15 W DC/DC Power Modules
24 V Input Series

- *SMD and Through-hole versions in 22 g metal case*
- *High power density of 17 W/in³*
- *Very small footprint and low profile 36.8 × 41.7 × 9.7 mm (1.45 × 1.64 × 0.38 in)*
- *MTBF is 4 million hours at +40 °C ambient temperature per Bellcore*
- *Wide input voltage range: 18–36 V*
- *Operating ambient temperature range –40 to +85 °C and max. case temperature +100 °C*
- *1,500 V dc isolation voltage*

The PKS 2000 I series of DC/DC power modules are designed for decentralized power distribution systems with distributed on-board converters using a system voltage of +24 V dc. Their low profile and high power density allows board spacings down to 18 mm or 0.7 in, or lower, depending on board size, while occupying a minimum of board area.
By using a ceramic substrate with all surface-mount components and a copper leadframe, excellent heat transfer is provided to the terminal pins which readily conduct the power dissipation to the printed circuit board. The extremely efficient thermal management and the very high reliability performance together with a fixed switching frequency makes these DC/DC power modules very suitable for demanding applications within e.g. Information Technology & Telecom, Industrial, Medical and Aircraft industry. The current mode forward power module topology features a very good static output regulation and fast dynamic response. A Remote on/off control makes it possible to turn off or start up with external control. Over-temperature and Short-circuit protection is included to prevent damage at fault conditions. Input to output isolation is 1,500 V dc.
The mechanical ruggedness is very high and together with the wide temperatur range they are also ideal for applications in not temperature controlled locations.
In production the strictest manufacturing and quality control standards are enforced and the PKS series are assembled in automated manufacturing lines using SMT, laser trimming and ATE final inspection.
Since 1991, Ericsson Components AB is a ISO 9001 certified supplier.

ERICSSON

General

Absolute Maximum Ratings

Characteristics		min	max	Unit
T_C	Case temperature[1]	–40	+100	°C
T_S	Storage temperature	–40	+110	°C
V_I	Input voltage	0	40	Vdc
V_{ISO}	Input to output isolation	1,500		Vdc
V_{RC}	Remote control voltage pin 1	0	7.0	Vdc

Stress in excess of Absolute Maximum Ratings may cause permanent damage. Absolute Maximum Ratings, sometimes referred to as no destruction limits, are normally tested with one parameter at a time exceeding the limits of Output data or Electrical Characteristics. If exposed to stress above these limits, function and performance may degrade in an unspecified manner.

Input

$T_C < T_{Cmax}$ unless otherwise specified

Characteristics		Conditions	min	typ	max	Unit
V_I	Input voltage range		18		36	V
V_{Ioff}	Turn-off input voltage	(See Operating Information)				
V_{Ion}	Turn-on input voltage	(See Operating Information)				
I_{Irush}	Inrush current	V_I = 26 V t = 5 ms			2	A
C_I	Input capacitance			0.47		µF
P_{Ii}	Input idling power	I_O = 0			0.7	W
P_{RC}	Input stand-by power	RC connected to pin 2			0.4	W

Note:

1) Corresponding ambient temperature range (T_A) at full output power is –40 to +85 °C mounted on a printed circuit board in free convection. See also Thermal Data.

