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

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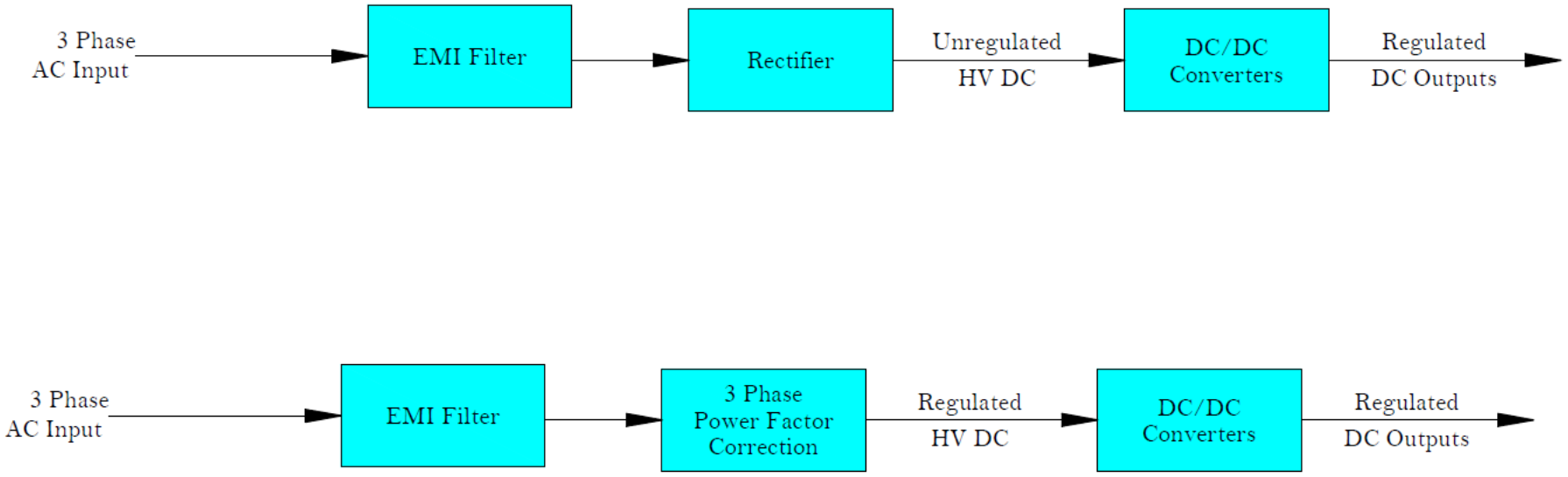
Typical AC Input Power Supply Block Diagram



Reasons for using 3 Phase Power Factor Correction in Military Power Supplies

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- 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

