

OPERATOR'S MANUAL

KFD 15-10-28W POWER SUPPLY

15 VOLTS OUTPUT
18 TO 36 VDC INPUT
150 WATTS

KEPCO INC.
An ISO 9001 Company.

MODEL KFD 15-10-28W POWER SUPPLY

ORDER NO.

REV. NO.

IMPORTANT NOTES:

- 1) This manual is valid for the following Model and associated serial numbers:

MODEL	SERIAL NO.	REV. NO.
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- 2) A Change Page may be included at the end of the manual. All applicable changes and revision number changes are documented with reference to the equipment serial numbers. Before using this Instruction Manual, check your equipment serial number to identify your model. If in doubt, contact your nearest Kepco Representative, or the Kepco Documentation Office in New York, (718) 461-7000, requesting the correct revision for your particular model and serial number.
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TABLE OF CONTENTS

SECTION		PAGE
1.0	Introduction:.....	1
2.0	Description:	1
3.0	Absolute Maximum Ratings:.....	1
4.0	Input Specifications (see Table 1):	1
5.0	Output Specifications (see Tables 2, 3, and 4)	2
6.0	General Specifications (see Table 5)	3
7.0	Feature Specifications (see Tables 6 and 7) 4	
8.0	Output Overvoltage Clamp.....	4
9.0	Current Limit.....	4
10.0	Remote ON/OFF	4
11.0	Output Voltage Reversal	5
12.0	Isolation	5
13.0	Parallel Operation.....	5
14.0	Forced Load Sharing.....	5
15.0	Remote Sense.....	6
16.0	Safety Considerations	6
17.0	Output Voltage Trim	6
18.0	Thermal Considerations	7
18.1	Case Temperature.....	7
18.2	Forced Convection.....	7
18.3	Heat Sink Models.....	7
18.4	Natural Convection	7
18.5	Use of Graphs.....	8
18.6	Thermal Models	8
18.7	Detailed Thermal Model.....	9
18.8	Radiation Heat Transfer.....	9
18.9	Horizontal Orientation	9
19.0	Fusing Considerations.....	9
20.0	General Features	10
21.0	Applications	10

LIST OF FIGURES

FIGURE	TITLE	PAGE
1	Test Setup For Output Voltage And Efficiency Measurements For The DC to DC Converter	11
2	Test Setup for the Input Reflected Ripple for the Single Output KFD DC To DC Converter.....	12
3	Mechanical Outline Drawing of the Single Output KFD DC to DC Converter	13
4	Remote On/Off Wiring Configuration for the Single Output KFD DC to DC Converter	14
5	Wiring Configuration For Redundant Parallel Operation Of The KFD DC To DC Converter	15
6	Circuit Configuration for Single KFD DC to DC Converter Remote Sense Operation.....	16
7	(Top) KFD DC to DC Converter Circuit Configuration for $R_{Trim\ Down}$, to Decrease Voltage Setpoint..	17
8	(Bottom) KFD DC to DC Converter Circuit Configuration for $R_{Trim\ Up}$, to Increase Voltage Setpoint	17
9	Heat Sinks for Vertical Orientation - Kepco Model KFD-02 and the Kepco Model KFD-04	18
10	Heat sinks for Horizontal Orientation - Kepco Model KFD-01 and the Kepco Model KFD-03.....	19
11	Forced Convection Derating, Power Dissipation Versus Local Ambient Temperature	20
12	Heat Sink Derating Curves, Natural Convection, Fins Oriented Along the Width	21
13	Heat Sink Derating Curves, Natural Convection, Fins Oriented Along the Length	22
14	Heat Sink Resistance Curves for Fins Oriented Along Vertical and Horizontal directions	23

LIST OF TABLES

TABLE	TITLE	PAGE
1	Input Specifications	1
2	Output Specifications For The Kfd Unit	2
3	Dynamic Response for the KFD Unit	2
4	Output Specifications	3
5	General Specifications	3
6	Remote On/Off	4
7	Feature Specifications	4

1.0 INTRODUCTION:

SCOPE OF MANUAL: This instruction brief contains information for the installation and operation of the Kepco KFD 150 Watt DC to DC Converter. For further operating and service information for the KFD 150 Watt DC to DC Converter contact your Kepco Representative directly, or write to Kepco, Inc., 131-38 Sanford Avenue, Flushing, New York 11352 U.S.A.

2.0 DESCRIPTION:

The Kepco KFD 150 Watt DC to DC Converter has a nominal 18-36 Vdc input and a 15 Volt DC output nominal voltage. The DC to DC Converter is a low-dissipative stabilizer, using pulse-width modulation to control the output. The unit features input/output isolation and remote ON/OFF. Remote ON/OFF is accomplished by an isolated TTL level signal that may use either mechanical or solid state closure. The output voltage may be adjusted with a trimmer terminal located in the upper right hand corner of the unit (see Figure 3, top view). The unit is guaranteed for one year when operated within the specifications given herein.

3.0 ABSOLUTE MAXIMUM RATINGS:

The DC to DC Converter described in this manual is rated for continuous operation when used in an ambient temperature range of 0° to 71°C. Within this range the unit will operate according to the specifications listed below, provided they are not subject to stress. The unit will function with degraded reliability and life if operated at the extreme ends of the temperature range, at -40° to 0°C, or 71°C to 90°C. Specifications Do Not Apply Throughout The Entire Operating Range (-40° To 90°C)

STRESSES IN EXCESS OF THE MAXIMUM RATINGS can cause permanent damage to the unit. THESE are absolute stress ratings only. Functional operation of the unit is not implied at these or any other conditions in excess of those in the following tables.

The following specifications apply to the power supply model listed below:

MODEL	INPUT	OUTPUT
KFD 15-10-28W	18-36 VOLTS DC	15 VDC 10A

4.0 INPUT SPECIFICATIONS (SEE TABLE 1):

TABLE 1. INPUT SPECIFICATIONS

Parameter	Description
Nominal Input Voltage	28 Vdc
Input Voltage Range	18-36 Vdc
Input Current Maximum*	12A ($V_i=0$ to 36 Volts)
Efficiency: $V_i=48$ Volts, $I_o=I_{o, max}$; $T_A=20^\circ\text{C}$ See Figure 1	85% typical 81% minimum
Switching Frequency	100KHz
Circuit Type	Forward Converter
Input Reflected Ripple Current (peak to peak, 5Hz to 20 MHz, 12 μ H source impedance, $T_A=25^\circ\text{C}$, see Figure 2)	50 mA peak to Peak
Input Ripple Rejection (120Hz)	60 dB typical
Inrush Current (I^2t)	2.0 A ² s maximum
*THE KFD MODULE IS NOT INTERNALLY FUSED, AN INPUT LINE FUSE MUST ALWAYS BE USED	

5.0 OUTPUT SPECIFICATIONS (SEE TABLES 2, 3, AND 4)

TABLE 2. OUTPUT SPECIFICATIONS FOR THE KFD UNIT

Parameter	Description
Output Voltage Nominal	15V
Output Current Nominal	10A
Output Power Maximum	150W
Ripple ¹	70mV RMS max.
Noise, 5Hz to 20Mhz	200 mV p-p max.
Output Current Minimum	0.333A
Output Current Maximum	10A
¹ At less than minimum load the DC to DC converter may exceed its output ripple specification	

TABLE 3. DYNAMIC RESPONSE FOR THE KFD UNIT

Characteristic	Specification	
Dynamic Response to Load Change	$\frac{\Delta I_o}{\Delta T} = \frac{1A}{10\mu S} \quad V_I=28 \text{ Volts, } T_A=25^\circ\text{C}$ From $I_o = 50\%$ to $75\% I_{o,max}$ and from $I_o=50\%$ to $25\% I_{o,max}$.	
	Typical	Unit
Peak Deviation	350	mV
Settling Time ($V_o < 10\%$ of Peak Deviation)	300	μS

