poor	VCLEFT, Blue Wire S	
Under Mirror	Multiple	Good	Good	Good	Good	Fair	Dome Light Panel C	Selected for this project
Above Tesla 15" Display	Multiple	Good	Good	Marginal	Marginal	Poor	Console Outlet S	Could attach to Topfit Mount
Under rear Dome Light	mswlogo	See Text	See Text	Good	OK; may be loss thru tint	Good	Subwoofer (right of trunk) S	Most creative! Use app instead of RD Display.

Figure 1. Comparison of RD Mounting Locations in the Tesla Model 3.
In the 12V Source column, C=Constant and S=Switched. More about 12 Volt sources later.

The bottom row of Figure 1 pertains to a most unique and creative mounting technique described in this TMC forum thread initiated by mswlogo:
https://teslamotorsclub.com/tmc/threads/12v-switched-power-in-rear-radar-detector-install.132411/ - post-5295591
An initial decision was to use this novel approach, but some concerns led to making a foam mockup to study it (see Figure 2.).

Figure 2. Rear Dome Light Location Mockup. On a flat, level parking lot from back seat.

It is apparent that the forward view is obstructed above the top of the windshield, even though the RD is spaced 2" below the dome light. Additional lowering would help, but unfortunately begin to intrude on rear passenger space and may cause structural issues during high-G maneuvering. There may be enough energy bouncing off the road and hood to still work, but range would likely be compromised, especially if the radar gun is located high, like on an overpass. It was therefore decided to proceed with an Under Mirror Mount, outlined in bold at the midst of Figure 1. Some of the shortcomings of this location would be mitigated by the Quick Mount design.

Also evident in Figure 2. Is the Topfit wireless phone mount above and to the left of the 15" Tesla display. An Android phone, which also serves as a key for the Tesla, resides there hosting an app that talks to the VI via Bluetooth.

Quick Mount (Under Mirror)

It is often advantageous to temporarily remove and hide the RD or take it with you to

- Keep it out of the sun while parked (heat is the enemy of reliability)
- Avoid tempting thieves
- Comply where RD are not legal, like military bases
- If an RD is not needed, remove it
- If running from a constant 12V source, keep it from draining the car's 12V battery

The Quick Mount is intended to make it very easy to remove/replace the RD from under the mirror. All you need to do is slide the RD in or out. There is no RJ-11 connection to fuss with, so it can be removed very quickly, one-handed without looking. And it is not connected to the mirror, so the mirror's adjustment won't be disturbed.

A prototype was constructed from available parts and materials, as detailed below. It could be done with hand tools, but a metal-cutting band saw, drill press, and belt sander make it much easier. Some parts might be amenable to 3D printing.

Figure 3. Completed Quick Mount Prototype. V1G2 in 2020 Tesla Model 3.

The Valentine One G2 visor mount that came with it was used without the spring steel clip, easily removed via the plastic latch. That clip was considered too tall for this application. A V1G1 visor mount almost fits, but it arches much higher.

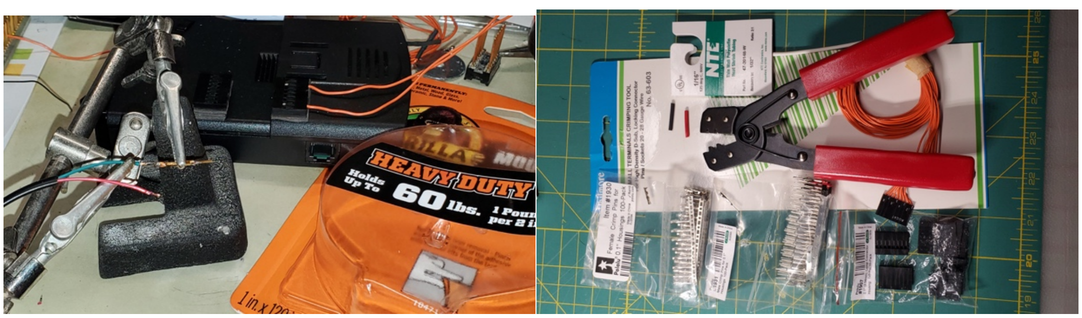

Figure 4. Using Gorilla HD Double Sided Tape to Mount the Connector Blocks, Parts & Crimp Tool Used Later.