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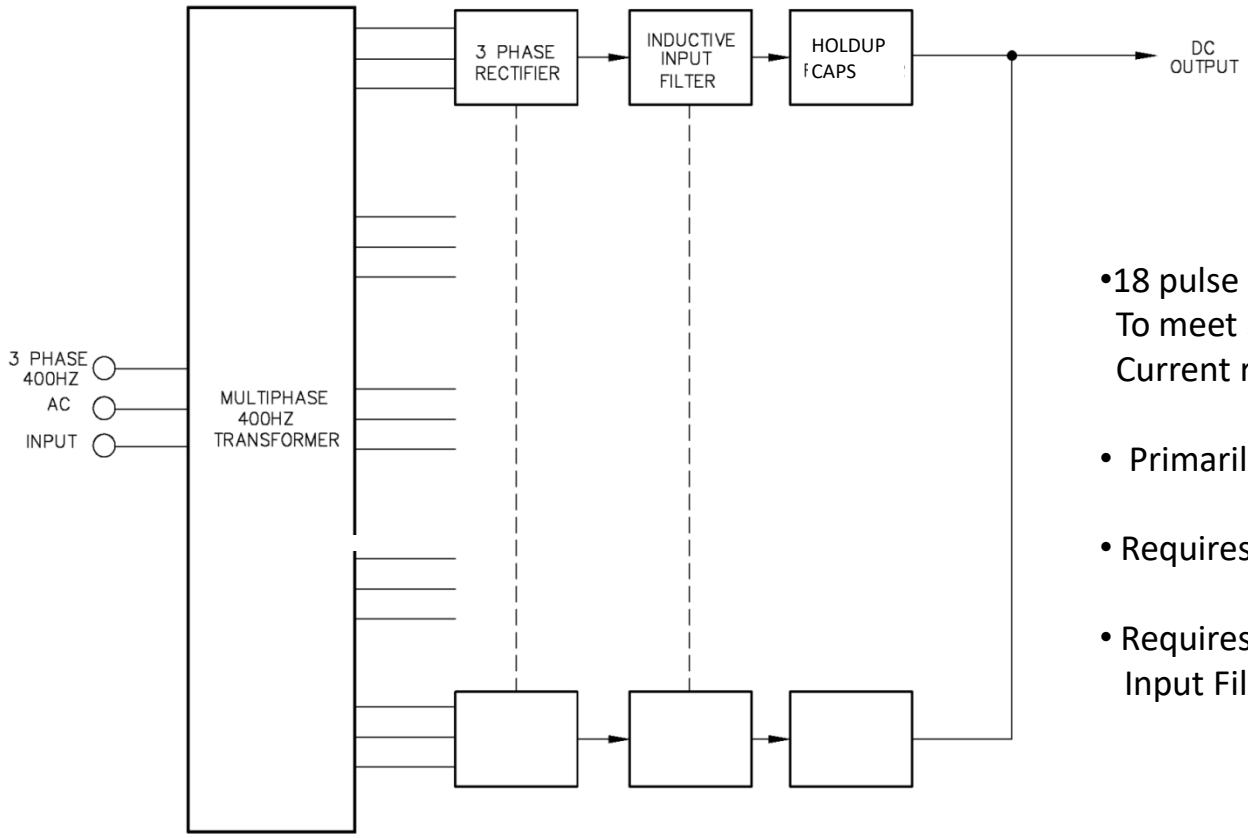

- 18 pulse Rectification needed To meet 3% Harmonic Line Current requirements
- Primarily used on Navy Ships
- Requires large bulky input transformer
- Requires Large bulky Inductive Input Filter

Passive Multiphase Rectification with High Frequency Boost Regulator for meeting Harmonic Line Current Requirements

