Eberle Design Inc.

SSM-LE Series

Enhanced Signal Monitor Unit

- Training Seminar -

EBERLE DESIGN INC.

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Introduction

- Goal: Better Understand Monitor & Cabinet System Operation.
- Topics
  - » General Signal Monitor Concepts
  - » EDI SSM-LE Installation
  - » Basic Trouble Shooting
  - » ECcom Software

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Not all symptoms of cabinet equipment malfunctions lead to the most obvious remedy.

These topics are intended to give an overall view of the important concepts needed to understand the operation of a basic signal monitor and in particular the EDI SSM-LE series Signal Monitor Unit.

These skills are needed to quickly and effectively trouble shoot a malfunctioning intersection.

Motivation

- Signal Monitors help ensure proper intersection operation.
- Signal Monitors help trouble shoot malfunctioning equipment.
- Liability risks have increased dramatically.
- Costs of trouble shooting & repairing malfunctions has increased.

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The purpose of the signal monitor is to detect and respond to improper and potentially dangerous operating conditions resulting from the malfunction of the cabinet equipment, field wiring, or signal heads.

The diagnostic tools built into modern signal monitors can be used to quickly diagnose the cause of the malfunction and document the details. The signal monitor should be considered a tool just as a voltmeter or laptop computer would.

STOP - LOOK - THINK - ACT

In order to help reduce liability risks, the first defense is to ensure that any malfunction is properly detected and responded to. A working and correctly installed signal monitor provides this function.

The sooner an intersection is returned to operation the better, both from a safety perspective and moving traffic perspective. Maintenance budgets are getting tighter putting more emphasis on quick and effective repair.

SSM-LE series Overview

- Exceeds all requirements of NEMA TS1-1994
- EDI SSM-LE enhanced functions
  - » Full LCD Intersection Display
  - » True Rms Voltages
  - » Dual Indication and Clearance Monitoring
  - » Full Event Logging

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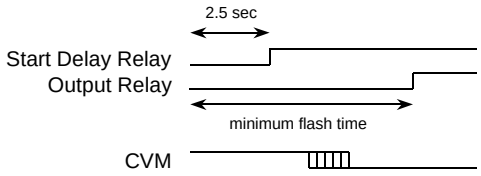
The SSM-LE is an enhanced monitor that meets or exceeds all the requirements of NEMA TS-1. Enhancements have been made to provide a broader fault coverage as well as more diagnostic capabilities.

Power-up & Flash Operation

- The monitor *Output* Relay controls the mercury contactor and flash transfer relays.
- The monitor *Start Delay* Relay controls AC power to the CU.



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The monitor Output Relay has the ultimate control of flashing operation. The relay provides the AC Line voltage to the mercury contactor and flash transfer relays when signal operation is desired. It usually is wired in series with the Police Flash switch.

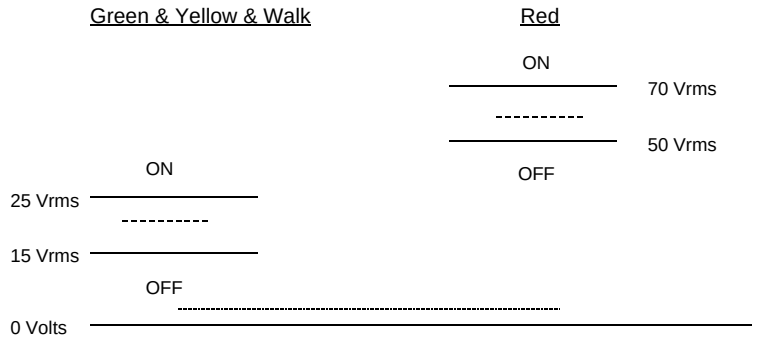
The Minimum Flash period is designed to provide up to 15 seconds of hardware flash following a power-up, power interruption, or low voltage condition. All equipment in the cabinet should be operational before the minimum flash interval times out.