Figure 4 Left shows how the connectors were mounted using black Heavy Duty (60 lbs) Gorilla double-sided mounting tape. On the Valentine mount, just one layer was used, while on the mating male connector on the V1 itself, 3 layers were needed so the connector pins align. Also shown is how the red and green wires from the short length of Valentine V1 flat power cable (from an old V1G1) were soldered to re-used crimped female pins containing male connector pins, 0.025" gold-plated wire-wrap pins. That was done before acquiring the crimp tool shown in Figure 4 Right, which would have been easier. Polarity was observed (red =+, green =-) even though the V1G2 likely has reverse tolerance. Additional conductors could have also been included if there were plans to use V1 accessories.

Old Augat 8-pin 0.1" spacing black plastic connector housings, visible with orange wires, were selected because 1) they have a big surface area that facilitates secure mounting with double-sticky tape and 2) they have nicely-beveled entry holes to facilitate reliable docking even with slight mis-alignment. Hundreds of connect/disconnect cycles (Figure 5.) were done so far with no problems. The connectors were positioned so that they are fully engaged just as the RD slides into the Valentine mount's detent, which was filed down slightly to reduce the force a bit. In retrospect, a second detent would be useful to hold the RD in place while slid rearward enough to temporarily disable it.

Figure 4 Right also shows currently-available similar-to-Augat connector housings, male and female crimp pins, and tool, and 1/16" heat shrinkable tubing used for insulation. White tubing can easily be colored using magic markers. These items, shown in Figure 4 Left, are available, e.g. from You-Do-It Electronics in Needham, MA.

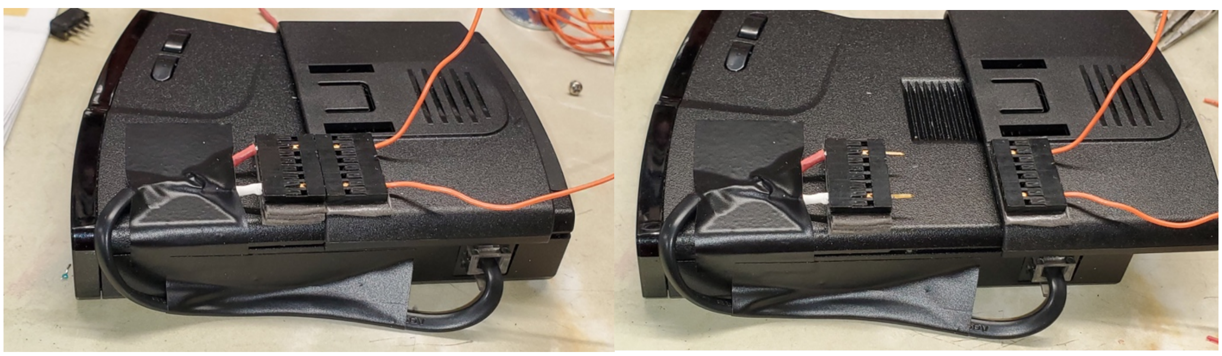

Figure 5. Quick Mount Connector on V1G2 Connected/Disconnected. Black electrical tape was later replaced with Black Gorilla Duct Tape, which sticks much better and looks like carbon fiber.

Figure 6. Attaching the Valentine Visor Mount, with Steel Spring Clip removed, to the Cross Bar via an Aluminum C-shaped part.

Figure 6. includes 2 views of the main C-shaped part that connects the Valentine plastic mount to the cross bar. The bottom is made of 1/16" thick 1" aluminum angle. It is about 1.108" wide and, using the steel clip as a pattern, shaped to fit and latch into the slot of the

Valentine plastic part. The square hole can be made with a drill, nibbler tool, and square files. The top portion is made from 1/8" thick aluminum angle, drilled and tapped for a single 10-32 screw. The two parts are joined using three 1/16" pop rivets. The complete C-shaped part can also be seen in Figures 7. and 8.

