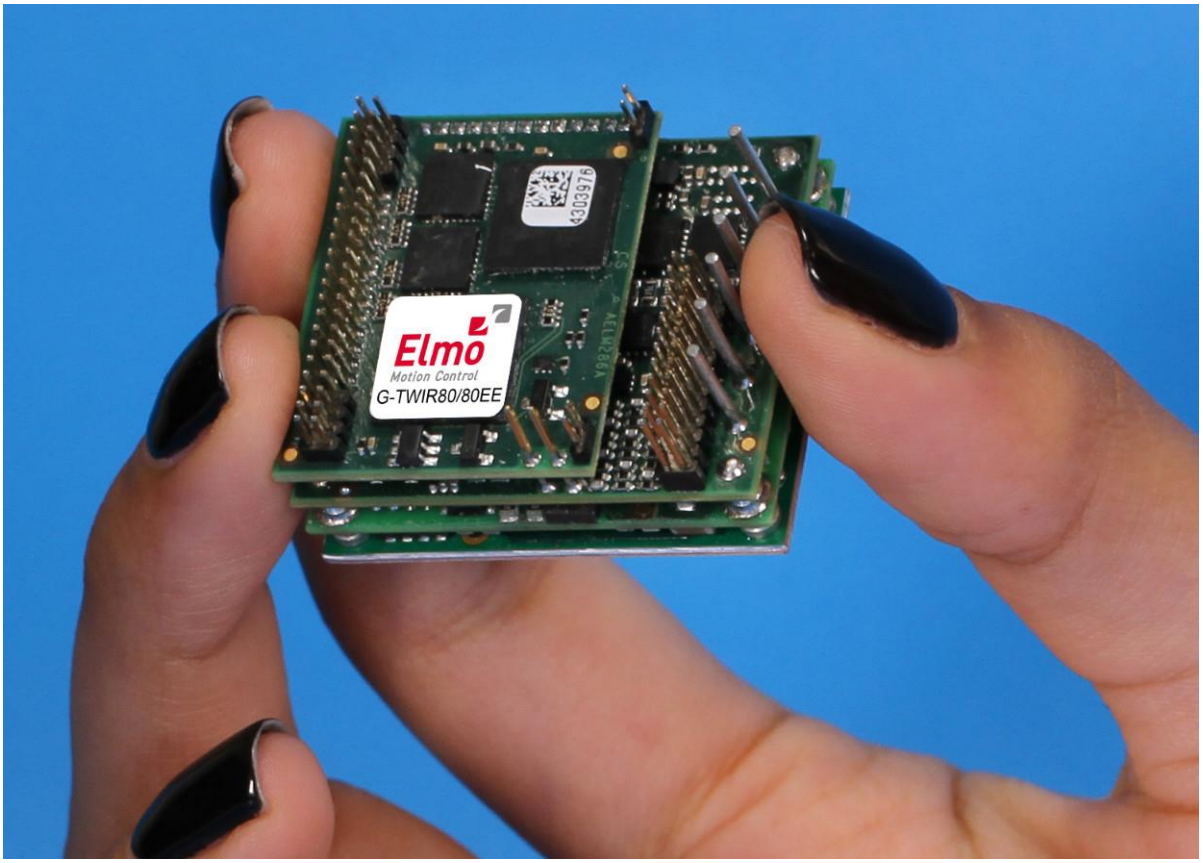
Inspiring Motion
Since 1988

Gold Twitter Power Supply Considerations



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Elmo
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Chapter 1: Abstract

The Gold Twitter is a tiny, highly concentrated very powerful servo drive with extreme capabilities of rapid transfer of very high power bursts to the motor (Motoring) and from the motor (Regeneration- Braking). Therefore, when designing the voltage supply sources to power the G-TWI, attention must be given for proper and reliable implementation.

Transient of power-on/ power -off and power peaking are the most risky instants that might cause errors due to not "paying attention" to the power supplies driving the GOLD Twitter

To ensure the high reliability operation two major very simple preventing actions should be taken.

1. **Grounding**. Poor wiring when carrying ultra high power with transients that can exceed 10KW might cause malfunctioning, or even failure of the servo drive.
   a. **The Remedy** is very simple: On the integration board make a high conductors width connection (ground plane is preferred) between the **PR- COMRET- VL-**
2. **VL <40VDC.** The VL voltage MUST never exceed 40VDC. In applications using a single power supply (VP+ shorted to VL+) The VL might exceed the limit of 40VDC in regeneration/ braking or due to fluctuation of the power supply voltage.
   a. **The Remedy:** In a single supply application set the software over voltage to ≈40VDC.
3. Whenever **using SMPS** there might be a problem in the bidirectional flow of power.
   a. **The Remedy**. Add capacitance to the DC bus that is

$$C_{external} > \text{“Drive’s Rated Current”} * 20uF$$

In Elmo's solo boards the **PR- COMRET- VL-** short connection is already done on board, while the VL<40 over voltage protection has to be done in "the field" and according to the power supply used in the application.

Results show that implementing the above recommendations improved dramatically the immunity of the GOLD Twitter against poor wiring, instable power supplies with ZEREO failures due to high power transients.

Implement those 2 (or 3 in the case of SMPS) very simple recommendations this will prevent pointless errors!

Chapter 2: Introduction

Powering servo drives from a DC power source there are 3 major supply options:

A. **Power Supply for Servo Drives (PSSD)**
This consists of an AC rectifier + DC Filtering & Smoothing + Shunt regulator + EMI filtering+ Isolation transformer+ safety "elements". This is a very common configuration for servo applications when operating in an ordinary operating area that is powered by AC source. In the case of powering the GOLD Twitter the only disadvantage of the PSSD is the isolation transformer.

B. **SMPS, Switch Mode Power Supply**
This is a compact option with high power/size ratio when comparing to the traditional PSSD, but with some severe limitations such as, no peak currnt capabilities, “no absorbing energy”, power can flow only from the SMPS to the Drive- Motor, and no Peak power capability. These drawbacks must be considered and evaluated.

C. **Battery.** A battery can carry power in both directions from the battery to the Drive- Motor and from the Motor- Drive back to the battery (charging the battery). Battery is the optimal power supply for servo drives

Chapter 3: Motoring

In the motoring mode when the power flows to the motor the three above special conditions are satisfied, so that the power needs are met.

Note: **SMPS do not have peak power capabilities for meeting the peak power requirement of 3 seconds. The peak power will only be the continuous rating of the SMPS.**

