
ExtrIQ

Dragonfly/Butterfly

Current Mode Servo Amplifiers for DC Brush and Brushless

Motors with Trapezoidal Commutation in

Extended Environmental Conditions

Installation Guide



January 2009 (Ver. 1.2)



www.elmomc.com

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Butterfly/Dragon Catalog Numbers:

<p style="text-align: center;">BUT- X/YYY</p> <p>Continuous Current (Amps) _____</p> <p>Maximum DC Operating Voltage _____</p>	<p style="text-align: center;">DRA- X/YY</p> <p>Continuous Current (Amps) _____</p> <p>Maximum DC Operating Voltage _____</p>
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Related Products:

Evaluation Board Catalog Number Evaluation Board User Manual	OCA-EVLBRD-1 (available upon request) MAN-EVLBRD-OCA (available on our web site)
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Chapter 1: Safety Information

In order to achieve the optimum, safe operation of the Dragonfly and Butterfly servo-amplifiers, it is imperative that you implement the safety procedures included in this installation guide. This information is provided to protect you and to keep your work area safe when operating the Dragonfly and Butterfly and accompanying equipment.

Please read this chapter carefully before you begin the installation process.

Before you start, ensure that all system components are connected to earth ground. Electrical safety is provided through a low-resistance earth connection.

Only qualified personnel may install, adjust, maintain and repair the servo drive. A “qualified person” has the knowledge and authorization to perform tasks such as transporting, assembling, installing, commissioning and operating motors.

The Dragonfly and Butterfly servo drives contain electrostatic-sensitive components that can be damaged if handled incorrectly. To prevent any electrostatic damage, avoid contact with highly insulating materials, such as plastic film and synthetic fabrics. Place the product on a conductive surface and ground yourself in order to discharge any possible static electricity build-up.

To avoid any potential hazards that may cause severe personal injury or damage to the product during operation, keep all covers and cabinet doors shut.

The following safety symbols are used in this manual:

	Warning: This information is needed to avoid a safety hazard, which might cause bodily injury.
	Caution: This information is necessary for preventing damage to the product or to other equipment.
	Note: This is auxiliary information that ensures the correct operation of the equipment.

1.1 Warnings

	<p>Cleaning after soldering</p> <p>To avoid the damage of the product's acrylic coating the Dragonfly/ Butterfly must not be cleaned after soldering by dissolving solvents and /or "water" cleaning process. For more details: www.elmomc.com/applications/article/Soldering-and-Cleaning_Application-Note.pdf</p>
	<p>To avoid electric arcing and hazards to personnel and electrical contacts, never connect/disconnect the servo drive while the power source is on.</p>
	<p>Power cables can carry a high voltage, even when the motor is not in motion. Disconnect the Dragonfly and Butterfly from all voltage sources before they are opened for servicing.</p>
	<p>The Dragonfly and Butterfly servo drives contain grounding conduits for electric current protection. Any disruption to these conduits may cause the instrument to become hot (live) and dangerous.</p>
	<p>After shutting off the power and removing the power source from your equipment, wait at least 1 minute before touching or disconnecting parts of the equipment that are normally loaded with electrical charges (such as capacitors or contacts). Measuring the electrical contact points with a meter, before touching the equipment, is recommended.</p>

1.2 Cautions

	<p>The Dragonfly and Butterfly servo drives contain hot surfaces and electrically-charged components during operation.</p>
	<p>The maximum DC power supply connected to the instrument must comply with the parameters outlined in this guide.</p>
	<p>When connecting the Dragonfly and Butterfly to an approved 12 ~ 95 VDC auxiliary power supply, connect them through a line that is separated from hazardous live voltages using reinforced or double insulation in accordance with approved safety standards.</p>
	<p>Before switching on the Dragonfly and Butterfly, verify that all safety precautions have been observed and that the installation procedures in this manual have been followed.</p>

1.3 Directives and Standards

The Dragonfly and Butterfly conform to the following industry safety standards:

Safety Standard	Item
In compliance with MIL-STD-704	Aircraft, Electric Power Characteristics
In compliance with MIL-STD-810	Environmental Engineering Considerations and Laboratory Tests
In compliance with MIL-STD-1275	Characteristics of 28 Volt DC Electrical Systems in Military Vehicles
In compliance with MIL-STD-461	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
In compliance with MIL-HDBK-217	Reliability Prediction of Electronic Equipment
In compliance with ISO-9001:2000	Quality Management
In compliance with UL508c	Power Conversion Equipment
In compliance with UL840	Insulation Coordination, Including Clearance and Creepage Distances of Electrical Equipment
In compliance with UL60950-1 (formerly UL1950)	Safety of Information Technology Equipment, Including Electrical Business Equipment
In compliance with EN60204-1	Low Voltage Directive, 73/23/EEC

The Dragonfly and Butterfly servo drives have been developed, produced, tested and documented in accordance with the relevant standards. Elmo Motion Control is not responsible for any deviation from the configuration and installation described in this documentation. Furthermore, Elmo is not responsible for the performance of new measurements or ensuring that regulatory requirements are met.

1.4 CE Mark Conformance

The Dragonfly and Butterfly servo drives are intended for incorporation in a machine or end product. The actual end product must comply with all safety aspects of the relevant requirements of the European Safety of Machinery Directive 98/37/EC as amended, and with those of the most recent versions of standards EN60204-1 and EN292-2 at the least.

According to Annex III of Article 13 of Council Directive 93/68/EEC, amending Council Directive 73/23/EEC concerning electrical equipment designed for use within certain voltage limits, the Butterfly and Dragonfly meet the provisions outlined in Council Directive 73/23/EEC. The party responsible for ensuring that the equipment meets the limits required by EMC regulations is the manufacturer of the end product.

1.5 Warranty Information

The products covered in this manual are warranted to be free of defects in material and workmanship and conform to the specifications stated either within this document or in the product catalog description. All Elmo drives are warranted for a period of 12 months from the time of installation, or 18 months from time of shipment, whichever comes first. No other warranties, expressed or implied – and including a warranty of merchantability and fitness for a particular purpose – extend beyond this warranty.

Chapter 2: Introduction

This Installation Guide is intended for design engineers who are integrating an Elmo Motion Control Dragonfly or Butterfly servo amplifier into a machine.