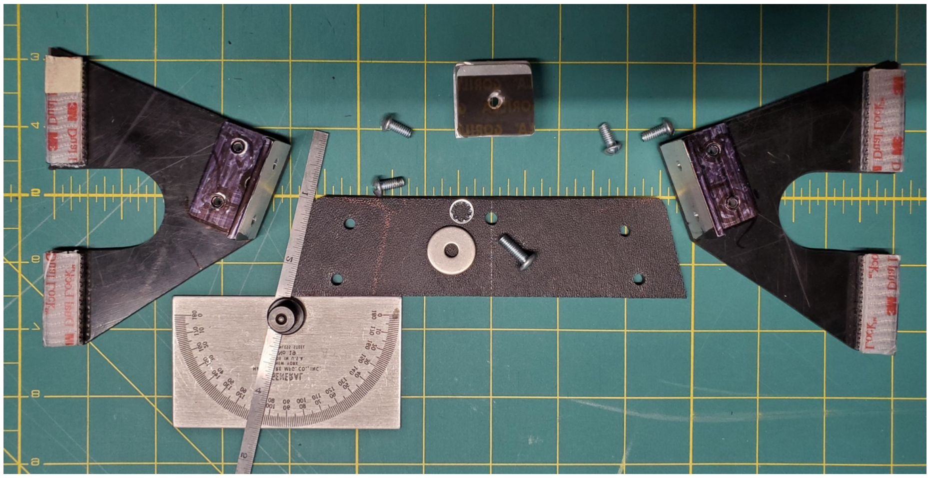

Figure 7. Quick Mount Parts Ready to Assemble

The main mount fastens to the sides of the Tesla black plastic cover ahead of the rear view mirror and under the 3 cameras, rain sensor, etc. No drilling of the Tesla is required. Four 0.5" by 1.5" 3M DualLock patches provide robust yet removable attachment (Figure 7.). DualLock was designed to tolerate auto windshield conditions well and is widely used for toll transponders.

The 3 main parts are made of 1/8" Thick Kydex, a black plastic material that is shiny on one side and has a wrinkle finish, similar to auto interior parts, on the other. Because the edges of the Tesla black plastic cover under the 3 cameras are curved slightly, it was necessary to cut a U-shaped slot in each side piece so the patches could twist a few degrees to conform.

Figure 7. shows the parts on a 1" grid, with a protractor to measure the angle. The 3 Kydex parts are joined using two 1/8" thick 1" angle aluminum corner braces drilled and tapped for 8-32 screws on the bottom and 3/16" pop rivets on the sides. The C-shaped part (bottom center of Figure 7.) was topped with a layer of Gorilla Double Sided tape to keep it from twisting. With the dimensions shown, there is about ¼" clearance between the back of the mirror and the left side piece, leaving room for mirror adjustment farther left than normal. There is no mechanical coupling to either the mirror or its stub/ball mount.

Figure 8. shows 2 views of the Quick Mount ready to be installed. In order to prevent any rattling against the windshield glass, the top edges of the side pieces were covered with Gorilla double-sticky tape with the top protective film left on.

Figure 8. Quick Mount Ready to Install. At center is the unused steel clip and a blue plastic trim tool.

For safety, corners facing passengers were rounded and the whole thing is quite frangible with the DualLock fasteners ready to yield. The whole mount can be easily removed, if necessary. The DualLock patches can easily be undone one at a time due to the flexibility of the Kydex. Shiny parts visible from outside were colored with black magic marker.

Except for the Kydex, which is available in sheets via several web sites, the other materials needed are standard hardware store items. Kydex may be heat-formed. If designed for production, a single piece with two gradual 90° bends could eliminate the two 1/8" thick 1" angle aluminum corner braces. Also, 1/16" thickness might be adequate. Other materials, like black anodized aluminum or clear plastic, might also work. The azimuth angle may be adjusted by loosening the single 10-32 screw. Other adjustments could be implemented, but were deemed unnecessary in this Tesla-Model-3-specific prototype.

Connection to 12V Source

Connections to two different 12V sources in the 2020 Tesla Model 3 were implemented: Front Dome Light Panel (Continuous) and Blue Wire Ahead of Driver's Door (Switched). The latter was much more work to install, but is superior and was left in the car.

Front Dome Light Panel

This concept was nicely described in the following YouTube video:
Removing Dome Light Panel by Jon Osborne
https://www.youtube.com/watch?v=QuSF3I0LpqE

It is by far the closest and easiest-to-access 12V source for an RD mounted below the rearview mirror. It has also appeared in other forum posts and videos. A video by Tech

Forum, discussed later, reveals that you don't have to remove the triangular piece at the edge of the dashboard under the wood trim.

