THREE PHASE POWER FACTOR CORRECTION AND HARMONIC LINE CURRENT CONTROL IN MILITARY POWER SUPPLIES

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Typical AC Input Power Supply
Block Diagram
• All US Army aircraft require AC loads to control input current harmonics in accordance with Mil-Std 461, CE-101.

• All Anti-submarine warfare (ASW) aircraft require AC loads to control input current harmonics in accordance with Mil-Std 461, CE-101.

• All Navy Surface Ships, and Submarines require AC loads to control input current harmonics in accordance with Mil-Std 461, CE-101. and Mil-Std 1399, section 300.

• All NATO Surface Ships, and Submarines require AC loads to control input current harmonics in accordance with STANAG 1008.
Other Reasons for using 3 Phase Power Factor Correction in Military Power Supplies

• Simplifies meeting Mil-Std 704 (Aircraft Power Spec) Transient and Holdup requirements.

• Simplifies meeting Mil-Std 1399 Section 300 (Ship and Submarine Power Spec) Transient and Holdup requirements.

• Smoothes AC Input currents in Pulsed Radar applications.
Passive Multiphase Rectification with Inductive Input Filter for meeting Harmonic Line Current Requirements

- 18 pulse Rectification needed To meet 3% Harmonic Line Current requirements
- Primarily used on Navy Ships
- Requires large bulky input transformer
- Requires Large bulky Inductive Input Filter
Passive Multiphase Rectification with High Frequency Boost Regulator for meeting Harmonic Line Current Requirements

- 18 pulse Rectification needed to meet 3% Harmonic Line Current requirements
- Primarily used on Navy Ships
- Requires large bulky input transformer
- High Frequency Boost Regulator minimizes the size and weight of Energy Storage Capacitors
Three Active Single Phase Boost PFC regulators operated Line to Line, followed by isolated DC/DC Converters

- Active Single Phase PFC’s get rid of large bulky Transformer.
- Each Power Unit requires it’s own Energy Storage. Potential issues with uneven holdup.
- Isolated DC/Dc Converters needed to combine into a single output
Three Phase PFC with Neutral, Block Diagram

- Active Three Phase PFC gets rid of large bulky Transformer.
- Single Energy Storage. For all Power Supply Outputs
- Small EMI Filter due to continuous Input current
Power Supplies using 3 Phase PFC with Neutral

MISSILE WARNING (CMWS) POWER SUPPLY

- Meets CE-101 for Army applications.
- 200 msec Holdup requirement

ARMY HELICOPTERS

RADAR ROCESSOR POWER SUPPLY

- Meets CE-101 for ASW applications.
- 50 msec Holdup requirement

CP140 ASW AIRCRAFT
Power Supplies using 3 Phase PFC with Neutral

- Meets CE-101 for ASW applications.
- 50 msec Holdup requirement
- 4 KW peak Output Power
- Absorbs Output Pulsed Load
Three Phase PFC without Neutral, Block Diagram

- Active Three Phase PFC gets rid of large bulky Transformer.
- Single Energy Storage. For all Power Supply Outputs
- Operates with 3 Phase AC Input, or 270Vdc Input (on two of the three Input lines)
- Small EMI Filter due to continuous Input current, and only 3 lines to filter.
Power Supply using 3 Phase PFC without Neutral

- 1200 watt output power
- 3 phase AC, or 270Vdc input power
- Less than 3 lb weight
- Meets CE-101 requirements
Power Supply using 3 Phase PFC without Neutral

- 8000 watt output power
- 3 phase AC input power
- Less than 8 lb weight
- Meets CE-101 requirements
- Operates Rescue Hoist for Army Helicopters
Three Phase PFC in Pulsed Radar Applications

- Long Range, low PRF Radar tends to modulate the T/R Module Power Supplies' AC input current.

- Severe input current modulation strains the generator driving the T/R module power supplies. Small aircraft generators are especially affected, with possible mechanical damage.

- If the Radar input power is a significant portion of the generator rated power, Radar PRF rates at or near the generator’s output frequency (60Hz or 400Hz), or its sub-multiples, tends to entrain (capture) the generator to run at the PRF rate.

- 3 Phase PFC front end of a T/R Module Power Supply can be designed such that the Radar pulse energy comes from the Holdup Capacitors, while the AC input current stays relatively constant.
Radar site employs a Motor-Generator set with heavy flywheel to absorb AC current “thump”

Motor-Generator shaft has been known to fracture
Example of Input Current Modulation at T/R Module
Power Supplies with 3 Phase PFC

Power Supply for Solid State RF T/R Modules
BC-6Kw: Military, Airborne, 6Kw 3 Phase PFC for a pulsed Radar application, 11Kw peak pulse power

BC-6K AC/DC converter, 370v 6Kw average, and 11Kw pulsed output, 3.7lbs, 97% efficiency
PFC Input and Output Currents at various PRF rates.
One of 3 phases shown.
Note that Output current pulses are not reflected to input current.
BC-6KW Input Harmonic Line Currents

BC6KW TEST DATA
INPUT CURRENT SPECTRUM

PHASE A INPUT CURRENT

PHASE B INPUT CURRENT

PHASE C INPUT CURRENT

HARMONICS ARE 30DB TO 50DB BELOW FUNDAMENTAL (2% DISTORTION)