2.1 *ExtriQ* Product Family

Elmo Motion Control's *ExtriQ* product family is a set of durable motion control products for applications operating under extreme environmental conditions. The products are capable of withstanding the following extreme conditions:

Ambient Temperature Range	Non-operating conditions	-50 °C to +100 °C (-58 °F to 212 °F)
	Operating conditions	-40 °C to +70 °C (-40 °F to 160 °F)
Temperature Shock	Non-operating conditions	-40 °C to +70 °C (-40 °F to 160 °F) within 3 min.
Altitude	Non-operating conditions	Unlimited
	Operating conditions	-400 m to 155,000 m (-1,300 ft to 510,000 ft)
Maximum Humidity	Non-operating conditions	Up to 95% relative humidity non-condensing at 35 °C (95 °F)
	Operating conditions	Up to 95% relative humidity non-condensing at 25 °C (77 °F), up to 90% relative humidity non-condensing at 42 °C (108 °F)
Vibration	Operating conditions	20 Hz -2,000 Hz, 14.6g
Mechanical Shock	Non-operating conditions	±40g; Half sine, 11 msec
	Operating conditions	±20g; Half sine, 11 msec

ExtriQ products have a high power density in the range of 50 W - 18,000 W and current carrying capacity of up to 140 A (280 A peak). *ExtriQ* has been tested using methods and procedures specified in a variety of extended environmental conditions (EEC) standards including:

- MIL-STD-704- Aircraft, Electric Power Characteristics
- MIL-STD-810- Environmental Engineering Considerations and Laboratory Tests
- MIL-STD-1275- Characteristics of 28 Volt DC Electrical Systems in Military Vehicles

- MIL-STD-461- Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
- MIL-HDBK-217- Reliability Prediction of Electronic Equipment
- ISO-9001:2000

2.2 Product Description

The Dragonfly and Butterfly are a series of miniature *ExtriQ* current mode servo amplifiers for DC brush and brushless motors with trapezoidal commutation. Both are light and highly compact solutions and can be used whenever reduced size and weight are essential to the application. The Dragonfly and Butterfly can withstand extended environmental conditions and are designed to deliver “the highest possible power density”. The Butterfly can deliver up to **1.4 kW of continuous power** or 2.8 kW of peak power in a matchbox size (2 in³ or 38cc) package. The Dragonfly delivers up to **240 W of continuous power** or 480 W of peak power.

The Dragonfly and Butterfly are designed for OEMs. In addition to their compliance with relevant MIL standards, the amplifiers also meet UL508c and the relevant CE regulations.

The servo amplifiers operate from a DC power source in current mode in conjunction with DC brush and brushless motors. The Dragonfly and Butterfly can operate as a stand-alone device or as part of a multi-axis system in a distributed configuration on a real-time network.

There are two categories of Dragonfly and Butterfly amplifiers, 60 VDC versions and 100 VDC versions. Power to the 60 V products is provided by a separate 0 ~ 59 V isolated DC power source. Power to the 100 V products is provided by a separate 0 ~ 95 V isolated DC power source.

Note: There is a separate VL terminal for the control/logic supply input. In the 60 VDC models this terminal can be connected to an external 11 ~ 59 VDC isolated supply. In the 100 VDC models this terminal can be connected to an external 12 ~ 95 VDC isolated supply whenever the user wants to control the logic supply with an auxiliary low power voltage source.

If power separation is not needed the VL and VP+ terminals can be shorted so that the main power supply will also power the control/logic supply and there will be no need for a separate control/logic supply.

The Dragonfly and Butterfly are PCB mounted devices which enable efficient and cost saving implementation.

2.3 Highlights

- Operates in current mode
- 0 ~ 59 VDC isolated DC power source for 60 V models
- 0 ~ 95 VDC isolated DC power source for 100 V models
- Zero deadband
- Excellent linearity
- Differential current command input
- Motor current monitor

- Current gain change for low inductance motors
- Status indication by four open collector optos
- External continuous and peak current-limit adjustments
- Interface via 2 mm pitch 0.51 mm square pins
- Package: plated AL 6063T5 with electroless nickel, plastic housing, UL94V0 recognized (Butterfly only)
- Ultra-compact size: Butterfly: 2.2" x 0.6" x 1.8" (55 x 15 x 46.5 mm), Dragonfly: 2" x .49" x 1.65" (51 x 12.5 x 42 mm)
- Weight: Butterfly- 1.6 oz (45g), Dragonfly- 0.76 oz (21.5 grams)

2.4 Fault Protection

Built-in protection against possible fault conditions, including:

- Shorts between the outputs or between each output and the power input/return
- Over-heating
- Under/over voltage
- Failure of internal power supplies
- Latch mode for each protective feature

2.5 How to Use this Guide

Installation is the first step in integrating and operating the Elmo Dragonfly and Butterfly servo amplifiers. After carefully reading the safety instructions in the first chapter, the following chapters provide you with installation instructions as follows:

[Chapter 3, *Installation*](#), provides step-by-step instructions for unpacking, mounting and connecting the Butterfly.

[Chapter 4, *Servo Control Operation*](#), explains how to control the operation of the servo amplifier.

The [Appendix, *Technical Specifications*](#), lists all the drive ratings and specifications.

Chapter 3: Installation

3.1 Before You Begin

3.1.1 Site Requirements

You can guarantee the safe operation of the Dragonfly and Butterfly by ensuring that they are installed in an appropriate environment.

Feature	Value
Ambient operating temperature	-40 °C to +70 °C (-40 °F to 160 °F)
Maximum relative humidity	95% non-condensing
Operating area atmosphere	No flammable gases or vapors permitted in area
 Note: Models for extended environmental conditions are available.	



The Dragonfly and Butterfly dissipate their heat by convection. The maximum ambient operating temperature of -40 °C to +70 °C (-40 °F to 160 °F) must not be exceeded.

3.2 Unpacking the Amplifier

To unpack the Dragonfly or Butterfly:

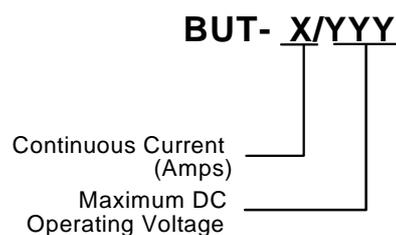
Carefully remove the servo amplifier from the box and the Styrofoam.

1. Check the amplifier to ensure that there is no visible damage to the instrument. If any damage has occurred, report it immediately to the carrier that delivered your amplifier.
2. To ensure that the Dragonfly or Butterfly you have unpacked is the appropriate type for your requirements, find the part number sticker on the side of the product:



BUT0001A

The P/N gives the type designation as follows:



P/N: DRA-3/60
S/N: DRA2055005

DRA0004A

DRA- X/YY

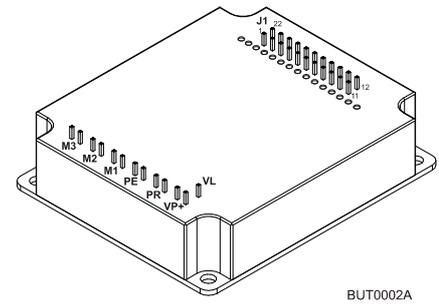
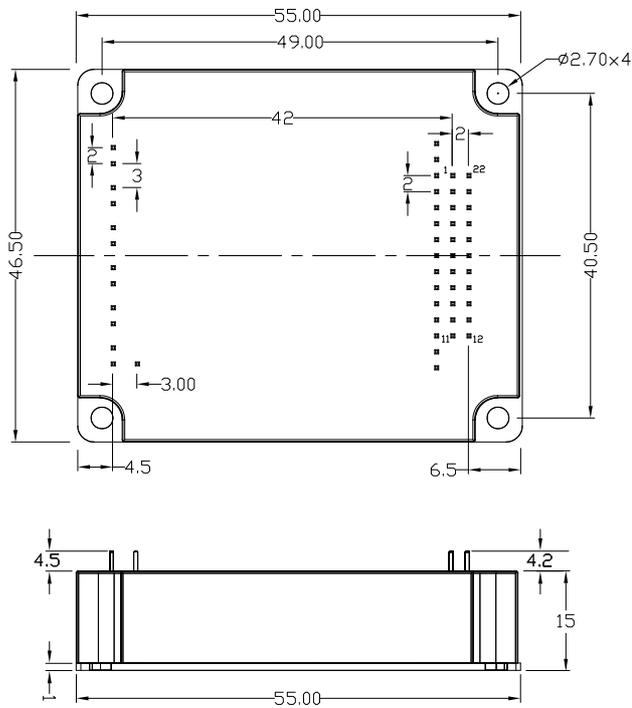
Continuous Current
 (Amps)