TABLE 4. OUTPUT SPECIFICATIONS

Parameter	Specification			
	MIN	MAX	TYP	UNIT
Output Voltage (Over All Operating Input Voltage, Resistive Load, And Temperature Conditions)	14.25	15.75		Vdc
Output Voltage Setpoint ($V_i=28$ volts, $I_o= I_{o,max}$, $T_A=25^\circ\text{C}$. Unit Operating In Parallel Or Parallel Pin Shorted To Sense (-) Pin (See Figure 3) Parallel Pin Open	14.70	15.30	15.00	Vdc
Output Short Circuit Current ($V_o = 250\text{mV}$)		17.0	13.5	A
Output Current Limit Inception	10.3	13.0		A
Output Current		10		A
Output Regulation : Line $V_i= 18\text{-}36$ Volts Load $I_o= 1.0\text{A}$ to $I_{o,max}$ Temperature $-T_A =0^\circ\text{C}$ to 90°C		02%	0.05%	%
		0.4%	0.2%	%
		150		mV

6.0 GENERAL SPECIFICATIONS (SEE TABLE 5)

TABLE 5. GENERAL SPECIFICATIONS

Parameter	Specification
Case Temperature (min-max)	Operating: 0° to 90°C Storage: -40°C to 125°C
Isolation Resistance	10M Ohms Minimum
Isolation Capacitance	1700 pF Typical
I/O Isolation Voltage	500 Vdc Maximum
Calculated MTBF (at 80% of $I_{o, max}$, $T = 40^\circ\text{C}$)	920000 Hours
Dimensions	0.66(16.8) X 4.8(121.9) X 2.5(63.5) See Mechanical Outline Drawing, Figure 3
Weight	7.0 OZS (198.45 Grams) Maximum
Cover Material	Non- Conductive Material

7.0 FEATURE SPECIFICATIONS (SEE TABLES 6 AND 7)

TABLE 6. REMOTE ON/OFF

State		Specification		
		Typ	Max	Unit
ON/OFF CURRENT	Logic Low		1.0	ma
ON/OFF VOLTAGE	Logic Low		1.2	V
	Logic High $I_{ON/OFF}=0$		18	V
Open Collector Switch Specifications				
Leakage Current During Logic High ($V_{ON/OFF}=18V$)			50	μA
Output Low Voltage During Logic Low $I_{ON/OFF}=1mA$			1.2	V
Turn On Time ($I_o=80\%I_{o,max}$; V_o within $\pm 1\%$ of $V_{o,set}$)		5	10	ms
NOTES: 1. Remote On/Off (0 Volts $<V_1 < 36$ Volts, Open Collector Or Equivalent, Signal Referenced to $-V_1$ Terminal) 2. Logic Low-module ON; Logic High-module OFF				

TABLE 7. FEATURE SPECIFICATIONS

Parameter	Specification		
	Typ	Max	Unit
Output Overvoltage Clamp, 16.5 Volts Minimum	18	20	V
Output Voltage Sense Range		1.5	V
Output Voltage Set Point Adjustment Range		10%	
Parallel Operation Load Sharing		20% $I_{o,max}$	

8.0 OUTPUT OVERVOLTAGE CLAMP

The KFD output voltage is controlled by the primary regulation loop. The control circuitry for the overvoltage clamp is independent of the KFD DC to DC Converter primary regulation loop. A secondary output voltage control is provided by the overvoltage clamp circuitry, thereby reducing the possibility of output overvoltage. This is realized by having the set point of the overvoltage clamp designed to be higher than the set point of the primary loop.

9.0 CURRENT LIMIT

The KFD DC to DC Converter is protected against output overload by internal current limiting. This mode of operation can be maintained for an unlimited time duration provided that the case temperature is maintained at or below 90°C. At the very point of current limit inception the DC to DC converter shifts from a voltage control to a current control mode.

10.0 REMOTE ON/OFF

The DC to DC Converter can be remotely controlled via a switch (that the user must supply) across the ON/OFF terminal and the $-V_{I\ terminal}$ ($V_{ON/OFF}$). At logic low $V_{ON/OFF}=0$ to 1.2 Volts, the unit is ON; and the maximum $I_{ON/OFF}$ (when the module is ON) is 1 mA. The switch should be able to sink 1 mA when it is at a logic low voltage. At logic high the maximum $V_{ON/OFF}$ of the KFD unit is 18 Volts. The maximum allowable leakage current of the switch (at logic high) is then 50 μa .

A jumper across the ON/OFF terminal and the $-V_1$ terminal can be used to override the Remote ON/OFF (see Figure 4). Either a user-supplied switch or the override jumper should be wired into the circuit via individual PWB current paths not common to the $-V_1$ current path. Connect the switch or jumper wire at the KFD terminals, across the common connection point and the Remote ON/OFF point. This connection will prevent noise from falsely triggering the Remote ON/OFF.

11.0 OUTPUT VOLTAGE REVERSAL

CAUTION

Do not apply a reverse polarity voltage across the KFD output terminals. Such an application will forward bias an internal diode of the Power Module and damage the KFD unit.

12.0 ISOLATION

The KFD output is fully isolated from the input. The KFD DC to DC Converter is encapsulated in nonconductive cases that mount on PC boards. The module is rated to full load at 71°C in a natural convection environment (without a heat sink or external filter).

13.0 PARALLEL OPERATION

The Power Module can be configured for parallel operation with forced load sharing, to provide for redundant operation or to satisfy additional power requirements. For a typical redundant operation, Schottky diodes or equivalent should be used to protect against a short circuit condition. The forward voltage drops across the diodes do not affect the set point voltage applied to the load because of the remote sensing compensation. If multiple units are used to develop combined power, in excess of the rated maximum (to satisfy additional power requirements), the Schottky diodes are not required.

14.0 FORCED LOAD SHARING

To implement forced load sharing, the following connections must be made at the pins of the KFD unit. In addition to that the wiring configuration must be arranged in a way that is compatible with good noise immunity

- a) The parallel pins of all the units connected in parallel must be connected together. The paths of these connections must be as direct as possible.
- b) All Remote Sense pins must be connected to the D.C to D.C. Converter bus at the same point. Connect all Remote Sense (+) terminals to the (+) side of the power bus at the same point, and all Remote Sense (-) terminals to the (-) side of the power bus at the same point.

NOTE

CLOSE PROXIMITY AND SHORT CONNECTING WIRES ARE NECESSARY FOR GOOD NOISE IMMUNITY

15.0 REMOTE SENSE

Remote Sense pins are provided to minimize the effects of distribution losses that come about from regulating the output voltage at the remote sense terminals. The KFD output voltage specifications refer to measurements taken at the Remote Sense terminals during parallel operation, or with the parallel pin shorted to the Sense (-) pin. The voltage between the Remote Sense pins and the KFD output terminals must not exceed the output voltage Sense range given in the KFD specifications. The combination of output set point adjustment range and output voltage Sense range given in the Feature Specifications Table, Table 7 cannot exceed 16.5 Volts between the Vo (+) and Vo (-) terminals.

16.0 SAFETY CONSIDERATIONS

For Safety Standard approval, the system that the Power Module is used in, must satisfy the following condition:

The Power Module must be installed in compliance with the spacing and separation requirements of the End Use Safety Agency Standard i.e., UL-1950, CSA 22.2-950, EN 60 950.

For the Converter output to satisfy the requirements of the Safety Extra Low Voltage Standard (SELV), one of the following conditions must be valid for the D.C. input:

The Converter input meets all requirements of SELV, or

The Converter must be provided with reinforced insulation to protect against hazardous voltages, including the A.C. mains; and comply with SELV reliability tests.

17.0 OUTPUT VOLTAGE TRIM

The output trim feature provides for the capability of increasing or decreasing the output voltage setpoint of the Power Module. This can be accomplished by using an external resistor between the TRIM pin and either the SENSE (+) or SENSE (-) pin (see Figures 7 and 8).

