Electroluminescent Lamp Driver Evaluation Board

Introduction

This Application Note introduces an Evaluation Board for IMP EL driver ICs. It is supplied with the IMP803 but can also be used with the IMP560 and IMP525: all 3 have identical pinouts.

EL Lamps and Drivers

An electroluminescent (EL) lamp consists of a phosphor coating on a dielectric that is sandwiched between two conductors. Electrically, it looks like a capacitor. Such a lamp requires drive from a high alternating voltage source in order to emit light. This can be obtained from IMP integrated circuits IMP803, IMP560 and IMP525 that convert low voltages into appropriate high-voltage waveforms.

Small EL lamps exhibit about 2 to 6nF/in^2. IMP Driver ICs are capable of powering EL lamps that have total equivalent load capacitances up to 30nF, so this works out to a maximum of around 15 square inches. "Powering" in this context means enabling enough light for the application, which can range from LCD backlights (relatively bright in a handheld device) to pagers (medium-bright, in a poorly-lit room), to night-lights (faint, in a dark room).

IMP Driver IC System Diagram

As shown in *Figure 1*, these ICs contain a high-voltage MOSFET switch, an output H-bridge, and oscillators to drive each. The switch, combined with an external inductor and diode, form a step-up (boost) converter that transforms the input voltage to 45-90 volts across capacitor C_S. This, in turn, is switched from one side of the load (the EL lamp) to the other by a commutating bridge, driven by its own oscillator. This action causes the lamp to experience twice the C_S value (i.e. 90-180 volts peak-to-peak) with no DC component.

A typical application uses a switch frequency of 80kHz and bridge commutation frequency of 360Hz. These frequencies are controllable via external resistors; R_{SW} for the boost converter and R_{EL} for the output driver. R_{EL} influences brightness, color and EL lamp life. R_{SW} controls converter efficiency. Both affect power consumption.

IMP Driver IC System Diagram

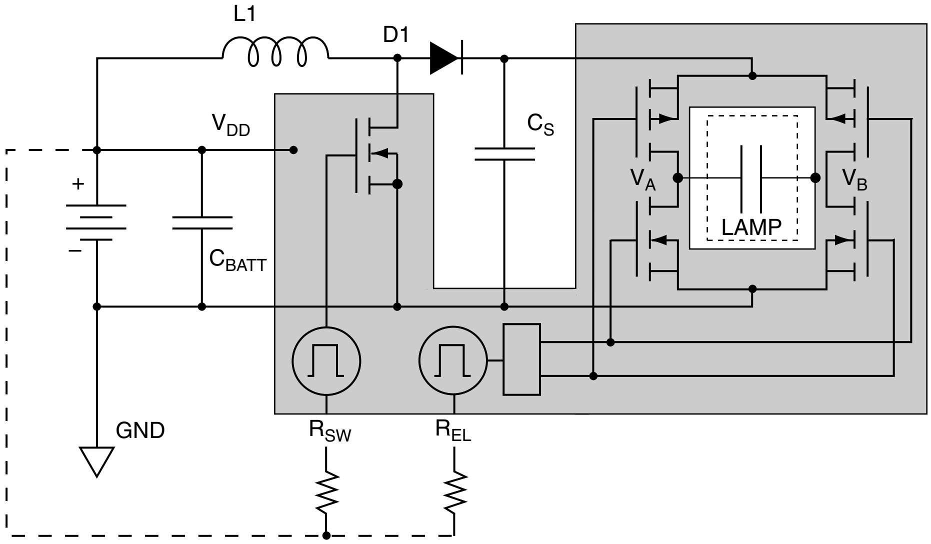

Figure 1. Circuitry in gray is on-chip.

Driver Variations

The IMP803, 560 and 525 have an internal regulating circuit (see *Figure 2*), that is useful where V_{IN} is expected to change considerably, as with an aging battery: as V_{IN} falls, V_{OUT} (and brightness) will remain substantially unaffected.

Table 1 is a general comparison of IMP EL Lamp drivers. It facilitates choices based on number of batteries, size of display, and regulation. Required display brightness will also need to be factored into the choice.