Maximum DC
 Operating Voltage

3. Verify that the Dragonfly or Butterfly type is the one that you ordered, and ensure that the voltage meets your specific requirements.

3.3 Dimensions

3.3.1 Butterfly Dimensions



BUT0002A

Figure 3-1: Butterfly Dimensions

3.3.2 Dragonfly Dimensions

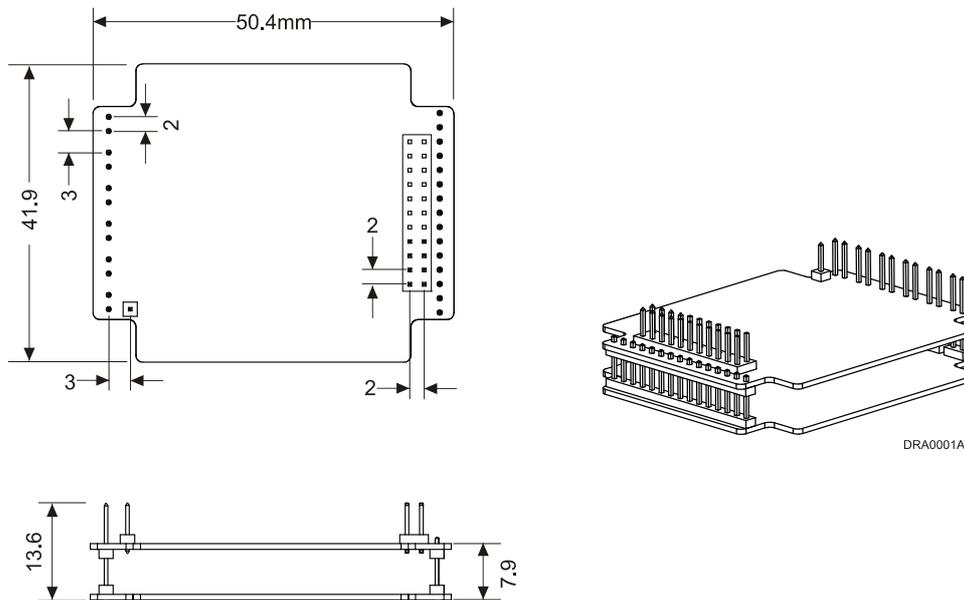


Figure 3-2: *Dragonfly Dimensions*

3.4 Mounting

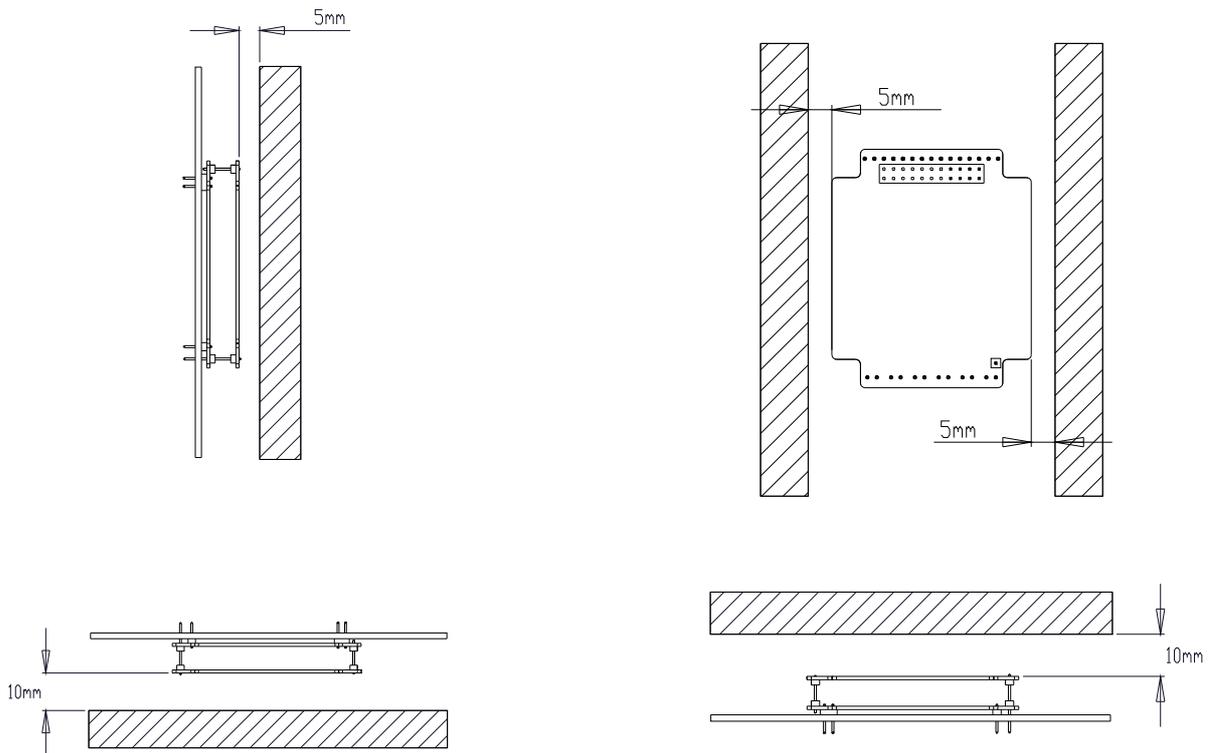
3.4.1 Butterfly

The Butterfly was designed for mounting on a printed circuit board (PCB). It is connected by 2mm pitch 0.51 mm square pins. When designing the Butterfly into a device, be sure to leave about 1 cm (0.4") outward from the heatsink to enable free air convection around the Butterfly. We recommend that the Butterfly be soldered directly to the board. Alternatively, the Butterfly can be attached to socket connectors mounted on the PCB. If the PCB is enclosed in a metal chassis, we recommend that the Butterfly be screw-mounted to it as well to help with heat dissipation. The Butterfly has screw-mount holes on each corner of the heatsink for this purpose.