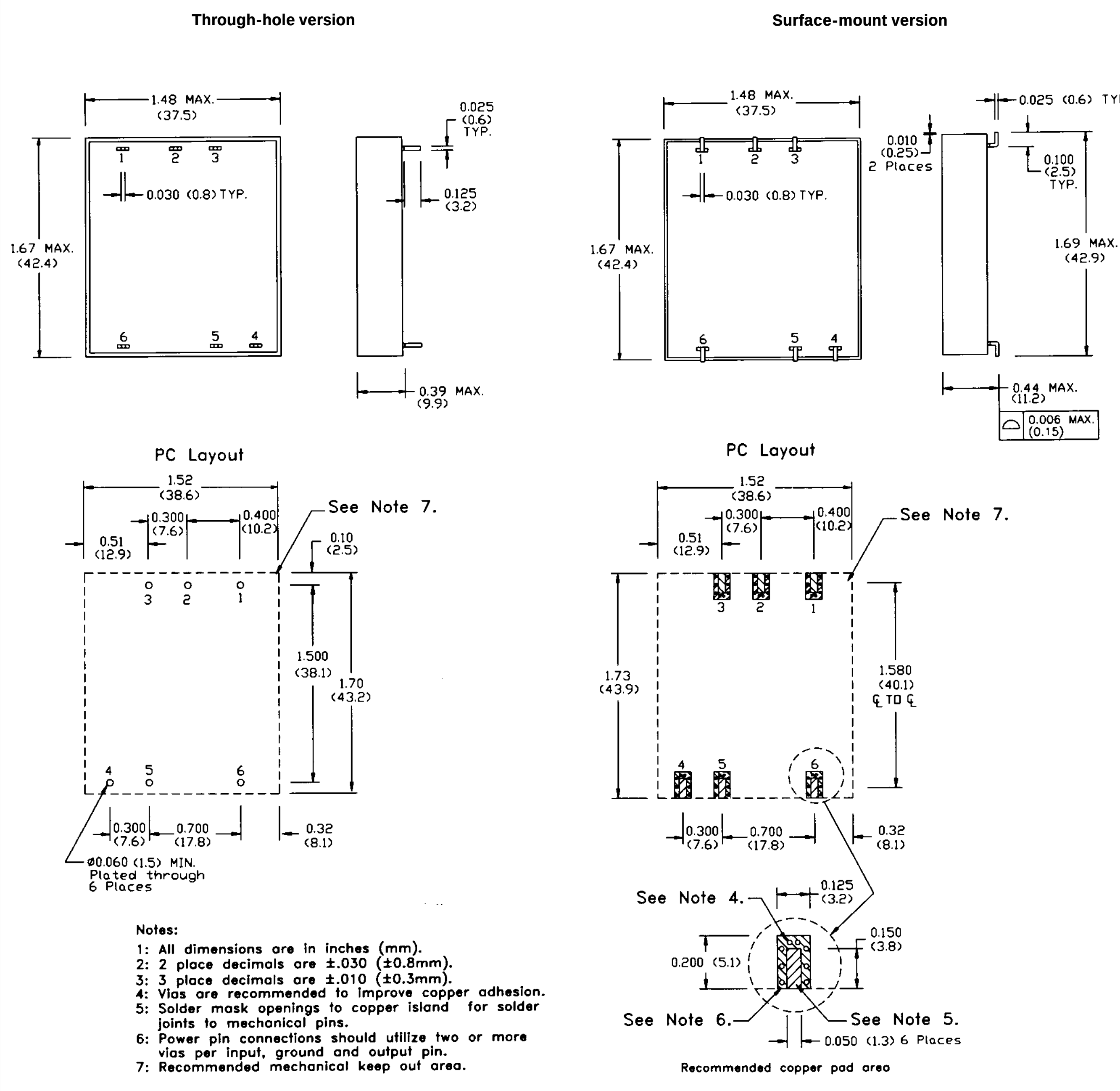
Environmental Characteristics

Characteristics	Test procedure & conditions		
Vibration (Sinusoidal)	MIL-STD-883D Method 2007.2	Frequency Acceleration Number of cycles	20…2000 Hz, 2 minutes 10 g 8 in each axis
Shock (Half sinus)	MIL-STD-883D Method 2002.3	Peak acceleration Shock duration Number of cycles	50 g 1 ms 5 in each axis
Temperature change	MIL-STD-202F Method 107	Temperature Number of cycles	–40°C…+125°C 200
Accelerated damp heat	MIL-STD-202F Method 103 with bias	Temperature Humidity Duration	85°C 85% RH 1000 hours

Safety

The PKS Series DC/DC power modules are designed in accordance with EN 60 950, *Safety of information technology equipment including electrical business equipment*.
The PKS power modules are recognized by UL and meet the applicable requirements in UL 1950 *Safety of information technology equipment* and the applicable Canadian safety requirements.
The DC/DC power module shall be installed in an end-use equipment and considerations should be given to measuring the case temperature to comply with T_{Cmax} when in operation. Abnormal component tests are conducted with the input protected by an external 3 A fuse. The need for repeating these tests in the end-use appliance shall be considered if installed in a circuit having higher rated devices.
When the supply to the DC/DC power module is isolated and meets all the requirements for SELV (<60Vdc), the output is considered to remain within SELV limits (level 3). The isolation is an operational insulation in accordance with EN 60 950.
The DC/DC power module is intended to be supplied by isolated secondary circuitry and shall be installed in compliance with the requirements of the ultimate application. If they are connected to a 60 V DC system reinforced insulation must be provided in the power supply that isolates the input from the mains. The power module is evaluated with the secondary output referenced to earth.
The terminal pins are only intended for connection to mating connectors of internal wiring inside the end-use equipment.
The galvanic isolation is verified in an electric strength test. Test voltage (V_{ISO}) between input and output is 1,500 Vdc for 60 s. In production the test duration may be decreased to 1 s.
The capacitor between input and output has a value of 1 nF and the leakage current is less than 5 µA @ 50 Vdc.

