DECADE ENGINEERING
5504 Val View Dr SE, Turner, OR 97392-9517 (USA) ~ **tel** 503.743.3194 ~ **fax** 503.743.2095
web www.decadenet.com

Power Supply Considerations for COG-5

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Unstable or noisy power sources for COG-5 can produce a rogues' gallery of trouble symptoms, from intermittent oddities to hard product failure. Symptoms of flash memory corruption are typically the first to be noticed, because this type of memory depends on incredibly tiny electrical charges stored on the floating gates of field-effect transistors. Out of millions, a single memory bit that is altered due to a power supply glitch can result in wrong configuration, bizarre program execution, or complete program derailment. If power supply glitches are persistent or severe, then physical IC damage occurs. In this case, it is no longer possible to correct failures by restoring configuration memory or reloading firmware. It often becomes impossible to load firmware at all.

In addition to cleaning up the power supply, many COG-5 users will benefit from implementing the power-fail detector (PFD) option, which is compatible with 12VDC nominal raw power sources. When connected and configured correctly, the PFD option allows time for COG-5 to store its most recent distance datum (from an incremental distance encoder) into flash memory prior to collapse of the 5VDC regulated power supply. A large electrolytic capacitor can provide short-term energy storage for this purpose, and simultaneously assist with power supply glitch filtering.

In a partial exchange for its high performance/cost ratio, COG-5 customers bear the burden of providing pure and stable power. This is one of the areas where system integrators earn their keep. COG-5 requires an exemplary power supply for two fundamental reasons: [1] It uses state-of-the-art IC chips that are intolerant of power supply glitches due to high feature density and greatly reduced internal clearances. [2] Cost increases from additional power supply filtering and overvoltage protection would unfairly burden customers who integrate COG-5 into systems with existing high-quality power supplies. Those features are most properly implemented at the system level, not inside the function modules.

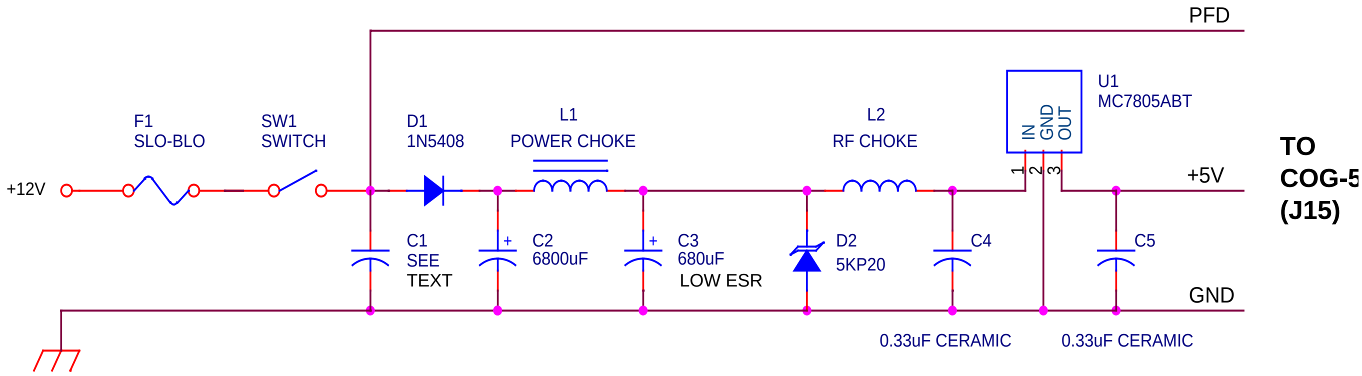
Sources of dirty system power include turn-on and turn-off transients, load-dump transients (from switching off a heavy load), battery charging power sources, and 'reflected' noise from unrelated loads. Severe transients can and do propagate through linear power supply regulators as well as switchmode converters, so they must be removed or at least brought within the regulator's input range by upstream filtering. Power brownouts/dropouts from motor starting events and other causes must be bridged by adding capacitors or batteries with steering diodes. Voltmeters are nearly useless for investigating these issues. Use a modern scope with digital memory to identify glitch sources and confirm effective treatment. System reliability is almost impossible to achieve without it.

Sanitary 5VDC power doesn't necessarily result from just dropping in a good quality DC/DC converter module. Old-fashioned linear voltage regulators are often superior in this application. Switchmode DC/DC converters generate copious electrical noise within the video signal spectrum, but the more insidious problem is that switching spike voltage can easily exceed the safe input range of associated equipment such as COG-5. Spikes do not appear in voltage readings taken with standard DMMs, but that doesn't make them any less damaging. Switching spikes can be removed by adding L/C filter networks between a DC/DC converter and its downstream load. If you take this approach, always confirm the intended effects and make sure that L/C resonance doesn't introduce new problems. Manufacturers of power converter modules think a bit like we do, in that extra filtering isn't included if many customers don't need it.