3.4.2 Dragonfly

The Dragonfly was designed for mounting on a printed circuit board (PCB). It is connected by 2mm pitch 0.51 mm square pins. When designing the Dragonfly into a device, be sure to leave about 1 cm (0.4") outward from the lower board to enable free air convection around the Dragonfly. We recommend that the Dragonfly be soldered directly to the board. Alternatively, the Dragonfly can be attached to socket connectors mounted on the PCB.

Note: Elmo recommends you leave approximately 1 cm (0.4 in) of space on the side opposite the terminals to allow for free air convection.



3.5 Integrating the Dragonfly and Butterfly on a PCB

The Dragonfly and Butterfly are designed to be mounted on a PCB, either by soldering the pins directly to the PCB or by using suitable socket connectors. In both cases the following rules apply:

3.5.1 Traces

1. The **size of the traces** on the PCB (thickness and width) is determined by the current carrying capacity required by the application.
 - The rated continuous current limit (I_c) of the Dragonfly and Butterfly is the current used for sizing the motor traces (M1, M2, M3 and PE) and power traces (VP+, PR and PE).
 - For control, feedbacks and Inputs/ outputs conductors the actual current is very small but “generous” thickness and width of the conductors will contribute to a better performance and lower interferences.
2. The **traces should be as short as possible** to minimize EMI and to minimize the heat generated by the conductors.
3. The **spacing** between the high voltage conductors (VP+, PR, M1, M2, M3, VL) must be at least:
 - Surface layer: 1.5 mm
 - Internal layer: 0.10 mm

Complying with the rules above will help satisfy UL safety standards, MIL-STD-275 and

the IPC-D-275 standard for non-coated conductors, operating at voltages lower than 100 VDC and at "unlimited altitudes" (above 10,000 meters – 30,000 feet).

3.5.2 Grounds and Returns

The “Returns” of the Dragonfly and Butterfly are structured internally in a star configuration. The returns in each functional block are listed below:

Functional Block	Return Pin
Power	PR (Power Return)
Internal Switch Mode P.S.	PR (Power Return)
Control section	Internal, not accessible
Feedback	SUPRET (J2/2)

The returns above are all shorted within the Dragonfly and Butterfly in a topology that results in optimum performance.

1. When wiring the traces of the above functions, on the Integration Board, the **Returns** of each function must be **wired separately** to its designated terminal on the Dragonfly and Butterfly. **DO NOT USE A COMMON GROUND PLANE.** Shorting the commons on the Integration Board may cause performance degradation (ground loops, etc).
2. **Return Traces:** The return traces should be as large as possible, but without shorting each other, and with minimal cross-overs.
3. **Main Power Supply and Motor Traces:** The power traces must be kept as far away as possible from the feedback and control traces.
4. **PE Terminal:** The PE terminal is connected directly to the Butterfly's heatsink or to the Dragonfly's two PE strips on its lower board. In the Butterfly, the heatsink serves as an EMI common plane. The PE terminal should be connected to the system's Protective Earth. Any other metallic parts (such as the chassis) of the assembly should be connected to the Protective Earth as well.
5. Under normal operating conditions, the PE trace carries no current. The only time these traces carry current is under abnormal conditions (such as when the device has become a potential shock or fire hazard while conducting external EMI interferences directly to ground). When connected properly the PE trace prevents these hazards from affecting the drive.

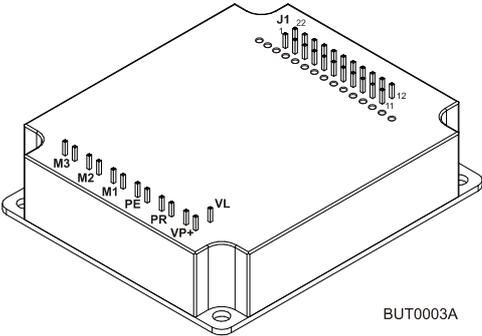


Follow these instructions to ensure safe and proper implementation. Failure to meet any of the above-mentioned requirements can result in drive/controller/host failure.

3.6 Pin Functions

The Dragonfly and Butterfly are PCB mounted analog servo drives. Their pinouts are described below.

3.6.1 Pinouts

No. Pins	Type	Port	Function	Connector Location
2x11	2 mm Pitch 0.51 mm SQ	J1	I/O connector	 <p>BUT0003A</p>
2		M3	Motor power output 3	
2		M2	Motor power output 2	
2		M1	Motor power output 1	
2		PE	Protective earth	
2		PR	Power input return	
2		VP+	Positive power input	
1		VL	Auxiliary power input	

3.6.2 Connector J1

Pin #	Short Form	Function	Description
1	EN+	Enable +	<p>Positive voltage input of the “Amplifier Enable” function. To enable operation of the amplifier, the optocoupler must be energized by applying voltage between this pin (+) and pin J1/22 (-).</p> <p>The optocoupler is isolated from the amplifier. See Figure 3-4.</p> <p>“OFF” voltage: $0\text{ V} < V_{in} < 1\text{ V}$.</p> <p>“ON” voltage: $2.5\text{ V} < V_{in} < 10\text{ V}$, 5 V typically with current consumption 2.5 mA.</p>
2	AOK	Amplifier OK	<p>When the amplifier under normal operating conditions, this output is in the “active low” state. When a failure occurs, this output is changed to the “open” state.</p> <p>The optocoupler is an isolated, open collector NPN type. See Figure 3-4.</p> <p>Maximum voltage = 30 V Maximum current = 8 mA “On” voltage: $V_{OUT(On)} < 0.8\text{ V}$</p> <p>Refer to Section 4.3.</p>
3	SO1	Status output 1	Specifications same as in pin J1/2.
4	HA	Hall A input	<p>Logic levels: TTL</p> <p>Maximum input voltage: 15 VDC.</p>
5	HB	Hall B input	<p>Logic levels: TTL</p> <p>Maximum input voltage: 15 VDC.</p>
6	HC	Hall C input	<p>Logic levels: TTL.</p> <p>Maximum input voltage: 15 VDC.</p>
7	LATCH	Latch mode	Latch mode input. For more details see the Latch Mode section in Chapter 4.
8	ECLRET	Current limits return	Current limit signals return.
9	ECLC	External current limit continuous	<p>External voltage scales down the rated value.</p> <p>Voltage range: 0 V to 3.75 V (3.75 V = rated I_c)</p> <p>Refer to Section 4.2.</p>
10	CM	Current monitor	<p>Analog output with a scale of $\pm 3.9\text{ V}$ for $\pm I_p$.</p> <p>Output resistance: 1 kΩ</p>
11	CREF+	Current command positive	<p>Positive input of a differential amplifier:</p> <p>Input operating voltage range: $\pm 3.75\text{ V}$</p> <p>Maximum input voltage: $\pm 20\text{ V}$</p> <p>Maximum common mode voltage: $\pm 6\text{ V}$</p> <p>Differential input impedance: 40 kΩ</p> <p>Refer to Section 4.1.</p>
12	CREF-	Current command negative	<p>Negative input of a differential amplifier.</p> <p>Same specification as in pin J1/11.</p>