With an external resistor connected between the TRIM pin and SENSE (-) pin ($R_{\text{TRIM-UP}}$), the output voltage setpoint ($V_{o, \text{TRIM}}$) increases to the higher voltage defined in this equation:

$$R_{\text{TRIM-UP}} = \left(\frac{1.25}{V_{o, \text{TRIM}} - 15} \right) 21500$$

With an external resistor connected between the TRIM pin and the SENSE (+) pin ($R_{\text{TRIM-DOWN}}$), the output voltage setpoint ($V_{o, \text{TRIM}}$) decrease to the lower voltage defined by this equation:

$$R_{\text{TRIM-DOWN}} = \left(\frac{V_{o, \text{TRIM}} - 1.25}{15 - V_{o, \text{TRIM}}} \right) (21500)$$

The Combination of output set point adjustment range and output voltage Sense range, given in the Feature Specifications Table 7, cannot exceed 16.5 Volts across the Vo (+) and Vo (-) terminals (see Figures 6, 7 and 8).

18.0 THERMAL CONSIDERATIONS

To ensure reliable operation of the KFD unit, thermal management is important. Heat dissipated by the unit is conducted to the case, and subsequently convection cooled to the surrounding air. Convection cooling can be improved by mounting a heat sink to the top of the unit. Six threaded holes, No. 4-40 [0.18 inches deep (46mm)] are provided for this purpose. A dry pad or thermal compound should be used to minimize thermal resistance between the case and the heat sink. The case temperature should not exceed 90 degrees C.

18.1 CASE TEMPERATURE

Proper cooling for the KFD D.C. to D.C. Converter can be verified by measuring the case temperature of the module. It is measured on the top surface of the unit at a sensing point--3 inches (76mm) from the left edge of the power module, and 0.7 inches (18mm) from the top edge of the unit. The case temperature must not exceed 95°C while the unit is operating in the final system configuration. After the module has reached thermal equilibrium, the measurement can be made with a thermocouple or surface probe. If a heat sink is mounted to the case, make the measurement at the base of the heat sink as close as possible to the heat sensing point. The contact resistance between the mounting surface and the heat sink must be taken into account when making this measurement.

Maintaining the operating case temperature (T_c) within the specified range keeps internal component temperatures within their specifications. That in turn helps keep the expected mean time between failure (MTBF) from falling below the specified rating. The KFD Power Module is designed with temperature resistant components such as ceramic capacitors that do not degrade during prolonged exposure to high temperatures, as do aluminum electrolytic capacitors.

18.2 FORCED CONVECTION

The discussion that follows can be applied to all high powered KFD board mounted power modules in the 4.8in (121.9mm) x 2.5in (63.5mm) x 0.5in (12.7mm) package.

Increasing the air flow over the module improves cooling. In that regard Figure 11 shows the power derating (P_D) versus local ambient temperature (T_A) at air flows, from natural convection to 800 ft./min. (4.1 m/s). The curves in this Figure were obtained from measurements made in a free stream of air approaching a vertically oriented module on a printed wiring board, positioned in a rectangular passage. The Figure can be used to determine the appropriate air flow for a given set of operating conditions.

For example, at $P_D=20W$ and $T_A=40^\circ C$, an air flow of 200 ft./min. (1.0 m/s) is sufficient to keep the module within its ratings.

18.3 HEAT SINK MODELS

Figures 9 and 10 show a number of standard heat sinks that are available for the KFD Power Module, labeled with their respective thermal resistances for natural convection. The heat sinks mount to the top surface of the power module using No. 4-40 hardware, torqued to 5 in.lbs. To minimize contact resistance and temperature drops, use a thermally conductive dry pad or thermal grease between the case and heat sink.

18.4 NATURAL CONVECTION

The plots in Figures 12 and 13 represent power derating for a power module in natural convection when attached to various heat sinks (these include designs with fins oriented along the length and designs with

the fins oriented along the width). Natural convection is the air flow produced when air in contact with a hot surface is heated. An open environment is required with no external forces moving the air. The Figures apply when the power module is the only source of heat present in the system.

18.5 USE OF GRAPHS

First determine the amount of power that is to be dissipated as heat, as well as the ambient operating temperature. Plot the data on the graph, and note the intersection point; the point indicates the appropriate heat sink to use. For instance, if $P_D=20\text{ W}$ and $T_a=30^\circ\text{C}$, a 0.5 inch (12.7mm) heat sink with fins oriented along the width, would keep the module within its operating temperature rating

18.6 THERMAL MODELS

The curves in Figure 14 are plots of thermal resistance against air velocity, for various types of heat sinks; with fins oriented along the width and with fins oriented along the length. The plots are determined experimentally without a heat sink and with the heat sinks illustrated in Figures 9 and 10. The highest values on the curves represent natural convection. In a system with free flowing air and other heat sources, there may be additional air flow.

The following two examples illustrate how the curves can be used to determine thermal performance under various air flow and heat sink configurations.

Example 1: To determine the air flow required to maintain $T_{c,max}$ (case temperature)= 95°C for the KFD 150W D.C. to D.C. Converter (the KFD 15-10-28W) without a heat sink, consider the following:

The KFD DC to DC Converter (150W) operates at $I_o=10\text{ Amps}$ and $T_A=50^\circ$ without a heat sink. The power dissipated by the unit can be determined from the difference between the input power and output power and the efficiency of the converter. It can be noted that the unit has a power dissipation of 26.4 watts. The thermal resistance that is necessary to maintain a 95°C case temperature is determined from the equations that follow:

The total thermal resistance of the unit is defined as the maximum case temperature rise divided by the power dissipation of the module:

- θ = Total thermal resistance
- $\Delta T_{c,max}$ = Maximum case temperature rise
- P_D = Power dissipated as heat

$$\theta = \frac{(T_{c,max} - T_A)}{P_D}$$

$$\theta = (95 - 50) \div 26.4 = 1.7 \frac{^\circ\text{C}}{\text{W}}$$

From Figure 14 the required air flow necessary to maintain a 95°C case temperature then is greater than 500 ft./min. (2.5 m/s)

Example 2: How to determine the case temperature for a specific operating environment. Say for example, that only an air flow of 150 ft./min is available and it is required to determine the case temperature using a one half inch fin heat sink oriented along the length. Consider the following:

For an air flow of 150 ft./min. using the same D.C. to D.C. Converter as in the last example and with a 0.5 inch heat sink with fins oriented along the length, refer to the thermal resistance plot. From Figure 14 the thermal resistance is 1.3°C/W.

$$\Delta T_C = P_D(\theta)$$

$$\Delta T_C = 26.4(1.3) = 34.3 \text{ } ^\circ\text{C}$$

After the delta change in case temperature is calculated, the actual case temperature is determined by the following:

$$T_C = (T_A + \Delta T_C) = (50 \text{ } ^\circ\text{C} + 34.3 \text{ } ^\circ\text{C}) = 84.3 \text{ } ^\circ\text{C}$$

18.7 DETAILED THERMAL MODEL

The thermal resistance previously includes heat transfer by conduction, convection, and radiation, from the entire module to the surrounding environment. Typically the KFD power module is soldered to a vertically oriented printed wiring board. Most of the heat transfer is by convection and radiation from the top mounting surface of the module. Significant amounts of heat are also removed by convection from the sides of the module, by conduction by the printed wiring board, and by convection off of the opposite side of the printed wiring board

18.8 RADIATION HEAT TRANSFER

Radiation is not dependent upon the air flow over the power module, but on the temperature difference between the module and the surrounding environment. For a particular KFD power module, θ_R due to radiation can be determined experimentally. For the KFD high power modules operating at $T_c=95^\circ\text{C}$ and $T_a=25^\circ\text{C}$, θ_R (Radiation Resistance) = 15°C/W

18.9 HORIZONTAL ORIENTATION

In some applications the power module is operated in natural convection and oriented horizontally. In that situation $\theta_{TOTAL} = 4.8^\circ\text{C/W}$ for the overall module thermal resistance (including the base plate resistance).