Mechanical Data



Connections

Pin	Designation	Function
1	RC	Remote Control to turn-on and turn-off the output
2	–In	Negative Input terminal
3	+In	Positive Input terminal
4	Rtn/0V	Output Return terminal
5	Out	Positive Output terminal
6	NC	The pin is Not Connected

Weight

22 g (0.78 oz).

Case

Blue anodized aluminum case.

Thermal Data

The PKS 2000 series is designed for very low thermal resistance from the internal components to the outer case. Copper traces with a thickness of 70 µm (2 oz/ft²) are used on the ceramic substrate to provide very low electrical resistance and excellent thermal conductivity. Tin plated copper leads are used for input and output terminals and also conduct dissipated power to the copper pads on the host printed circuit board. Consequently, the thermal performance of the PKS 2000 series can be enhanced by maximizing the copper area around the pins of the power module. Figure 1 shows recommended layout pattern which maximizes this copper area (please refer to mechanical data for footprint dimensions). 70 µm copper is recommended for optimum performance.

The ceramic substrate of the PKS 2000 series is also thermally connected to a blue anodized aluminum case. By creating very low thermal resistance, heat is readily conducted and evenly distributed to the case. This prevents “hot spots” and allows the internal component temperatures to remain close to the case temperature.

The thermal performance is very dependent on the amount of ambient airflow. Air velocity in free convection is 0.2–0.3 m/s (40–60 lfm).

The PKS 2000 series are also protected from thermal overload by an internal over-temperature shutdown circuit.

Over-Temperature Protection

When the internal junction temperature of the custom control IC reaches 125 °C, the power module will automatically shut down. It will automatically restart when the junction temperature cools below 115 °C.

Solder Side Copper

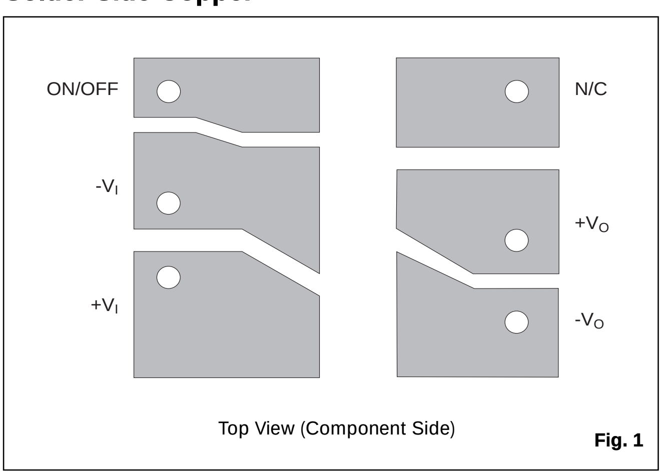


Fig. 1

Surface Mount Soldering Guidelines

The following guidelines apply when soldering the surface mount DC/DC power modules. All the modules are designed to be compatible with industry standard low temperature solder reflow processes and industry standard aqueous or semi-aqueous wash systems. We recommend a low tempeature 63% tin, 37% lead solder, or similar, with a nominal melting point of 183 °C.

Ericsson uses a high temperature 96.5% tin, 3.5% silver solder with a melting tempeature of 221 °C in the manufacturing process of the DC/DC power modules. To avoid potential opens or shorts due to internal solder reflow, use the following maximum reflow parameters:

– Preheat and cool-down rampsshould not exceed 2 °C/second to prevent internal component failures due to thermal stress.

– If possible, avoid elevating the temperature above 220 °C (Leading manufacturers of 63/37 solder with nominal 183 °C melting points recommend maximum oven temperatures of 220 °C).

– If your reflow process creates DC/DC power module body temperatures above 220 °C, then limit the time above this tempeature to a maximum of 30 seconds.