Pin #	Short Form	Function	Description
13	CMRET	Current monitor return	Current monitor (CM) signal return.
14	ECLP	External current limit peak	External voltage scales down the rated value. Voltage range: 0 V to 3.75 V (3.75 V = rated I_p) Refer to Section 4.2.
15	LMRET	Latch Mode return	Return for Latch Mode signals.
16	GAIN	Current gain change	Shorting this pin to LMRET pin (J1/15) reduces the proportional gain of the current loop by 70%.
17	HARET	Hall supply voltage return	Return used only for Hall supply.
18	HALL+5V	+5 V Hall supply voltage	+5 V supply voltage for Hall sensors. Output current: maximum of 13 mA.
19	SORET	Status output return	Status output common AOK, SO1, SO2, SO3. Isolated from circuit common. See Figure 3-4.
20	SO2	Status output 2	Status indication output 2. Same specification as in pin J1/2.
21	SO3	Status output 3	Status indication output 3. Same specification as in pin J1/2.
22	EN-	Enable -	Negative voltage input of "Amplifier Enable" function. Optocoupler is isolated from the amplifier. For details, see pin J1/1.

3.7 Dragonfly/Butterfly Connection Diagram

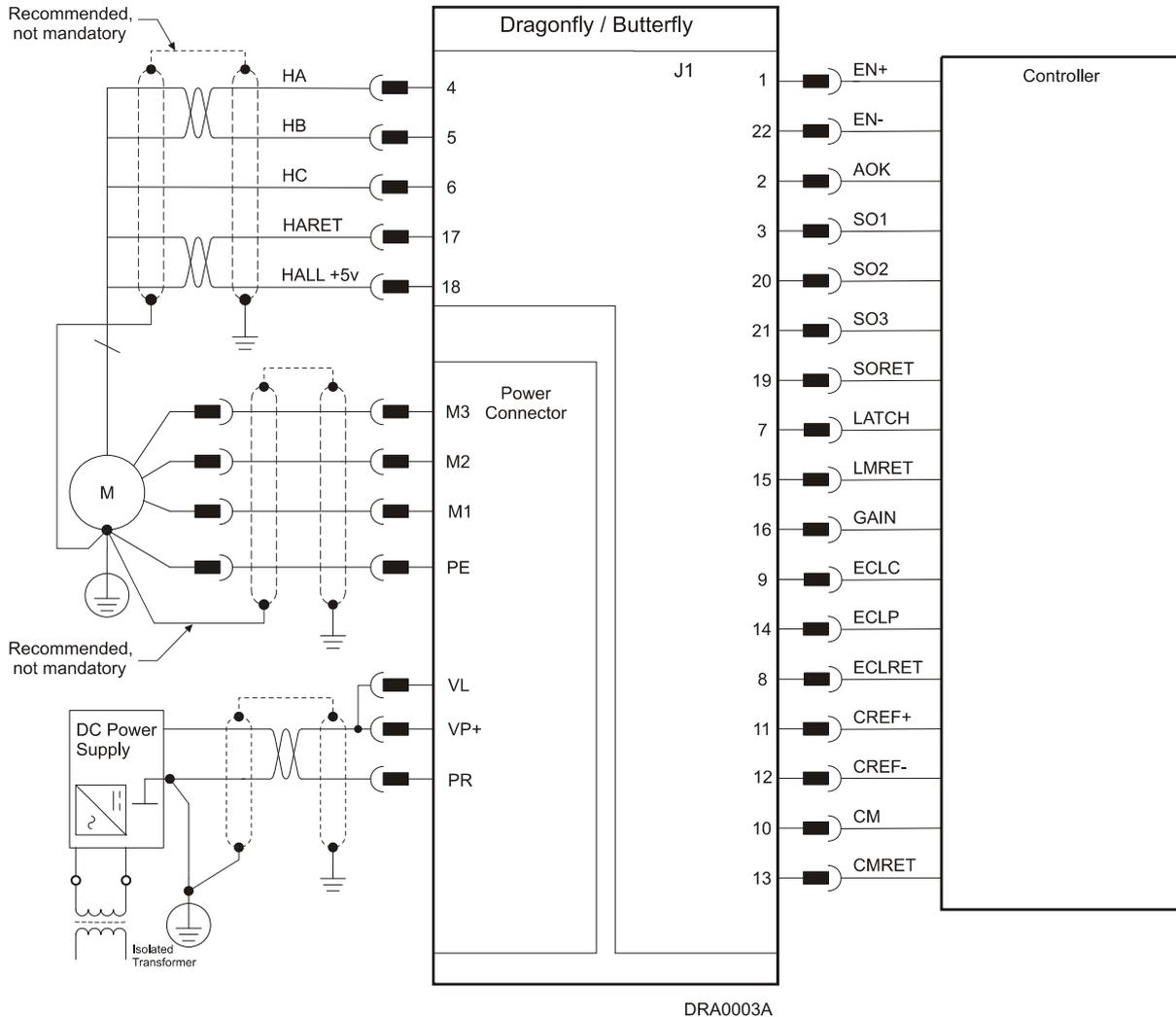


Figure 3-3: Dragonfly/Butterfly Connection Diagram

3.8 Evaluation Board and Cable Kit

The same circuit board used for the Ocarina and Castanet is also available for evaluating the Dragonfly and Butterfly. It comes with standard terminal blocks for power connections and D-sub plugs/sockets for signal connections. The Evaluation Board is provided with a cable kit.

Evaluation Board Catalog Number	OCA-EVLBRD-1
Evaluation Board User Manual	MAN-EVLBRD-OCA (available on our web site)

3.9 DC Power Supply

The DC power supply can be at any voltage in the range defined in the technical specifications (the Appendix of this guide). The supply source must comply with the safety aspects of the relevant requirements, in accordance with the most recent version of the standard EN60950 or equivalent Low Voltage Directive Standard, all according to the applicable over-voltage category. If the power source to the power supply is the AC line (through an isolated transformer), safety margins must be considered in order to avoid activating the under/over voltage protection due to line variations and/or voltage drop under load.

In addition to the above, the transformer must comply with the safety aspects of the relevant requirements in accordance with the most recent version of the standard EN60742 (Isolating and Safety Isolating Transformers). The nominal DC bus voltage should be in the following range:

$$1.2 V_{dcmin} < V_{dc} < 0.9 V_{dcmax}$$

where:

V_{dcmin} is the minimum DC bus

V_{dcmax} is the maximum DC bus

The recommended minimum power supply capacitance for a single-phase rectified DC source connection is as follows:

Amplifier Range	Voltage	60 V	100 V
Recommended capacitance		$\geq 470 \mu\text{F}$	$\geq 470 \mu\text{F}$

The transformer power should be calculated such that it will be able to deliver power to the amplifier (including peak power) without significant voltage drops.

The power supply should be located as close as possible to the amplifier. The maximum distance is 30 cm (1 foot). While driving high-inertia loads, the power supply must be equipped with a shunt regulator; otherwise, the amplifier will be disabled whenever the capacitors are charged above the maximum voltage, during motor break down.