19.0 FUSING CONSIDERATIONS



THE KFD MODULE IS NOT INTERNALLY FUSED; AN INPUT LINE FUSE MUST ALWAYS BE USED

The encapsulated KFD Power Module can be used in a stand alone operation, or as an integrated part of a complex power architecture. To achieve maximum safety and system protection always use an input line fuse. To aid in the proper fuse selection for a given application, information on inrush energy and maximum current is provided in the KFD specifications. It is also recommended to refer to the fuse manufacturer's data for additional data.

20.0 GENERAL FEATURES

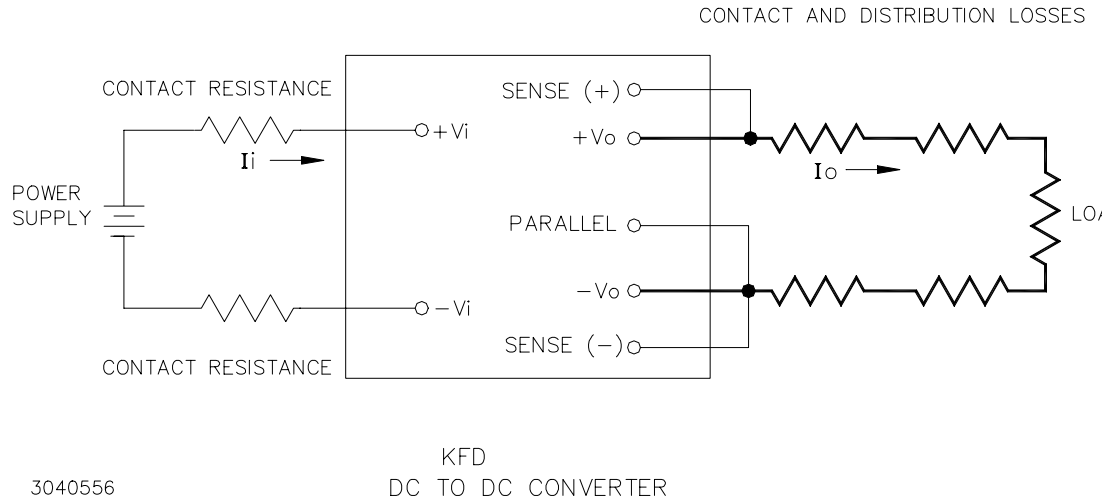
Among the general features of the KFD D.C. to D.C. Converter are the ones listed below:

- Low Profile: 0.5 inch
- Internal EMI Filter
- Complete Input And Output Filtering
- Input To Output Isolation
- Short Circuit Protection
- Output Overvoltage Clamp: 16.5 Volts minimum
- High Efficiency: 85% Typical
- Fabricated with Surface Mount Technology
- Compatible for printed circuit board mounting
- Compatible for heat sink
- Meets FCC Requirements for Telecommunications

21.0 APPLICATIONS

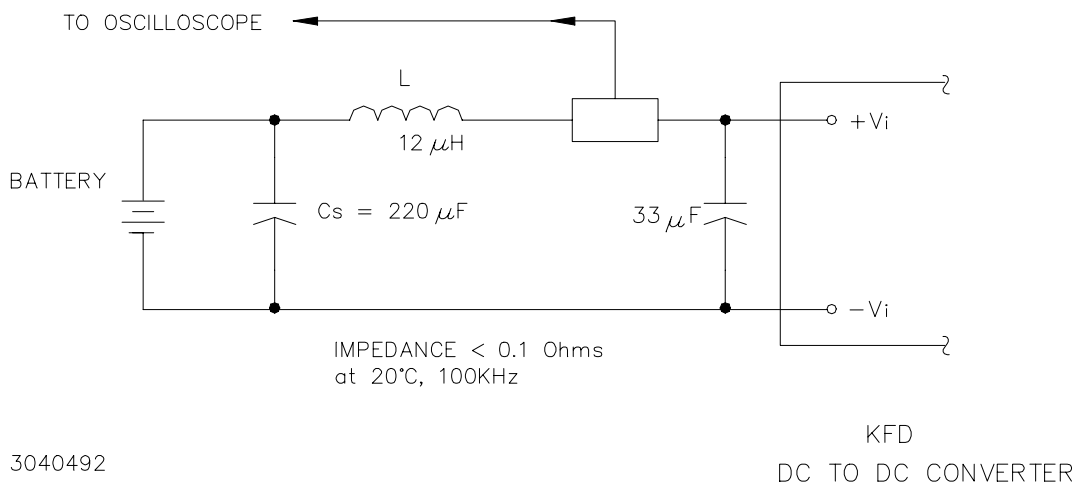
Among the possible applications of the KFD D.C. to D.C. Converter are the following:

- Redundant Power Architecture
- Distributed Power Architecture
- Telecommunications
- Private Branch Exchange



NOTE: WHEN PLACING THE POWER MODULE INTO A PRINTED CIRCUIT BOARD SOCKET, USE KELVIN CONNECTIONS AT THE POWER MODULE INPUT AND OUTPUT TERMINALS TO AVOID MEASUREMENT ERRORS DUE TO SOCKET CONTACT RESISTANCE.

FIGURE 1 TEST SETUP FOR OUTPUT VOLTAGE AND EFFICIENCY MEASUREMENTS FOR THE DC TO DC CONVERTER



NOTE: AT THE INPUT THE REFLECTED RIPPLE IS MEASURED WITH A SIMULATED SOURCE IMPEDANCE OF $12 \mu\text{H}$; THE CAPACITOR, C_s , OFFSETS POSSIBLE BATTERY IMPEDANCE. CURRENT IS MEASURED AT THE INPUT OF THE POWER MODULE.

FIGURE 2 TEST SETUP FOR THE INPUT REFLECTED RIPPLE FOR THE SINGLE OUTPUT KFD DC TO DC CONVERTER.

