Innovative DC Terminal Block Solution for Networking Integrated Services Routers

White Paper

June 2011

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1. Introduction

Modern power architectures are advancing miniaturization of semiconductors and other discrete devices. These advancements require migrating to more progressive design topologies to increase density and efficiency. This shift in developing new technology is transforming all facets of the design process. At the same time, the need for components conforming to environmentally friendly standards for international acceptance (Green procurement) provides additional challenges and opportunities.

This white paper examines how Curtis Industries was presented with the challenge of adapting the AC power interface of a Networking Integrated Services Router to a DC power input option. Impending product launch deadlines resulted in an urgent need for a viable connectivity solution.

Within an extremely tight time frame, Curtis Industries successfully designed the custom product, built prototypes and acquired safety agency approvals while adhering to stringent Green procurement requirements. Partnering with a Global 100 corporation and a Fortune 500 networking leader, Curtis Industries solved this complex design challenge for a DC power connected interface solution while achieving significant electrical and, thereby, thermal efficiencies. The end result is one of the world's smallest terminal block footprints incorporating multi-functionality in an integrated solution.

2. Design Challenge (Problem)

Shortly after introduction of the AC Powered Networking Integrated Services Router platform, the DC input power supply version was stalled in the preliminary design phase. The predominant challenge was sourcing a standard DC terminal block with the same footprint as the more prevalent AC version (with the same functionality). After a thorough review of the marketplace, it was determined that this type of standard terminal block was not commercially available. In addition, manufacturers of existing terminal block designs were unable or unwilling to develop a practical custom solution in the timeframe required.

This created an opportunity for the Global 100 Corporation to collaborate with design expert Curtis Industries to develop a custom DC terminal block solution that would meet the stringent technical and environmental requirements.

Figure 1: *Integrated Services Router AC power input module. Optional DC wiring module was required to mount in same available space.*

2.1 Design Requirements

The DC power supply option required integration of a three-terminal, 40-Amp DC power input connection including a signal-level power switch and LED status indicator. The dilemma was fitting this solution into the same 30.5mm x 53.3mm footprint established for the AC version using the standard IEC AC inlet module. In addition to these requirements, the DC terminal block needed to meet the following technical requirements:

- Terminals to accept 8AWG lugged wire
- Finger Safe Terminals (incorporating a cover kit)
- 60VDC/33A per Terminal Ratings (accounting for standard design margins)
- Height above panel/mounting surface (including cover, switch & LED) < 13.7mm
- “Green” compliance environmentally friendly materials for all components and raw materials.
- Meeting Standards; UL 1059, CSA 22.2 No.158, IEC/EN 60950 and NEBS GR-1098

The Green procurement requirement itself is a much more stringent environmental compliance requirement than RoHS or similar heavy-metal reduction initiatives. The Green procurement activities included a “Cadmium-Free” manufacturing requirement defined by Cadmium (and Lead) contents of less than 5ppm in resins, inks, paints and packaging materials. These requirements were supported with documented source selection and approval records including inductively-coupled plasma (ICP) test data, meticulous procurement source control and secondary supplier management to the same requisite Environmental Quality Assurance activities. The latter resulted in Curtis Industries coordinating, testing and documenting material changes to standard third-party products in an effort to satisfy the Green procurement requirements.

2.2 Standard Product Results

The Global 100 Corporation conducted an extensive search for applicable standard DC input power terminal blocks. That search resulted in zero candidates for stand-alone standard products as well as no potential existing products that could be modified to meet the specification. Standard products were eliminated from consideration due to the following shortcomings:

- 2-Pole configuration only (3-Pole required)
- Lack of integrated switch and LED indicator
- Base dimensions in excess of specified 30.5mm x 53.3mm maximums
- Mounted height in excess of specified 13.7mm maximum (typ. 19.1 - 25.4mm)
- Compliance with the environmental (Green procurement) requirements was not readily available or, in some cases, not achievable. As a result, environmental compliance was not verifiable.

In addition to a lack of available standard options, terminal block manufacturers were technically incapable of or unwilling to develop a custom solution that met all design requirements.