Switchmode DC/DC converters normally include a 'soft-start' feature that makes output voltage ramp up slowly at turn-on time. Note that COG-5 requires less than 25mS of ramp time and a continuous upward slope (no dips).

The following material is conceptual in nature. It is not intended for direct implementation without due diligence from system integrators.

Here's a tutorial example of power processing circuitry that may be appropriate for COG-5 installation by itself in mobile system environments:



F1 is required to limit fault current in the event of short-circuit failures downstream. A time-delay fuse may be chosen to prevent fuse failure at power-up time due to the C2 charging surge. Self-resetting PPTC devices such as the PolySwitch may be acceptable at F1 if the extra series resistance is taken into account. COG-5 consumes 250~300mA plus any power supplied to attached peripherals such as keyboards and distance encoders, so 500mA might be a good preliminary holding current specification for this device. Higher-rated fuses have lower internal resistance.

COG-5 ignores false trigger events on the PFD line if they last less than roughly 50uS. That might not be long enough to ignore major negative-going noise spikes or dropouts in some systems. If false power-fail events are causing COG-5 shutdown or unintended reconfiguration problems, the simplest cure is to add capacitance to ground on the PFD line (shown as C1). PFD trigger latency can be pushed out to about 5mS, for instance, by adding 0.47uF at this location. If used, C1 must be rated to withstand worst-case glitches in the raw power supply. Increase the value of C2 proportionately if PFD delay is extended beyond a few milliseconds.

D1 protects C2 from rapid discharge by heavy input-side loads and blocks input voltage reversal. D1 (and SW1) must withstand the C2 charging surge at power-up time, which is limited only by fuse resistance and diode forward voltage drop. A diode voltage rating of 200V or more should withstand any reverse voltage glitches likely to be encountered in motor vehicle applications. Rectifiers in the 1N5402~5408 series are more than satisfactory, with a 200A surge current rating.

To give adequate power-fail warning time, C2 must store enough energy to keep the regulator's input above its dropout voltage (typically 7V) for 35mS after a power-fail event. For example, using an estimated loss of 1V in D1 and L1, C2 voltage must fall no further than 4V in 35mS. The minimum value of C2 for an estimated load current of 400mA is therefore:

$$C = dT / dV * I = .035S / 4V * 0.4A = .0035F = 3500uF$$

C2 may be specified at 6800uF to assure adequate margin for added loads, device tolerance, capacitor aging, etc.

The following L1/C3 network is intended to remove major positive-going glitches from the raw power supply. Component values aren't critical, but L1's DC resistance should be well under one ohm to keep voltage loss within reason and C3 should have low ESR (equivalent series resistance). Nichicon RHT1D151MDN1 is a suitable 680uF 20V capacitor with 20 milliohm ESR and a selling price around one dollar in small quantities. L1's current rating should be far above the highest expected continuous current in normal operation. Major glitches will cause L1 core saturation if the current rating is inadequate, which effectively shorts this component out of the circuit. JW Miller 2324-V-RC is a 1mH ferrite toroid inductor that is suitable for suppression of moderate glitches, and it's cheap enough to use in multiples. Stancor TC-1 is an economical 3mH iron-core device, but its current rating is only 1A. Triad C-56U is a generous 35mH at 2A, but its DC resistance is 0.79 ohms. Car stereo and marine electronics installers often have access to low-cost imported chokes that may be useful in this application.

If glitches are a major headache, then consider adding a second L/C network of this type. Choke DC resistance has to be considered more carefully in this case. Be aware that L/C networks can resonate, resulting in boosted glitches under some circumstances. Iron-core chokes and standard electrolytic capacitors are lossy enough to eliminate this phenomenon in most cases, but it's never wise to assume. Use your scope!

D2 is a transient voltage suppressor (TVS), which is a Zener diode that is optimized for glitch suppression. It forms the last-ditch defense against destructive positive-going glitches in this circuit. We know that U1, the regulator IC, has an absolute maximum input rating of 35V. Without foreknowledge of system glitch severity, we simply look through the Mouser catalog and find that Littelfuse's 5KP20 stands off 20V but limits terminal voltage to 35.8V at a peak pulse current of 139A. This device sells for about three dollars in small quantities and seems like a good fit for the job. TVS diodes normally fail shorted under heavy assault, so it's best to go with substantially over-rated devices when there's doubt.