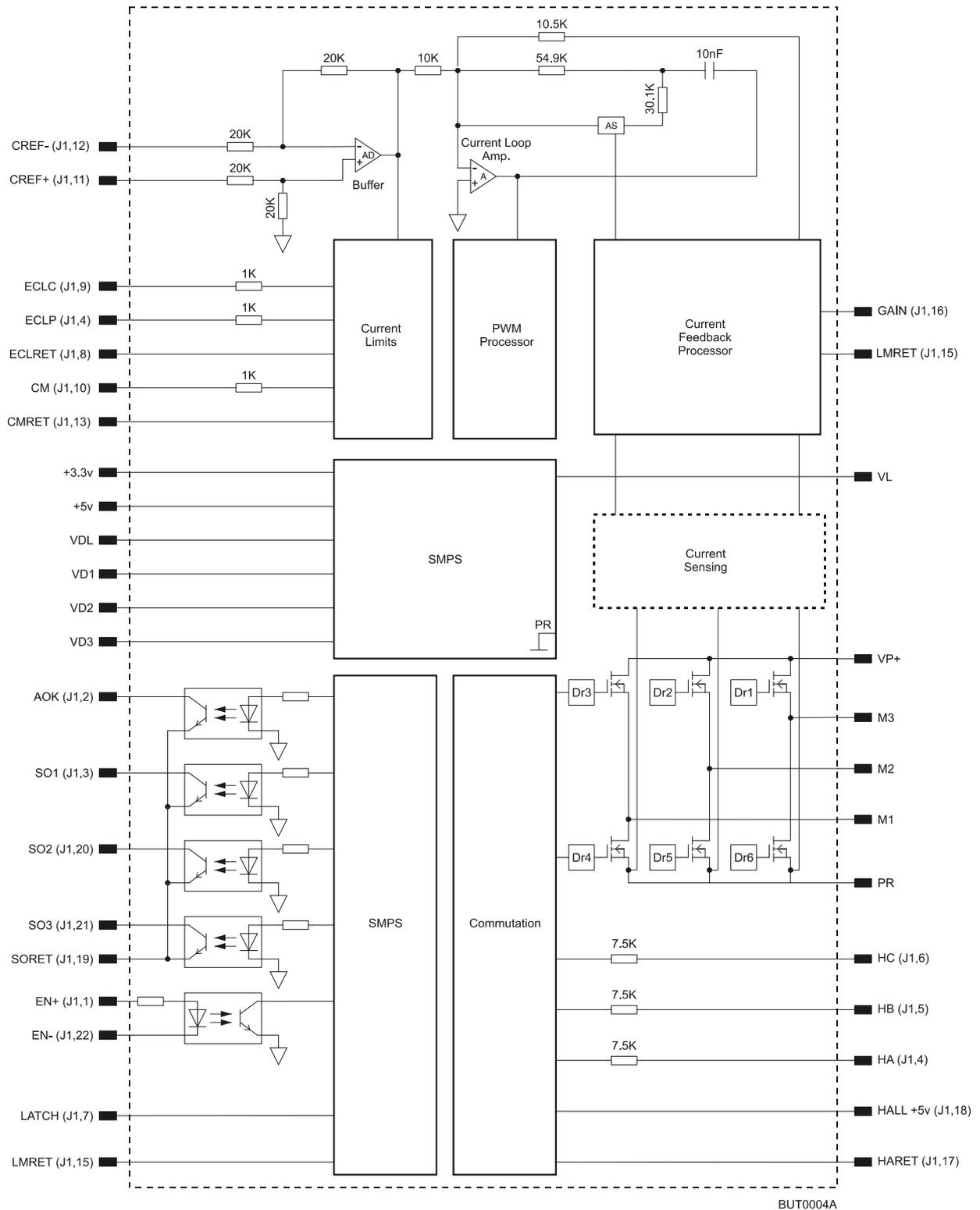


Figure 3-4: Detailed Dragonfly/Butterfly Internal Block Diagram

3.10 Heat Dissipation

3.10.1 Butterfly

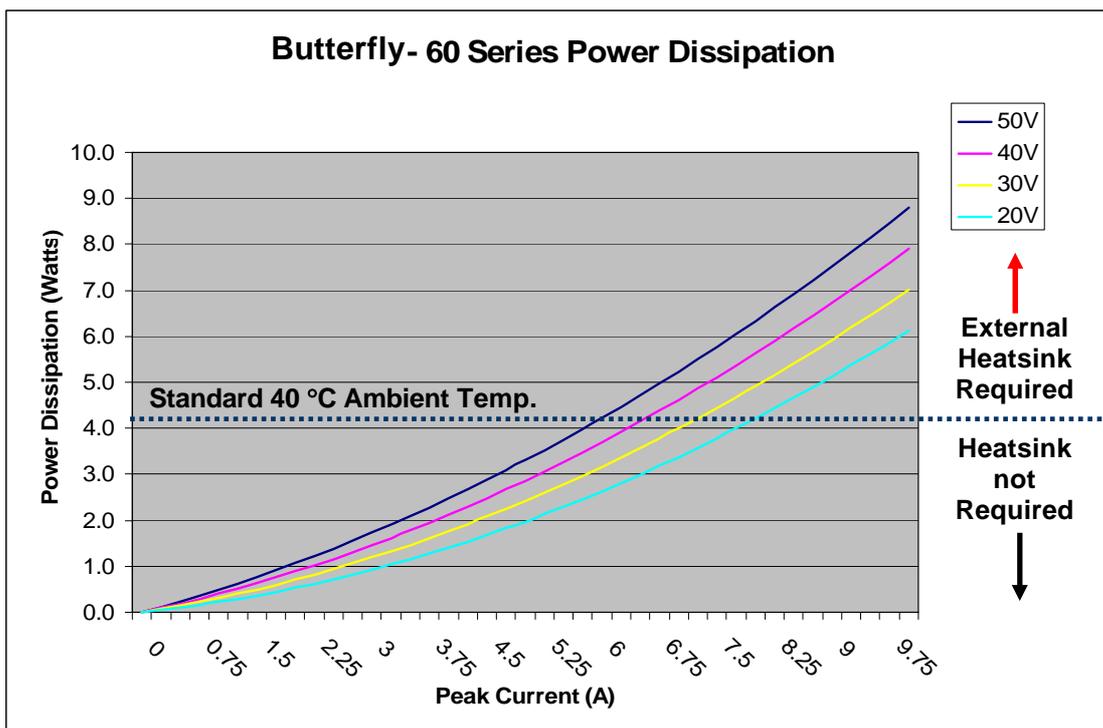
The best way to dissipate heat from the Butterfly is to mount it so that its heatsink faces up. For best results leave approximately 10 mm of space between the Butterfly's heatsink and any other assembly.