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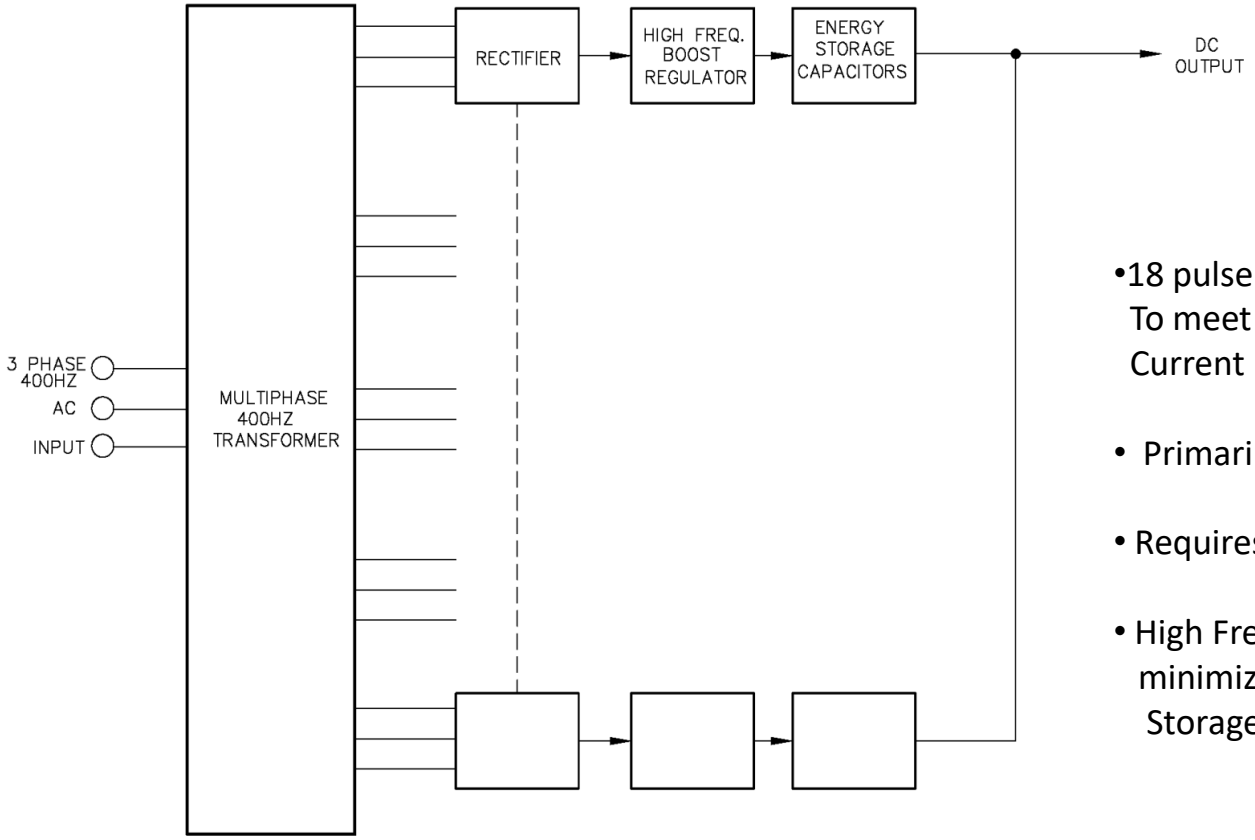

- 18 pulse Rectification needed To meet 3% Harmonic Line Current requirements
- Primarily used on Navy Ships
- Requires large bulky input transformer
- High Frequency Boost Regulator minimizes the size and weight of Energy Storage Capacitors

Three Active Single Phase Boost PFC regulators operated Line to Line, followed by isolated DC/DC Converters

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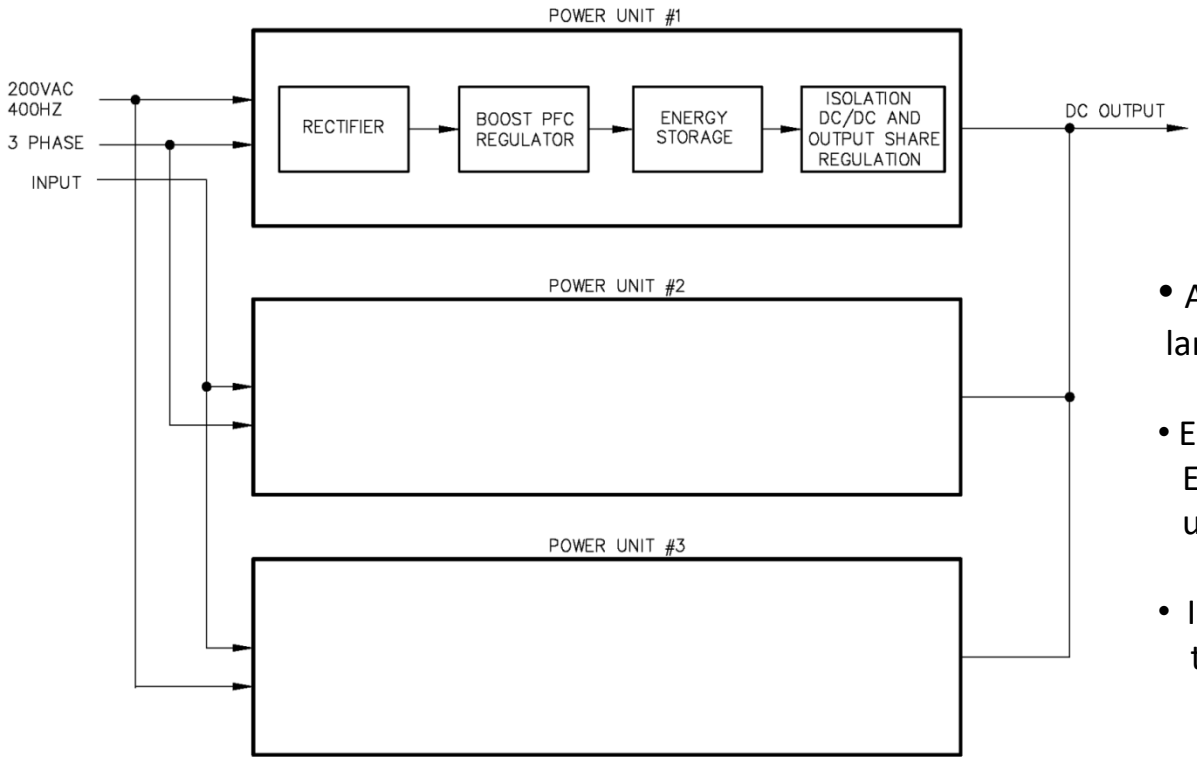