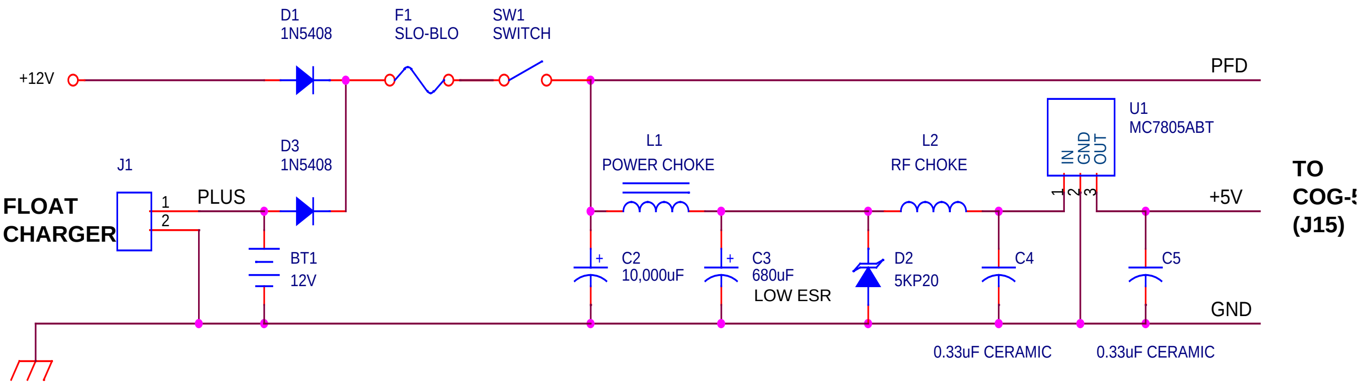
While power chokes and electrolytic caps are great for suppressing low-frequency noise, they perform poorly in the RF (radio frequency) spectrum. L2 and C4 act to suppress RF garbage that survives passage through the previous filters. C4 also provides a minimum input capacitance required by the 7805 regulator IC for stability. Both of these components are optional, assuming a short connection between C3 and U1, but RF interference rejection is often helpful in video systems. L2 can be a cheap 2.5-turn wound ferrite bead such as Fair-Rite 2944666671. C4 must be ceramic, to assure lowest inductance. Its minimum value (0.33uF) may be increased without limit.

U1, the 7805 regulator IC, has On Semiconductor's "ABT" suffix in order to specify tight tolerance on output voltage, operating temperature down to –40°C, and the TO-220 package. Be aware that cheaper commercial-temperature devices may fail to start at temperatures below 0°C (32°F). COG-5 specifies a 5% tolerance on power supply voltage, but staying close to the center of this range insures that its analog video processing circuits deliver their best performance. Be sure that heat dissipation arrangements are adequate when using any type of linear regulator.

C5 is another optional component. This capacitor improves regulator performance against load current transients. Even though COG-5 is replete with capacitors to smooth internal load transients, the use of C5 is a cheap way to gain additional power supply stability and noise rejection.

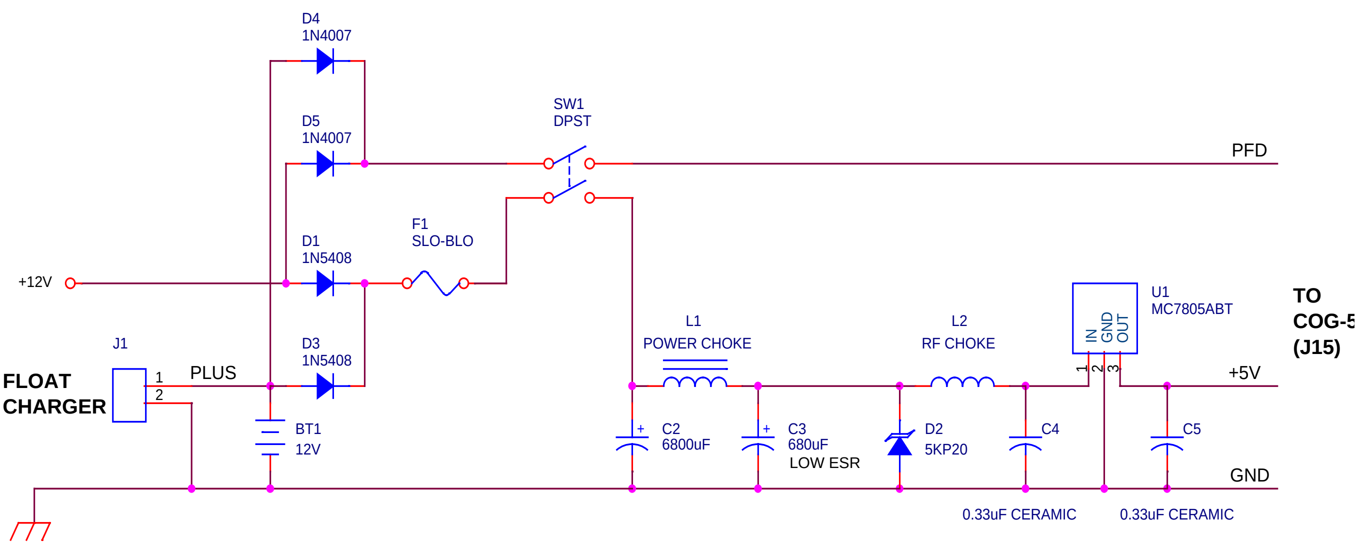
IC manufacturers now offer many alternatives to the old 7800 series 3-pin positive regulators. National's LM2940, for instance, is optimized for motor vehicle applications. Its dropout voltage is low enough to maintain regulated +5V output during engine cranking in many cases, and it tolerates input transients as high as 60V as well as input reversal. Unfortunately, like most LDO (low-dropout) regulators, it can oscillate vigorously with some combinations of load capacitance and ESR. Always read the datasheet closely before using this type of regulator IC.