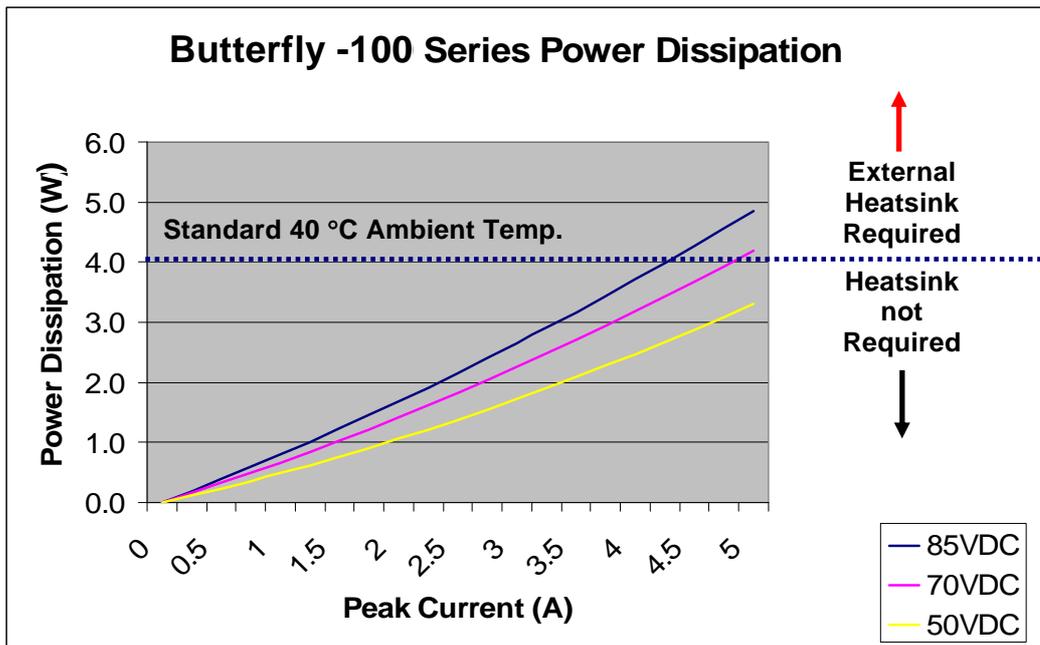
3.10.1.1 Thermal Data

- Heat dissipation capability (θ): Approximately 10 °C/W.
- Thermal time constant: Approximately 240 seconds (thermal time constant means that the Butterfly will reach 2/3 of its final temperature after 4 minutes).
- Shut-off temperature: 86 °C – 88 °C (measured on the heatsink)

3.10.1.2 Heat Dissipation Data

Heat Dissipation is shown in graphically below:





3.10.1.3 How to Use the Charts

The charts above are based upon theoretical worst-case conditions. Actual test results show 30% - 50% better power dissipation.

To determine if your application needs a heatsink:

1. Allow maximum heatsink temperature to be 80 °C or less.
2. Determine the ambient operating temperature of the Butterfly.
3. Calculate the allowable temperature increase as follows:
 - for an ambient temperature of 40 °C, $\Delta T = 80\text{ °C} - 40\text{ °C} = 40\text{ °C}$
4. Use the chart to find the actual dissipation power of the drive. Follow the voltage curve to the desired output current and then find the dissipated power.
5. If the dissipated power is below 4 W the Butterfly will need no additional cooling.

Note: The chart above shows that no heatsink is needed when the heatsink temperature is 80°C, ambient temperature is 40 °C and heat dissipated is 4 Watts:

3.10.2 Dragonfly

The best way to dissipate heat from the Dragonfly is to mount it so that its lower board faces upwards. For best results leave approximately 10 mm of space between the Dragonfly's lower board and any other assembly.

Chapter 4: Servo Control Operation

4.1 Current Command Input

The Dragonfly and Butterfly have a single differential input. The input operating voltage range is ± 3.75 V, meaning that a 3.75 V signal will result in a fully rated peak current. The current limit circuits will override this signal if the peak duration exceeds 2.7 seconds and/or the required current exceeds the values set by the ECLC and ECLP signals. If the input command voltage exceeds 3.75 V, input scaling must be implemented by adding a pair of external resistors, according to the following formula:

$$R_{in} \text{ (k}\Omega\text{)} = (5.33 * V_{in}) - 20$$

Be careful not to apply input voltage above the maximum allowed input voltage as this will cause the input operational amplifier to operate beyond its limits (± 20 V) and in extreme cases, may even damage it.

4.2 External Current Limit - Continuous (ECLC)

The continuous current limit of the Dragonfly and Butterfly amplifiers can be scaled down by an external voltage or by an external resistor connected from pin J1/9 (ECLC) to pin J1/8 (ECLRET).

4.2.1 External Voltage

$$I_{C(\text{new})} = \frac{V_{\text{ECLC}}}{3.75\text{V}} * I_{C(\text{nom})}$$

An external positive voltage (0 to 3.75 V) to terminal J1/9 (ECLC) in reference to terminal J1/8 (ECLRET) will control the continuous current limit from zero to I_c (nom).

The voltage is internally clamped to 3.75 V whenever the external V_{ECLC} is greater than 3.75V.

The external voltage source must be able to source/ sink at least ± 0.2 mA.

The maximum absolute V_{ECLC} allowed to be connected is 5 V.

4.2.2 External Resistor

$$R_{\text{ECLC}} (\text{Kohm}) = 37.4 * \frac{I_{\text{c}}(\text{new})}{I_{\text{c}}(\text{nom})} - 1$$

Connect an external resistor between terminal J1/9 (ECLC) and terminal J1/8 (ECLRET).
The resistor value is given by:

$$0 < R_{\text{ECLC}} < 36.4 \text{ K (1/8 Watt)}$$

At R_{ECLC} greater than 36.4 K, the current limit will be internally clamped to the nominal value.

$I_{\text{c}}(\text{nom})$ is the nominal continuous current limit of the amplifier.

4.2.3 External Current Limit - Peak (ECLP)

The peak current limit of the Dragonfly and Butterfly amplifiers can be scaled down by an external voltage or by an external resistor connected between pin J1/14 (ECLP) and J1/8 (ECLRET).

4.2.4 External Voltage

An external positive voltage (0 to 3.75 V) to terminal J1/14 (ECLP) in reference to terminal J1/8 (ECLRET) will control the peak current limit from zero to $I_{\text{p}}(\text{nom})$.

$$I_{\text{p}}(\text{new}) = \frac{V_{\text{ECLP}}}{3.75\text{V}} * I_{\text{p}}(\text{nom})$$

The voltage is internally clamped to 3.75 V whenever the external V_{ECLP} is higher than 3.75 V.

The external voltage source must be able to source/sink at least ± 0.2 mA.

The maximum absolute V_{ECLP} allowed to be connected is 5 V.

4.2.5 External Resistor

$$R_{ECLP} \text{ (Kohm)} = 37.4 * \frac{I_p(\text{new})}{I_p(\text{nom})} - 1$$

Connect an external resistor between terminal J1/14 (ECLP) and terminal J1/8 (ECLRET). The resistor value is given by:

$$0 < R_{ECLP} < 36.4 \text{ K (1/8 Watt)}$$

At RECLP greater than 36.4K, the current limit will be internally clamped to the nominal value.