- Active Single Phase PFC's get rid of large bulky Transformer.
- Each Power Unit requires it's own Energy Storage. Potential issues with uneven holdup.
- Isolated DC/Dc Converters needed to combine into a single output

Three Phase PFC with Neutral, Block Diagram

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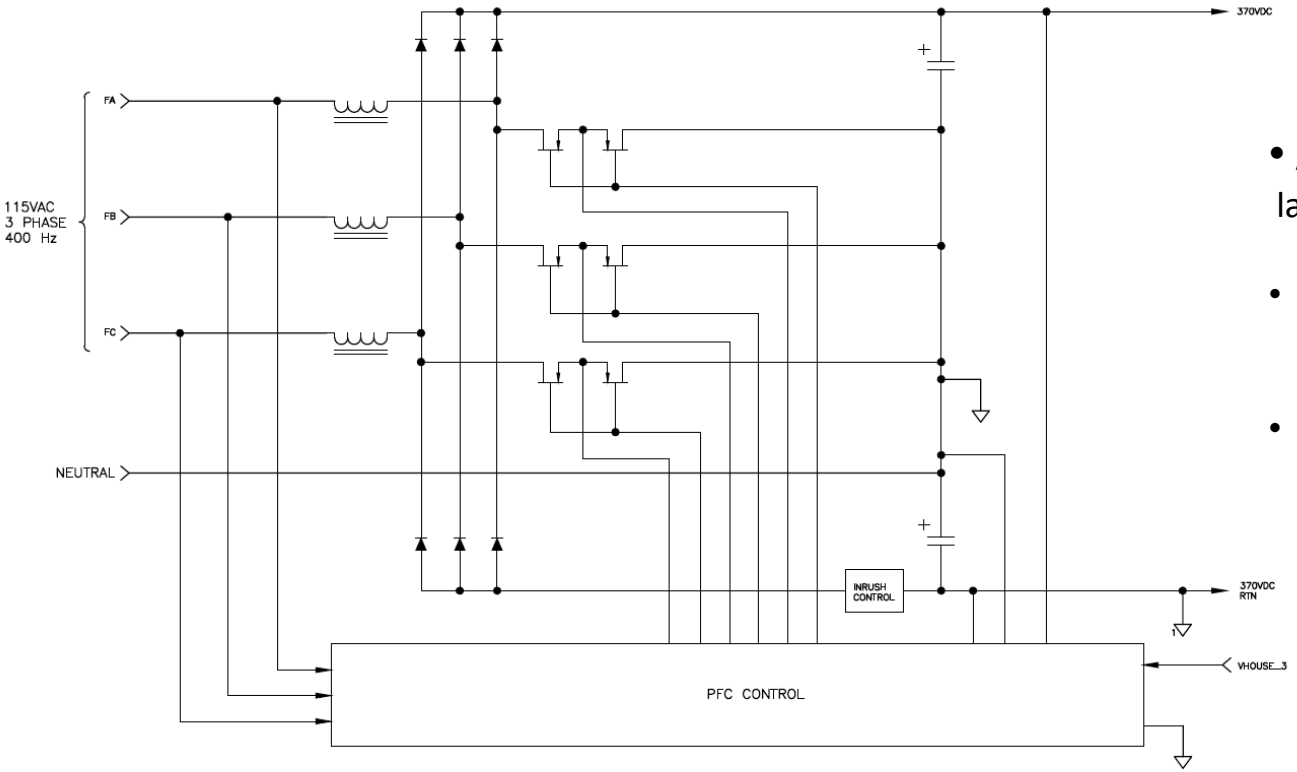