Table 1. General Characteristics of IMP EL Lamp Drivers

Device	V_{IN}	V_{OUT}	Regulated Output	Max. Switch R(on)
IMP803	2.4 – 6.5V	$180V_{PP}$	Yes	8Ω
IMP560	2.4 – 6.5V	$120V_{PP}$	Yes	8Ω
IMP525	0.9 – 2.5V	$112V_{PP}$	Yes	15Ω

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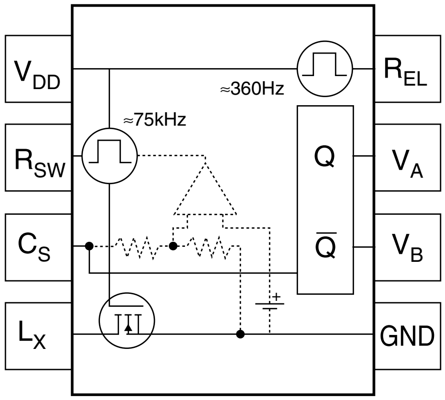


Figure 2. Block Diagram for IMP circuits. Dotted components are equivalent to regulation circuitry (see text).

Basic Circuit, Plus Variations

In normal operation, V_{DD} is one or two 1.5V cells and L1 is a tiny ferrite-bobbin inductor. R_{SW} and R_{EL} control their respective oscillators. If a logic-controllable shutdown is desired, R_{SW} may be switched between V_{DD} and GND (I_{DDQ} = 1µA max.). Conversely, if shutdown is via V_{DD}, R_{SW} should then be connected to V_{DD} as shown by the dotted line in *Figure 3*.

R_{CL} is included to protect the bridge against peak currents during commutation. A value of 500Ω to 2kΩ is suitable.

In use, the inductor current can reach several tens of milliamperes, so in single-battery applications it is recommended that the low-current shutdown capability of the driver IC be utilized. This is done by connecting R_{SW} (point A on the schematics) to either V_{DD} (ON) or GND (OFF). With power source(s) connected, shutdown (standby) current is typically much lower than 1µA.

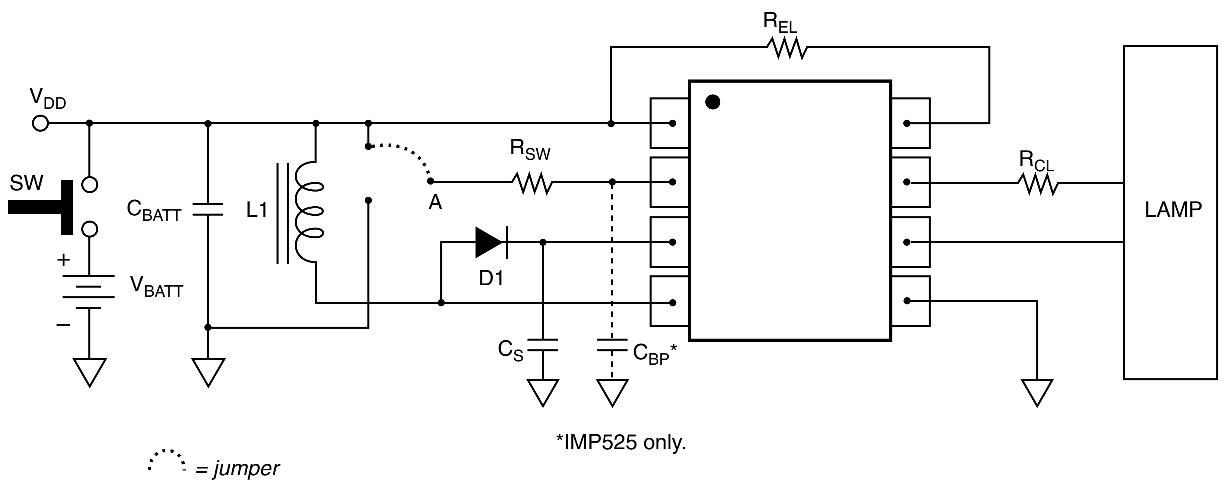


Figure 3. Basic EL Lamp Driver.

