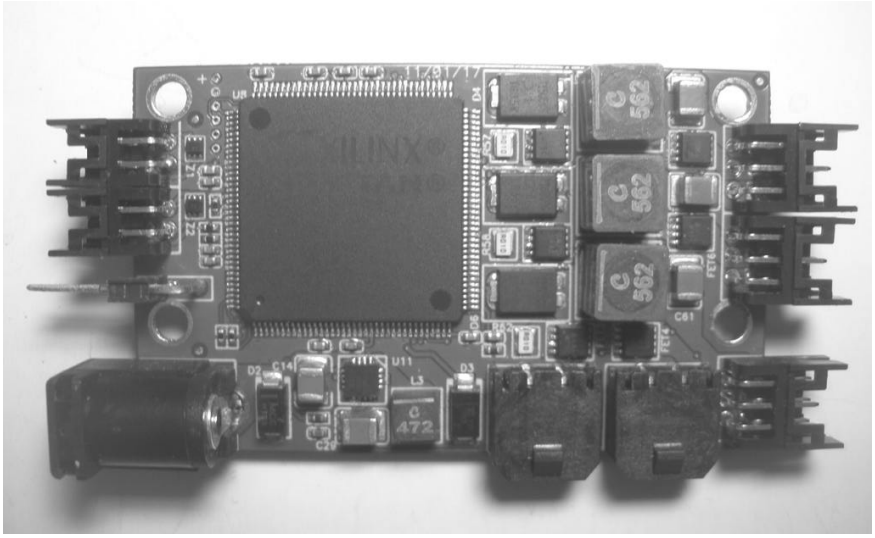
Ajile Light Industries

Ajile 3-Channel LED Controller Hardware User's Guide

AJL-LED-04-02

Draft Version 1.0 – March 26th, 2018



Revision History

March 26th, 2018	DSO	Initial Release

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1.0 - Introduction

1.1 - Board Overview

Congratulations on your choice of the Ajile AJL-LED-04-02 3-channel LED controller board. This controller board provides a complete solution for driving 3 separate LED channels, and is compatible with the Ajile suite of controllers and carrier boards using a simple, 4-wire interconnect. A passthrough connector is present to allow for connection of a second LED board, allowing for 6-channel LED control across both controllers. LED current for each channel can be individually adjusted for current between zero and 4A using independent 6-bit digital words, and each channel also features high-speed synchronous PWM control (~1.0 us accuracy) for two independent LED control mechanisms.

Also included is 4 channels of thermistor-based temperature monitoring, one assigned to each of the 3 LED channels, and one connected to a board-mounted thermistor to report LED driver temperature for applications monitoring. A multi-speed fan controller is also included, providing power for up to 200 mA of fan load.

Operating from any primary power voltage between +12 and +32 VDC, this controller is optimized for operation using +15 VDC drive for typical loads. Internal board power is generated from a +5 VDC rail derived from primary power, with this +5 VDC rail providing up to 1.8A of current for powering devices connected to two AJP Power connectors. Since permissible input voltages range over a wide span of values, input voltage can be optimized to minimize board power dissipation by selecting a primary power voltage that is no less than +12 VDC (due to board limits) but need only be about +2 VDC above maximum LED string voltage requirements. As a complement to this, the fan controller is configured to allow for fan voltage selections of +10, +12, +22, and +24 VDC allowing standard +12 and +24 VDC fans to have predictable operating points over variable primary power voltages.

Overview of Ajile 3-Channel LED Controller Board Features

- *Full 3-channel LED controller capable of sourcing up to 4A per LED channel*
- *True independent channel configuration, with no inter-channel operational constraints*
- *Independent 6-bit channel current control range, with programmable drive currents ranging from 0-4 A.*
- *Independent channel PWM control with 1 us timing accuracy*
- *Per-channel thermistor port for temperature monitoring, specification: 10k @25C*
- *On-board thermistor to monitor LED driver temperature*
- *Very wide acceptable input primary power range, +12-32 VDC, 6A maximum current*
- *High voltage input allows for LED arrays of up to +30 VDC total voltage when primary power is set to the maximum voltage of 32 VDC*
- *Two (2) AJP Power ports for powering external devices, 1.8A maximum load current*
- *Fan port, with programmable drive voltage of +10, +12, +22, or +24 VDC @ 200 mA*
- *Simple 4-wire connection to Ajile controller or carrier with a passthrough port allowing for connection of a second LED board for control of an additional 3 LED channels*
- *Data port has switch-selectable I/O voltage (2.5/1.8 VDC) for maximum interface compatibility.*
- *Status indicators for FPGA and board power state, plus two user indicators*
- *Extremely compact board size, optimized for thermal characteristics*

