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Power Converters for Interfacing Tractors and Trailers

The Objective

This paper describes three circuit configurations for achieving tractor trailer interfacing. Prevailing methodologies are described together with an analysis of their reliability, performance and relative cost.

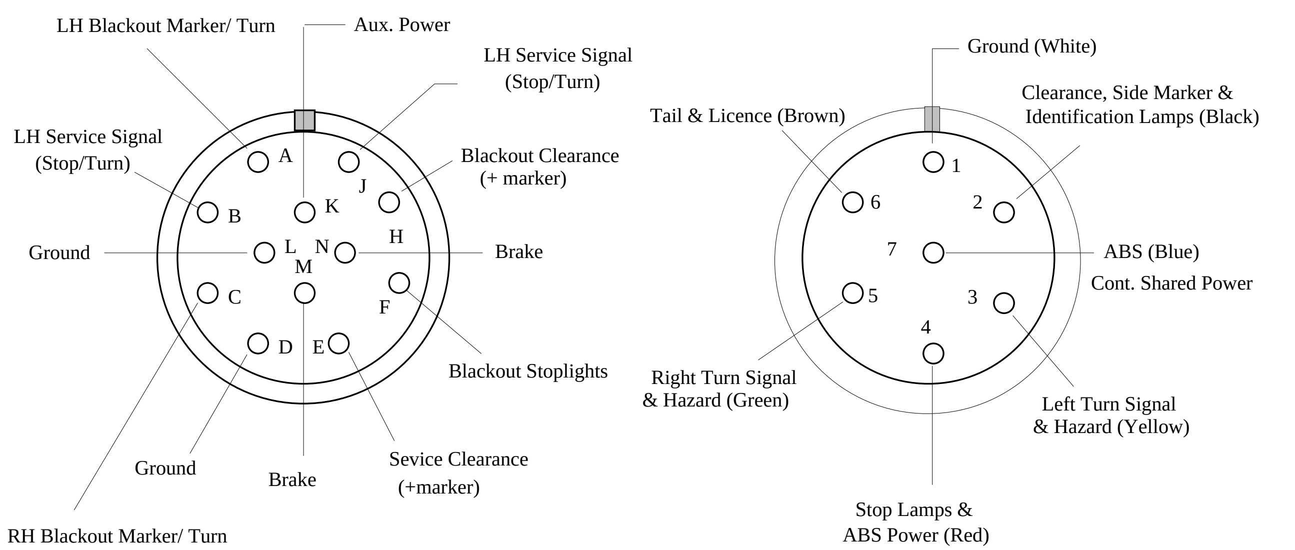
The Purpose of Interfacing

Electrical Systems of North American Commercial vehicles are unlike those of Europe and the NATO Military. They operate at different voltages and use dissimilar connectors. As a result the direct coupling of a North American commercial trailer to a military highway tractor or military trailer to North American tractor is not readily possible. The same holds true for cross connecting European and American vehicles.

Electrical Trailer Interfaces make possible such cross coupling.

The Differences Between the Military and Commercial Electrical Pin Outs

See Figure #1 below for configuration differences.



24 Volt Connector Pin Functions For a Military Tractor
(Connector A)
MS75021

12 Volt Connector Pin Functions on Commercial Trailer
(Connector B)
SAE J560

Figure 1

The Task of the Interface

a) To ensure that the presence of signal at any given pin or combination of pins of the tractor are translated into an equivalent functional signal at the proper pin of connector of the trailer.

b) To convert the voltage level of a power signal or combination of signals at the tractor output connector to a power signal of acceptable voltage at the intended pin of the trailer connector.

Configurations

There are three commonly known topologies available for achieving such an interface. They are:

A) Power resistor voltage divider configuration
B) Centralized power switching regulator configuration
C) Distributed switching regulator configuration

They are described below with commentary citing their respective advantages and disadvantages.