Constant 12V (vs. Switched) is not ideal, but several work-around ideas, listed in Appendix A, were considered. The extra components located near the RD and the additional work at first seemed easier than tearing some of the interior apart to get to a switched 12V connection, rare and hard to access in the Model 3. But these ideas were shelved and work proceeded using the Quick Mount to easily shut off the RD with manual intervention. This action may become automatic if the RD is routinely unplugged from the Quick Mount to hide it. Forgetting to remove it won't matter with the model 3 connected to a garage home charger.

Across the yellow (pin 1) and black (pin 16) wires in the Tesla dome-light panel connector, about 14 V was measured with a Fluke DVM. Other videos or postings say it shuts off after the car goes to sleep. To investigate, an LED+resistor that was visible from outside without waking up the car was attached. The LED did stay on for at least 24 hours, even with the car not connected to its charger, so it must be constant. A post was later found that says it drops from 12V to 9V when the car sleeps. But the V1 would still draw current at 9V. Figure 9. lists measurements with the V1G2 on with bluetooth, but not receiving any Radar or Lidar signals. It is interesting that the current increases as the voltage decreases, exhibiting roughly constant power. Dropping to neither 9 nor 0 Volts was seen.

Voltage at V1 (fror JBV1)	Current (mA) thru V1 per Fluke DVM with Hickock 10A shunt.	Power (Watts) in V1G2
9.1	280	2.548
9.86	260	2.564
11.5	240	2.760
11.73	220	2.581
12.75	210	2.678
13.9	200	2.780
14.62	180	2.632
	Average	2.649

Figure 9. V1G2 Power Characteristics.

The Tesla microphone, also in that panel with the dome lights, intermittently did not work initially, but that was corrected by re-seating the connector and has been fine thereafter. Voltage measurements ranged from 12.9 to 14.7V under various conditions as the Tesla 12V regulator does its job.

The current capacity of this source is limited and protection mechanisms unknown, so two methods of protection were employed: 1. Use smaller wire than the Tesla (better to burn up what you added vs. wires in a far-reaching and expensive Tesla harness) 2. Use a fuse. But there is little room above the dome light panel for a fuse holder and it is challenging to remove to check or replace a fuse, while letting the fuse holder hang out would be ugly.

So a PolySwitch Resettable fuse was employed. There were some left from resuscitating Bosch headlight wipers in old Saabs, so the lowest current one available (1.85A) was used. Those shown in Figure 10 Left are obsolete, but similar replacements are available, e.g. from Digi-Key. Figure 10 Right shows steel pins soldered to the small wires and insulated with heat-shrink tubing. Plated steel pins, e.g. as used for quilting, solder well and are very strong compared to brass. They slip nicely into the connector housing alongside the pin, with no insulation piercing or soldering to the car's wiring.

Figure 10. Polyswitch Resettable Fuse

Figure 11 Left shows the added connections ready to install. Figure 11 Right also shows that, plus a reflection of the other side of the connector in the mirror, as well as the wires snaked under the headliner to just above the mirror. That was done by working a 12" Ty-Rap through, then putting some tubing over the end and pulling it back, then snaking the wires through the tubing. There is no need to remove or pull down the headliner.