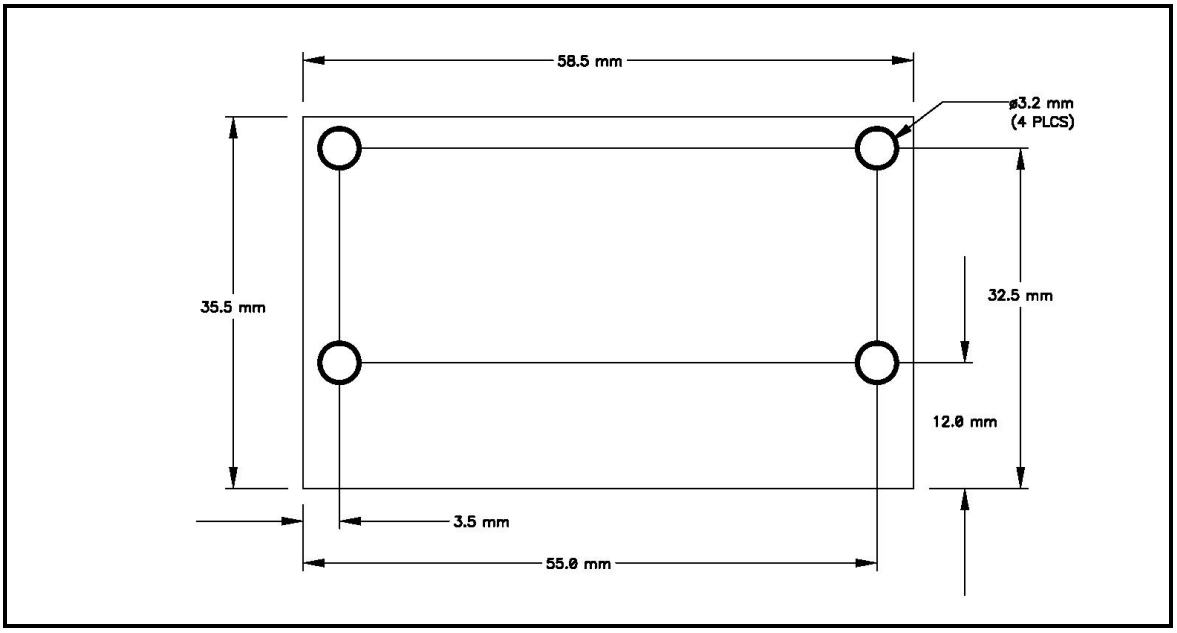
The form factor of this board is designed for highest component and power density, and features a mounting pattern compatible with other Ajile system boards allowing for convenient board-stacking when used as part of a multi-board module. This board has been optimized for thermal characteristics, and with enough cooling airflow is capable of running at full power with no additional heatsinking, albeit at the cost of noise.

The Ajile AJL-LED-04-02 is designed for reliable, high-performance service as part of Ajile applications requiring high-current LED drive with full current and PWM control over 3 independent channels. Optimized board thermals allow for tailored cooling solutions depending on overall thermal load, and for applications not requiring continuous illumination may only require minimum cooling for effective operation, with no restriction on pulse current or channel interaction so long as thermal limits are observed.

1.2 - Basic Installation and Mounting

Four (4) mounting holes are provided to suitably affix the board to a support plate or chassis in the end-use device. Note that these holes are in a standard configuration to allow for stacking of Ajile boards for prototyping or production. Overall board dimensions and hole locations are as noted below:

Ajile 3-Channel LED Controller, Mechanical Dimensions for Mounting, Top View



Note that these dimensions are circuit-board dimensions, and do not take into account peripheral space required for connectors. Mounting should also take into consideration overall cooling considerations and issues. These are noted in the following section.