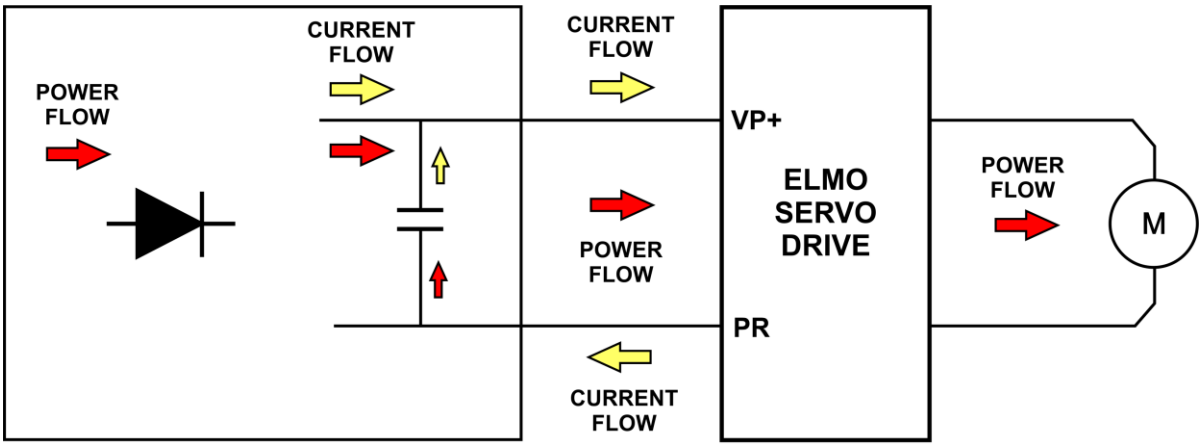

Figure 1: Power flows from the power supply to the motor via the drive

Chapter 4: Regeneration – Braking

4.1 PSSD, Regenerating/ Braking

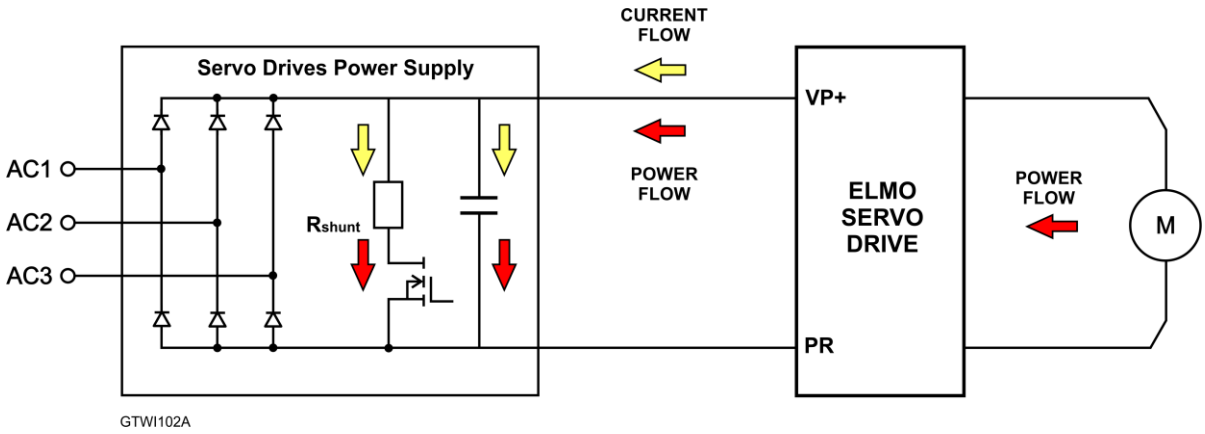

Figure 2: Power flows from the mechanical load back to the power supply

The PSSD (Power Supply for Servo Drives) is the most common method to power motion applications. The energy is initially absorbed by charging the DC bus capacitance. Then the DC bus voltage increases and upon reaching a predetermined voltage, the shunt regulator is switched on and the extra regenerated energy is dissipated by the shunt resistance *Rshunt*.

4.2 SMPS Regenerating/ Braking

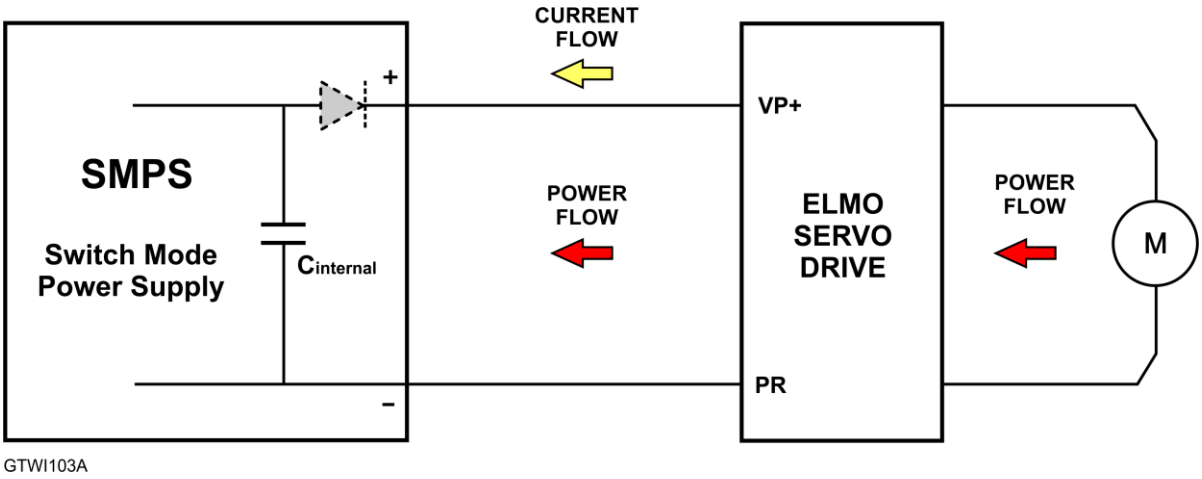

Figure 3: Regenerating (Braking) - SMPS Blocks Returning Power from the Servo drive - motor

The SMPS has no capability to absorb energy, but only delivers power to the load, i.e. the Servo drive - motor. This is a huge risk when operating a dynamic servo system that is characterized by fast transitions of energy flow in both directions. When running the Gold Twitter with a power supply that has no regeneration/ braking capability, the DC bus voltage might increase sharply upon braking, at a very high rate, such as ~$5*10^6$ Volts/Sec to an extremely high voltage, exceeding the limits of the drive and/ or of the SMPS, causing total burn out.

A possible remedy is to insert a capacitance across the DC bus, which will suffice to absorb the regenerating energy, in many cases.

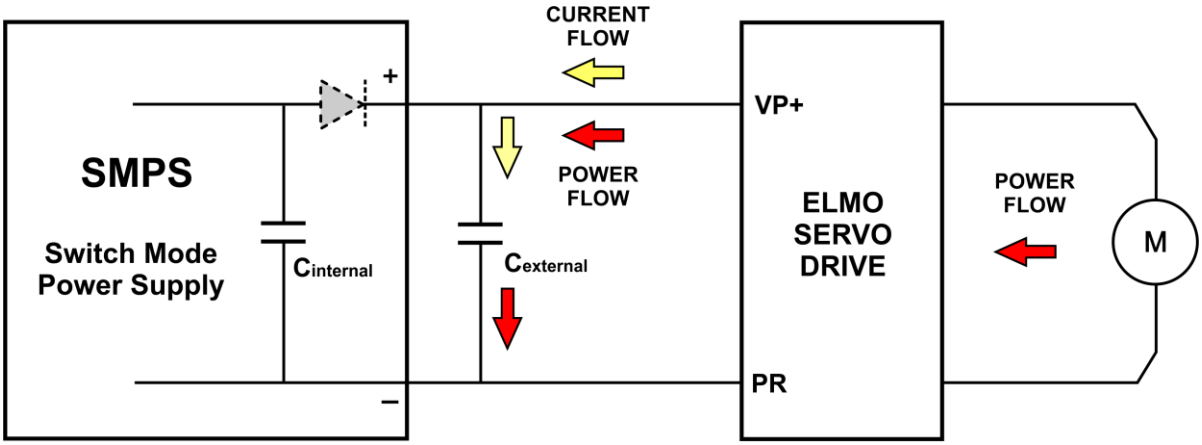

Figure 4: SMPS Regenerating (Braking)

How does it work?

The capacitance will be charged during motor-braking and in many situations, it will be sufficient to absorb the returning energy and allow normal operation. With high inertia loads or a scenario with many fast accelerations and decelerations, the additional capacitance might not be enough and Over Voltage protection will be activated.

How large a capacitance should be used?

It is very hard to predict as it mainly depends on the actual operation scenario and on the load's mechanical characteristic. Elmo recommends the minimum capacitance to insure that no Excessive Voltage failure occurs:

$C_{external}$ > "Drive's Rated Current" *20uF

For examples: For a G-TWI10/100 insert C > 10*20uF = 200uF

For a G-TWI3/200 insert C> 3*20uF = 60uF

4.3 Battery Regenerating/ Braking

A Battery has the capability to "handle" power flow in both direction, from the battery to the Drive-Motor, and from the Motor-Drive back to the battery. In the power regeneration the battery is charged and there is no need to dissipate power.

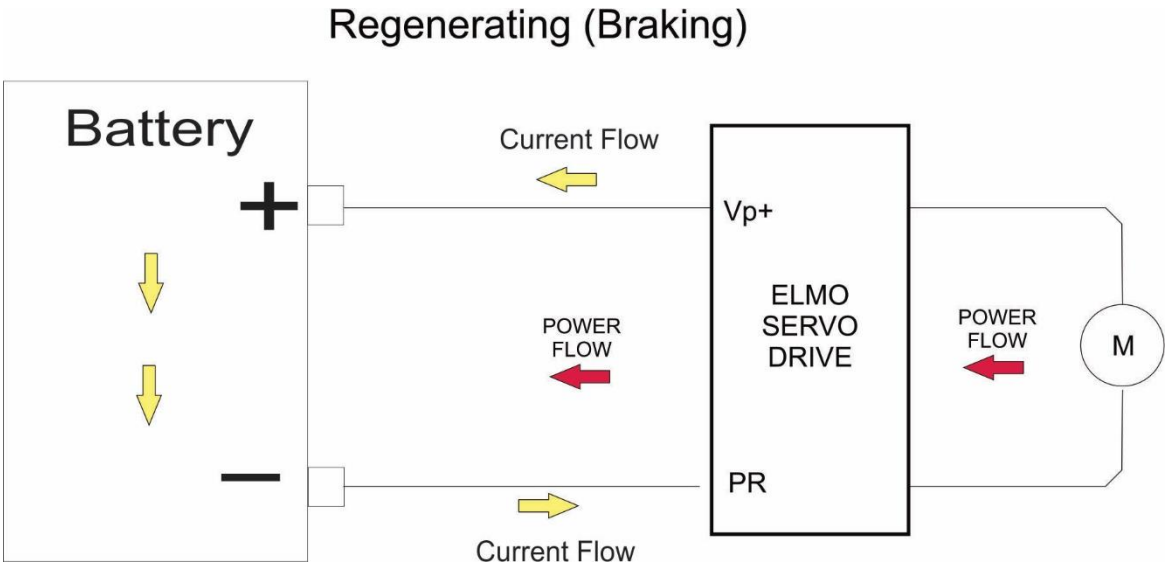

Figure 5: Battery Regenerating (Braking)

Battery is the optimal power source solution when regeneration/ braking is significant in the application.