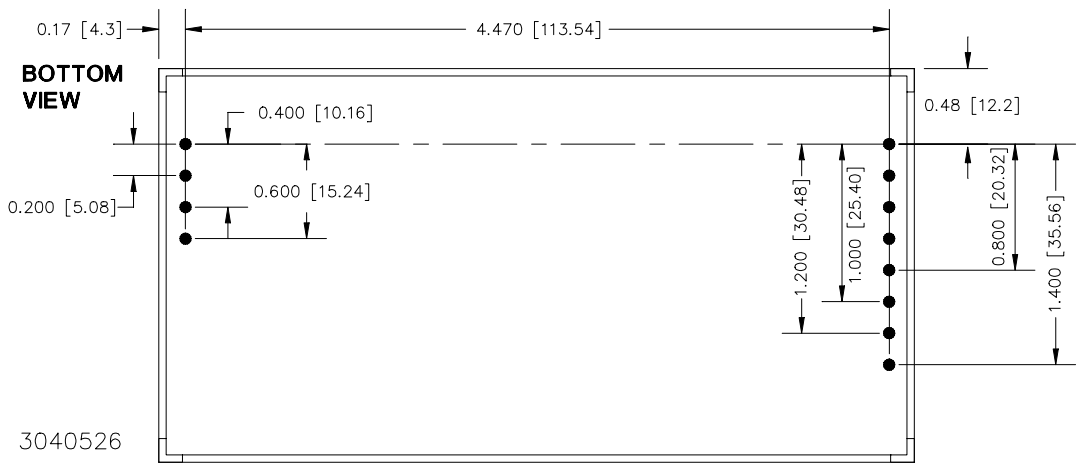
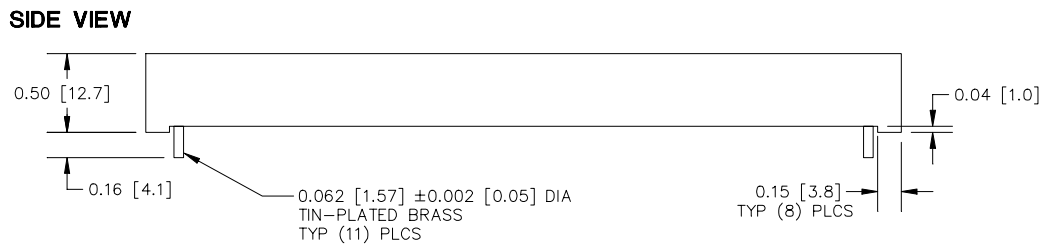
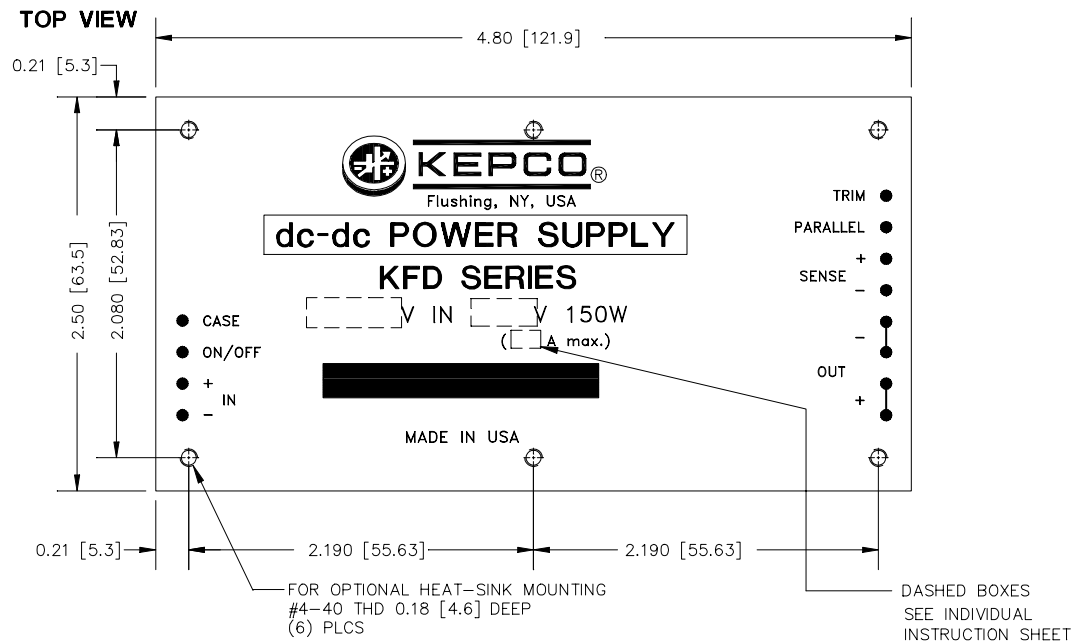
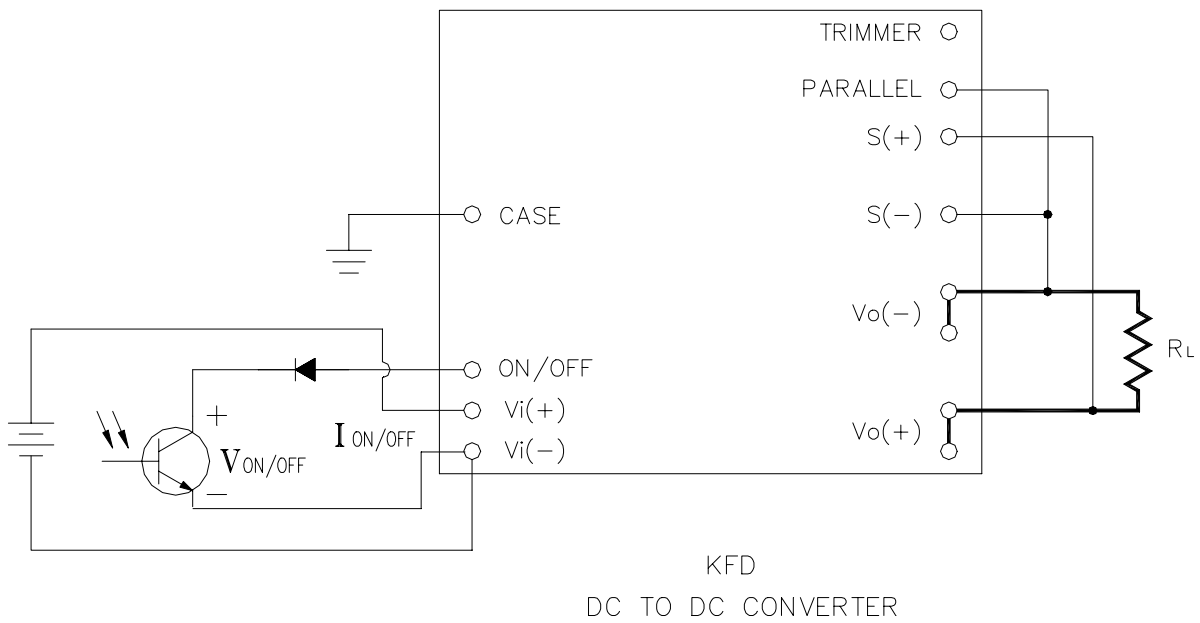
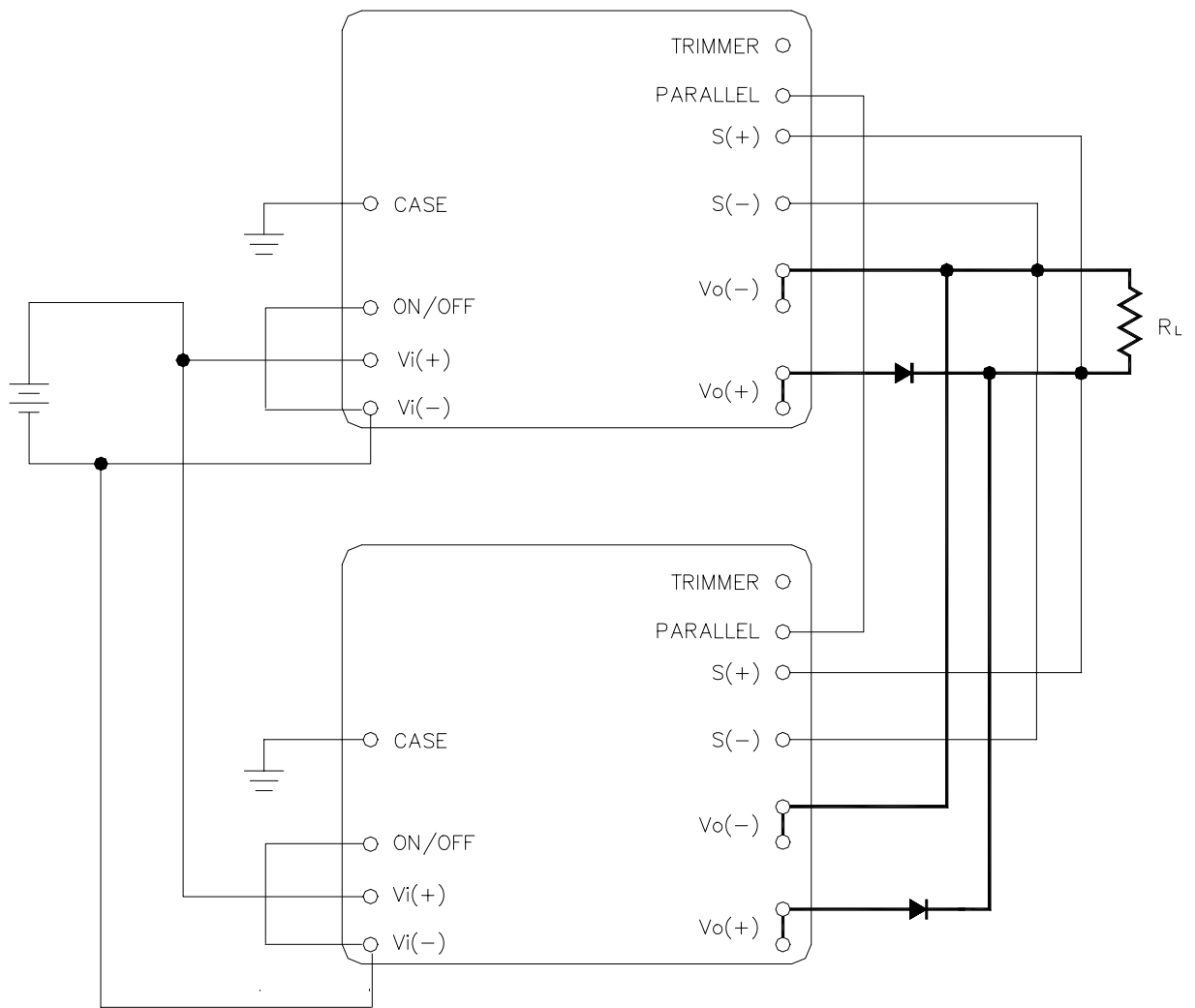