Reducing Component Count

Having said that keeping R_{CL} is a good idea, it is true that removing as many components as possible may also be desirable. For the IMP803, R_{EL} and R_{SW} may be combined as shown in *Figure 4*. Varying R_{EL} causes a visible change in brightness and color, but a similar variation in R_{SW} (affecting oscillator frequency and power consumption) is much less noticeable. Combining the two is thus a valid way to save a resistor. The bypass capacitor C_{BP} (IMP525 only) reduces display flicker in noisy environments, such as when there is no ground plane.

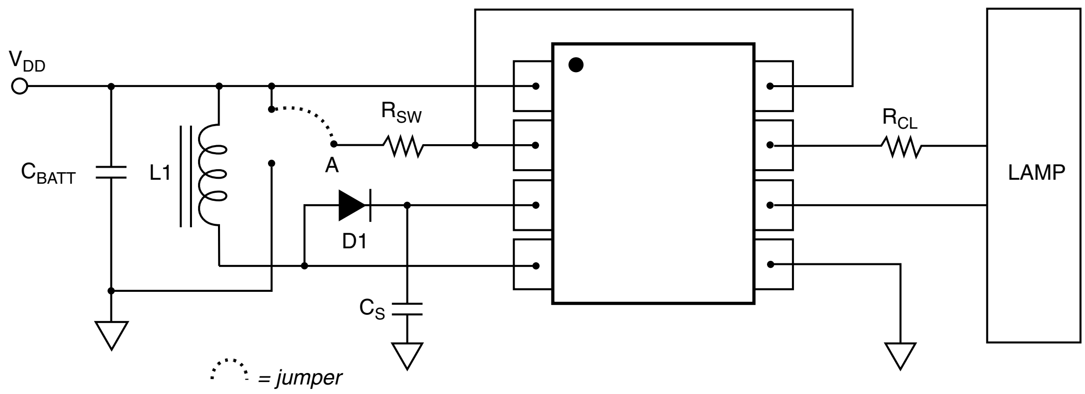


Figure 4. Using R_{SW} to supply current for both switch and EL oscillators, and also serve as a low-current on/off switch (IMP803 only).

Using the circuit in *Figure 5*, one can utilize an available V_{IN} that is higher or lower than the allowable V_{DD}. The logic shutdown may also be separated from V_{DD}. Such arrangements are helpful when the inductor supply is too low for the IC, or the display size requires a voltage that is too high for the IC. A higher V_{IN} will need a higher switching frequency to keep the inductor out of saturation. In all cases, note the presence of HIGH VOLTAGE!

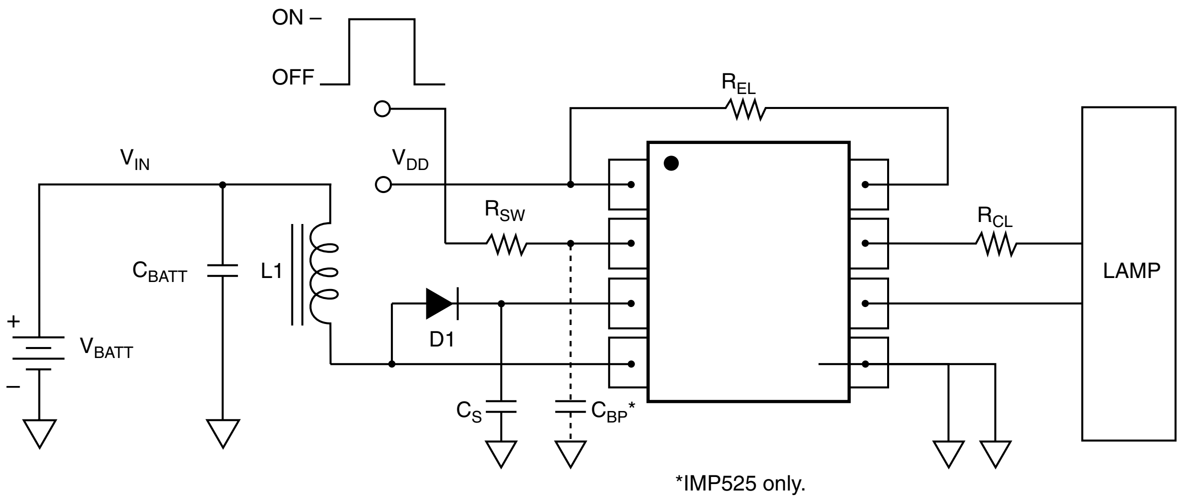


Figure 5. General Circuit, where chip V_{DD}, on/off logic and V_{IN} are all different.