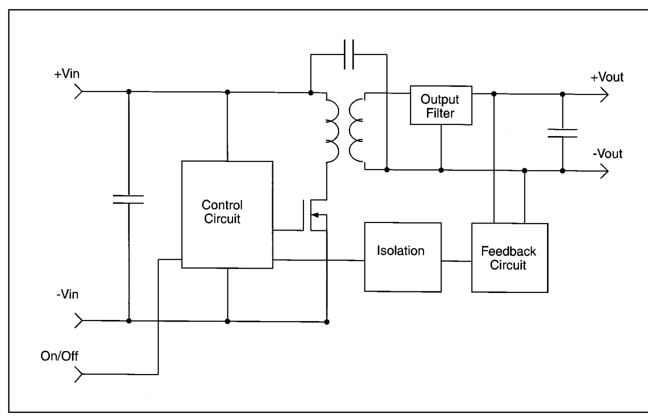
– To avoid over-stressing internal components, do not exceed body tempeatures of 230 °C during the reflow process.

Please contact your local Ericsson Sales office if you have questions or need additional information.

Electrical Data

Fundamental circuit diagrams

Single output



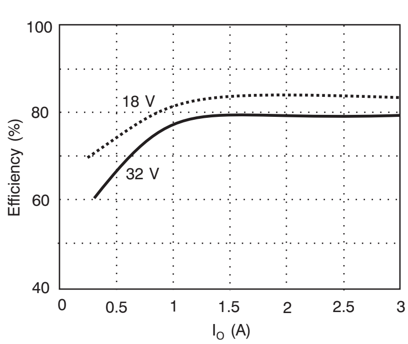
Output

T_C = 0…+85°C, V_I = 18...36 V unless otherwise specified.

Characteristics		Conditions		Output 1			Unit
				min	typ	max	
V_O	Output voltage tolerance band	$I_O = 0.1…1.0 \times I_{O max}$ and long term drift		4.90	5.00	5.10	V
	Line regulation	$I_O = I_{O max}$				100	mV
	Load regulation	$I_O = 0.1…1.0 \times I_{O max}$, V_I = 26 V				100	mV
t_{tr}	Load transient recovery time	$I_O = 0.1…1.0 \times I_{O max}$, V_I = 26 V load step = $0.5 \times I_{O max}$				200	µs
V_{tr}	Load transient voltage					+250	mV
						–250	mV
t_r	Ramp-up time	$I_O = 0.1…1.0 \times I_{O max}$, V_I = 26 V	$0.1…0.9 \times V_O$		0.6		ms
t_s	Start-up time		From V_I connection to $V_O = 0.9 \times V_{Oi}$		0.7		ms
I_O	Output current			0		3.0	A
$P_{O max}$	Max output power			15			W
I_{lim}	Current limiting threshold	$T_C < T_{C max}$		3.1			A
I_{sc}	Short circuit current	V_I = 26 V			6.3		A
$V_{O ac}$	Output ripple & noise	$I_O = I_{O max}$, T_A = 25 °C	DC… 20 MHz			100	mV_{p-p}
SVR	Supply voltage rejection (ac)	f = 100/120 Hz sine wave, 1 V_{p-p}, (SVR = 20 log (1 $V_{p-p}/V_{O p-p}$))			60		dB

Miscellaneous

Efficiency (typ)



Characteristics		Conditions	min	typ	max	Unit
η	Efficiency	$I_O = I_{O max}$, V_I = 26 V		81.5		%
P_d	Power dissipation	$I_O = I_{O max}$, V_I = 26 V		3.4		W

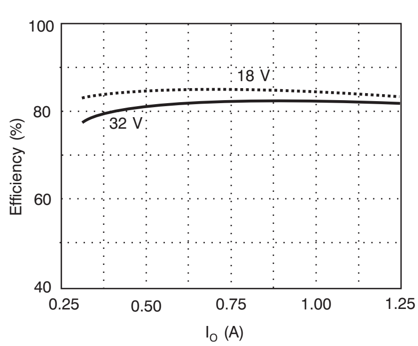
Output

T_C = 0…+85°C, V_I = 18...36 V unless otherwise specified.