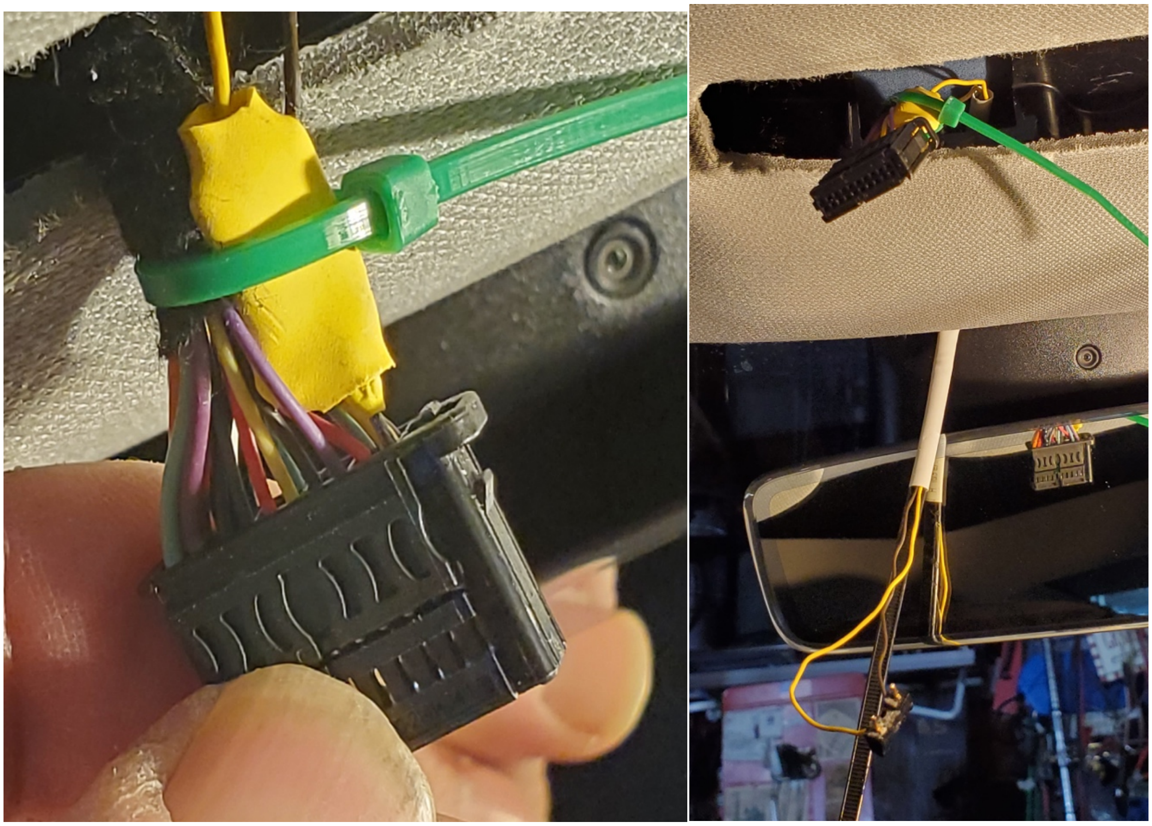

Figure 11. Making the Connection.

This connection was in effect for a few days and worked as expected. It still might be the best way to go for some, depending on individual requirements and capabilities. It was removed and replaced by the switched implementation covered in the following section.

Blue Wire Ahead of Driver's Door

It was decided to change to a switched connection, along with providing a better source of USB power to the Topfit cell phone holder, visible in Figure 2. The most accessible 12V switched source location found is also from Jon Osborne:
https://www.youtube.com/watch?v=wc3KchAv270

Another alternative by ingineerix that could have been implemented instead is covered here:
https://www.youtube.com/watch?v=bXNjgyrcGno&t=0s

In order to confirm that the blue wire is indeed connected to the 12V console outlet, Jon's experiment with a DC clamp-on current probe was successfully repeated. Also, voltage measurements at both ends were within a millivolt or so, and the resistance was about 0.5 Ohm. That means it is indeed directly connected, which is good news because the 12V console outlet is designed for owner use with much more capacity (12A continuous, 16A peak) than is needed by any RD. It is also protected and, per the Tesla manual, "leaving an accessory plugged in does not deplete the 12 Volt battery." It is on whenever the vehicle is considered "awake", for any of many reasons.

Some have observed that it has become constant due to a software change. So an experiment was run to measure how long it stays on after the car is ignored. The result was 59 minutes, ending in a clunk from the car. During that time, an RD drawing 200mA would consume about 0.2 AH, which is only about 0.6% of the 12Volt battery's 33AH capacity, so there should be no problem.

The following description was written beginning from the Quick Mount. A video by Tech Forum, in the first 3:20 minutes, shows how to remove the left A pillar cover. It also reveals that you don't have to remove the triangular piece at the edge of the dashboard under the wood trim.
https://www.youtube.com/watch?v=azyQXNLj3lU

It is best to remove the A pillar cover so the added cable can be Ty-Rapped to the existing harness without crossing the side-curtain airbag. An 8' Valentine V1 flat power cable from an old V1G1, which looks the same as what came with the V1G2, was used. To mate with its RJ-11 connector, a female RJ-11 connector, probably from an old phone, was attached to the left upright via a Ty-Rap, as shown in Figure 12. That allows the entire mount to be removed, as would be necessary, e.g. in an autocross.