A) Power Resistor Voltage Divider

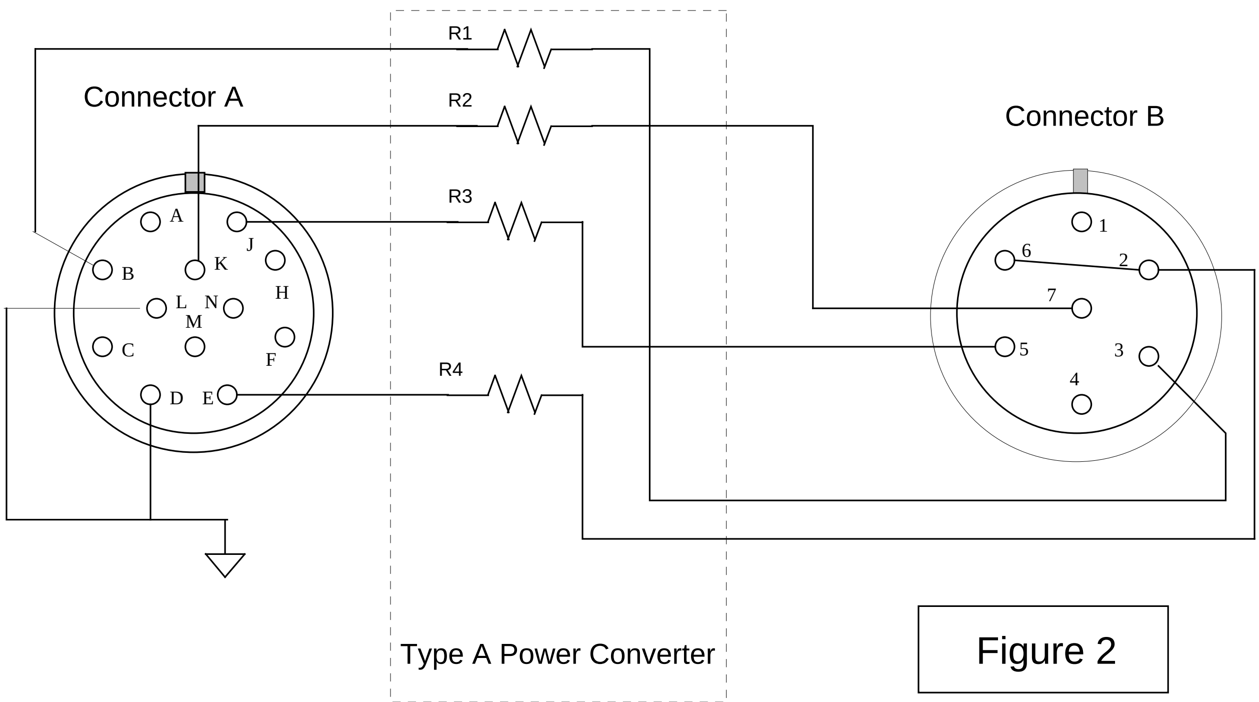


Figure 2

Figure 2 illustrates the Power Resistor Divider for reducing the voltage to the respective pins that are supplied from Connector A to Connector B.

The voltage is reduced by drawing current through fixed resistors. The value of any one resistor is determined by dividing the voltage which is to be dropped across the resistor by the current which it is intended to conduct. For this particular example, the voltage to be dropped across the resistor will be approximately 12 Volts, in order to bring the voltage to the Connector B pin down to 12 VDC from 24 VDC.

For example if pin 7 on connector B had a fixed 10 Amp load, the resistance R2 would be calculated to be 12/10 or 1.2 ohms.

This resistor would also have to dissipate power which is calculated by multi[plying the volts across itself by the amperes going through it. In the case above, 12 VDC x 10 A = 120 Watts

Method A disadvantages:

1) Ideally this method of power transformation can be no more than 50% efficient i.e. for every watt of power transformed, 1 watt is dissipated as heat. The ramifications for an entire trailer is that 400 to 800 watts would have to be dissipated as heat under anticipated operating conditions. The source for this dissipated power, the tractor electrical system would have to be able to furnish this power.

2) The housing to contain the power resistors has to be of large volume in order to enable the components inside to remain within their operating temperature limits.