Characteristics		Conditions		Output 1			Unit
				min	typ	max	
V_O	Output voltage tolerance band	I_O = 0.1…1.0 × $I_{O max}$ and long term drift		11.76	12.00	12.24	V
	Line regulation	I_O = $I_{O max}$				240	mV
	Load regulation	I_O = 0.1…1.0 × $I_{O max}$, V_I = 26 V				240	mV
t_{tr}	Load transient recovery time	I_O = 0.1…1.0 × $I_{O max}$, V_I = 26 V load step = 0.5 × $I_{O max}$				200	µs
V_{tr}	Load transient voltage					+600	mV
						–600	mV
t_r	Ramp-up time	I_O = 0.1…1.0 × $I_{O max}$, V_I = 26 V	0.1…0.9 × V_O		1.0		ms
t_s	Start-up time		From V_I connection to V_O = 0.9 × V_{Oi}		1.1		ms
I_O	Output current			0		1.25	A
$P_{O max}$	Max output power			15			W
I_{lim}	Current limiting threshold	T_C < $T_{C max}$		1.3			A
I_{sc}	Short circuit current	V_I = 26 V			2.5		A
$V_{O ac}$	Output ripple & noise	I_O = $I_{O max}$, T_A = 25 °C	DC…20 MHz			150	mV_{p-p}
SVR	Supply voltage rejection (ac)	f = 100/120 Hz sine wave, 1 V_{p-p}, (SVR = 20 log (1 V_{p-p}/$V_{O p-p}$))			60		dB

Miscellaneous

Efficiency (typ)



Characteristics		Conditions	min	typ	max	Unit
η	Efficiency	I_O = $I_{O max}$, V_I = 26 V		81.5		%
P_d	Power dissipation	I_O = $I_{O max}$, V_I = 26 V		3.4		W

PKS 2115 PI

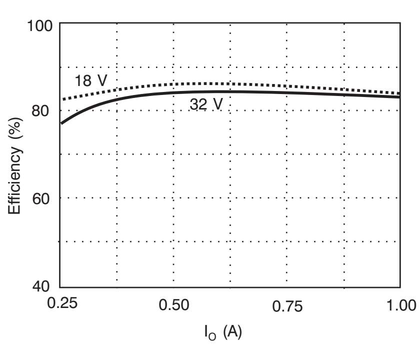
Output

T_C = 0…+85°C, V_I = 18...36 V unless otherwise specified.

Characteristics		Conditions		Output 1 min	Output 1 typ	Output 1 max	Unit
V_O	Output voltage tolerance band	I_O = 0.1…1.0 × $I_{O max}$ and long term drift		14.70	15.00	15.30	V
	Line regulation	I_O = $I_{O max}$				300	mV
	Load regulation	I_O = 0.1…1.0 × $I_{O max}$, V_I = 26 V				300	mV
t_{tr}	Load transient recovery time	I_O = 0.1…1.0 × $I_{O max}$, V_I = 26 V load step = 0.5 × $I_{O max}$				200	µs
V_{tr}	Load transient voltage					+750	mV
						–750	mV
t_r	Ramp-up time	I_O = 0.1…1.0 × $I_{O max}$, V_I = 26 V	0.1…0.9 × V_O		1.2		ms
t_s	Start-up time		From V_I connection to V_O = 0.9 × V_{Oi}		1.3		ms
I_O	Output current			0		1.0	A
$P_{O max}$	Max output power			15			W
I_{lim}	Current limiting threshold	T_C < $T_{C max}$		1.1			A
I_{sc}	Short circuit current	V_I = 26 V			2.0		A
$V_{O ac}$	Output ripple & noise	I_O = $I_{O max}$, T_A = 25 °C	DC…20 MHz			200	mV_{p-p}
SVR	Supply voltage rejection (ac)	f = 100/120 Hz sine wave, 1 V_{p-p}, (SVR = 20 log (1 V_{p-p}/$V_{O p-p}$))			60		dB

Miscellaneous

Efficiency (typ)