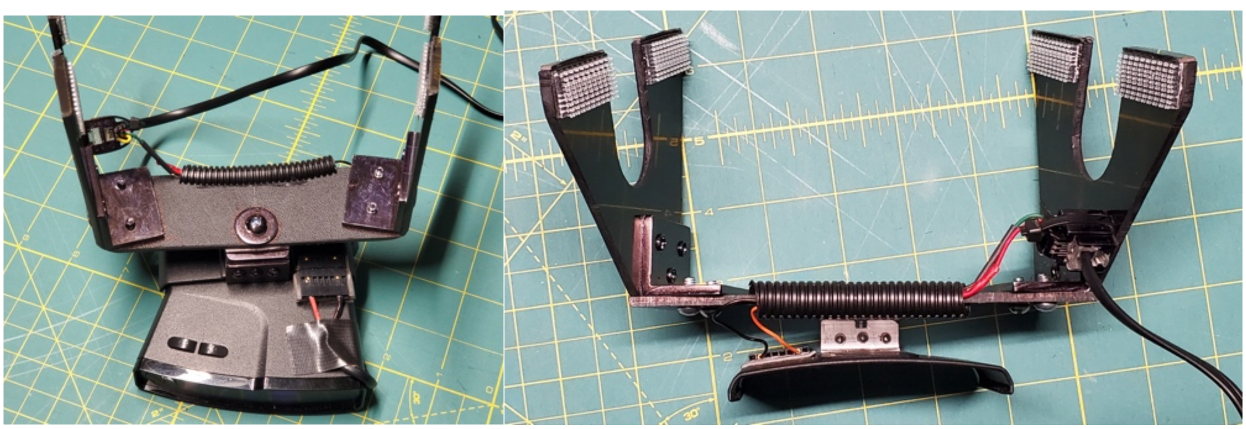

Figure 12. Quick Mount with RJ-11 Connector Attached to Left Upright. V1 power cable plugged-in

The photo in Figure 13., taken from above the frunk, shows how the power cable was easily pushed behind the headliner above the windshield, using a plastic trim tool. It was not necessary to unfasten the headliner.

Figure 13. Tucking the Power Cable Behind the Headliner.

In Figure 14., attachment of the power cable to the existing A-pillar harness is shown with Ty-Rap ends not yet trimmed so you can see them. Nothing added can interfere with the side curtain air bag.

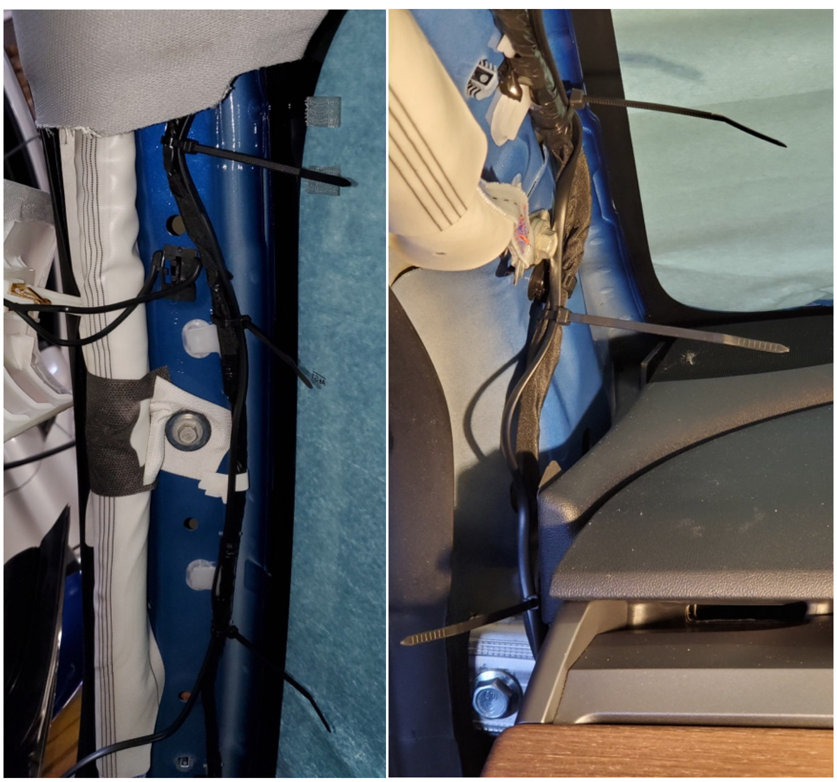

Figure 14. Attaching the Power Cable to the Existing A-Pillar Harness.