Evaluation Board

The ELD002 is a PC board for evaluation and experimentation purposes. More compact arrangements are easily achieved by using surface-mounted components exclusively. The various possible connections mirror the options discussed in the data sheet and the Application Note. While the IMP803 is supplied on the board, other pin-compatible drivers may be substituted.

The two dark patches are the connections for the EL lamp which are made using conductive double-sided tape. The display itself is held down with ordinary double-sided tape. Taping is advantageous for several reasons, among which are that lamps with staked connecting terminals generally cost more, and they are a possible site for mechanical (and thus electrical) failure.

As a general precaution, note that HIGH VOLTAGE exists on the board; around 180V or so. The current level is low so there is no danger, except possible pain if a tender skin area or open cut contacts the HV sections.

There are extra holes for capacitors (if needed), and the hole spacings are wide enough to accommodate 1/4W resistors. Corner mounting holes have also been provided.

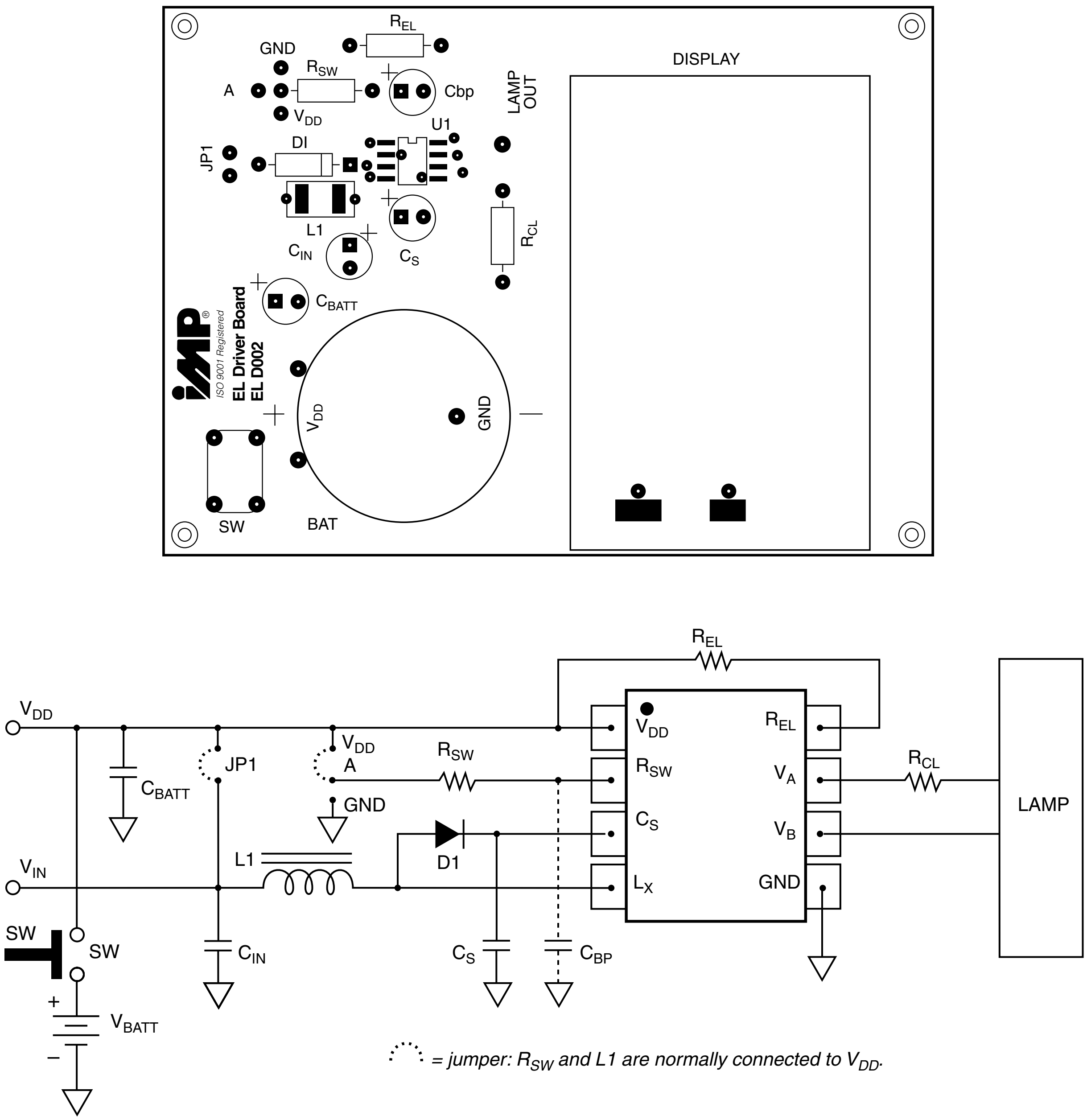


Figure 6. Evaluation Board Layout and Schematic.

Some Battery Considerations

To keep the board light in weight, a Li-Mn power source was selected. When energized, the drain from the circuit is around 22mA, thus the CR battery chemistry is preferred over the BR for its superior pulse performance. If long-term continual illumination is anticipated and space is not an issue, alkaline batteries may be more economical.

With the IMP803 and 560µH inductor supplied, regulation begins at about 3-3.5V, but display illumination appears virtually unchanged above 2.7V. When choosing the battery chemistry, it is a good idea to match the cell "plateau" voltages to this. For example, a typical NiCad plateau is 1.2V under load, so more than 2 cells would be needed. Alkaline plateaus are somewhat higher, and they differ with size, shape and duty, so 2 cells could suffice. Li-Mn coin cells have their voltage plateau under load at about 2.85 volts. They can drop lower, but they also return to close to 3V when the load is removed.