FIGURE 3 MECHANICAL OUTLINE DRAWING OF THE SINGLE OUTPUT KFD DC TO DC CONVERTER



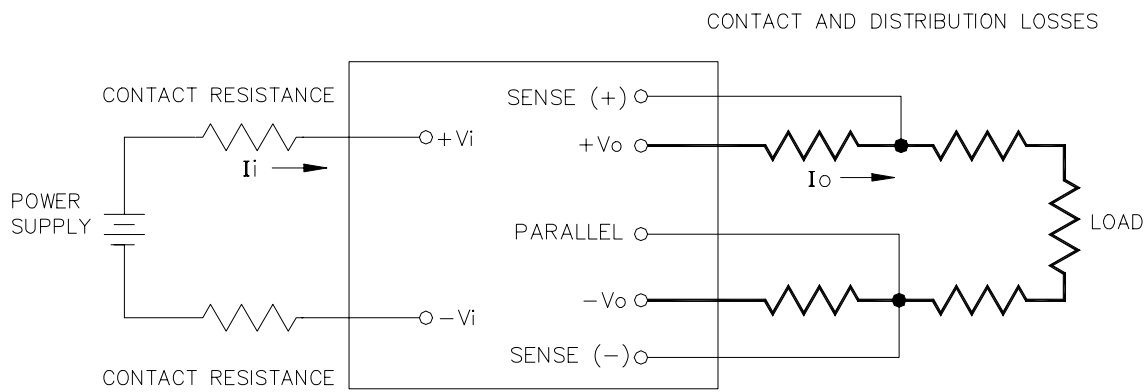
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FIGURE 4 REMOTE ON/OFF WIRING CONFIGURATION FOR THE SINGLE OUTPUT KFD DC TO DC CONVERTER



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FIGURE 5 WIRING CONFIGURATION FOR REDUNDANT PARALLEL OPERATION OF THE KFD DC TO DC CONVERTER



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KFD
DC TO DC CONVERTER

**FIGURE 6 CIRCUIT CONFIGURATION FOR SINGLE KFD DC TO DC CONVERTER
REMOTE SENSE OPERATION**

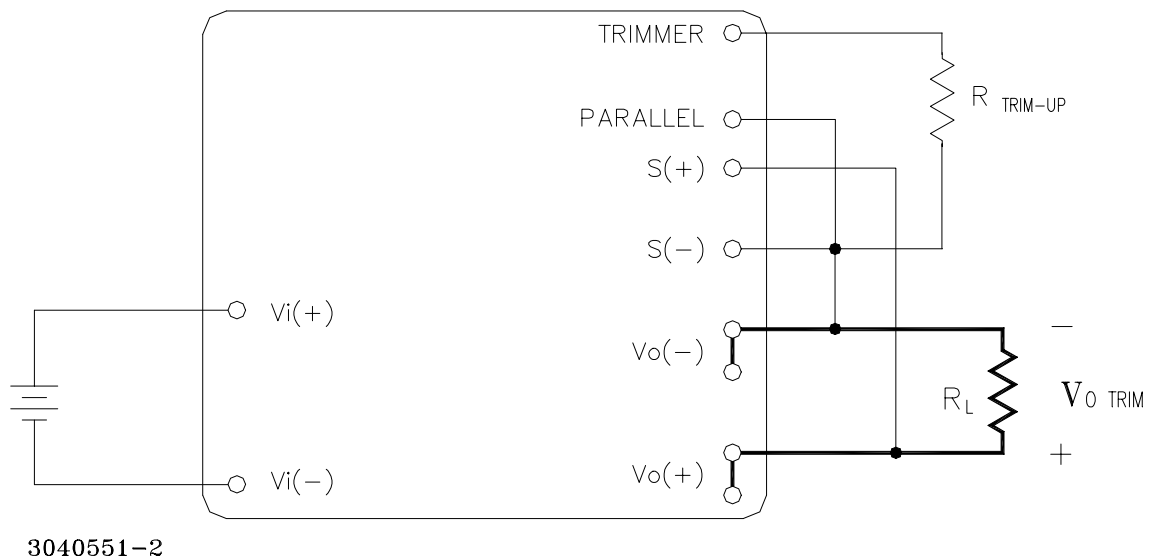
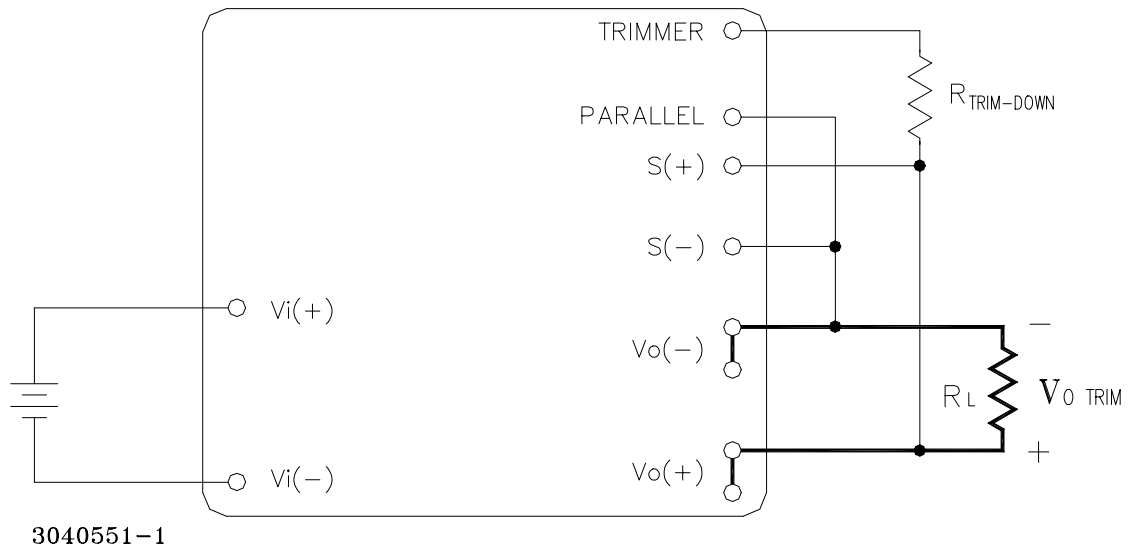
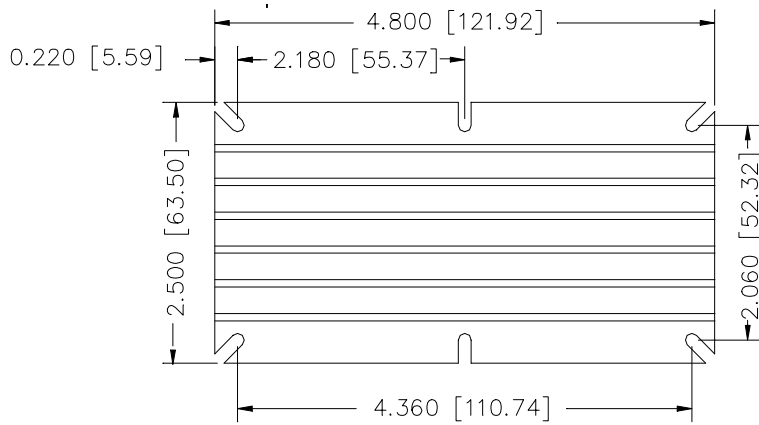
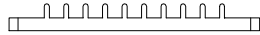