The Start Delay Relay is wired to provide AC Line to the Controller Unit (CU). A 2.5 second delay will occur following a power-up, power interruption, or low voltage condition, before power is restored to the CU. This helps ensure that the AC service has stabilized and the CU has been initialized.

The CVM output may be asserted False by the CU until it has completed power-up diagnostics. This ensures that the intersection will not leave flash mode before the CU is ready.

Field Input Thresholds

- The SSM-LE is a voltage sensing device



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Signal monitors are voltage sensing devices. The thresholds for sensing a signal as ON or OFF are set differently for Green and Yellow colors than Red. This is due to the nature of the fault monitoring for each color set.

For Conflicts the monitor should sense a signal ON when the bulb first becomes visible as the voltage is increased. The Conflict fault exists when a signal is On when it should be Off. For Red Fail, the monitor should sense a signal OFF when the bulb first starts to become not visible as the voltage is decreased. The Red Fail fault exists when a signal is Off when it should be On.

A monitor shall sense a signal as OFF when its RMS voltage is below the lower threshold (15v / 50v). A monitor shall sense a signal as ON when its RMS voltage is above the upper threshold (25v / 70v). A monitor may or may not sense a signal as ON when the voltage lies between the upper and lower thresholds.

SSM-LE Faults

- Conflict
  - » Detects two or more active *proceed* channels which are programmed to be incompatible.
  - » Timing: 200 ms to 450 ms, 350 ms typical.
- Red Fail
  - » Detects a channel which has no active inputs (R or Y or G).
  - » Timing: 700 ms to 1000 ms, 800 ms typical.
  - » Enabled by Red Enable input.

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Conflict

The Conflict function detects two or more active *proceed* channels which are programmed to be incompatible.

A proceed color is a Green, Yellow, or Walk. Conflicts are usually caused by a load switch output shorted ON, a short circuit in the field, or loss of load in the field. Improper programming of the CU or the monitor Program Card can also cause conflicts.

Red Fail

The monitor senses voltage across the load. In most cases a Red Fail is caused by the CU not turning on a load switch, a faulty load switch not turning on an output, or improper programming.

A “dark” signal head may have voltage present at the monitor inputs due to other causes such as loss of the load. A loss of load will NOT cause a Red Fail. Load switch leakage current will usually provide enough voltage that the monitor will sense an active signal. This results in a Conflict or Dual Indication fault.

SSM-LE Faults

- Controller Voltage Monitor (CVM)
  - » The CU will use this logic signal output to indicate a CU problem or to force the monitor to the flash state.
  - » Timing: 150 ms typical, non-latching.
- 24 Volt Monitor (24V-1 & 24V-2)
  - » Monitors two 24 Vdc power supplies.
  - » Voltage: <18 Vdc = fault, >22 Vdc = operate
  - » Timing: 150 ms typical, non-latching.

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Controller Voltage Monitor (CVM)

This logic level signal is normally used by the CU to indicate a malfunction in the CU or improper programming or operation. It may also be used to force a hardware flash state in the monitor for events such as time-of-day flash. CVM may also be False during a start-up sequence while the CU is initializing.

24 Volt Monitor (24V-1 & 24V-2)

These inputs monitor 24V power supplies for proper operation. Proper operation is defined as greater than 22 Vdc. Improper operation is less than 18 Vdc.

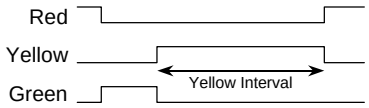
Non-Latching vs Latching

Both functions are defined as non-latching. They may each be programmed to a latching mode using switches on the front panel.

Caution should be taken when latching CVM faults as they are not always indicative of a *fault* condition.

SSM-LE Faults

- *Minimum Yellow* Clearance Fail
  - » Measures the Yellow Change interval for an MUTCD 3 second minimum.
  - » Timing: 2.6 to 2.8 seconds
  - » Enabled by Red Enable input and SSM switches



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The Minimum Yellow Clearance mode ensures that a Green to Yellow to Red sequence has an MUTCD three second Yellow clearance interval. It is measured on vehicle channels which have a true Yellow signal.