With Elmo servo drives there is no need to add bus capacitance for proper operation.

Note: Keep in mind that a Battery has relatively wide range of output voltage. For example:

- The output voltage of a "24VDC" battery can be as high as 28VDC -32VDC (MIL- STD – 1275).
- The output voltage of a "36VDC" battery can be as high as 42VDC- 48VDC.
- The output voltage at a "48VDC" Battery can reach 56VDC- 64VDC.

Chapter 5: Dual Supplies Topology

In any case that the VP+ is >40VDC a separate supply for the Logic is required.

Both supplies, the Power and Logic are required to be isolated-from-the-mains:

A. A main DC power source derived from the Mains (VP+, PR), according to specification

B. A control supply for the logic (VL+, VL-)

5.1 Using "Power Supply for Servo Drives"(PSSD)

This option describes an Ordinary power supply for Servo drives with sufficient internal capacitance and shunt regulator to handle power flow in both directions to-and-from the motor. The following figure describes this connection of main power and control power.

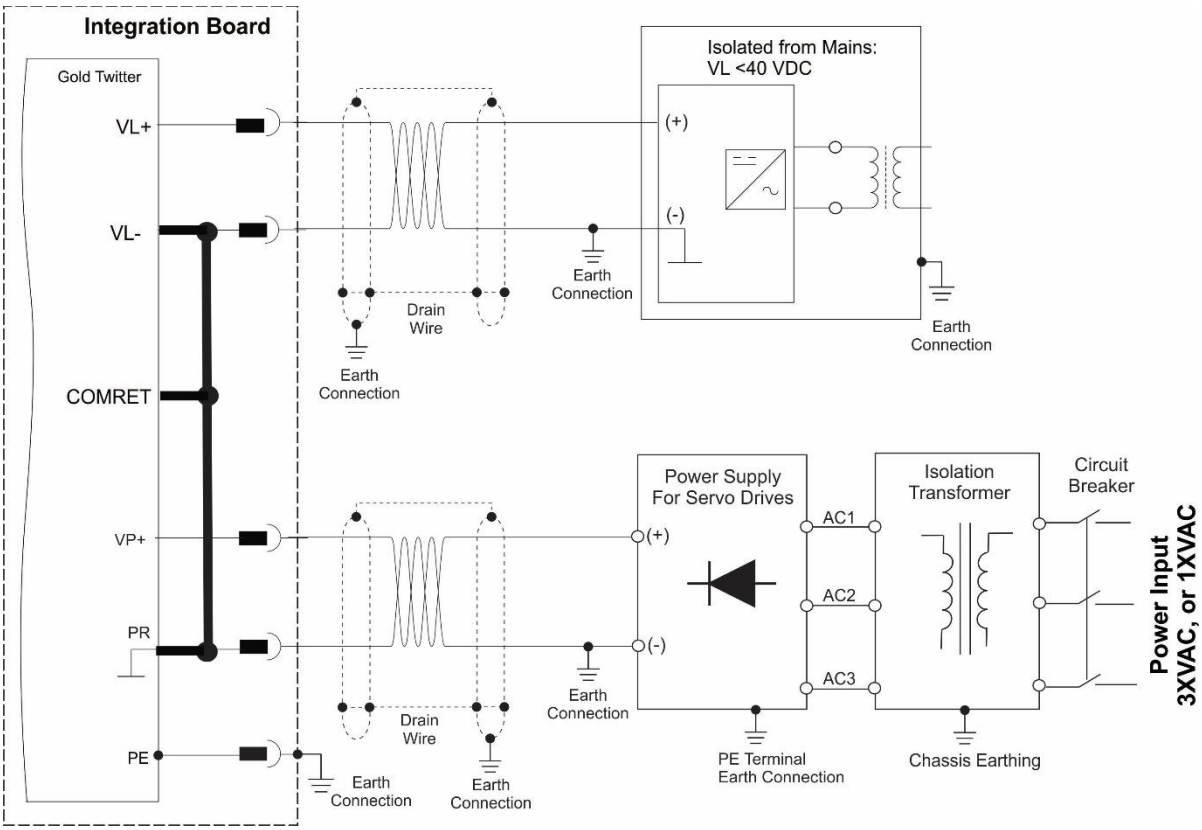

Figure 6: Ordinary Option: Separate VP and VL Power Supplies Connection Diagram

Note:

It is highly recommended to do the **"PR – COMRET - VL-"**connection on the integration board. In Elmo's GOLD SOLO TWITTER this connection is done by a "ground plane", this connection contributes significantly to "immune" the drive from performance degradation or even malfunctioning due to "poor wiring".

A. It is preferred that the **"PR – COMRET - VL-"** connection is done on the integration board by a ground plane or by a thick conductor (3- 4 mm). If The **"PR – COMRET - VL-"** connection can not be done on the integration board, it can be done externally by wires on the connectors.

5.2 Dual Supplies Using SMPS

The main drawback of using SMPS (Switch Mode Power Supply) is that there is no Regeneration/ Braking capabilities.

"Some" Braking capability can be achieved by adding capacitance on the DC bus. The $C_{external}$ value depends on the regeneration / braking energy produced by the application. In many cases this simple remedy helps to overcome this drawback of the SMPS.

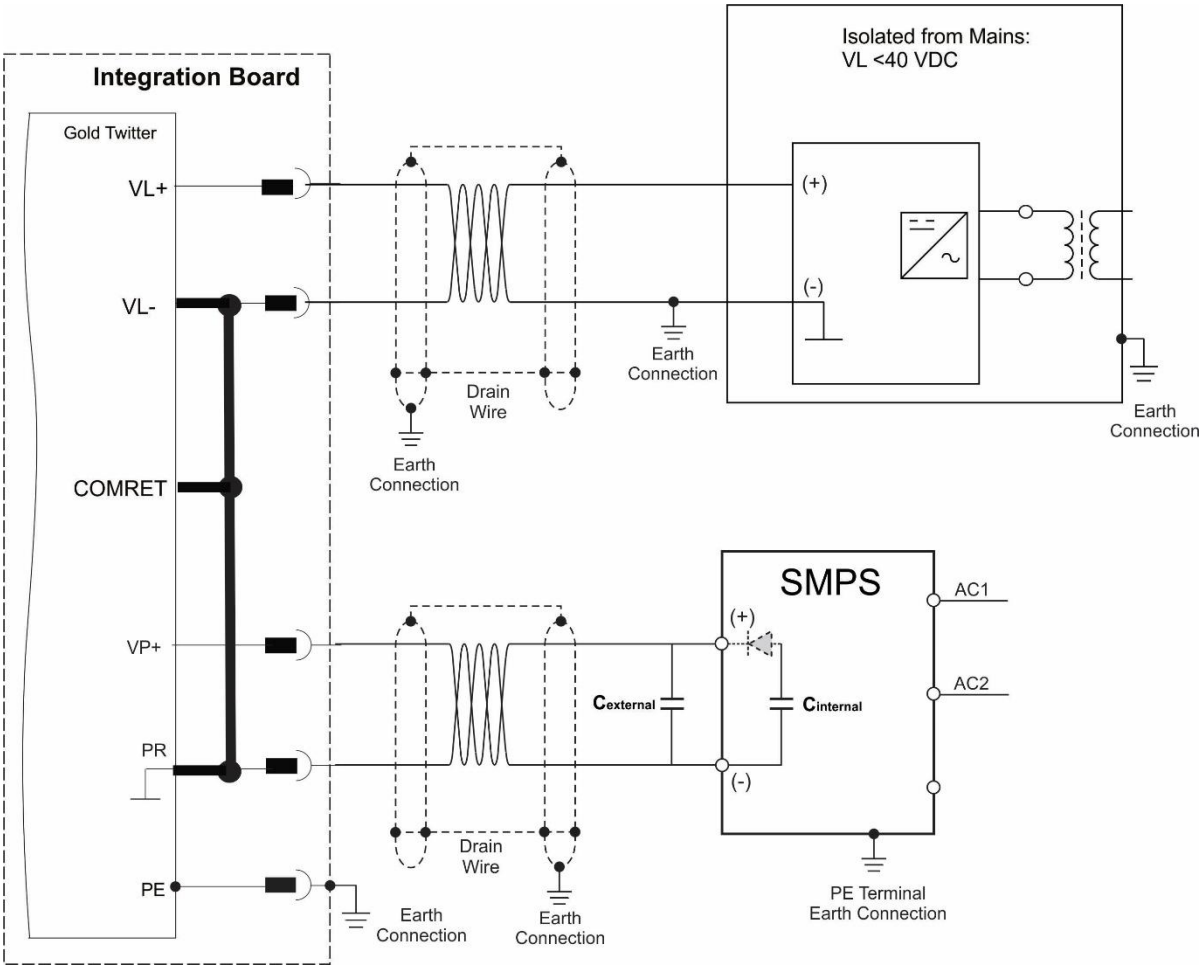

Figure 7: SMPS Option: Separate VP and VL Power Supplies Connection Diagram

Note:

It is highly recommended to do **the "PR – COMRET - VL-"**connection on the integration board. In Elmo's GOLD SOLO TWITTER this connection is done by a "ground plane". This connection contributes significantly to "immune" the drive from performance degradation or even malfunctioning due to "poor wiring".