3) Because the voltage drop across the resistor depends on the load current, this method has inherently very poor regulation and can lead to sequential component failures. For example, there are four bulbs loaded on one pin as shown in figure #3.

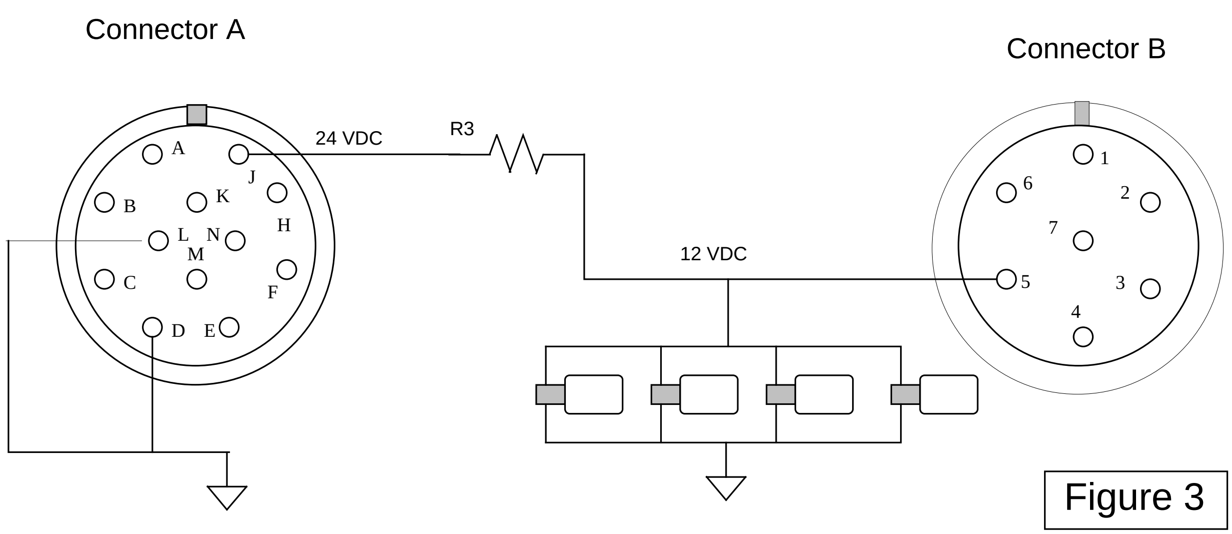


Figure 3

Should one of the bulbs burn out and become open circuited, the voltage at pin 5 would climb by approximately 2 to 3 Volts. This higher voltage would precipitate the failure of the another bulb in the remaining functioning group of three. Its failure in turn would cause the voltage to climb an additional 2 to 3 volts. The remaining bulbs would fail very quickly thereafter.

4) This characteristic of poor voltage regulation, i.e. a measure of how well the voltage is maintained at the output pin, would also limit the number and characteristics of accessories that could be loaded off the auxiliary (blue) pin.

5) If a short circuit were placed across the load at pin 5, the resistor R3 would have to withstand double the power dissipation that it would normally support under full load. Therefore its wattage (power) rating would have to be at least twice its intended full load dissipation level (this is without safety margins).

6) Power resistors of high dissipation capacities are large, and do not withstand shock and vibration as well as small components. Because of their high hot spot temperatures, they are inherently unreliable. They have a very low MTBF (based on Mil handbook 217).

7) This method cannot be used for stepping up voltage as in the case of a 12V tractor and 24V trailer.

Method A advantages:

1) This method is the least expensive when compared to alternate methods.

2) Has a simple circuit with low component count.

