W H I T E P A P E R

PREVENTIVE DIAGNOSTICS v1.01

5th of November 2015

1. General

Emparro 3ph Switched Mode Power Supply – Premium Power

85693 – Emparro 40-3x360-500/24 with Preventive Diagnostics.

2. Preventive Diagnostics

2.1 General

The Preventive Diagnostics feature with Emparro 3-phase 40A brings additional benefits for the customer by indicating the need for unit replacement.

A diagnostic signal is delivered for the customer by a simple potential free – normal closed type – contact, located next to standard alarm contact. This preventive diagnostic contact is open while the device is not connected to the input and closes with the supply. It remains closed during power supply's operation and it first opens again in case the diagnostic algorithm defines that it is time to change power supply. The contact is non-resettable and after a diagnostic change has occurred - even after power down (mains restart) - signal remains open.

2.2 Power supply lifetime and preventive diagnostics

The diagnostics log is an incremental type and is checking the status of the power supply every second of operation. The diagnostic log can be read from power supply internally by Murrelektronik.

Limiting factors for the power supply life are mainly:

1. Electrolytic capacitor lifetime
    - Highly related to operating temperature of components
2. Semiconductor lifetime
    - Related to operating temperature of components
    - Related to non-continuous operations (i.e. start-up, shut-down)
3. Statistical fault situations
    - Mainly calculated and estimated with MTBF
4. Random failures
    - Related to cooling and warming cycles. More thermal cycling causes increased stress for components and soldering joints (start-up, shut-down)
    - Electrical stress of the unit over specification

When creating the estimation of the power supply's lifetime, additional testing during the development process is made to verify the expected lifetime of the power supply. The following measurements are taken into account:

- Inside temperatures of the power supply (temperature sensor)
- Number of power supply start-ups from the mains
  (Please note: Hold-up time is no start-up!)
- Output loading of the system (stress)

With these measurements results, electrolytic capacitor and semiconductor lifetime can be estimated for the power supply, as both are related to Arrhenius law. Arrhenius law can be approximated that lifetime of the components are doubled when the temperatures are 10°C lower. Internal calculation for the lifetime is dependent on the more precise Arrhenius calculator than this rough approximation.

Internal sensors take into account both output loading and internal temperatures. Most severe conditions for the lifetime are the operation points where ambient temperature is high and power supply is loaded with maximum output current. By having slightly lower output current level and lower ambient (from maximum) power supply lifetime can be increased.

Start-up cycles are also calculated as limiting factor for the lifetime of the power supply due to the increased stress for the semiconductors, electrolytic capacitors and soldering joints. Start-up of the unit causes higher electrical stress for the internal components and at the same time causes thermal expansion stress (thermal cycle) for the soldering joints, connections and components. This additional stress shortens the expected lifetime of the units.

On table (Table 1) preventive diagnostics events are showed, four different basic algorithms are used for the preventive diagnostics contact.

Table 1

No.	**Description**	**Thermal condition**	**Loading conditions**	**Min. Duration**	**Max. Duration**
1	Start-up counter	NA	NA	100 000 start-ups	
2	Lifetime estimator	Algorithm based on temperatures and loading		according to stress	max. 15 years
3	Permanent overload	> 45°C ambient or restricted airflow	> 120% Load (continuous)	48 hours	
4	Permanent over-temperature	> 60°C	100 % load	10 000 hours	
		> 70°	75 % load		

2.3 Start-up counter

Start-up counter of the power supply calculates the number of startups made for the power supply. This calculator is an incremental type and is triggered when unit is cold started. Short interruptions, where power supply remains operable and auxiliary voltages of the power supply remains intact are not taken into account. Start-up count value is saved to EEPROM.

2.4 Lifetime estimator

The main preventive diagnostics algorithm is based on estimating the power supply's expected lifetime with steady conditions. This algorithm is triggered if the calculated lifetime of internal components is close to the end and it is suggested to replace the unit with new one. End of service lifetime indicates that power supply operation might not be according to specifications and i.e. output ripple voltage may be increasing.

Maximum service lifetime of the power supply is limited to 15 years due to component manufacturer's lifetime specifications.

Values of the lifetime estimator are generated by testing internal temperatures of critical parts from the power supply and verifying the relation of the actual temperatures to internal measured temperatures with operating temperature of the critical parts. Electrical stress of the critical parts are also verified and taken into account with the lifetime calculation algorithm.

Because the lifetime calculation is made with every second of power supply operation, different thermal conditions are giving acceleration factors for power supply lifetime. This acceleration factor in principal means that the lifetime of the power supply can be even 7 times shorter with maximum stress conditions, and will reduce the estimated lifetime up to 7 times faster for the power supply!

Actual lifetime with weighted value depending of internal temperatures are calculated every second and saved to EEPROM every 10 minutes. This value is incremental style and it can't be reset by switching the power supply off. After power down, calculation will continue from the last value.

2.5 Permanent overload

Permanent overload diagnostic is triggered in case the power supply is continuously operated with higher than nominal output current and ambient temperature is higher than 45 °C. This is for protecting that the customer does not continuously try to use extra power range of 120% with higher than accepted ambient temperatures (rated below 45°C). Using extra power range continuously with high ambient temperatures will reduce power supply lifetime significantly and may cause early failure of the unit.

Permanent overload is also triggered in case of insufficient cooling conditions and loading of the power supply is higher than 120 %.

The unit is recommended to be changed after it has operated 48 hours under these hard conditions (ambient higher than 45°C and loading higher than 120%). Because of the preventive nature of the diagnostic contact, it will open after cumulated 48 hours under these hard conditions during its complete lifetime. The usage of an occasionally power boost range does not affect the values for this calculator.

2.6 Permanent over temperature

The Permanent over temperature diagnostic function triggers contact when power supply is continuously operated for 10,000 hours with excessive ambient temperature and loading conditions.

The Permanent over temperature is triggered when internal temperatures of the power supply are higher than normal for more than 10, 000 hours during the power supply lifetime. For example, these conditions apply when:

- Power supply is rated with nominal load (100%) when surrounding air temperature of higher than 60 °C or convection is restricted in the cabinet
- Power supply is rated with nominal load (75%) at surrounding air temperature of higher than 70 °C or convection is restricted in the cabinet

Due to the incremental count of the overload calculator, the unit is recommended to be changed after the unit has operated 10,000 hours under these hard conditions of high thermal conditions during its lifetime. This value cannot be reset in any way.

3. LED indication

3.1 Blinking green – 90 % pre-warning

In order to ease up the operation of Emparro 3ph 40A in real life conditions, intelligent LED signalization for the end user is integrated. This feature is well known from Murrelektronik MICOs which indicates for the user when loading level of Emparro 3ph 40A is high. Indication of the loading level is made through OK / ALARM LED, which will start to blink green when 90% of the nominal output power is reached.

90 % pre-warning by blinking LED is helping the user to notice when loading of the Emparro 3ph 40A is getting close to the maximum recommended for long lifetime.

3.2 Steady Green and Red

A standard feature of the Emparro power supplies is indication of the power supply status, through OK/ALARM LED. This LED is green when everything is ok with the power supply and the loading is below 90 % power level.

Red LED indicates errors, such as overtemperatures, overloads or short circuits.