- Active Three Phase PFC gets rid of large bulky Transformer.
- Single Energy Storage. For all Power Supply Outputs
- Small EMI Filter due to continuous Input current

Power Supplies using 3 Phase PFC with Neutral

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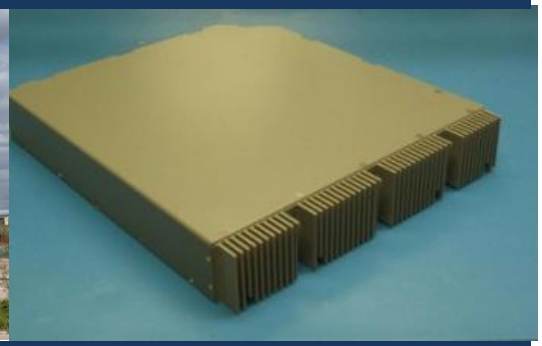
MISSILE WARNING (CMWS) POWER SUPPLY

ARMY HELICOPTERS

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

RADAR ROCESSOR POWER SUPPLY



CP140 ASW AIRCRAFT

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

Power Supplies using 3 Phase PFC with Neutral

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Power Supply for IFF System

P8 Poseidon Submarine Hunter Aircraft

- 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

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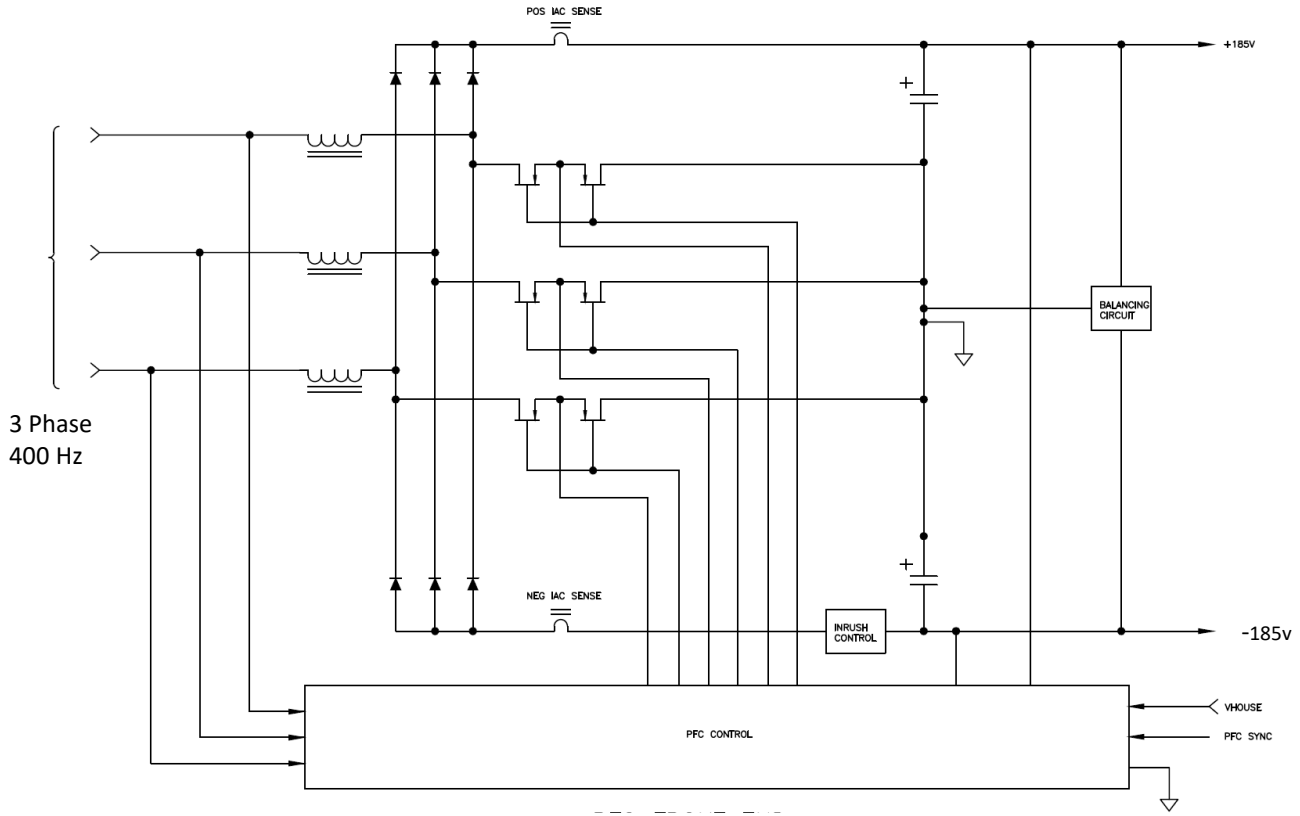