FIGURE 7 (TOP) KFD DC TO DC CONVERTER CIRCUIT CONFIGURATION FOR $R_{Trim\ Down}$, TO DECREASE VOLTAGE SETPOINT

FIGURE 8 (BOTTOM) KFD DC TO DC CONVERTER CIRCUIT CONFIGURATION FOR $R_{Trim\ Up}$, TO INCREASE VOLTAGE SETPOINT



0.25 IN.(6.4) $\vartheta_H=6.3^\circ \text{ C/W}$



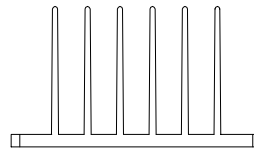
0.25 INCH NOT AVAILABLE

0.5 IN.(12.7) $\vartheta_H=5.7^\circ \text{ C/W}$



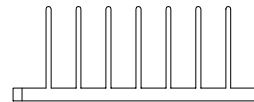
KEPCO PART NUMBER 136-0391
 KEPCO MODEL FIN KFD-02
 THERMALLOY MODEL P6337B-G15
 VERTICAL ORIENTATION
 0.5 INCH HIGH

1.5 IN.(38.1) $\vartheta_H=2.4^\circ \text{ C/W}$



1.5 INCH NOT AVAILABLE

1.0 IN.(25.4) $\vartheta_H=3.1^\circ \text{ C/W}$

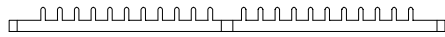
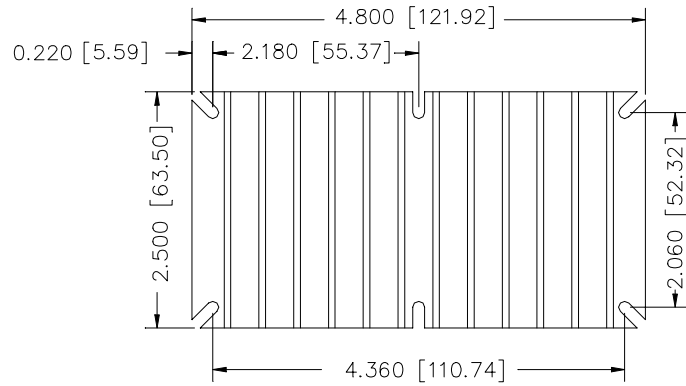


KEPCO PART NUMBER 136-0393
 KEPCO MODEL FIN KFD-04
 THERMALLOY MODEL P6339B-G15
 VERTICAL ORIENTATION
 1 INCH HIGH

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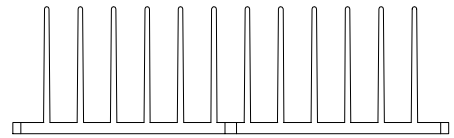
THE EXACT FIN HEIGHT DIMENSIONS OF KEPCO
 HEAT SINK MODELS FIN KFD-02 AND FIN
 KFD-094 ARE RESPECTIVELY 0.94(23.88)
 AND 0.422(11.23)

**FIGURE 9 HEAT SINKS FOR VERTICAL ORIENTATION - KEPCO
 MODEL KFD-02 AND THE KEPCO MODEL KFD-04**



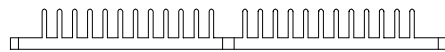
0.25 IN.(6.4) $\psi_H = 5.6^\circ\text{C}/\text{W}$

0.25 INCH HIGH FIN NOT AVAILABLE



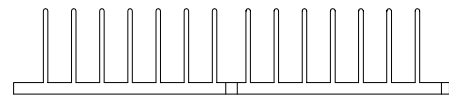
1.5 IN.(38.1) $\psi_H = 2.1^\circ\text{C}/\text{W}$

1.5 INCH HIGH FIN NOT AVAILABLE



0.5 IN.(12.7) $\psi_H = 4.8^\circ\text{C}/\text{W}$

KEPCO PART NUMBER 136-0390
 KEPCO MODEL FIN KFD-01
 THERMALLOY MODEL P6336B-G15
 HORIZONTAL ORIENTATION
 0.5 INCH HIGH FIN