A. It is preferred that the **"PR – COMRET - VL-"**connection is done on the integration board by a ground plane or by a thick conductor (3- 4 mm).
B. If The **"PR – COMRET - VL-"**connection can't be done on the integration board, it can be done externally by wires on the connectors.

5.3 Dual Supplies Using a Battery

Using a battery is the best power supply option for servo drives. The capability to absorb power from the Motor- Drive is an inherent characteristic of the battery. In addition, the battery can deliver also very high peak power.

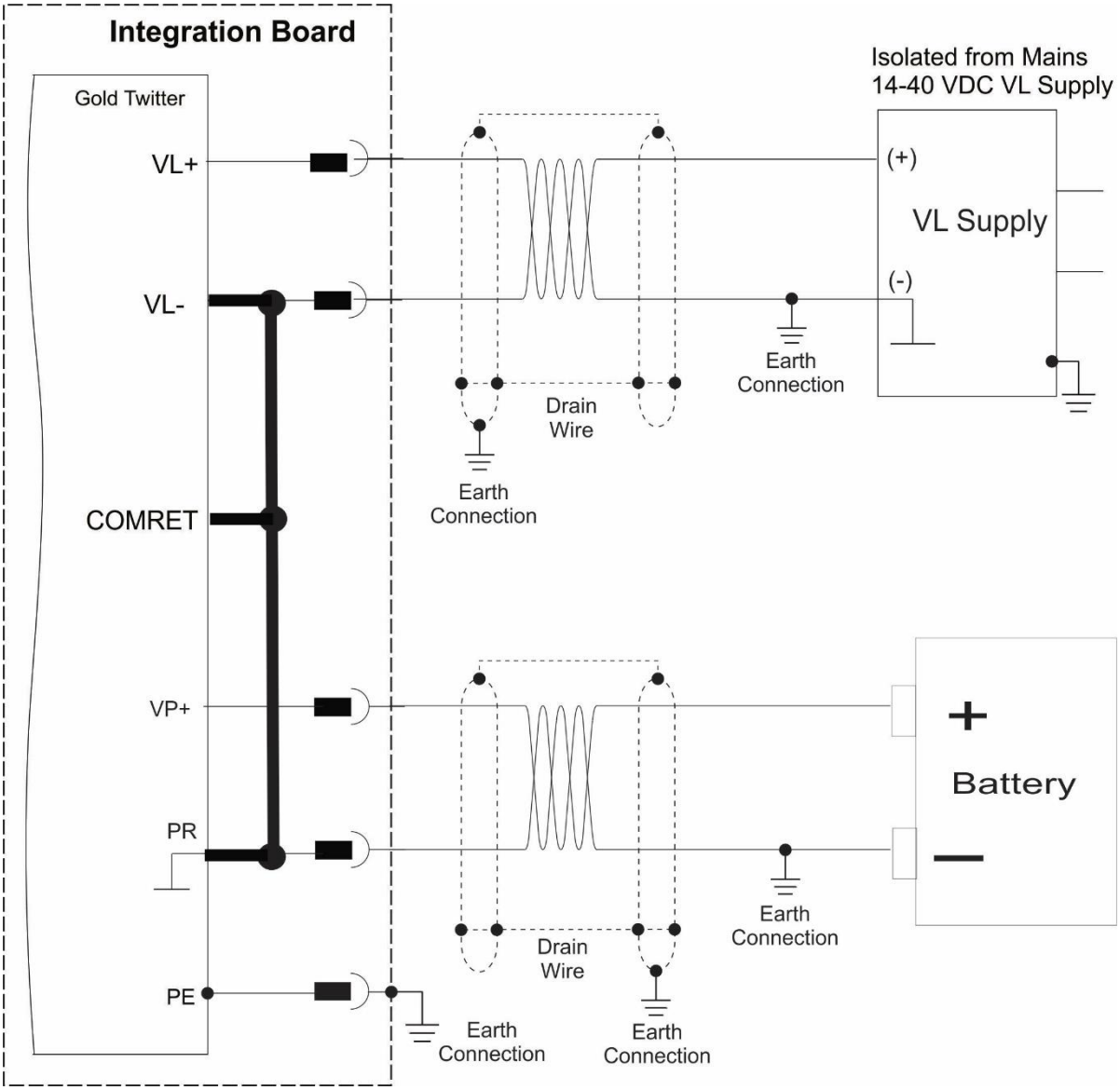

Figure 8: Battery Option: Separate VP and VL Power Supplies Connection Diagram

Note:
It is highly recommended to do the **"PR – COMRET - VL-"**connection on the integration board. In Elmo's GOLD SOLO TWITTER this connection is done by a "ground plane". This connection contributes significantly to "immune" the drive from performance degradation or even malfunctioning due to "poor wiring".

A. It is preferred that the **"PR – COMRET - VL-"**connection is done on the integration board by a ground plane or by a thick conductor (3- 4 mm).
B. If The **"PR – COMRET - VL-"** connection can't be done on the integration board, it can be done externally by wires on the connectors

Chapter 6: Single Power Supply Topology (VP+< 40 VDC)

A single power supply can be used to power both the main and control if the application DC bus is lower than 40VDC.

Under all conditions the VL < 40VDC must be kept!

When regeneration or braking occurs, the DC bus might increase immediately and exceed the VL limit of over 40VDC, and thus the VL might fail.

To ensure perfect performance and reliable operation the few rules described below must be kept.

6.1 Single Supply, Using a single "Power Supply for Servo Drives" (PSSD)

The PSSD is the common method to power Servo drives. The PSSD includes "step down" isolation transformer, AC rectifying, DC bus capacitance, Shunt regulator, protections, EMI filter. In case that a single power supply is used (VL+ connected to VP+) the absolute maximum VP+ & VL+ voltage must be < 40VDC to prevent VL+ supply failure.