Figure 2: *Typical feed-through terminal block, switch and indicator offerings for telecomm and similar applications*

3. Innovative Product (Solution)

The Global 100 Corporation shared their DC Terminal Block specifications with over 10 leading terminal block manufacturers. Most participants "no bid" the project stating it was "impossible" or "unachievable" to develop in the available footprint. Curtis Industries was the only company to present a unique design that met project requirements on-time and within budget.

3.1 Product Design Highlights

The requirements specified a high-current DC wire entry in a small modular footprint, combined with an on/off switch and power indicator LED. Curtis Industries viewed this specification challenge as an opportunity to showcase its Innovative Engineering Solutions expertise and commitment to design excellence.

The following four (4) distinct project requirements highlight the design methodology and sequence:

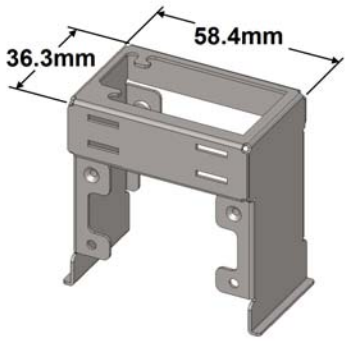


Figure 3: *Defined footprint for the DC input module, the same as the AC Power Entry Module.*

Understand Product Intent

Curtis Engineers analyzed the product application and specification requirements for the DC Power Option.

Selection of Standard Product Components

Material sourcing required an extensive search to obtain standard commercially available building blocks (switches, LEDs, Wire Lugs) etc.

Environmental (Green procurement) Compliance

One hundred percent of materials (above) were selected for Green procurement compliance in accordance with the design specification.

Design Layout

The DC Block design required a creative approach to layout decisions critical to placement of components. There was insufficient space to accommodate component devices on a simple X-Y plane, so Curtis Industries selected placement of certain components (above and below) each other. This unconventional approach to device placement allowed Curtis to meet technical and agency requirements associated with project specifications.

Figure 4: *Final design model which meets all requirements as defined by both OEM design control organizations.*

3.2 Key Benefits

Curtis Industries was able to successfully integrate the DC Terminal Block into a space similar to height and width of a

standard 9-volt battery. Curtis Industries designed a three pole wire entry (rated at 33 amperes) with a rocker switch, power indicating LED and a transparent finger-safe cover that met NEBS telecommunication equipment requirements. In addition, the complete design was constructed so that it mounted into a punched sheet-metal opening with only two screws, hidden from below for a tamper-proof installation to promote additional user safety.

Curtis Industries utilized the space available within the metal mounting bracket to drop the threaded electrical terminals below the mounting surface. This innovation allowed the design to remain within the 13.7mm height restriction and created "pockets" which surrounded each terminal, aiding in the finger-safe functionality and maintaining spacing requirements per UL.

The signal-level switch and LED were integrated into a common cable assembly and then terminated with a conventional connector. This Design-for-Installation allowed the user to simply mount the DC Terminal Block with two screws, and then plug in the connector to the mother board.