Additional Points

1) To experiment with the *Figure 4* scheme, a jumper may be run from the rightmost pad of R_{EL} to the leftmost pad of C_{BP} (with the + above it). Start with an R_{SW} of 750kΩ. Short leads and a ground plane are more critical in this arrangement.

2) C_S should be 10nF - 100nF.

3) The IMP803, IMP560 and IMP525 datasheets show performance with different inductors. For example, high-voltage regulation is reached earlier with lower L, but this requires more current. This may be partially offset by adjustment of the oscillator resistors.

4) To experiment with multiple supplies, the appropriate jumpers may be removed.

5) The inclusion of R_{CL} should be stressed: while 500Ω to 10kΩ has been used, 2kΩ is the best all-around value.

Layout Rules for Other Arrangements

1) A ground plane is recommended to keep stray high frequencies confined. In a very small area, the need for a ground plane may be nil. A totally surface-mount arrangement would make such a plane difficult anyway.

2) Locate high voltages away from the high-impedance elements R_{EL} and R_{SW}.

3) Make sure that C_S has a rating of at least 100V.

4) The diode should have good reverse-recovery characteristics (the general-purpose 1N4148 is adequate) and should be rated for pulsed BV > 100V for the IMP803, and pulsed BV > 75V for the IMP560 and IMP525.

5) Shutdown by a logic-level signal is possible by connecting R_{SW} to ground (R_{SW} is normally connected to V_{DD}). This on/off logic uses only 1µA max. when connected at this location.

7) Required voltage ratings for the capacitors other than C_S are flexible, and need only reflect actual stresses plus a safety margin.

Bill of Materials for ELD001

Component	Description	Manufacturer	Part Number
Resistors (±5%)	See Table, below		
Capacitors (±20%)	See Table, below	Murata	RPE121/122 Series
Switch	SPST, momentary	Panasonic	P8008S
Battery	3.0V Li-Mn Coin	Sony Panasonic	CR2450-HE4 CR2354-IGU
Inductor	L1 = 560µH	Murata	LQH4N561K04
Diode	D1 = 1N4148		
Lamp	1.3” x 2.05”	MetroMark or other	
Conductive Tape	Connects display	Adhesives Research	ARclad 8001
Double-Sided Tape	Holds display down	3M	Type 665