- Active Three Phase PFC gets rid of large bulky Transformer.
- Single Energy Storage. For all Power Supply Outputs
- Operates with 3 Phase AC Input, or 270Vdc Input (on two of the three Input lines)
- Small EMI Filter due to continuous Input current, and only 3 lines to filter.

Power Supply using 3 Phase PFC without Neutral

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Airborne Missile Power Supply

- 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

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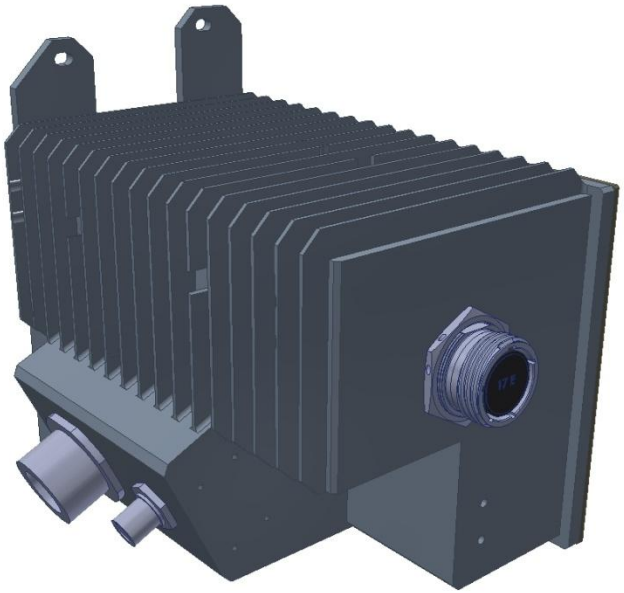

- 8000 watt output power
- 3 phase AC input power
- Less than 8 lb weight
- Meets CE-101 requirements
- Operates Rescue Hoist for Army Helicopters

Three Phase PFC in Pulsed Radar Applications

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- 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 on near the generator's output frequency (60Hz or 400Hz), or it's 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.

