Reliability Prediction for PT3100/4100 Isolated DC-DC Converters

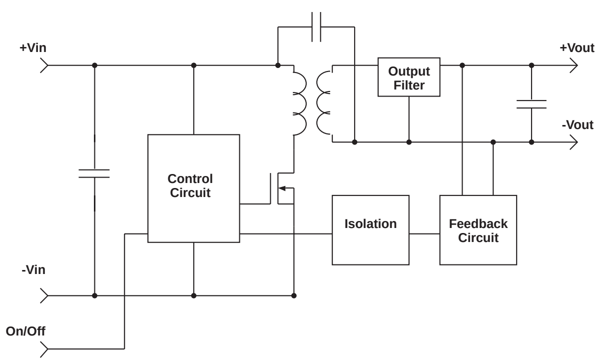
Power Trends' isolated DC-DC converters are designed for high efficiency, small size, and high reliability.

Reliability prediction is used not only for estimating time to failure but also as an important design tool. The calculations can help locate problem areas by identifying overstressed parts or finding the highest contributor to failure. It determines the reliability impact of design changes as well as the degree of environmental control needed to achieve a desired reliability objective. To attain the best reliability, Power Trends uses the latest and most advanced technology in power supply components and very low thermal resistance materials for packaging.

Design and Construction The Power Trends' PT3100/4100 Series uses a forward converter topology as shown in Figure 26. These converters switch at fixed frequencies of 650Khz or 850Khz depending on the unit. The high frequency allows for small magnetics and capacitors. The unit is packaged using a copper leadframe, ceramic printed circuit board, and aluminum case. It is designed to have very low thermal resistance from the internal components to the outer case. Thermal characteristics are important to understand because device temperature is a significant variable in reliability calculations.

Figure 26

PT3100/4100 SERIES BLOCK DIAGRAM



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 uses Bellcore's Technical Reference **TR-NWT-000332,** *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 reliability for the PT3100/4100 Series is 250 FITs (Failures in 10^9 hours) or an MTBF (Mean Time Between Failure) of 4,000,000 Hours. See Table 19. MTBF is the inverse of FIT. 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-217F 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, Equation (1) is the formula for calculating the part failure rate, λ_p, for a fixed film resistor.

Equation (1)

$$\lambda_p = \lambda_b \times \pi_R \times \pi_Q \times \pi_E \quad \text{Failures/106 Hours}$$

where,

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

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:

Equation (2)

$$\text{MTBF} = \frac{1}{\sum \lambda_p}$$

The PT3100/4100 Series has a predicted reliability of over 1,000,000 hours MTBF in a ground benign environment. See Table 19. The part quality factor used as stated in MIL-HDBK-217 is equal to “lower” (lower than military rated components). The operating conditions are 48 volts input and maximum load current in a 25°C ambient temperature environment.

Figures 27 and 28 show the MTBF with respect to temperature, input voltage, and output load. The MTBF decreases exponentially with temperature. The graphs also show that reliability decreases as the input voltage increases because the voltage stress ratio and component junction temperatures increase. Higher output loads also 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.

Table 18

PREDICTED RELIABILITY FOR PT3100/4100 SERIES

Method	**Parameter** 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 (Ta= 25°C, ground benign)	963	1,038,000

Figure 27

MTBF VS TEMPERATURE AND INPUT VOLTAGE

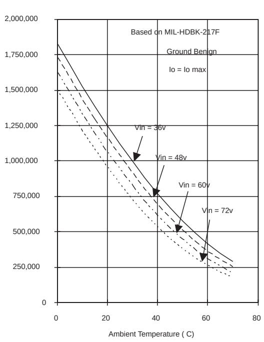
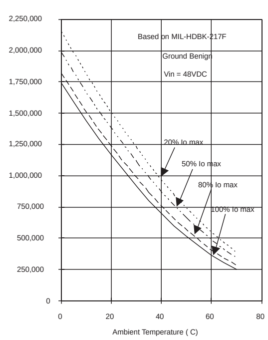


Figure 28

MTBF VS TEMPERATURE AND OUTPUT CURRENT



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