3) If the output of one pin should fail the others remain unaffected

Method B - Centralized Power Switching Regulator (Figure 4)

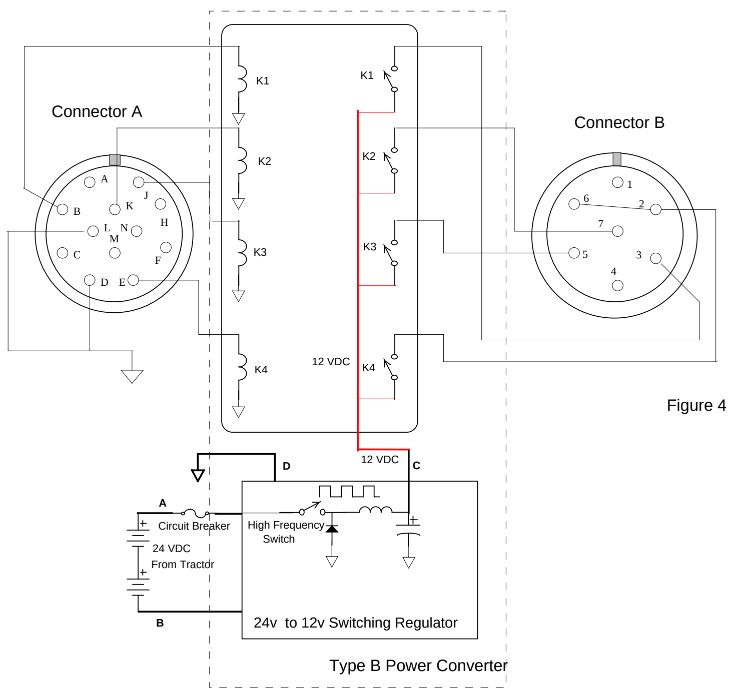


Figure 4

Description of Figure 4

Bulk power is imported from the tractor through cables A and B to the 24V to 12V switching regulator mounted on the trailer. These cables must be of sufficient gauge in order to carry the complete electrical demand of the trailer. The Switching Regulator (SR) converts the 24 Volts to 12 VDC at a high efficiency. Signals are then applied from the tractor connector pins (connector A) to a relay network which is housed with the SR in the same converter box. The relay network is energized in a fashion as to translate the tractor signal into an equivalent signal on (Connector B) the commercial connector.

Method B Advantages:

1) The transformation of power from 24 VDC to 12 VDC is efficient, usually about 85% to 88%. This translates into dissipative losses of up to approximately 100 Watts for output load conditions of 800 Watts. This condition is manageable from a heat evacuation stand point.

2) This configuration offers excellent regulation, i.e. the 12 VDC output of the switching regulator will fluctuate very little as load is varied.

Method B Disadvantages:

1) The towing military tractor would require the addition of connectors/wire harnessing to enable the delivery of the trailer’s entire electrical demands through the two wires A and B.

2) The nature of this converter configuration implies that should the switching regulator fail, the entire trailer would lose power.

3) A heavy circuit breaker would have to be installed in line A for short circuit protection.

4) Some of the magnetic components of the switching regulator would be relatively large, making them vulnerable to shock and vibration effects.

Method C - Distributed Power Switching Regulators (Figure 5)