Moving lower, Figure 15 Left shows the PolySwitch again, along with the parts needed to make the ground connection, including a 6 mm bolt, toothed washer, and lug with 14AWG solid wire crimped and soldered. The washer goes under the lug where it can pierce the body paint to make a good ground connection. The terminal block allows for possible future connections.

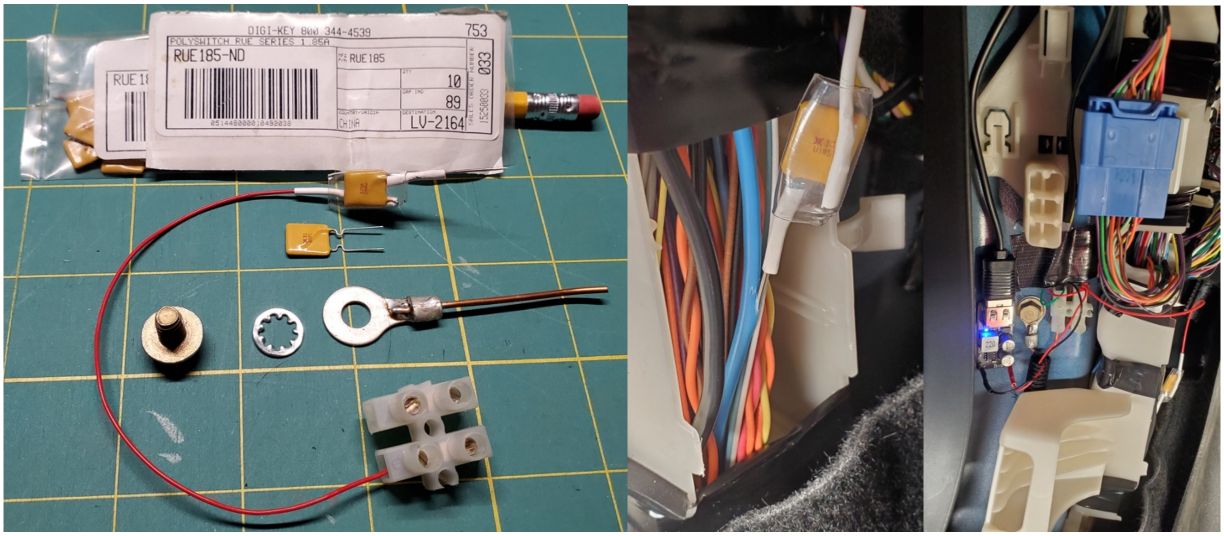

Figure 15. Grounding Parts, Connecting to the Blue Wire, Final Layout.

Unfortunately, there was no Tesla connector visible, so the insulation of the blue wire had to be pierced. Figure 15 Center illustrates how the steel needle was pushed about ½" into the blue wire to form a good connection. An insulation displacement tap could have been used, but the wire gauge is unknown, causing risk of damaging the conductor or blue insulation.

Figure 15 Right reveals the final layout. The terminal block was mounted via HD mounting tape and the stiff ground wire. About 6" of the V1 power cable was cut off. That could be used at the other end—see Figure 5. The outer sheath was cut back and the red and green wires stripped then connected to the terminal block. All wires were twisted together before being clamped in the terminal block. The unused black and yellow wires were folded back and taped.

A DROK USB Buck Converter, pictured with its blue LED lit, and available from Amazon, efficiently converts 12V to 5V to power the Topfit cell phone holder above the 15" Tesla display. Square wire-wrap pins were soldered into the input terminals at the corners of the little PC board. The converter was mounted to the steel door jamb next to the ground bolt using 2 layers of HD mounting tape. Female pins were crimped to the ends of the 2 wires connecting to the terminal block. Service loops were stuffed into short lengths of loom.

Measurements of current into the USB buck converter revealed that less that 1A of additional current drain from the 12V source can be expected:

	@ 12V	@14V
• No-load	1.66mA	
• S10+ Phone fast-charging directly (not used in Tesla)	1.3A	1.2A
• S10+ Phone charging through Top Fit wireless charger		0.81A
• Above, plus phone holder while USB-powered arms opening		0.93A
• Above, after phone removed		20 mA

Figure 16 shows how the USB cable was routed under the dash, avoiding LED lights, air outlets, and the Knee air bag. Black Gorilla tape and stick-on 1” x 1” mounting bases with Ty-Raps were used. These items are available at hardware stores, Home Depot, or Lowes.