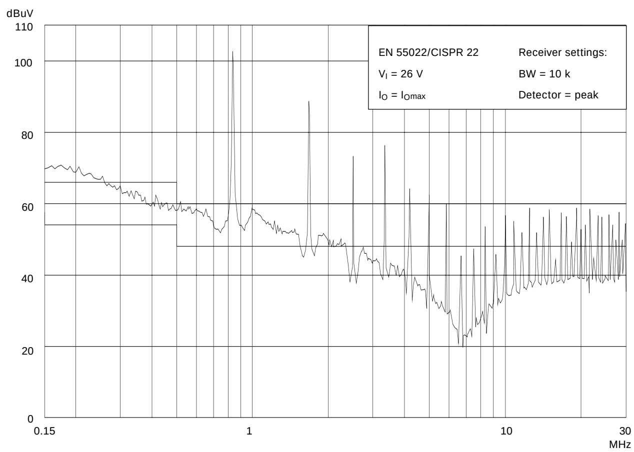
Characteristics		**Conditions**	**min**	**typ**	**max**	**Unit**
η	Efficiency	I_O = $I_{O max}$, V_I = 26 V		82.5		%
P_d	Power dissipation	I_O = $I_{O max}$, V_I = 26 V		3.2		W

EMC Specifications

The PKS DC/DC power module is mounted on a double sided printed circuit board (PB) with groundplane during EMC measurements.

The fundamental switching frequency is 850 kHz ± 10% in PKS 2111 and 650 kHz ±10% in PKS 2113 and PKS 2115 @ $I_O = I_{Omax}$.

Conducted EMI (input terminals)



PKS series typical conducted EMI performance

Test set up

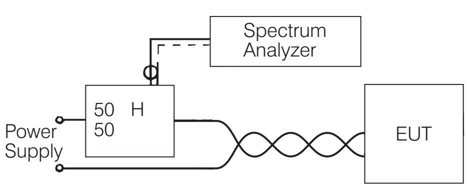


Fig. 2

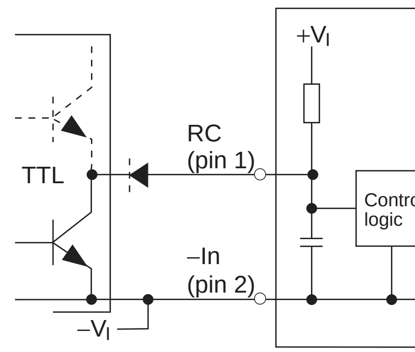


Fig. 3

Input and Output Impedance

Both the source impedance of the power feeding and the load impedance will interact with the impedance of the DC/DC power module.

It is most important to have the ratio between L and C as low as possible, i.e. a low characteristic impedance, both at the input and output, as the power modules have a low energy storage capability. A capacitive compensation is necessary if the source or load inductance is larger than 10 µH. Use wet electrolytic capacitors.

Their equivalent series resistance together with the capacitance acts as a lossless damping filter. Suitable capacitor values are in the range 10–100 µF. Tantalum capacitors are not suitable due to their low ESR value.

Over Voltage Protection (OVP)

The remote control can be utilized also for OVP by using the external circuitry in fig. 4. Resistor values are for 5 V output applications, but can easily be adjusted for other output voltages and the desired OVP level.

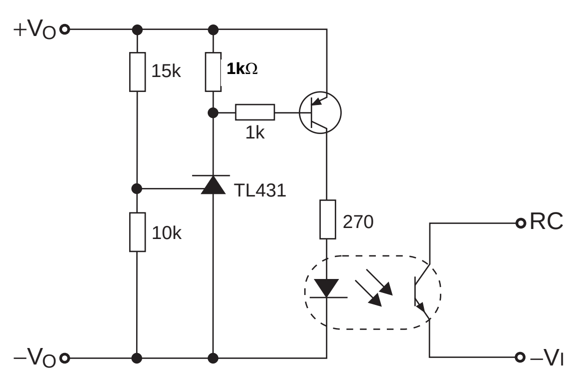


Fig. 4

Operating information

Remote Control (RC)

Turn-on or turn-off can be realized by using the RC-pin. Normal operation is achieved if pin 1 is open (NC). If pin 1 is connected to pin 2 the PKS DC/DC power module turns off. To ensure safe turn-off the voltage difference between pin 1 and 2 shall be less than 0.8 V. RC is TTL open collector compatible (see fig. 3). Pin 1 is an output and no current should be driven into pin 1. Use a diode if necessary e.g. totem pole TTL logic. The internal pull-up resistance is 10 kΩ to a 2.5V reference voltage.

Undervoltage lockout

The PKS 2000 series is designed to operate over an input voltage range of 18 to 36 V dc. If the rise time of the input voltage source is very slow, a few hundred milliseconds for instance, the power modules will draw excessive current during start-up as long as the source voltage is less than the minimum rated voltage. In these situations, an undervoltage lockout circuit can be added as shown in fig. 5.