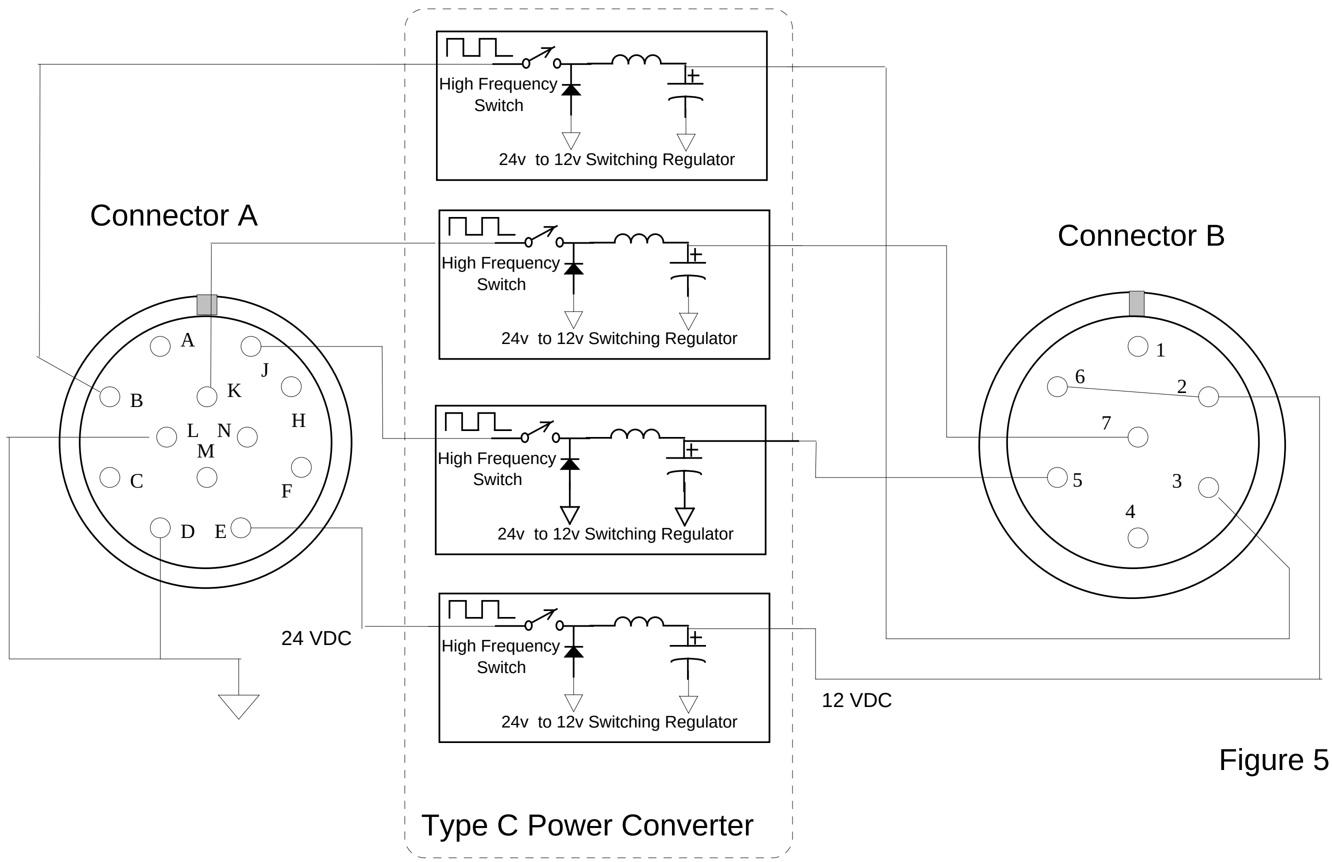


Figure 5

Description of Figure 5:

The Type C power Converter has multiple lower power switching regulators of the type described in Method B. Each switching regulator is designed to deliver only the maximum intended power of the trailer pin that it is servicing. Each switching regulator takes its input power from a designated tractor pin and then delivers its output power to a specific trailer pin. In this way the signals of the Military connector are reconfigured to be compatible with the commercial connector convention.

Method C Advantages:

1) This converter offers the highest efficiencies of all of the configurations at 92% causing minimal heat dissipation.

2) The entire trailer demand is distributed through multiple switching regulators each with inherently higher efficiency than the single bulk regulator type (method B). This results in physically small circuit components that lend themselves to encapsulation. Encapsulation can be used to fortify the circuit against shock, vibration and environmental effects.

3) Because each switching regulator operates independently, its failure would have no effect on the pins powered by the other switching regulators in the system.

4) Because the entire trailer power consumption is channeled through multiple switching regulators, whatever little heat is generated, is dissipated evenly within the converter. Thus hot spotting is avoided.

5) Because each switching regulator is designated to deliver power for one function with limited current, the maximum current load can be electronically current limited in each regulator thereby eliminating the need for additional fusing.

6) This configuration requires no special additions to the towing vehicle as part of installation.

7) Designed without large electronic components this circuit lends itself to low profile packaging.

8) Of all the configurations, it is the most reliable.

Method C Disadvantages:

1) Of all the configurations, it is the most costly to produce.

SEC trailer interface models have a method C topology.

written by: D. Davis
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