Figure 16. USB Cable Routing from Topfit Phone Mount to 12V Source

Figure 17. It is Always Darkest Just Before the Dawn.

CONCLUSION

Hard-wiring an RD to a 2020 Tesla Model 3 is more challenging than most ICE cars, but has been demonstrated to be feasible using a prototype novel Quick Mount and either of two methods to connect 12 V power. After everything was re-assembled, it has been working perfectly for a few days. The mount is solid, with no rattles. Comments or questions are welcome.

Appendix A: Ideas to Mitigate Constant 12V, with Observed or Envisioned Drawbacks:

Constant 12V (vs. Switched) is not ideal, but several work-around ideas, listed below, were considered to varying degrees. The extra components located near the RD and the additional design/implementation work at first seemed easier than tearing some of the interior apart to get to a switched 12V connection, which are rare and hard to access in the Model 3. It was far easier to find and connect to ignition-switched 12V to power RDs in previous ICE cars, including Saabs, Volvos, and Acuras. Also, these cars could not change the behavior of 12V sources via software updates like the Tesla can do. Key requirements here are use of 12 Volt power, low standby power to avoid draining the 12V battery, and compactness so it can be unobtrusively attached to the mount near the RD.

PIR to "see" the driver. An experiment using a low- 50 microamp standby current PIR, type GC-SR501 and a A2SHB N-channel enhancement mode power FET to switch the ground of the RD revealed that it would basically work, but was subject to shutting off even while the driver is still moving i.e. not totally and reliably re-triggerable. It has a 5-second "induction blocking time". There are many commercially-available lighting control devices that have this problem, leading to a need for frantic hand waving to keep the lights on. It might also be subject to false triggering.

Vibration sensors. A few were found, but they are big, expensive, and have high standby current. They might also be subject to false triggering, like some car alarms that sense vibration.

Acceleration sensors. A compact level sensor(s) could trigger a low-power CMOS 555 timer, when the car is manouvering, but it is difficult to get long times with leaky large-value capacitors, and the 555 cannot handle the ~200mA current of the V1G2, so a drive circuit would be needed. The 555 is also not inherently re-triggerable. The level sensor is also mechanical, basically a conductive ball in a tube with contacts at one end. It might rattle annoyingly. An Arduino 3-axis accelerometer could work, but it needs a very low supply voltage and a computer running software…way overkill. But it might be interesting to also measure lateral and longitudinal acceleration like the old Geez Cube.

Radio. Transmitter keyed by driver sitting in seat, receiver near RD turns it on when seat is occupied.

Bluetooth. From your phone. Would be easy if the RD had a power on/off command.

NFC. From your Android phone, but requires manual action of moving the phone near the stick-on NFC tag, and some receiver with switch at the RD.

Radar. Compact Sensors becoming available.

Sonar. Like parking sensors.

Imaging of driver by inside camera. Tesla could do it, but it would be easier to just provide a switched 12V source near the rear-view mirror.

RD Time Out. Some RD have a built-in shut down timer after a long period of non-use.

Phone Presence Sensor. (This was a last minute addition conceived only after the project was done.) When the phone is in the Topfit wireless charger, current to the USB Buck Converter jumps dramatically from 20 to over 800 mA. Sensing that to turn on power to the RD would mean that the RD would only be powered when the phone is there. The phone also serves as the key, so is never left in the car by most users. A simpler version would just add a microswitch to the Topfit phone mount. But there would still need to be wiring or some sort of radio link up to the RD, only about a foot away. Perhaps an LED that shines a beam up there to an receiver/switch could do it.

Quick Mount. (or use the V1G2 power switch if you can spare 5 seconds). Easy way to shut off the RD, but requires manual intervention. This action may become automatic if the RD is routinely unplugged from the Quick Mount to hide it. Forgetting to turn it off won't matter in a garage connected to a charger. Work proceeded with this approach, while the others were shelved. Others are encouraged to investigate these further, motivated by the easy access to 12 Volts Constant in the front dome light panel.