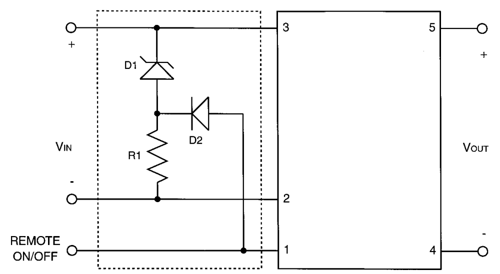


Fig. 5

Undervoltage Lockout Circuit Components

	Part no.
D1	IN4745B Zener Diode 16 V, 1 W, 5%
D2	MBR190 Schottky Diode 90 V, 1 A
R1	Resistor, Film 10 kΩ, 1/2 W, 5%

Circuit Operation

When the input voltage is below the zener voltage of D1, the remote ON/OFF pin is pulled to the same potential as the minus input pin through resistor R1, keeping the DC/DC power module off. When the input voltage rises above the zener voltage D1 will conduct, producing a voltage drop across resistor R1 greater than 1.8 V above the minus input pin, turning the power module on. Diode D2 enables the remote ON/OFF pin to function normally with other external circuitry.

This undervoltage lockout circuit will keep the power module off until the input voltage source reaches the zener voltage.

Maximum Capacitive Load

The maximum recommended capacitance connected directly to the PKS DC/DC power modules output without resistance or inductance in series is 100 μF/A (output current rating). Connect capacitors across the load for maximum effectiveness and maximum stability margins.

Current Limiting Protection

Two independent output current detection circuits protect the PKS 2000 series from any damage if the output is overloaded or shorted. Due to its current mode control and laser trimming of the current sense resistor, a precision current limit operating point is set. During an overload condition, the output voltage and duty cycle are reduced. When a short-circuit or very low impedance condition such as a shorted capacitor, is present, the power module operates at a very narrow duty cycle to limit its internal power dissipation. The power module will automatically resume normal operation after the overload or short-circuit condition is removed.

Quality

Reliability Prediction Methods

While several prediction standards exist, no one standard can be considered optimum for all situations. A particular standard must be chosen based on the operating conditions and the operating environment that best reflects the end application.

The telecommunications industry often uses Bellcore's Technical Reference TR-NWT-00332, *Reliability Prediction Procedure for Electronic Equipment* as their standard. This document includes 3 different prediction methods – “Parts Count Method”, “Combining Laboratory Data With Parts Count Data” and “Predictions From Field Tracking”. Within each method are several different cases that define the various conditions.

MIL-HDBK-217, *Reliability Prediction of Electronic Equipment* is a widely used standard that defines two prediction methods – Part Stress Analysis Prediction that is applicable during later design phases and Parts Count Reliability Prediction that is applicable during early design phase and during proposal formulation.

Bellcore

Using Bellcore's TR-NWT-000332, Method 1, Case 1, the predicted failure rate for the PKS series is 250 FITs (Failures in 10^9 hours) or an MTBF (Mean Time Between Failure) of 4,000,000 hours. MTBF is the inverse of the failure rate. This number is derived using the parts count method and it assumes that all components have 50% stress and an ambient temperature of 40 °C in a ground, fixed, controlled environment. TR-NWT-000332 states that Method 1 prediction must be provided for all units unless the requesting organization allows otherwise. Using the same method but for a ground, fixed, uncontrolled environment, the calculated reliability would be 375 FIT or an MTBF of 2,666,667 hours.

MIL-HDBK-217

For a Part Stress Analysis Prediction, reliability is determined by adding the failure rate of each part. The failure rate of each part is evaluated individually and is calculated by including the variables of temperature, stress level, base failure rate, power rating, part quality factor, and operating environment factor. For example, Eq [1] is the formula for calculating the part failure rate, λ_p, for a fixed film resistor.

$$\lambda_p = \lambda_b \times \pi_R \times \pi_Q \times \pi_E \text{ Failures}/10^6 \text{ Hours} \qquad [1]$$

where,

$$\lambda_b = 5 \times 10^{-5} (3.5)^{\frac{T+273}{398}} \exp\left[S \times \frac{T+273}{273}\right]$$

π_R = Resistance factor

π_Q = Quality factor

π_E = Environment factor

λ_b is the base failure rate where T is the ambient temperature in degrees C and S is the ratio of operating power to rated power. The values are found in lookup tables within MIL-HDBK-217. The MTBF is equal to the inverse of the sum of all the part failure rates:

$$\text{MTBF} = \frac{1}{\Sigma \lambda_p} \qquad [2]$$

The PKS series has a predicted reliability of over 1,000,000 hours MTBF in a ground benign environment. The part quality factor used as stated in MIL-HDBK-217 is equal to “lower” (lower than military rated components). The operating conditions are 26 volts input and maximum load current in a 25 °C ambient temperature environment.