Key to Components and Ratings

Component	Value	Function	Comments
R_{SW}	30kΩ to 3MΩ	Sets switch osc. frequency.	Decrease R to increase frequency.
R_{EL}	500kΩ to 10MΩ	Sets bridge osc. frequency.	Decrease R to increase frequency.
R_{CL}	500Ω to 2kΩ	Limits output current.	Protects IC.
C_S	0.01µF to 0.1µF, 100V	Stores high voltage.	Use low values for large lamps.
C_{BATT}	0.1µF, 10V	Supply bypass.	Keeps supply impedance low.
C_{BP}	1nF, 10V	Lowers noise at R_{SW}.	IMP525 only.
C_{IN}	0.1µF to 22µF	Supply bypass.	Keeps supply impedance low.
L1	100µH to 1mH	Stores energy.	Small L, high f increases V_{OUT}.
D1	100V, 10mA (1N4148)	Passes energy from L to C_S.	Use fast recovery type.

APPENDIX: Introduction to EL Lamps

Chemical compounds, called phosphors, glow when energy is applied to them. This excitation energy can come from conducted or radiated electrons, or an electric field. A common example of this process is found in the emitted (radiated) electrons that impinge on the dots and stripes of color monitors and TVs, whose phosphors emit everything from pure colors to white light, depending on their formulations.

Backlights and lamps generally are simpler, employing a manganese-activated zinc sulfide phosphor (ZnS:Mn) that is excited by a high-voltage (> 40V) AC electric field (DC can shorten the lamp life). Fabrication involves depositing the phosphor as a thin film onto a BaTiO3 dielectric between conducting planes, like a capacitor: one of the planes is the transparent conductor, indium tin oxide (ITO). The lamp color depends on phosphor formulation, but also on its physical realization (i.e. encapsulation, resins, dyes, etc.), plus the characteristics of the drive circuitry.

The IMP line of drivers is targeted mainly at applications like backlight EL and stand-alone pre-printed or segmented lamps. Backlights are used with the Liquid-Crystal Displays found in cellular telephones, pagers, Personal Digital Assistants (PDAs), and general-purpose local lighting applications where low power consumption without heat is important (e.g. airline cockpits, medical instrumentation).

The excitation required for lamps ranges from tens to hundreds of volts, at frequencies from 60Hz to a few kHz. Each display has an optimum combination depending on size, color, efficiency and desired brightness.

In general, the changes in brightness with frequency and voltage are nearly linear. These facts allow tradeoffs. For example, if going above a certain voltage is not allowed, an increase in drive frequency may achieve the same result.

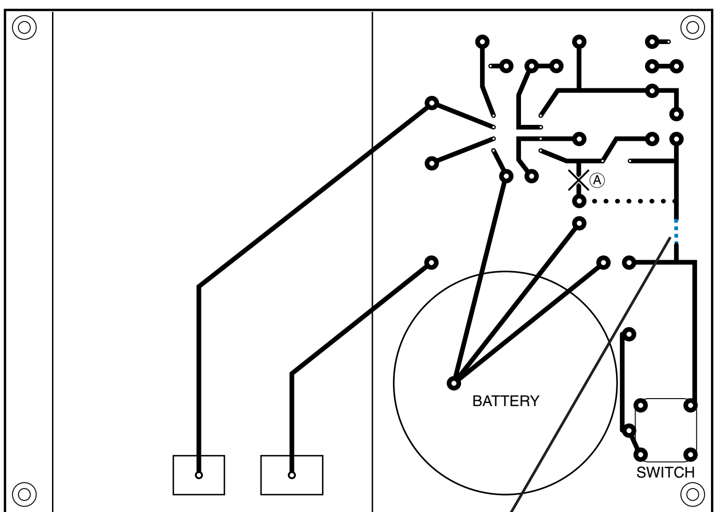
Addendum

The new evaluation board ELD002 is now available and will be sent out to all new purchasers. This Addendum will serve to explain the differences and update the information in AN-1.