The following figure describes this connection of main power and control

If an Integration board is being designed the following will be implemented

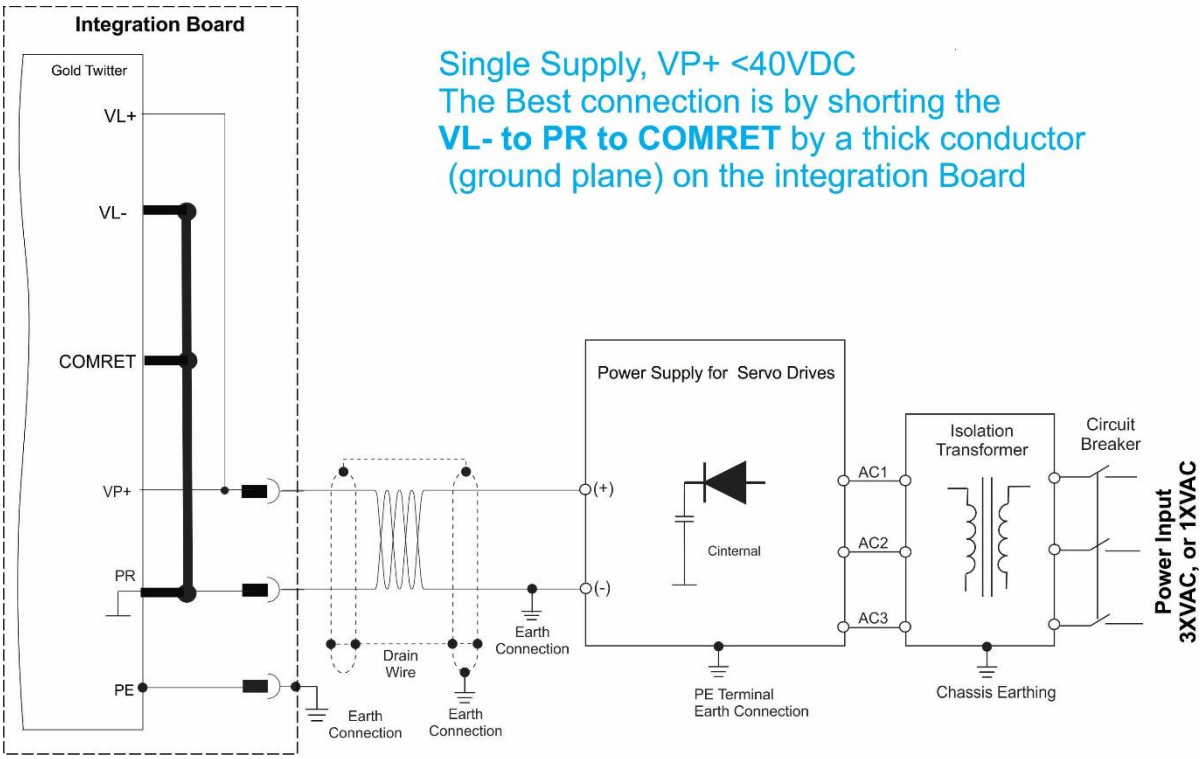

Figure 9: Recommended Single Power Supply (VP+ < 40V) Connection Diagram with VL+ Connected Internally

For applications where the recommended single power supply is used, the following conditions must apply:

A. Operating with a single power supply (VL+ connected to VP+) the maximum voltage must be VL+ < 40VDC under all conditions.

B. In a single power supply application (VL+ connected to VP+) the over voltage protection must be set to around 38VDC -40VDC by the drive software command **XP[1]**=40 (This

command over rides the default over voltage protection of the G-TWI that is higher than 40VDC)

C. In many cases the internal capacitance of the power supply is sufficient to absorb the regeneration/ braking energy, and thus there is no need for a "shunt Regulator".

   It is always simpler to increase the capacitance of the DC bus than to install a shunt regulator. So, before installing a shunt regulator, try to increase the capacitance of the DC bus.

D. If there is a shunt regulator in the application the "shunt on" trip voltage must be set 2-3 V lower than the Over Voltage setting (Shunt on =40V-3V =37V).

E. It is preferred that the "**PR – COMRET - VL-**" mandatory connection is done on the integration board by a "Ground Plane" (prefferd), or by a thick conductor (3- 4 mm).

F. If The **"PR – COMRET - VL-"** connection can not be done on the integration board, it must be done by wires on the connector.

Using Elmo's SOLO Board

A. In Elmo's GOLD SOLO TWITTER the "**PR – COMRET - VL-**" connection is done by a "ground plane".

B. This connection contributes significantly to "immune" the drive from performance degradation or even malfunctioning due to "poor wiring".

C. The VP+ to VL+ connection is done externally

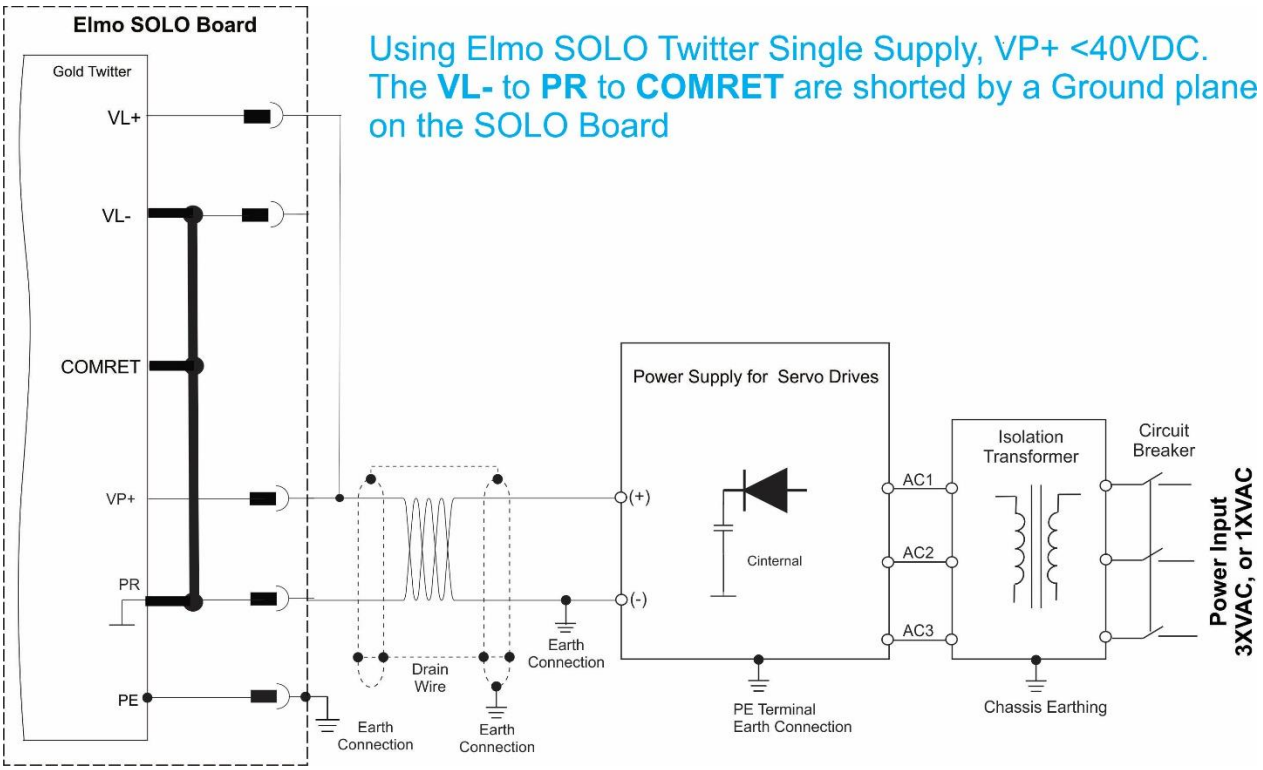

Figure 10: Recommended Single Power Supply (VP+ < 40V) with Elmo SOLO Board

6.2 Single Supply, Using SMPS

Using SMPS to power servo drives is very tempting, it is simple, it is small and it is cost effective. But, SMPS is designed to carry power only from the SMPS to the load. SMPS has no capabilities to "handle" regenerating / braking power that flows from the motor- drive back to the DC bus. The remedies to this drawback depends mostly on the application nature. In many cases adding capacitance on the DC bus resolves this drawback of the SMPS.

Rules for single (VL+ connected to VP+) SMPS supply:

A. VP+ < 40V

B. Ensure that the DC bus capacitance is at least **$C_{external}$ > "Drive's Rated Current" *20uF**

C. Set the Over Voltage of the Gold Twitter to 40V by using the drive software command **XP[1]**=40 (over-voltage set to 40V).

D. If the over voltage protection is triggered the simplest is to increase the DC bus capacitance.
   1. Be aware that increasing the DC bus voltage by Regenerating / braking might shut down the SMPS due to "imposing" to high voltage on the SMPS. For remedy of such event look in Power Supply For Servo Applications

E. If a shunt regulator is used (we've seen cases that a shunt is used with SMPS) in the application the "shunt on" trip voltage must be set 2-3 V lower than the Over Voltage setting (Shunt on =40V-3V =37V).