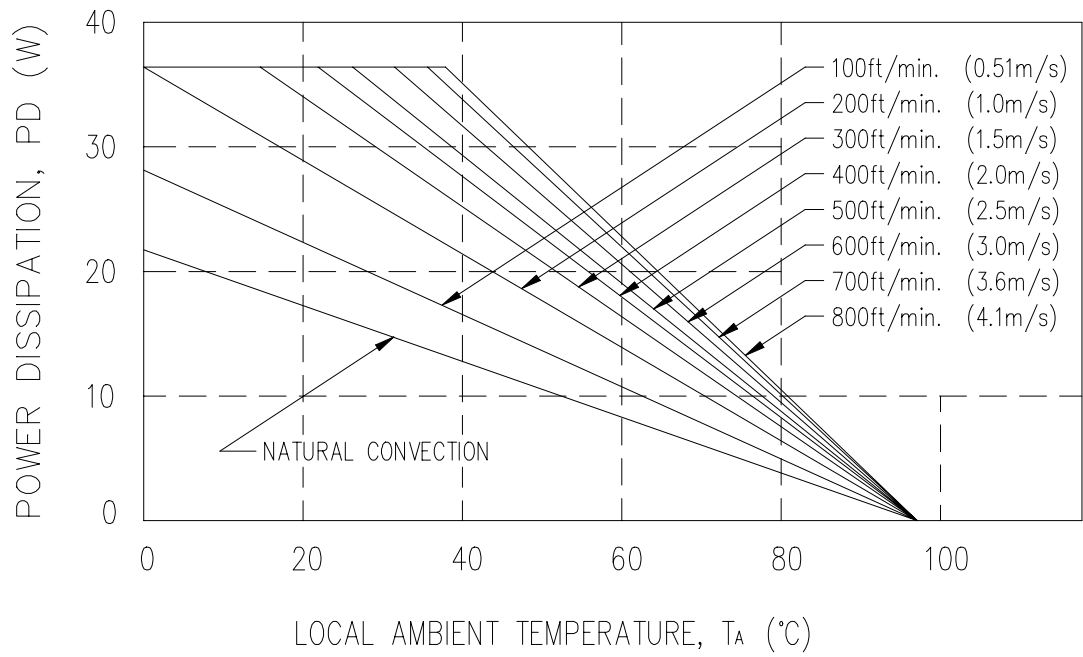


1.0 IN.(25.4) $\psi_H = 2.6^\circ\text{C}/\text{W}$

KEPCO PART NUMBER 136-0392
 KEPCO MODEL FIN KFD-03
 THERMALLOY MODEL P6338B-G15
 HORIZONTAL ORIENTATION
 1 INCH HIGH FIN

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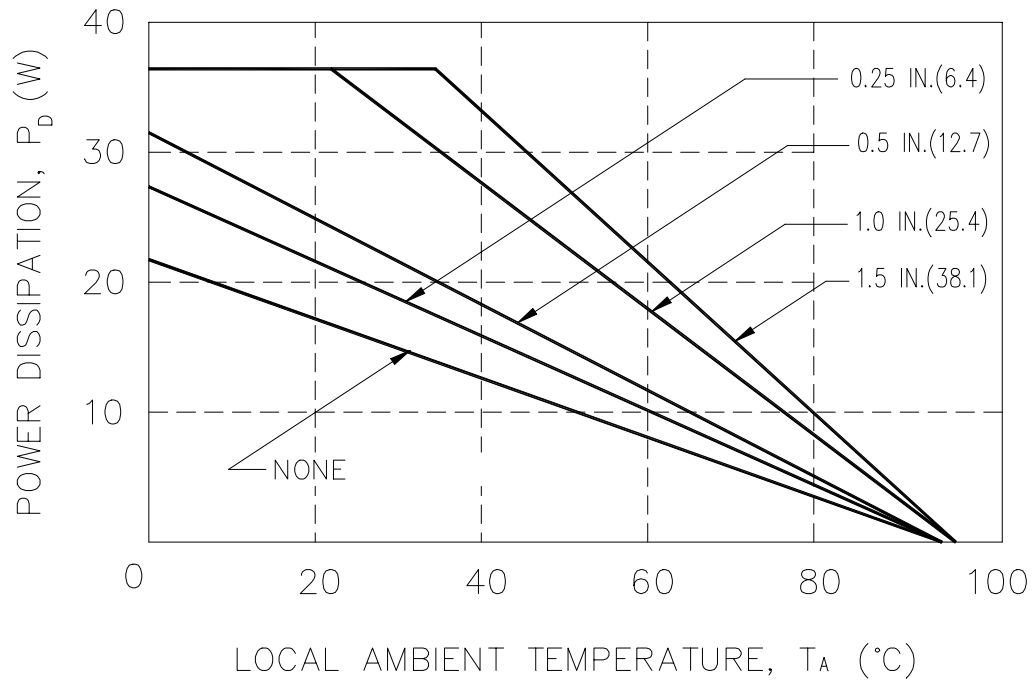
FIGURE 10 HEAT SINKS FOR HORIZONTAL ORIENTATION - KEPCO MODEL KFD-01 AND THE KEPCO MODEL KFD-03



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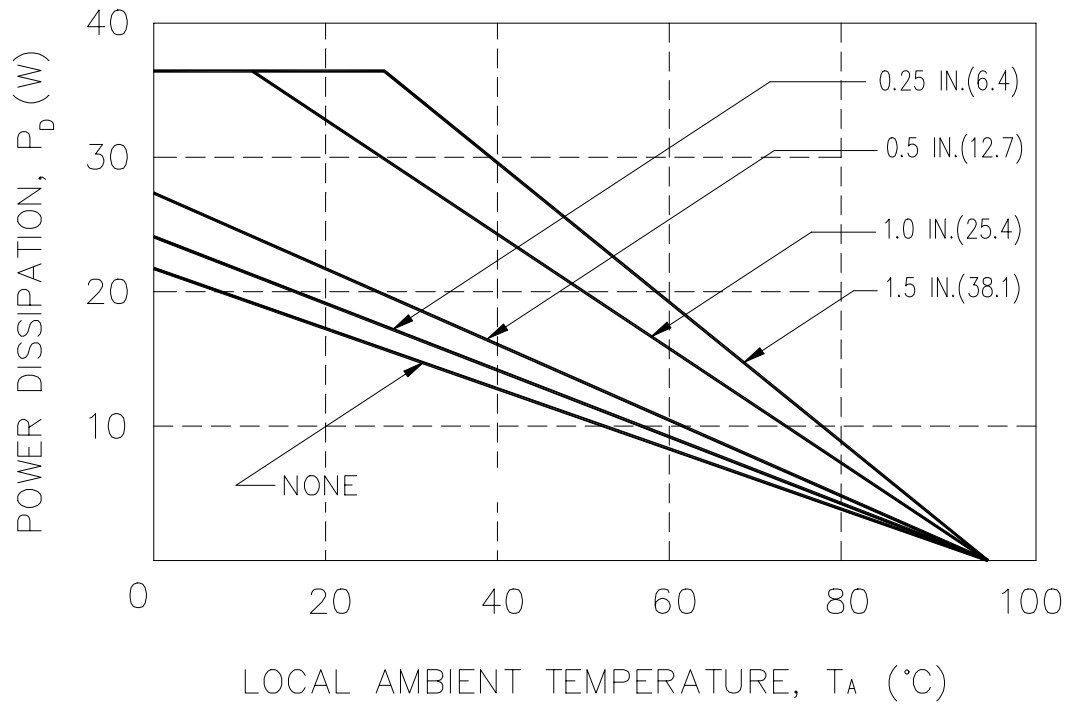
NOTE: THE GRAPHS ARE PLOTTED AS A FUNCTION OF THE AIR FLOW WITHOUT THE USE OF A HEAT SINK (FOR THE KFD POWER MODULE COOLING)

FIGURE 11 FORCED CONVECTION DERATING, POWER DISSIPATION VERSUS LOCAL AMBIENT TEMPERATURE



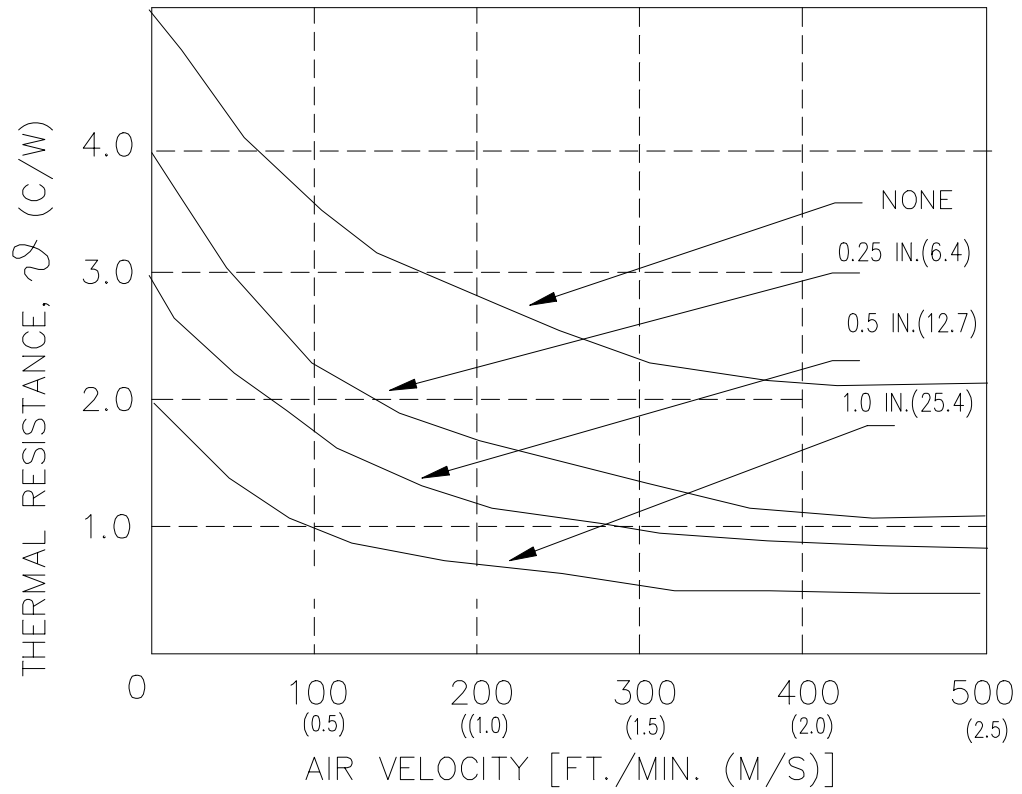
3040649

FIGURE 12 HEAT SINK DERATING CURVES, NATURAL CONVECTION, FINS ORIENTED ALONG THE WIDTH



3040650

FIGURE 13 HEAT SINK DERATING CURVES, NATURAL CONVECTION, FINS ORIENTED ALONG THE LENGTH



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FIGURE 14 HEAT SINK RESISTANCE CURVES FOR FINS ORIENTED ALONG VERTICAL AND HORIZONTAL DIRECTIONS