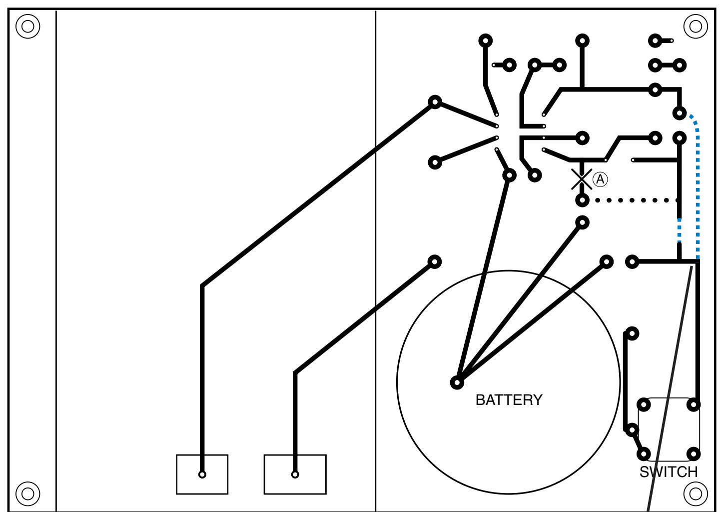
Changes

The diagrams below show the basic wiring of ELD001 (see AN-1, *Figure 6*) on the left and ELD002 on the right. The difference is that, with ELD002, the 3V cell is switched to the V_{DD} pin, and this voltage only goes to the inductor if JP1 is connected. If JP1 is open, an alternate voltage can be used to power the inductor.

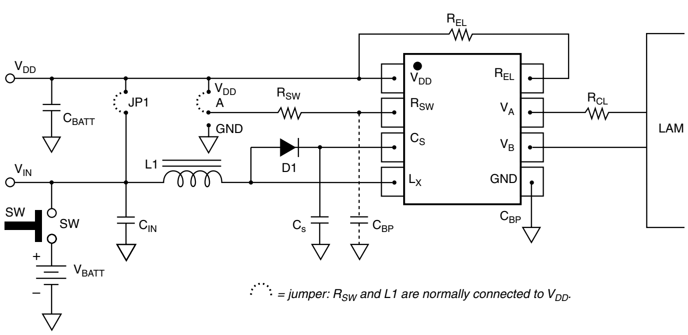
In contrast, the ELD001 switched power to the inductor, and to V_{DD} only if JP1 was connected. This was intended to demonstrate the logic-level shutdown ability of the IMP803: by using the pushbutton for the heavy current to the inductor, the V_{DD} pin could be tied to a voltage source and the chip enabled/disabled by a logic level of V_{DD} or ground applied to R_{SW}. The ELD002 board allows both features to be exercised. For ELD001 users who wish to modify their boards, the changes are shown below.



Cut the trace at this point.



Extend the trace (using wire) and connect at this point.



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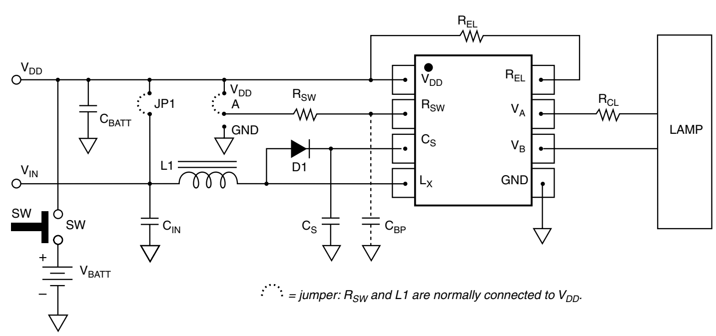

ELD002

Updates

1) *I_{DDQ} is listed as 1µA max. (AN-1, pp 3, 6, 7). Extensive testing has shown this to be much too conservative: 25nA is much more typical.*
2) *In using R_{SW} to shut-down the IMP803 (only 25nA), R_{EL} can remain connected to the V_{DD} pin; only 1 resistor then needs to be switched.*
3) *Under some circumstances, R_{CL} can be omitted. Consult IMP for details.*
4) *For single-battery systems (the vast majority), the capacitor shown on the diagram as C_{IN} is not needed. For cases where it is needed, further "surgery" is required: cut the trace shown as Ⓐ and reconnect it as per the dotted line.*

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