1.3 - Cooling

The Ajile AJL-LED-04-02 is a very thermally dense board, but has excellent internal thermal transfer characteristics. As such, with enough airflow a stock board can work with no external heatsinking at full load if enough airflow is present. Overall thermals are such that if the intended application has a very limited duty cycle, full-power unconstrained pulses can be generated by the driver board and absorbed into the overall board structure with minimal airflow. For intermediate duty-cycle applications, more cooling air is required to maintain board operation. If the LED driver exceeds it's safe operating temperature, it will shut down and report an error but should not otherwise cause any damage to the controller.

Since board thermals are measured by a thermistor very much in the most thermally active portion of the board, it should be easy to model thermals in a test environment. To verify an end use case, the board is operated as close to regular operating conditions of current and duty cycle, and increasing cooling airflow is applied until the board stabilizes at a suitable temperature. This establishes a thermal equilibrium point for the operating case, and should be a suitable point to work out overall thermals for the end-use application. Note also that this board is generally not suitable for conduction-cooled structures, as thermals are optimized for forced-air cooling.

The AJL-LED-04-02 3-channel LED controller board is designed to run 'hot', but operating temperature as measured by the on-board thermistor should not exceed 75C for best board reliability. Since this is a very power-dense board, the overall cooling should be analyzed and tested as part of a complete system when used in an end-use assembly.

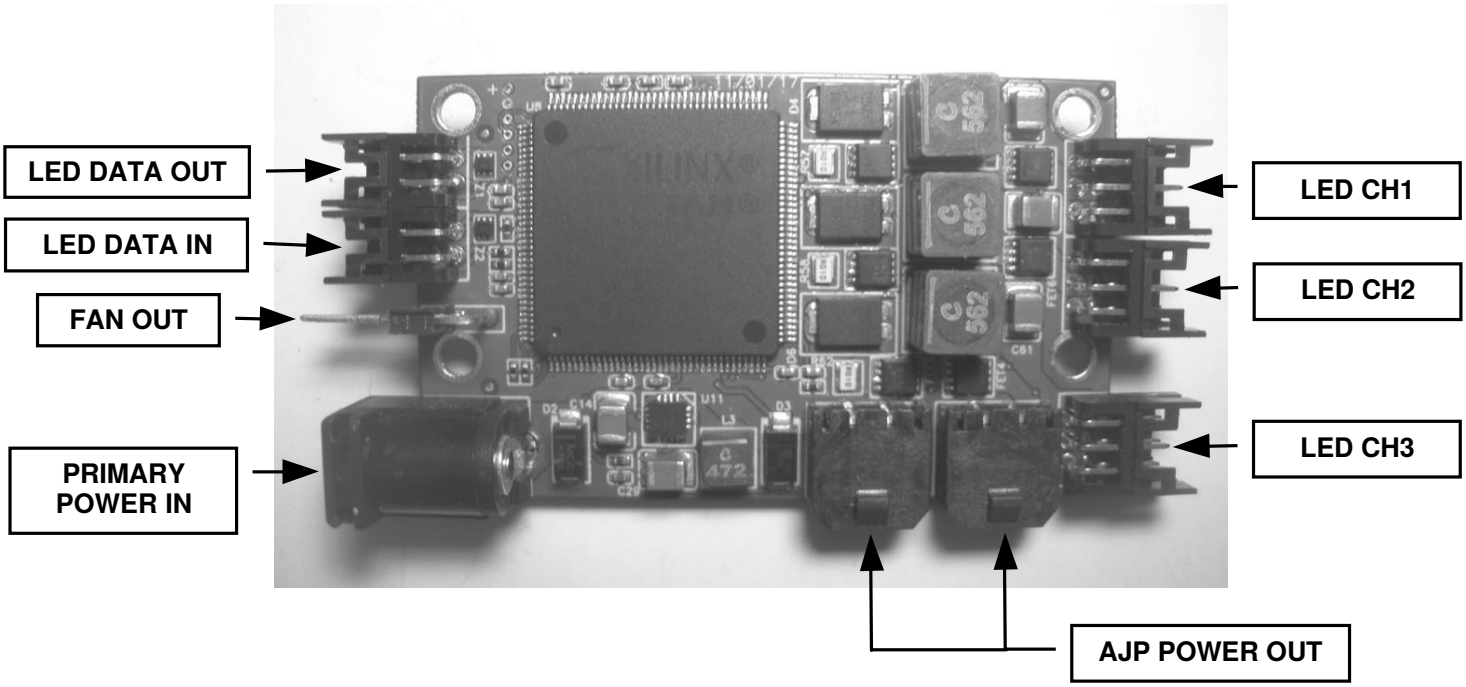
1.3.1 - Reducing board power dissipation