To disable this function for a channel which does not have a true Yellow signal, the front panel SSM switch must be in the Off position. This would be the case for pedestrian and protected-permissive left turn channels for example.

This problem is usually related to a controller malfunction, preemption problem, or programming error. In TS-1 monitors, Clearance Fail detection is defined by the manufacturer and different results could be obtained depending on the product type.

SSM-LE Faults

- Dual Indication Fault
  - » Detects more than one active input (color) on a channel.
  - » Can *anticipate* Conflict malfunctions before they are displayed on the signals.
  - » Enabled by Red Enable input and SSM switches (per channel).

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Dual Indication Fail

This monitoring function will detect more than one input of a channel active at the same time. This may be caused by a load switch output stuck ON, a short circuit in the field, or a loss of load (burned out bulbs or open field wire).

If a Green (or Yellow) signal stays ON due to short circuit or load switch failure it will be detected as a Dual Indication fault when the Yellow (or Red) signal on that channel activates. This will put the intersection to flash before the next conflicting phase is active, preventing a conflict display in the field.

Similarly, a loss of the Red load will be detected when that channel cycles to Green.

This function also works in conjunction with Red Fail to ensure that all channels are being monitored (e.g. harness problem).

Timing: 300 ms to 450 ms, 400 ms typical.

SSM-LE Faults

- Ext Watchdog Fault (CVM / Watchdog)
  - » Used to monitor an external toggling logic signal. Must be harnessed at the factory.
  - » Enabled by WD ENABLE Option switch.
- Diagnostic Fail
  - » Internal MPU watchdog circuit
  - » ROM, RAM, or EEPROM failure
  - » Internal power supply failure

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External Watchdog Monitor

Used to monitor external flashing logic circuits or other devices. This function expects to sense a logic transition at least every 1500 ms. The input is harnessed internally to a spare MS pin.

Diagnostic Fail

The SSM-LE has many internal diagnostic tests that ensure proper operation of the monitor. THIS DOES NOT TAKE THE PLACE OF REGULAR MONITOR TESTING! If the Diagnostic Fail LED has illuminated, other LEDs or LCD displays may not be valid. The unit should be tested before returning to service.

SSM-LE Faults

- Recurrent Pulse Detection
  - » Detects intermittent or pulsing signal conditions which may not meet the requirements of typical continuous fault detection algorithms.
  - » The RP STATUS indicator will illuminate with the Conflict or Red Fail or Dual Indication indication.

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The Recurrent Pulse detection (RP STATUS) function is designed to respond to fault conditions which are intermittent in nature and do not meet the continuous timing requirements of the normal detection algorithms, yet may still produce improper signal displays. These input conditions are differentiated by their longer time constant and fault response times.

The figure shows an example of a recurrent Conflict fault. Channel 2 Green is detected active due to a malfunction of the load switch which caused the output to “flicker” On for 100 ms approximately every 200 ms. Since normal Conflict detection requires a continuous fault of at least 350 ms typical, this event could go undetected. The Recurrent Pulse detection algorithm will combine these pulses into one event and trigger a Conflict fault once the longer recurrent timing threshold is exceeded.

AC Line Power Failure

- Power Failure is defined as AC+ voltage less than 92 Vac.
- SSM-LE will respond if failure is greater than 500 ms.
  - » Start Delay and Min Flash sequence
- SSM-LE will not respond if failure is less than 450 ms.
- The SSM-LE restore voltage is 96 V max.