Modulation at T/R Module Power Supplies without 3 Phase PFC

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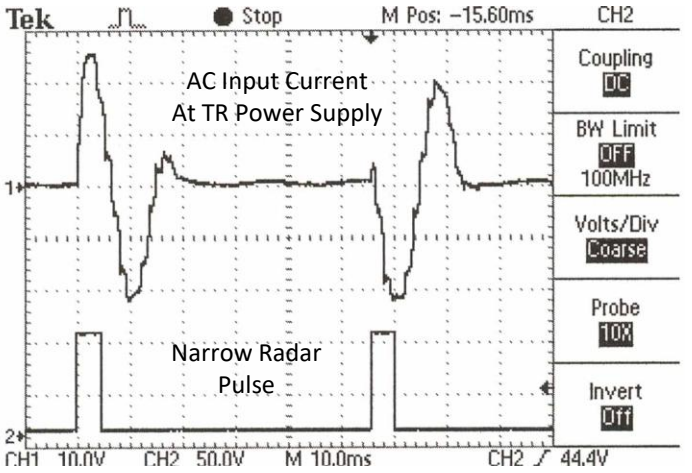
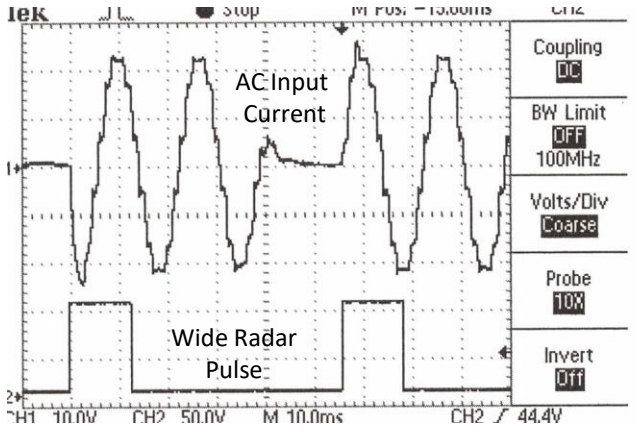
Ground Based UHF Phased Array Radar





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

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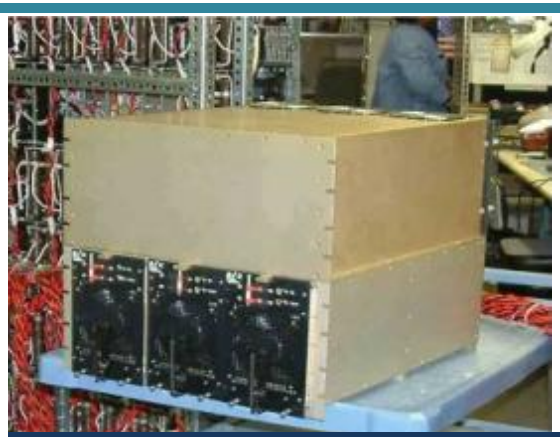
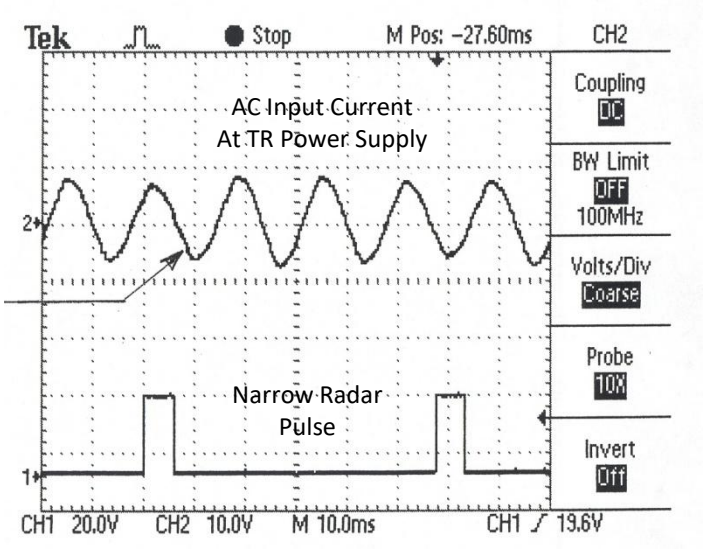
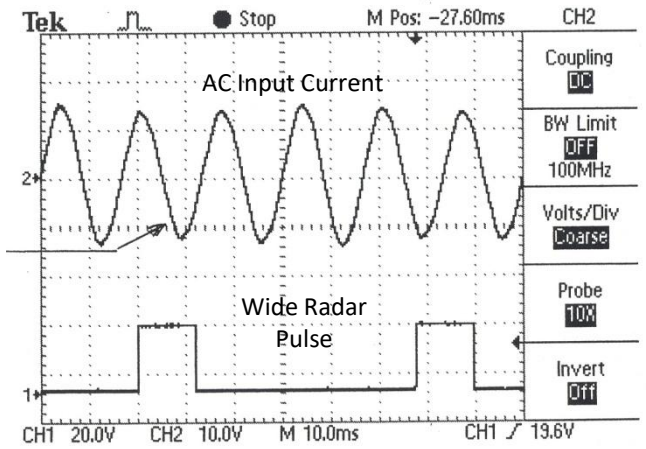