Board dissipation can be controlled by selecting a primary input voltage no less than +12 VDC but need be no greater than +2 VDC more than the overall voltage requirements of a connected LED array for normal operation. Typical operation for LED voltages below +13 VDC would normally use a +15 VDC supply, and board efficiency is generally maximized at this primary power voltage over these operating conditions.

Another means of reducing board dissipation is fan voltage choice. To keep board power dissipation down, +24 VDC fans are recommended for primary voltages above +22 VDC as this minimizes current "burn-off" in the fan controller by minimizing input-output voltage differential.

One final means of reducing board power dissipation is to forgo use of the AJP Power connectors, reducing overall board power load. In this case, the system AJP power would be derived from another Ajile board such as a carrier board.

1.4 - External Connections



1.4.1 - LED Data In, LED Data Out

These connectors provide upstream and downstream connectivity for a 4-wire bus that carries the Ajile LED control data to and from the LED driver board. Normally an Ajile controller or carrier is connected to the Data In port, and in the case of a second Ajile LED controller being used in a system, the Data Out port is used to provide a connection for the Data In port on the second board. There are no provisions for more than 2 Ajile LED boards on one LED data bus connection currently in the Ajile System, so the Data Out port on the second board would then be unused.

1.4.2 - Fan Power Out

This connector provides power to drive an external cooling fan. The fan controller used provides the ability to enable and disable this output, and provides for a regulation output voltage of +10, +12, +22, and +24 VDC. This provides the ability to use and control +24 VDC fans for applications that require high LED voltage, but normally provides a consistent +10 and +12 VDC for standard applications using +15 VDC primary power. Fan current is limited to 200 mA at all voltages.

1.4.3 - Primary Power In

This is the primary power input to the Ajile AJL-LED-04-02 LED driver board. Primary voltage can range from +12 VDC to +34 VDC input and is fused by a PTC to 6A of current, note that this limit affects overall primary power envelope of the board at lower voltages. At higher primary voltages, controller limitations limit overall power. Overall, the controller is designed to operate at maximum efficiency with a nominal +15 VDC for all LED voltages below +13 VDC and particularly for single and dual-LED arrays, so these considerations only start to become an issue for LED array voltages above this.