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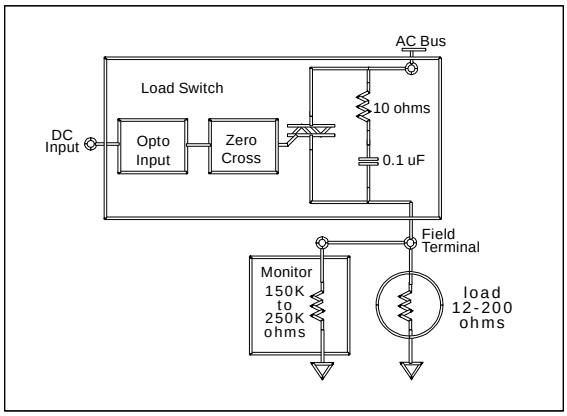
In TS1, an AC interruption was defined as zero volts. Early monitors would not differentiate between a true interruption and a low voltage condition (AC < 95 Vac). Because of a lack of definition in the Standard, power-up, power-down, and low voltage operation often resulted in nuisance faults requiring a service call to reset the monitor.

The SSM-LE is designed to be the first device to recognize a low voltage condition (resulting in flash) and the last device to recognize proper operating voltage (resulting in colors).

Factory levels for the SSM-LE thresholds are typically set for 92 Vac drop-out and 96 Vac restore.

Load Switch Leakage Current

- Load Switch Block Diagram



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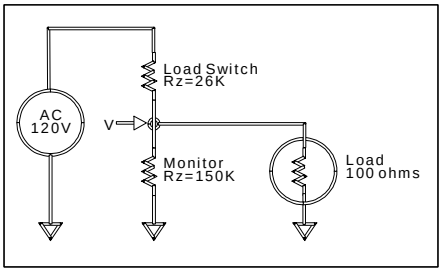
Because a monitor only senses voltage across the signal load and not current, the effect of driving the load with a solid state Load Switch can produce unexpected results when a component malfunctions. The effect of leakage current is important to understand for trouble-shooting reasons and proper system design especially as new signal technologies become available.

The load switch has a DC input which is optically isolated from the AC Line voltage. When a voltage less than 6 Vdc is applied to the input the input circuit will activate. The zero-cross circuit synchronizes the turn-on to the AC Line. The triac device will only conduct in one half cycle periods.

The triac needs to be protected against transient voltages by the resistor / capacitor snubber circuit shown. Off-state leakage current does not come through the triac switch, but through this snubber.

Load Switch Leakage Current

- AC impedance of snubber capacitor
  - » 1/(2*pi*f*C) = 26 Kohms (C=0.1 uf, f=60 hz)
- Leakage current approximation
  - » 120v / 26K = 5 ma
  - » Vm = (99 / 26.9K) * 120v = 0.5 Vac



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The leakage current can be easily estimated by knowing the value of the snubber components. A capacitor looks resistive to an ac voltage. The equivalent *impedance* is calculated as shown. Typical values for snubber capacitors range from 0.05uf to 0.1uf.

Most off-state signals will have a residual voltage due to this leakage current on the order of 0.5 Vac to 3 Vac depending on the value of the snubber and load. Since this value is less than the 15 V and 50 V thresholds, they are sensed as OFF.

The off-state voltage can be estimated by the leakage current (5ma) multiplied by the load resistance (100 ohms). When this off-state voltage increases to the 15 V to 25 V range on a Green or Yellow or Walk input, the monitor may incorrectly sense it as ON.

The maximum TS2 load impedance can be shown to be 2100 ohms for Green, Yellow, and Walk, and 7000 ohms for Red. New technologies using solid state power supplies and LEDs must accommodate this *parameter*.

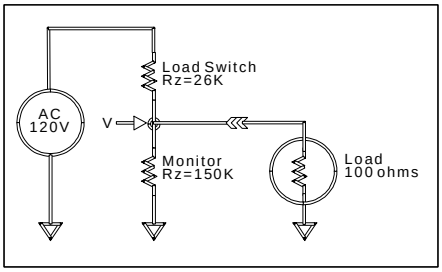
Capacitors can also be used as loads where power dissipation is an issue. Care should be taken since capacitor discharge times will skew the monitor sensing point and may cause Conflict or Dual Indication faults.