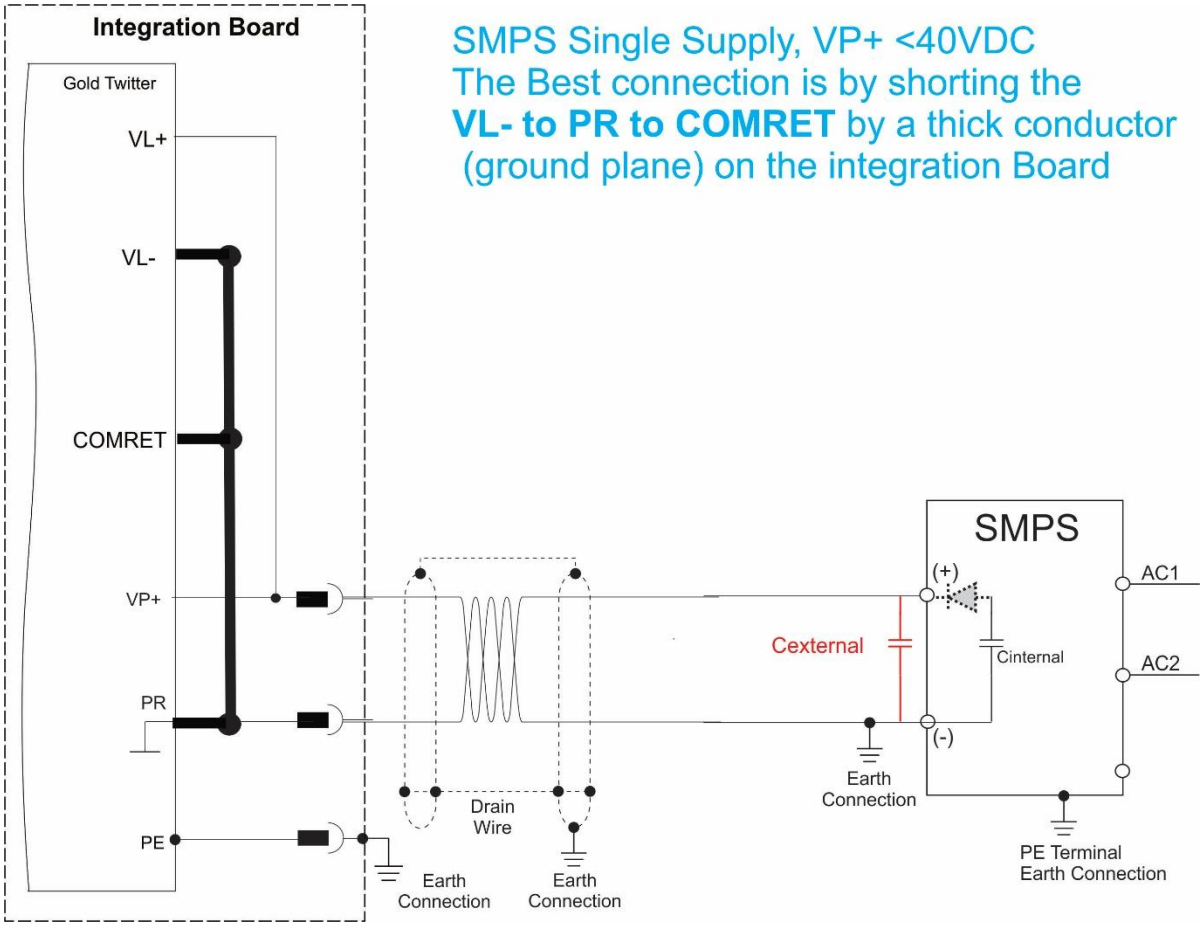

Figure 11: SMPS Single Power Supply (VP+<40V) Connection Diagram with VL+ Connected Internally

A. It is preferred that the "**PR – COMRET - VL-**" mandatory connection is done on the integration board by a "Ground Plane" (prefferd), or by a thick conductor (3- 4 mm).

B. .If The **"PR – COMRET - VL-"** connection can not be done on the integration board, it must be done by wires on the connector.

Using Elmo's SOLO Board

A. In Elmo's GOLD SOLO TWITTER the "**PR – COMRET - VL-**" connection is done by a "ground plane".

B. This connection contributes significantly to "immune" the drive from performance degradation or even malfunctioning due to "poor wiring".

C. The VP+ to VL+ connection is done externally

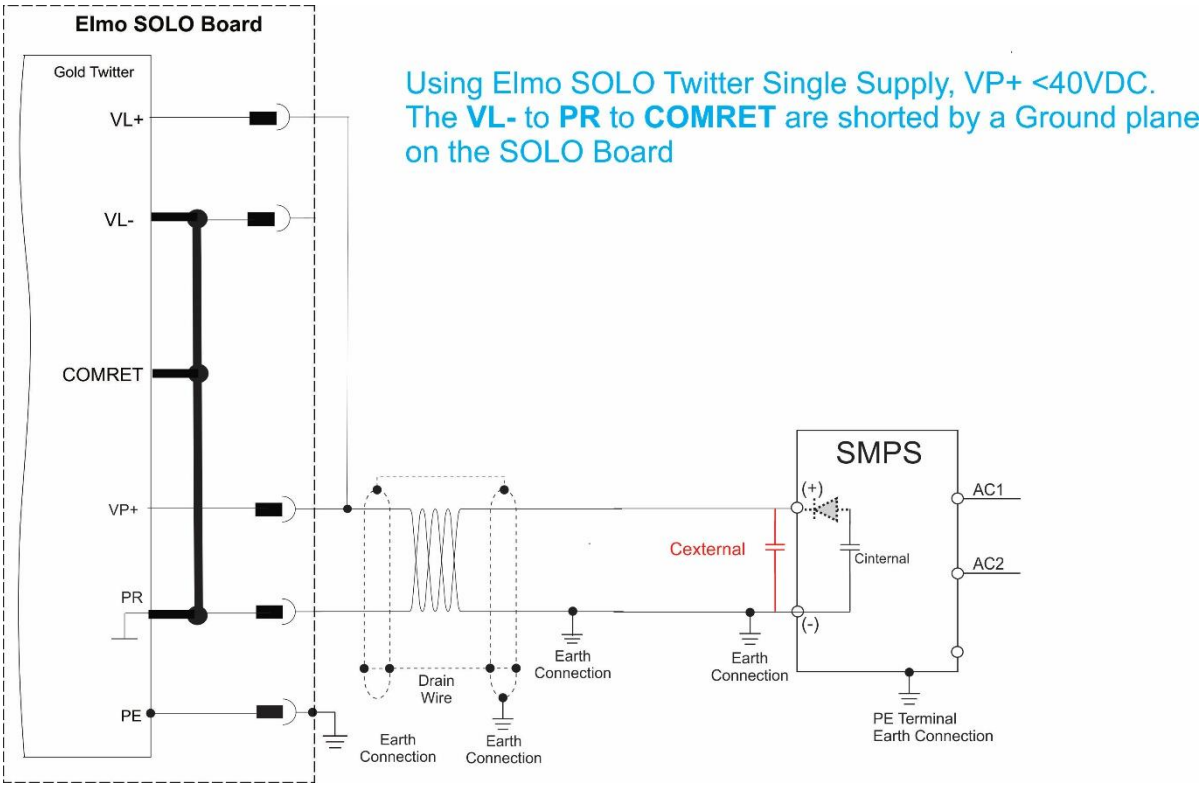

Figure 12: SMPS Single Power Supply (VP+<40V) using Elmo's SOLO Board

6.3 Single Supply, Using a Battery

Direct connection to a battery is the optimal power topology. A battery has the capabilities to carry power from the battery and back to the battery.
The regeneration/ braking is charging the battery and thus reduces the power losses and increase the efficiency of the application. Adding capacitance on the DC bus is required only if the BUS wires are very long.

A. It is recommended (not mandatory) to set the Over Voltage of the Gold Twitter to 40V by using the drive software command **XP[1]**=40 (over-voltage set to 40V).

B. 36VDC battery? A nominal 36VDC battery can reach, when fully charged, 43- 48VDC. In this case the "Single Supply Topology" can't be used and separate VL (<40VDC) source is required.