4. Summary

4.1 Product Innovation

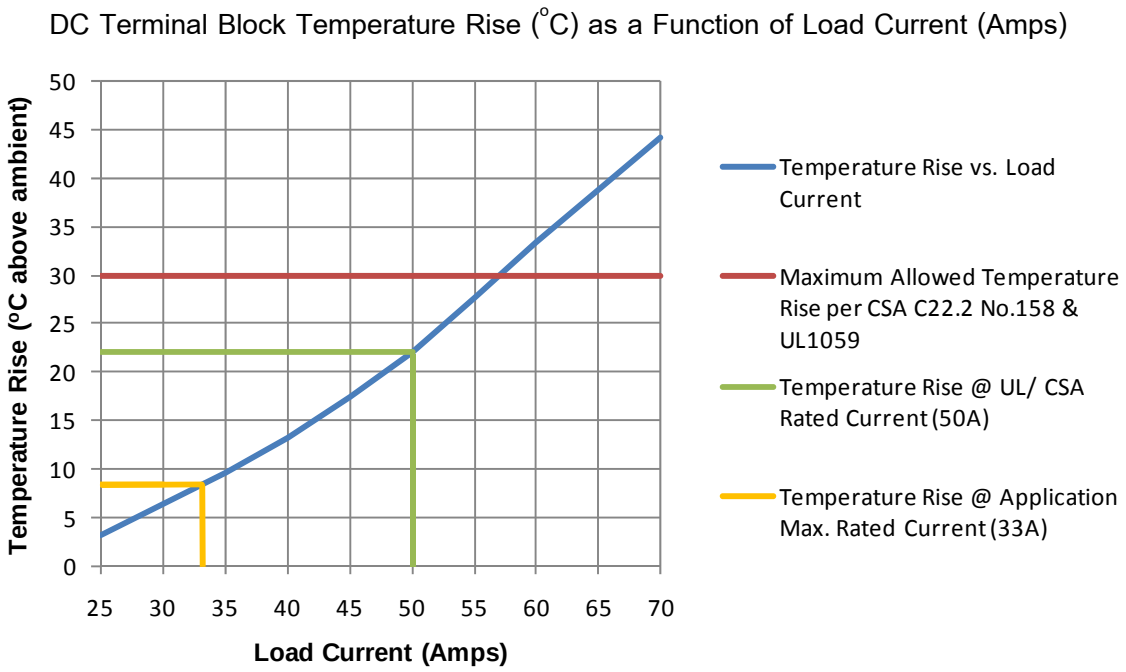
Curtis Industries quickly implemented internal design and development procedures after a detailed analysis of the electrical and thermal specification, regulatory, and environmental requirements.

The next step was to produce a viable DC terminal block integrated design for consideration by the customer. Once the design was pre-approved, further development of solid models allowed for product evaluation of the solution before tooling fabrication was initiated. The pre-production phase began following the completion of verification procedures. Curtis Industries was able to incorporate several key design and cosmetic change requests thoughout the entire soft-tooling fabrication process to meet the evolving specifications and ensure proper fit, form and function.

Curtis Industries initiated various rapid prototyping design and regulatory evaluations of the proposed solution. Included in the design analysis, as well as regulatory evaluation, was a thermal analysis of the terminal connections and subsequent heating of the terminal block component. The goal was to enhance electrical efficiencies to minimize the thermal impact to the overall power supply design.

In pursuit of this objective, Curtis Engineers focused on an electrically efficient mechanical connection developed through the proper selection of conductor material, plating, terminals and hardware while maintaining "green" procurement compliance requirement. The result was a thermal temperature rise, within the terminal block alone, of less than 9^{o}C at the (end-item) maximum rated current of 33 Amps. The design also yielded a moderate 22^{o}C rise at the component design current of 50 Amps. With a 30^{o}C rise (above ambient) allowed by regulatory standards, there is additional margin for application de-rating or an increased maximum current rating.

Figure 5: *Custom terminal block solution integrated with the Integrated Services Router DC power supply.*



Upon full (customer and regulatory) approval of the design, Curtis Industries was able to quickly transition from pre-production to volume mass production within the defined schedule requirements. Drawing upon its resource teams in the USA, China and Mexico, Curtis Industries successfully coordinated the smooth integration of the activities and produced prototypes and end products that met the customer's critical timeline.

Curtis Industries' collaborative design approach and efficient design process allowed for delivery of an innovative solution to this real-world problem. Curtis managed the development schedule, tracking the design progress, product synthesis and measured results of the performance evaluations. This led to timely delivery of an innovative, fully compliant custom product within budget.

4.2 Custom Capabilities

Curtis Industries' key market differentiator is its ability to solve complex technical challenges for prominent OEM clients. The company's engineering team takes on the role of consultant/analyst to propose unique and compelling product solutions.

Curtis Industries is currently celebrating its 78th year as an innovative global provider of hardware solutions to leading Fortune 500 and Military corporations. Product core competencies include EMI filtering technologies, terminal blocks, engineered molded products, and custom cable assemblies. With capabilities in the USA, Mexico, and China, Curtis is able to respond quickly and effectively in offering solutions, on-going manufacturing and support.

From a strategic perspective, Curtis creates collaborative design and development partnerships to support next generation OEM designs and technology roadmaps. If you are designing a new or modified device for a project, please call Curtis Industries @ (414) 649-4215 to get started.