Example calculation for a 2000 ohm equivalent capacitor:

C = 1 / (2*pi*f*R) = 1.3 uf

Load Switch Leakage Current

- Loss of load does *not* produce a Red Fail!
  - » Vm = (150K / 176K) * 120V = 102 Vac
- The Monitor will detect a loss of load as an <u>active</u> signal.



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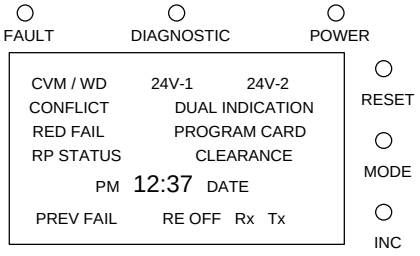
When the load is removed from the load switch output, the <u>monitor</u> becomes the load. Recalculating the off-state voltage shows a residual voltage of 102 Vac. This will be sensed as an *active* signal by the monitor whether it is a Green, Yellow, Walk, or Red.

Thus, a loss of load will not cause a Red Fail, but will be detected as a Conflict fault (for Green, Yellow, or Walk) or a Dual Indication fault (for Green, Yellow, Walk or Red).

A good trouble shooting practice is to measure the off-state voltage of each input and ensure that is is less than the monitor minimum threshold.

SSM-LE Fault Status Display

- The Fault Status display shows the type, time, and date of the fault. The FAULT led will be illuminated.
- If no fault is present, current time and date are shown.



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The top display panel shows the current fault status. If no fault is present the display shows current time and date alternately.

If a fault is present (FAULT Led illuminated), the display will indicate the type of fault detected and the time and date of the fault event. This data is latched until the fault is reset.

RE OFF is illuminated if the Red Enable input is not active. Rx and Tx are illuminated to indicate that the RS-232 port is active.

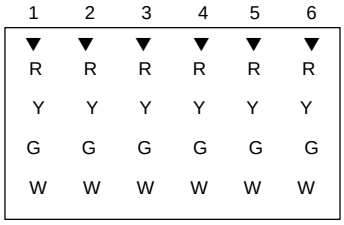
PREV FAIL will be illuminated when the Previous Failure event log is being displayed.

The DIAGNOSTIC Led will be illuminated when an internal Diagnostic error is detected in the monitor hardware.

The POWER Led will be illuminated when AC power is above the brownout threshold. It will flash when the AC power is below the brownout threshold. It will extinguish when the AC power is less than 75 Vac.

SSM-LE Channel Status Display

- The Channel Status display indicates currently active signals or signals active at the time of the fault.
- The ▼ symbol indicates channels involved in the fault event.



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The Channel Status display shows the complete intersection field signal status. If no fault is present (FAULT Led Off) the display shows currently active field signal states. If a fault is present (FAULT Led On), the display indicates signals active at the time of the fault.

The ▼ symbol will be displayed above any channels that were involved in the fault.

SSM-LE Display Modes

- The MODE button will control the display mode:
  - » Current Status
  - » Previous Fail Event Log
  - » AC Event Log
  - » Program Card & Front Panel Switch Verification
  - » Clock Set
- The INC button changes the page displayed in the selected mode.

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Each time the MODE button is pressed the display changes to the next mode.

Previous Fail Event Log displays fault type, time and date plus signal status for 25 previous fault events. The INC button displays the next fault event.

Pressing the MODE button again brings up the next display mode, AC Line events. Each event (40) is shown as an AC ON or AC OFF event with time and date. Only an AC Line condition that causes the Output Relay to transfer is entered into the log.

Pressing the MODE button again brings up the next display mode, Configuration status. The primary channel is denoted with the ▼ symbol. Each secondary channel that is permissive with the primary channel is shown with the GYW indicators illuminated. Pressing the INC button moves to the next primary channel.

Following the last primary channel, the SSM switch status is shown for each channel with the ▼ symbol and the RYGW indicators illuminated.

If the unit is not currently in the fault mode the next MODE button closure changes to the clock set mode.

EDI SSM Switches

- Signal Sequence Monitor (SSM) switches enable both Dual Indication monitoring and Clearance monitoring when in the ON position.
- The switches should be in the ON position for vehicle channels and other channels which have a true Red, Yellow, and Green load.

