



Power Supply Considerations for BOB-4 Modules

15 November 2013

Unstable or noisy power sources for BOB-4 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.

In a partial exchange for its high performance/cost ratio, BOB-4 customers bear the burden of providing pure and stable power. BOB-4 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 BOB-4 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 other 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 very difficult 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 spikes can easily exceed the safe input voltage range of associated equipment such as BOB-4. Spikes do not appear in voltage readings taken with standard DMMs, but that doesn't make them any less damaging. For instance: If BOB-4 is powered by a 5V DC/DC converter module that sneaks up to 5.25V under some [line + load + transient + temperature + tolerance] conditions, and it has noise spikes above 0.25V peak, then you've exceeded BOB-4's **absolute maximum** power supply voltage (+5.500V). BOB-4 does **not** take kindly to excessive power supply voltage, regardless of time scale. Microsecond spikes are fully capable of corrupting flash memory, and this applies to virtually all modern microcontroller chips.

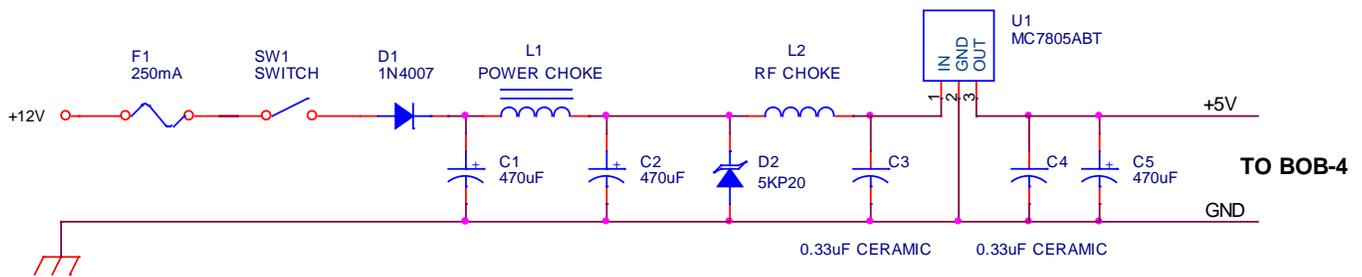
Switching spikes can be removed by adding L/C filter networks between a DC/DC converter and its downstream load. If you take this approach, always confirm the intended effects and make sure that L/C resonance doesn't introduce new problems. Manufacturers of power converter modules think a bit like we 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 BOB-4 specifications call for 4.5mS maximum ramp-up time and a continuous upward slope (no dips). It's necessary to provide at least 100uF of low-ESR bulk capacitance to ground at BOB-4's power supply input pin, but this capacitance can increase voltage rise time due to power supply current limiting. As a point

of reference, it has been determined by measurement that a lab power supply current limit setting of 1.5A yields 4.5mS voltage rise time when there's a 470uF capacitor on the +5V line to BOB-4. The final arbiter of allowable power supply rise time is Atmel's specification for VDDCORE on the AT91SAM7S256 processor chip: 6V/mS. That works out to 300uS maximum rise time for this 1.8V rail, which is not accessible at a BOB-4 pin. If necessary, VDDCORE can be accessed at the ungrounded end of any capacitor in the range of C5~C10, in BOB-4H as well as BOB-4S.

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

Here's a tutorial example of power management circuitry that may be appropriate for BOB-4 installation in mobile system environments:



F1 is required to limit fault current in the event of short-circuit failures downstream. A time-delay fuse or higher fuse rating may be chosen to prevent fuse failure at power-up time due to the filter capacitor charging surge. Self-resetting [PPTC](#) devices such as the PolySwitch may be acceptable at F1 if the extra series resistance is taken into account. BOB-4 consumes about 100mA. Higher-rated fuses have lower internal resistance. D1 blocks input voltage reversal. D1 (and SW1) must withstand the capacitor charging surge at power-up time. A diode voltage rating of 200V or more should withstand any reverse voltage glitches likely to be encountered in motor vehicle applications.

The C1/L1/C2 network is intended to remove major positive-going glitches from the raw 12V power supply. Component values aren't critical, but L1's DC resistance (DCR) should be well under one ohm to keep voltage loss within reason. 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. Stancor TC-1 is an economical 3mH iron-core device. Triad C-56U is a generous 35mH at 2A. 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 using an additional L/C filter stage similar to L1/C2. Choke DCR has to be considered more carefully in this case. Low-ESR electrolytic capacitors can be useful as well. 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 curtail 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. TVS diodes normally fail shorted under heavy assault, so it's best to go with substantially over-rated devices when there's doubt.

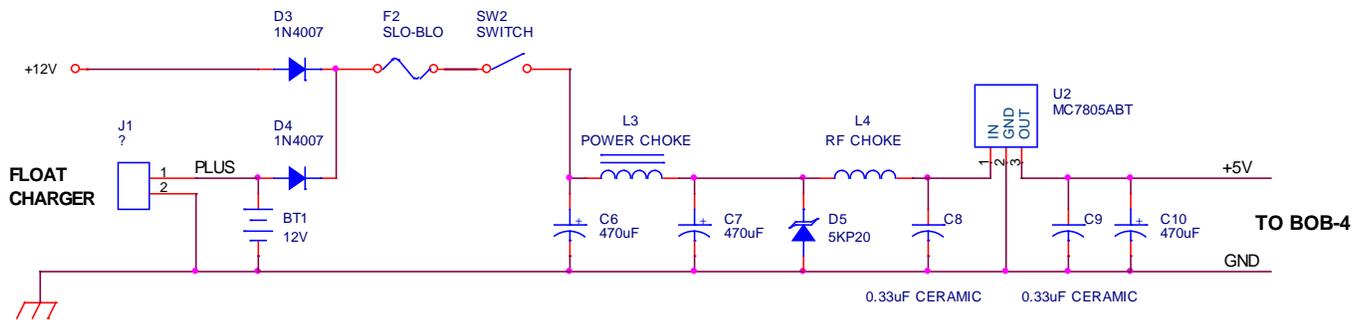
While power chokes and electrolytic caps are great for suppressing low-frequency noise, they perform poorly in the RF (radio frequency) spectrum. L2 and C3 act to suppress RF garbage that survives passage through the previous filters. C3 also provides a minimum input capacitance required by the 7805 regulator IC for stability. Both of these components are optional, assuming a short connection between C2 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. C3 must be ceramic, to assure low 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). BOB-4 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.

C4 is another optional component. This capacitor improves regulator performance against load current transients. Even though BOB-4 is replete with capacitors to smooth internal load transients, the use of C4 is a cheap way to gain additional power supply stability and noise rejection. C5 is required by BOB-4, to insure adequate local bulk energy storage. It must be located close to the BOB-4 module connector.

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, 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 BOB-4 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.

Finally, let’s consider some aspects of system grounding. Remote video inspection systems often deploy long cables between camera head 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 ground terminals of BOB-4 to cause damage.