C. In the "Single Supply using a Battery" a nominal battery voltage of max "24VDC" can be used.

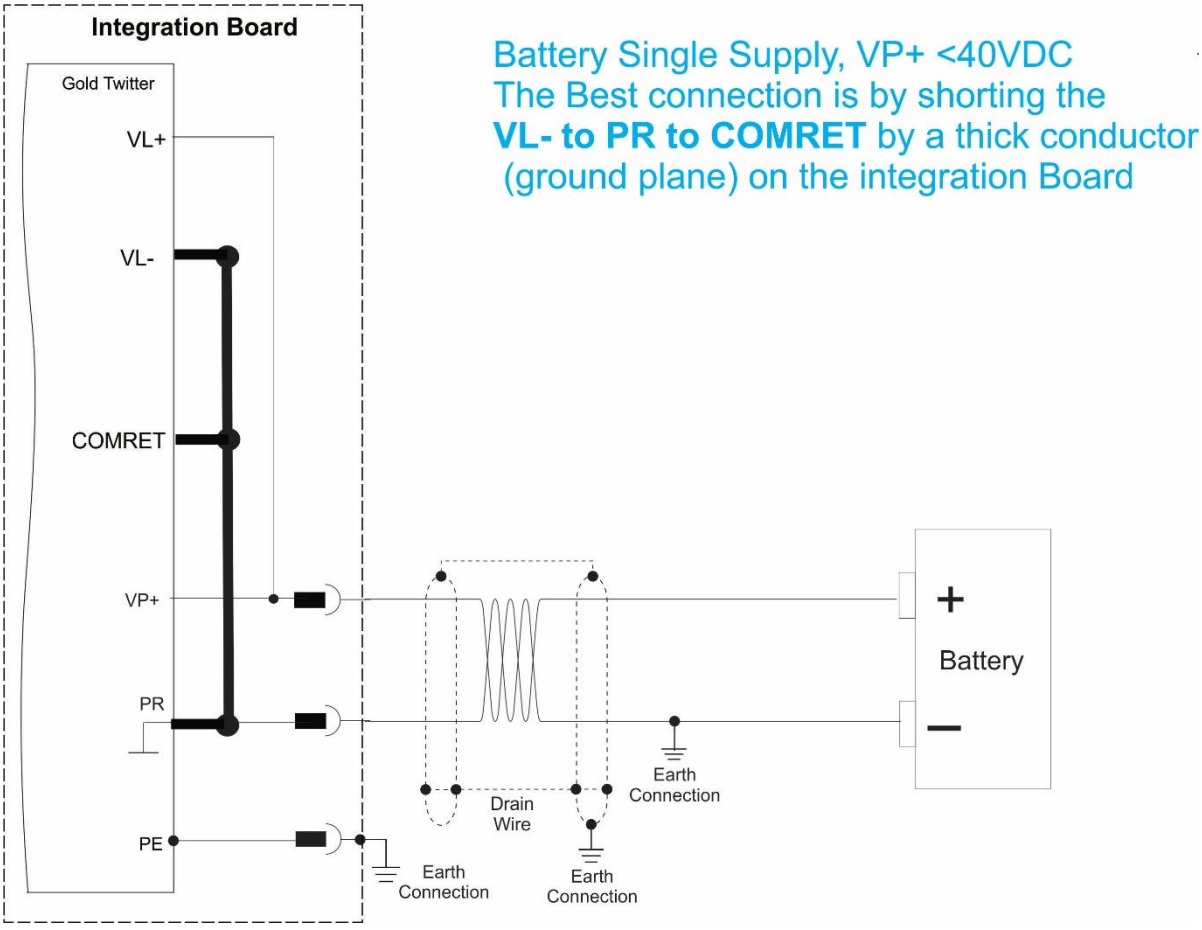

Figure 13: Battery Single Power Supply (VP+<40V) Connection Diagram with VL+ Connected Internally

A. It is preferred that the "**PR – COMRET - VL-**" mandatory connection is done on the integration board by a "Ground Plane" (prefferd), or by a thick conductor (3- 4 mm).

B. If The **"PR – COMRET - VL-"**connection can not be done on the integration board, it must be done by wires on the connector

Using Elmo's SOLO Board

The **"PR – COMRET - VL-"**connection is already "on board" by a Ground Plane.
The VP+ connection is done externally