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Signal Sequence Monitor (SSM) switches in the ON position enable the Dual Indication and Clearance monitoring functions on an individual channel basis.

An SSM switch should be OFF for channels that have the Red input tied to AC Line such as the left turn signal of a 5 section head, pedestrian channel, or any unused channels. An SSM switch should also be OFF for any channels that do not monitor all three outputs of the corresponding Load Switch such as a pedestrian channel with no Yellow load.

EDI Option Switches

- GY ENABLE
  - » Provides G-Y Dual Indication monitoring for 5 section heads
- RP DISABLE
  - » Disables Recurrent Pulse Monitoring for test purposes
- WD ENABLE
  - » Activates the External Watchdog Monitor

continued

GY ENABLE

This function may be used for 5 section signal heads with the missing Red arrow input tied to AC Line.

If the GY ENABLE switch is in the ON position, then all channels will detect a Green and Yellow Dual Indication fault on that channel.

If the GY ENABLE switch is in the OFF position, then any channel that has its SSM Switch in the OFF position will not detect any Dual Indication fault on that channel.

RP DISABLE

To facilitate monitor bench testing, it may be necessary to disable the Recurrent Pulse detect function. Placing the switch in the ON position DISABLES RP monitoring.

WD ENABLE

Placing this switch in the ON position causes the unit to monitor a watchdog output from another device. It must be correctly harnessed by the factory to operate. If this option is not used then the switch should always be in the OFF position.

For all EDI monitor products, the *name* of the option switch is what happens when the switch is in the ON position.

EDI Option Switches

- Walk Disable
  - » Excludes Walk inputs from Red Fail detection
- CVM Latch
  - » CVM fault is latching
- 24V Latch
  - » 24 Volt fault is latching
- CVM LOG DISABLE
  - » Prevents CVM events from being logged

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WALK DISABLE

Placing this switch in the ON position removes the Walk inputs from the Red Fail calculation. Red Fail -> G=Off and Y=Off and R=Off.

CVM LATCH

Placing this switch in the ON position makes a CVM fault latching. This requires proper setup of minimum flash time and controller operation.

24V LATCH

Placing this switch in the ON position makes a 24 Volt fault latching.

CVM LOG DISABLE

If CVM events are not intended as fault events (such as TOD flash), placing this switch in the ON position will prevent all CVM events from being placed in the event log.

For all EDI monitor products, the *name* of the option switch is what happens when the switch is in the ON position.

EDI *ECcom* Software

- Displays RMS field status, cabinet voltages and temperature, time clock, ID
- Retrieves, displays, stores event logs:
  - » Previous Fail events
  - » Fault Reset events
  - » AC Line events
  - » Configuration Change events
  - » Chronological event sort
- Signal Sequence history of signals 30 s prior to fault

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The EDI *ECcom* software package interfaces a Computer to the SSM-LE. All events are time stamped with the time and date of the event. A monitor ID number and description may be assigned to the monitor.

RMS Field status and control input status can be obtained from the monitor in real time. Current configuration is displayed as well as time clock setting, monitor ID, cabinet voltage, temperature, and configuration check value.

Event logs may be uploaded, displayed, stored as Ascii files, and printed. Monitor logs may also be cleared individually. The following event logs are available: Previous Failures, AC Line Events, Manual Reset Events, Configuration Change Events.

A chronological sort displays all event types sorted together by time stamp value.

The Signal Sequence display will show all signal states for up to 30 seconds prior to the current fault. This buffer is retained after reset but is overwritten with the next fault. This display is extremely useful for diagnosing intermittent signal problems.

SSM-LE Enhanced Signal Monitor

Setting the Standard
For
Quality and Reliability

Eberle Design Inc.

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Thank you for using Eberle Design products.

Our goal is to provide you with the highest reliability, performance, and customer satisfaction possible.

Your inputs and comments are highly appreciated.