Fig. 6 shows the MTBF with respect to temperature, and output load. The MTBF decreases exponentially with temperature. Higher output loads raise the component junction temperatures and decrease the reliability. In essence, a high efficiency design using good thermal management maximizes the reliability by reducing junction and case temperatures.

MTBF vs Temperature and Output Current

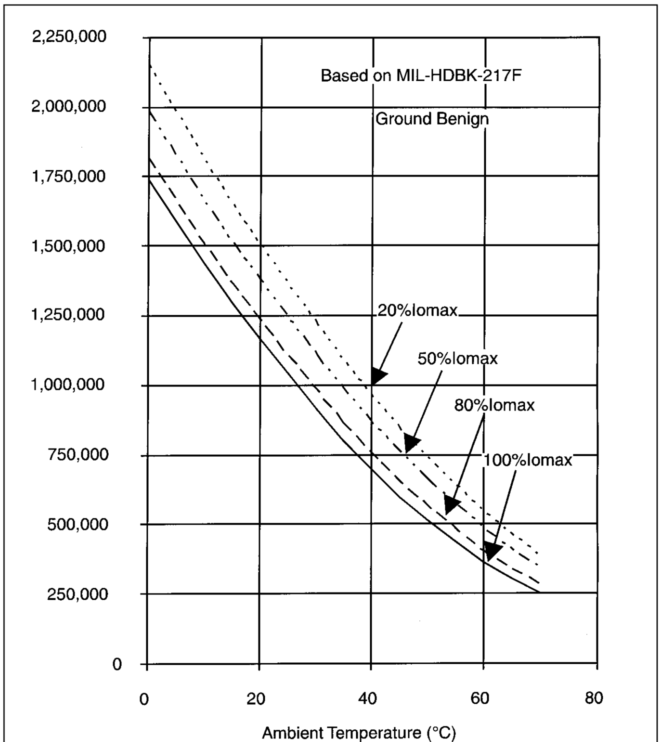


Fig. 6

Predicted reliability for the PKS series

Method	**FITs (Failures in 10^9 hours)**	**MTBF (Hours) (Mean Time Between Failures)**
Bellcore TR-NWT-000332 Parts Count (ground fixed, controlled environment)	250	4,000,000
(ground fixed, uncontrolled environment)	375	2,666,667
MIL-HDBK-217F Part Stress Analysis (T_A = 25°C, ground benign)	963	1,038,000

Quality Statement

The products are designed and manufactured in an industrial environment where quality systems and methods like ISO 9000, 6 σ and SPC, are intensively in use to boost the continuous improvements strategy. Infant mortality or early failures in the products are screened out by a burn-in procedure and an ATE-based final test. Conservative design rules, design reviews and product qualifications, plus the high competence of an engaged work force, contribute to the high quality of our products.

Warranty

Ericsson Components warrants to the original purchaser or end user that the products conform to this Data Sheet and are free from material and workmanship defects for a period of five (5) years from the date of manufacture, if the product is used within specified conditions and not opened. In case the product is discontinued, claims will be accepted up to three (3) years from the date of the discontinuation.

For additional details on this limited warranty we refer to Ericsson Components AB's "General Terms and Conditions of Sales", EKA 950701, or individual contract documents.

Limitation of liability

Ericsson Components does not make any other warranties, expressed or implied including any warranty of merchantability or fitness for a particular purpose (including, but not limited to, use in life support applications, where malfunctions of product can cause injury to a person's health or life).

Product Program

V_I	V_O/I_O max	P_O max	Ordering No.	
	Output 1		Through-hole	SMD
24 V	5 V/3.0 A 12 V/1.25 A 15 V/1.0 A	15 W 15 W 15 W	PKS 2111 PI PKS 2113 PI PKS 2115 PI	PKS 2111 SI PKS 2113 SI PKS 2115 SI

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Data Sheet

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