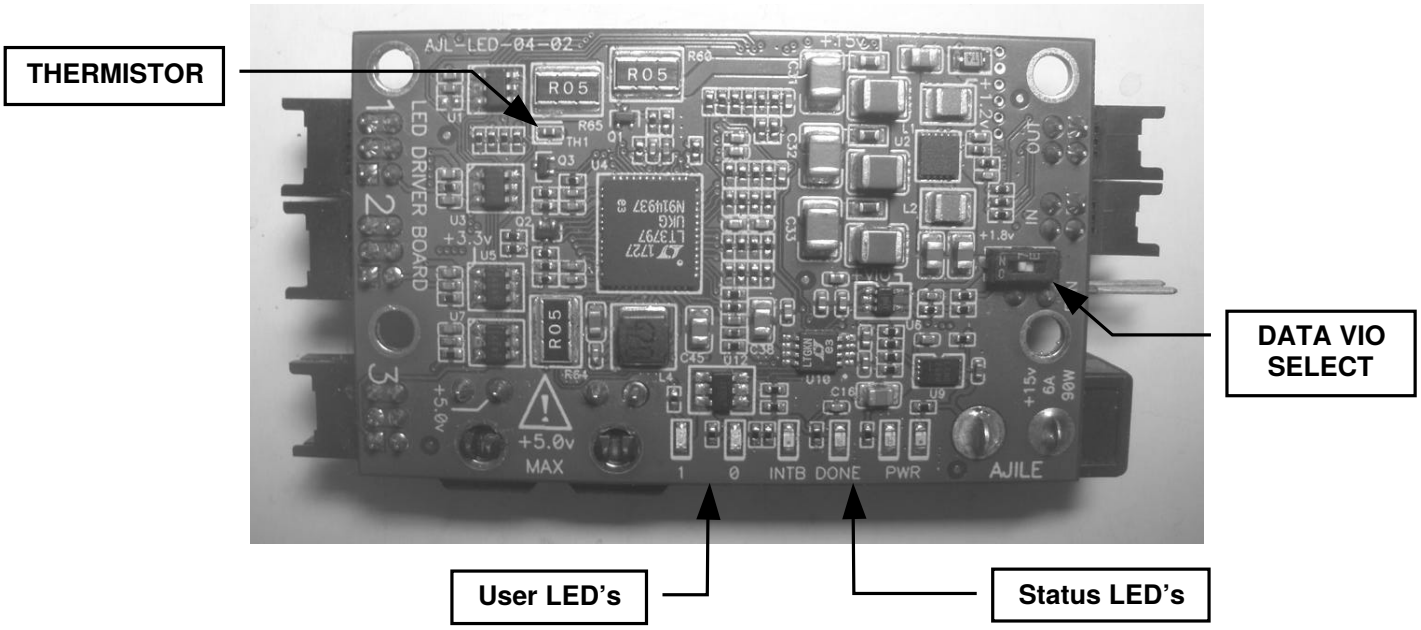
1.4.4 - AJP Power Out

These two connectors are used to supply AJP power to external devices, providing +5 VDC at up to 1.8A. Although this bus powers core logic on the LED driver board and will do so if an external +5 VDC source is connected here, primary power is required for the power stage of the LED driver electronics only obtainable from the Primary Power input. Note however that thermistor temperatures can be read with only core-logic power since this will adequately power the thermistors and board data interface, a combination that may be useful in some applications.

1.4.5 - LED Channel Connectors

These three connectors are the primary LED drive connectors, and include a pin-pair for connection of a 10k (@25C) thermistor for temperature monitoring for each channel. Pin wiring on each of the connectors is equivalent, allowing compatible cables to be moved from port-to-port when testing. Output current is up to 4A per channel with PWM control accurate to 1 us, with no inter-channel constraints on timing or power other than overall thermal and power limits for the entire board

1.5 - Status Indicators and Adjustments



1.5.1 - Overview of indicators

A number of LED indicators are present on the Ajle LED controller to indicate board state. These indicators are summarized as follows:

Ajile 3-Channel LED Controller - Indicators

LED	Colour	Function
PWR	Orange	Indicates state of primary power input
PWR	Green	Indicates state of 3.3v board internal main power
DONE	Blue	Indicates Zynq 'DONE' state as part of initial configuration
INTB	Red	Indicates Zynq 'INIT B' state as part of initial configuration
0	Violet	User LED 0 – driven by application code
1	Violet	User LED 1 – driven by application code

1.5.2 - Boot-mode indicators – normal startup

Under normal conditions during power up, the two PWR indicators will light first indicating the main board is receiving primary power and the internal 3.3v power supply has successfully started. Almost immediately, the INTB LED will flash briefly and then go dark. After a short pause (as configuration is loaded into the Spartan), the DONE LED will light a steady blue to indicate successful configuration of the device. If the Spartan configuration process is somehow interrupted, the final state of these two indicators can be an aid towards diagnosing boot issues.

For more information on the usage of 'INIT B' and 'DONE' and their specific application during the Spartan initialization process, please refer to the document ***UG332 – Spartan-3 Generation Configuration User Guide*** *for complete details.*

1.5.3 - User indicators

User LED's are fully under control of the application code, and are connected to Spartan pins. Since these are application-driven, their usage is unique to the code running on Spartan, and thus this configuration data and associated application code that defines their usage. Please refer to the relevant application documents for these details.

1.5.4 - Data VIO Select

This switch is used to select the LED Data VIO voltage. Options here are +2.5 or +1.8 VDC, allowing for maximized host compatibility. The voltage selected here is valid for both the Data In and Data Out ports but otherwise does not change other aspects of LED board operation. There is a marking indicating the switch selection associated with +1.8 VDC operation printed on the PCB, if this is the desired voltage the switch should be set to the associated end. For +2.5 VDC operation, the switch is set opposite to this.