IP(nom) is the nominal peak current limit of the amplifier.

4.2.6 Latch Mode (LM)

By connecting J1/7 to J1/15, the amplifier is latched to disable mode whenever a Short, Commutation or Over Temperature failure occurs. Disabling the amplifier temporarily by removing the power from Enable pin J1/1 resets the latch. Be sure to restore the Enable connection when the reason for the event no longer exists.

4.3 Status Indications

The following table lists the Dragonfly and Butterfly amplifier status indications.

	Function	Latch Option	AOK	SO1	SO2	SO3
1	Amplifier OK (AOK)	N/A	Low	Open collector	Open collector	Open collector
2	External disable	No	Low	Low	Open collector	Low
3	Current limit	No	Low	Open collector	Open collector	Low
4	Short	Yes	Open collector	Low	Open collector	Low
5	Over temperature	Yes	Open collector	Open collector	Low	Low
6	Internal supplies protection	No	Open collector	Low	Low	Open collector
7	Under voltage	No	Open collector	Low	Open collector	Open collector
8	Over voltage	No	Open collector	Open collector	Low	Open collector

	Function	Latch Option	AOK	SO1	SO2	SO3
9	Shunt*	No	Low	Open collector	Low	Open collector
10	Power up reset	No	Open collector	Open collector	Open collector	Open collector
11	Commutation failure	Yes	Open collector	Low	Low	Low

* This indication can be used as a digital input for activating an external shunt regulator.

Table 4-1: Dragonfly/Butterfly Status Indications



Notes:

- *Without latch mode:*
The status indications are reset when the fault disappears.
- *With latch mode:*
The Short, Over Temperature and Commutation Failure status indications are reset when the enable signal is temporarily removed from the enable input.
- *Multiple faults:*
Only the reading of the first fault is reliable. Additional faults add on to the status outputs and the indication is therefore meaningless.

Appendix: Specifications

A.1 General Specifications

A.1.1 Butterfly

Feature	Units	15/48	5/60	10/60	15/60	2.5/100	5/100	10/100	15/100
Minimum supply voltage	VDC	11	11		20				
Nominal supply voltage	VDC	42	50		85				
Maximum supply voltage	VDC	48	59		95				
Maximum continuous power output	W	700	280	570	850	230	460	920	1400
Efficiency at Rated Power (at nominal conditions)	%	Up to 99%							
Maximum output voltage		93% of DC bus voltage at f=32 kHz							
DC and trapezoidal commutation continuous current limit (Ic)	A	15	5	10	15	2.5	5	10	15
Peak current limit	A	2 x Ic							
Weight	g (oz)	45 g (1.6 oz)							
Dimensions	mm (in)	55 x 15 x 46.5 (2.2" x 0.6" x 1.8")							
Mounting method		PCB mount							

A.1.2 Dragonfly

Feature	Units	3/60	2.5/100
Minimum supply voltage	VDC	11	20
Nominal supply voltage	VDC	50	85
Maximum supply voltage	VDC	59	95
Maximum continuous power output	W	190	240
Efficiency at rated power	%	Up to 99%	
Maximum output voltage		93% of DC bus voltage at f=32 kHz	
DC and trapezoidal commutation continuous current limit (Ic)	A	3.3	2.5
Peak current limit	A	2 x Ic	
Weight	g (oz)	21.5 g (0.76 oz)	
Dimensions	mm (in)	51 x 12.5 x 42 (2" x 0.49" x 1.65")	
Mounting method		PCB mount	

A.2 Environmental Specifications

Ambient Temperature Range	Non-operating conditions	-50 °C to +100 °C (-58 °F to 212 °F)
	Operating conditions	-40 °C to +70 °C (-40 °F to 160 °F)
Temperature Shock	Non-operating conditions	-40 °C to +70 °C (-40 °F to 160 °F) within 3 min.
Altitude	Non-operating conditions	Unlimited
	Operating conditions	-400 m to 155,000 m (-1,300 ft to 510,000 ft)
Maximum Humidity	Non-operating conditions	Up to 95% relative humidity non-condensing at 35 °C (95 °F)
	Operating conditions	Up to 95% relative humidity non-condensing at 25 °C (77 °F), up to 90% relative humidity non-condensing at 42 °C (108 °F)
Vibration	Operating conditions	20 Hz -2,000 Hz, 14.6g

Mechanical Shock	Non-operating conditions	±40g; Half sine, 11 msec
	Operating conditions	±20g; Half sine, 11 msec

A.3 Standards Compliance

A.3.1 Quality Assurance

Specification	Details
ISO 9001:2000	Quality Management

A.3.2 Design

Specification	Description
In compliance with MIL-STD-704	Aircraft, Electric Power Characteristics
In compliance with MIL-STD-810	Environmental Engineering Considerations and Laboratory Tests
In compliance with MIL-STD-1275	Characteristics of 28 Volt DC Electrical Systems in Military Vehicles
In compliance with MIL-STD-461	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
In compliance with MIL-HDBK-217	Reliability Prediction of Electronic Equipment
<ul style="list-style-type: none"> ▪ IPC-D-275 ▪ IPC-SM-782 ▪ IPC-CM-770 ▪ UL508c ▪ UL840 	<p>Reliability prediction of electronic equipment (rating, de-rating, stress, etc.)</p> <p>Printed wiring for electronic equipment (clearance, creepage, spacing, conductors sizing, etc.)</p>
In compliance with VDE0160-7 (IEC68)	Type testing

A.3.3 Safety

Specification	Details
Recognized UL508c	Power conversion equipment
In compliance with UL840	Insulation coordination, including clearance and creepage distances of electrical equipment

In compliance with UL60950	Safety of information technology equipment, including electrical business equipment
In compliance with EN60204-1	Low voltage directive, 73/23/EEC

A.3.4 EMC

Specification	Details
In compliance with EN55011 Class A with EN61000-6-2: Immunity for industrial environment, according to: IEC61000-4-2 / criteria B IEC61000-4-3 / criteria A IEC61000-4-4 / criteria B IEC61000-4-5 / criteria B IEC61000-4-6 / criteria A IEC61000-4-8 / criteria A IEC61000-4-11 / criteria B/C	Electromagnetic compatibility (EMC)

A.3.5 Workmanship

Specification	Details
In compliance with IPC-A-610, level 3	Acceptability of electronic assemblies

A.3.6 PCB

Specification	Details
In compliance with IPC-A-600, level 3	Acceptability of printed circuit boards

A.3.7 Packing

Specification	Details
In compliance with EN100015	Protection of electrostatic sensitive devices

A.3.8 WEEE*

Specification	Description
In compliance with 2002/96/EC	Waste Electrical and Electronic Equipment regulations

* Please send out-of-service Elmo drives to the nearest Elmo sales office.

A.3.9 RoHS

Specification	Description
In compliance with 2002/95/EC (effective July 2006)	Restrictions on Application of Hazardous Substances in Electric and Electronic Equipment