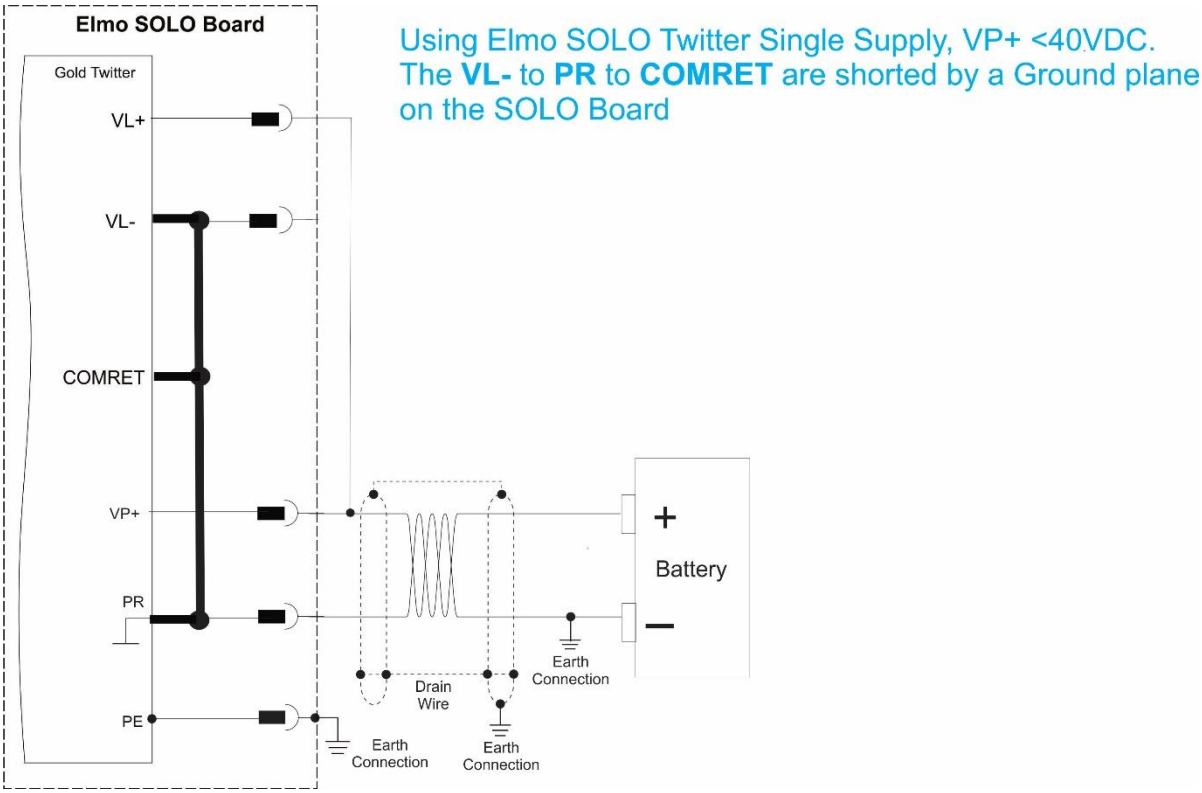

Figure 14: Battery Single Power Supply (VP+<40V) using Elmo's SOLO Board

Chapter 7: Summary: Some Rules to ensure the perfect operation

A. Never exceed **VL< 40VDC**

B. **Always short the "PR – COMRET - VL-"** by a Ground Plane on the integration Board.

C. **In Elmo's SOLO board** the short **"PR – COMRET - VL-"** is done on the board by a Ground plane.

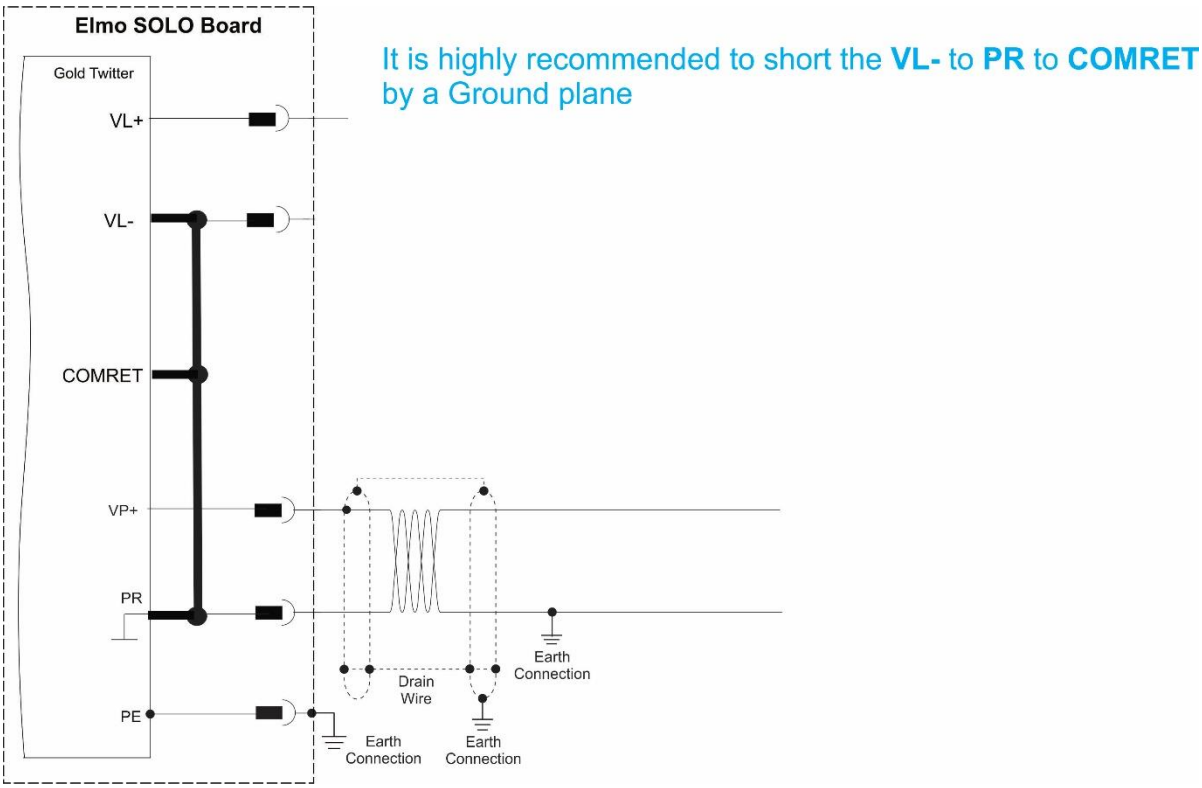

Figure 15: Elmo's SOLO Board at Single Power Supply (<40V) Connection

D. In a single supply topology always set the "software" **over voltage** of the G-TWI to around 40VDC

E. Do NOT use the single supply topology by wiring each supply separately!

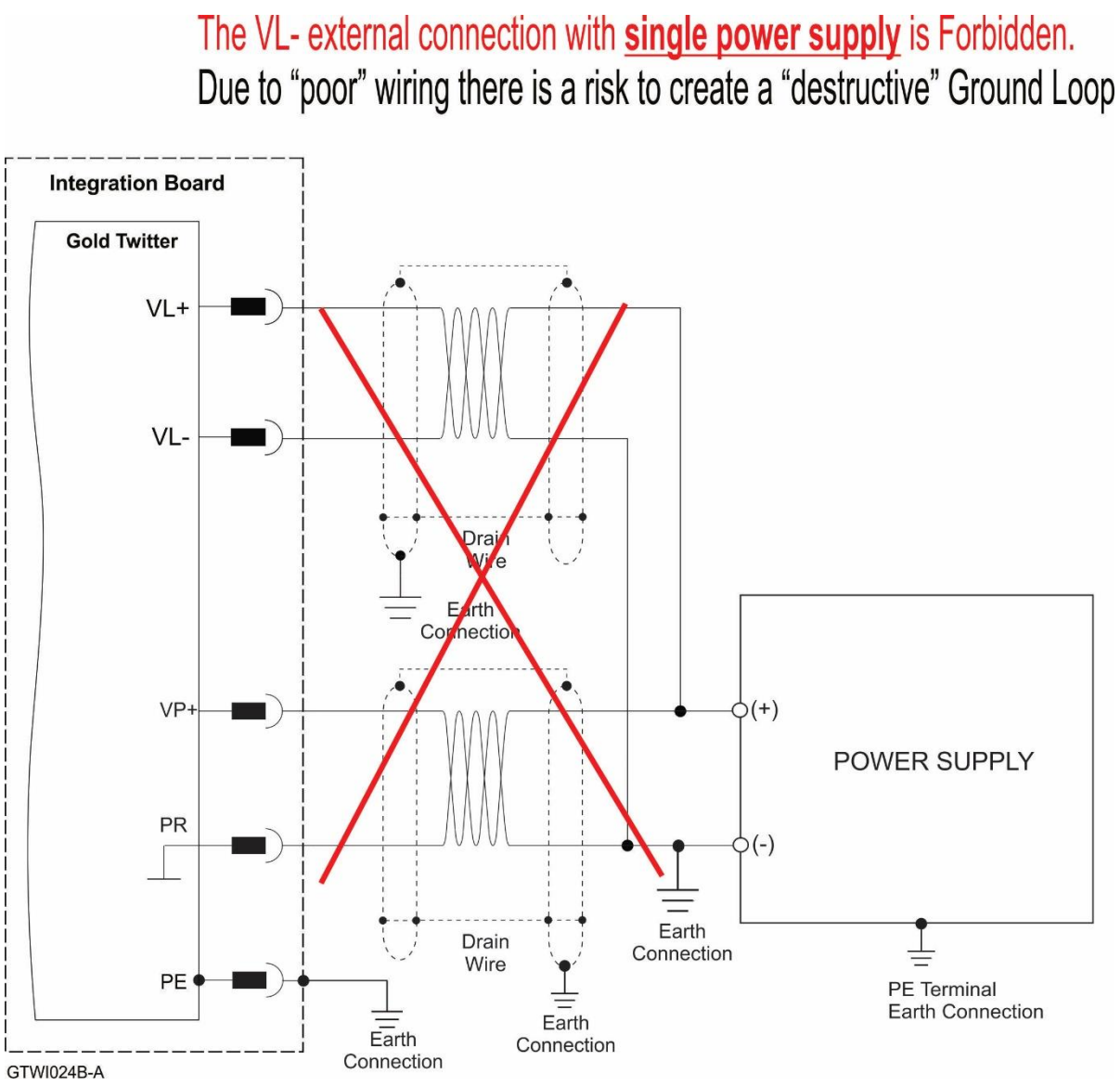

Figure 16: Forbidden Single Power Supply (<40V) Connection Diagram with VL- Cable Connected Externally

F. If the **"PR – COMRET - VL-"** connection can't be done internally it is suggested to do it externally by a thick wire and as close as possible to the G-TWI terminals.

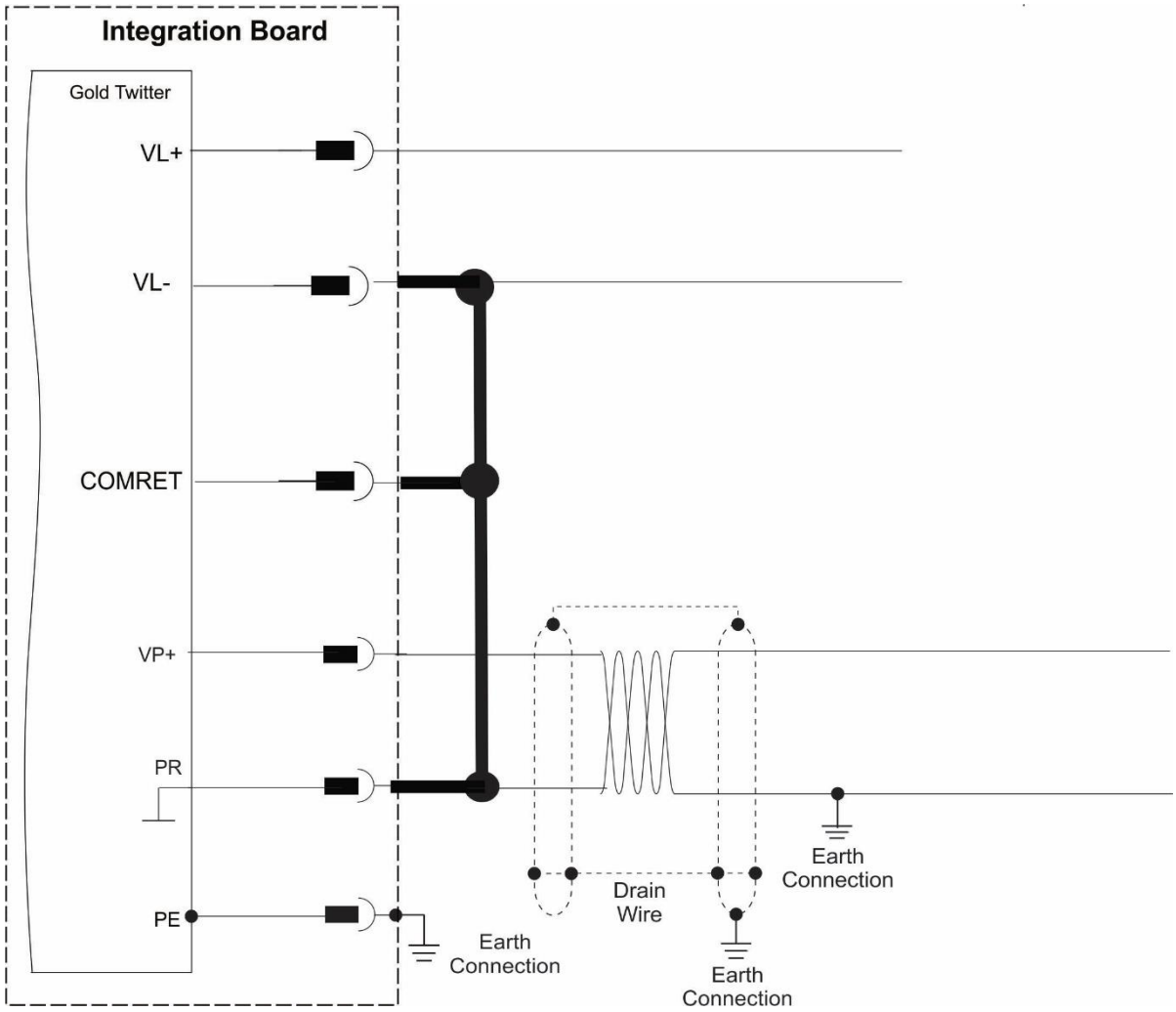

Figure 17: External "PR – COMRET - VL-"connection

G. Whenever **using SMPS** Add capacitance to the DC bus that is

$C_{external}$ > "Drive's Rated Current" *20uF