Here’s a possible COG-5 power solution for systems where power dropouts last longer than milliseconds:



A lead-acid backup battery (BT1) can easily bridge long interruptions in the main power supply. It requires charging current, but simple float charging is adequate because duty cycle is minimal. To avoid battery life impairment, confirm that the charger is well matched to the battery. The recommended float charging voltage for most low-pressure lead-acid batteries is between 2.25V and 2.27V per cell, or 13.56V total for a 12V nominal battery. A charging voltage of 13.80V or more indicates excessive float charging current.

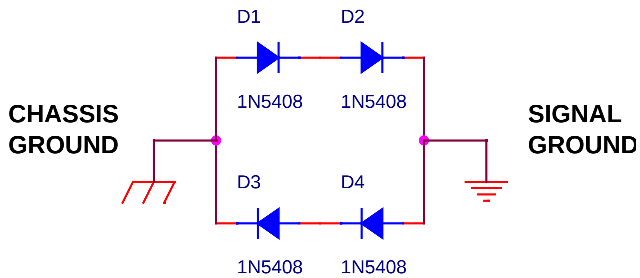
PFD arrangements are more difficult in this case due to the necessary downstream connection. COG-5 detects power failure at 9V on the PFD line, so there’s only two volts of margin between the PFD event and regulator dropout. C2 has therefore been increased to 10,000uF and may benefit from further increase. Other possible solutions include driving PFD from a comparator IC with its reference input set to a higher trigger voltage, or doing something like this:



Finally, let’s consider some aspects of system grounding. Remote video inspection systems often deploy long cables between camera and viewing station. Power fed through the cable encounters resistance that produces a substantial voltage difference between “ground” in the camera control unit (CCU) and “ground” in the camera head. If power supplies feeding the cable are not isolated from CCU ground, then power supply current flows in the return video cable shield and the returning video signal voltage is offset from CCU ground. That offset includes noise voltage due to power supply current modulation. The consequences may not be pretty, especially if those power supplies don’t have ultra-clean DC output or the remote loads are noisy. Aside from video noise problems, a few amps of video cable shield current can develop enough voltage between video and power supply terminals of

COG-5 to cause damage. The most likely time for damage to occur is when camera cables are connected, disconnected, or damaged during system operation.

Be aware that destructive ground loops can occur on the downstream side of COG-5 as well. Devices connected to COG-5 video outputs may be linked to "earth ground" through 3-wire power cords, for instance. If COG-5 board ground is also linked to earth ground through another path, then it's entirely possible to have current flowing in the video cable shields due to earth ground voltage offset. One way to deal with this problem is to isolate the CCU electrical safety ground (chassis) from signal ground with an opposing parallel diode network:



This network allows up to 1.2V (peak) of potential difference between safety ground and signal ground, which is often sufficient to break troublesome ground loops without compromising electrical safety. It's usually wise to add a small amount of capacitance between the ground systems in order to suppress RF interference. The best place to do this is at video input and output connectors, directly to the chassis wall nearby. RF ingress via video cable shields isn't a problem, of course, if the video jacks are grounded directly to the chassis where they're mounted. That's a strong incentive to link safety ground and signal ground, and it can be a successful strategy due to the very low resistance of a metal chassis.

Component Sources

To quickly locate distributor stock of any component part numbers quoted in this app note, try the search engine at:

www.findchips.com

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