Power Supply for Solid State RF T/R Modules





BC-6Kw: Military, Airborne, 6Kw 3 Phase PFC for a pulsed Radar application, 11Kw peak pulse power

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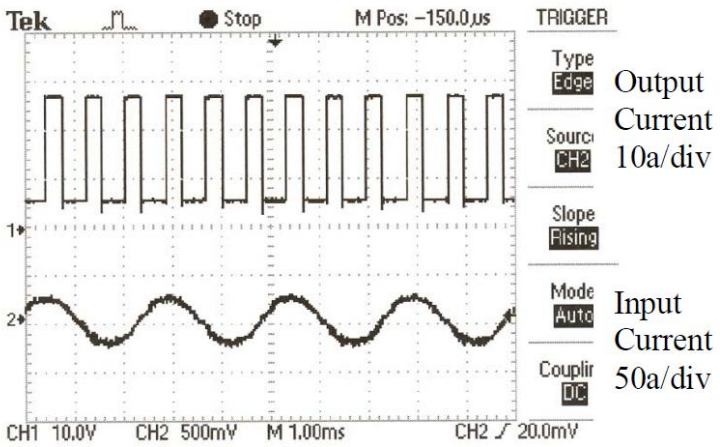
BC-6K AC/DC converter, 370v 6Kw average, and 11Kw pulsed output, 3.7lbs, 97% efficiency

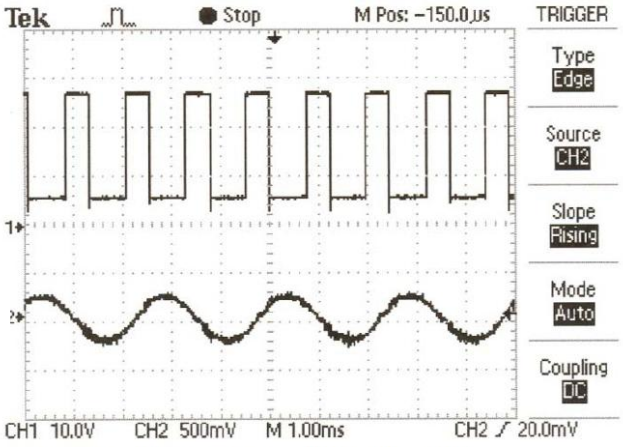
PFC Input and Output Currents at various PRF rates.
One of 3 phases shown.
Note that Output current pulses are not reflected to input current.



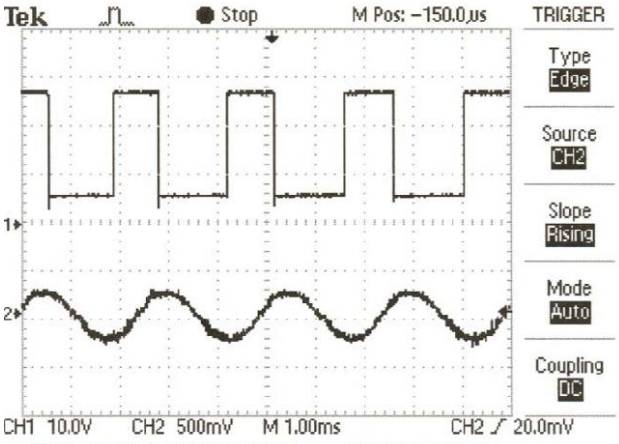
Output Current 10a/div

Input Current 50a/div

BC-6K TEST DATA, 1200 HZ PRF



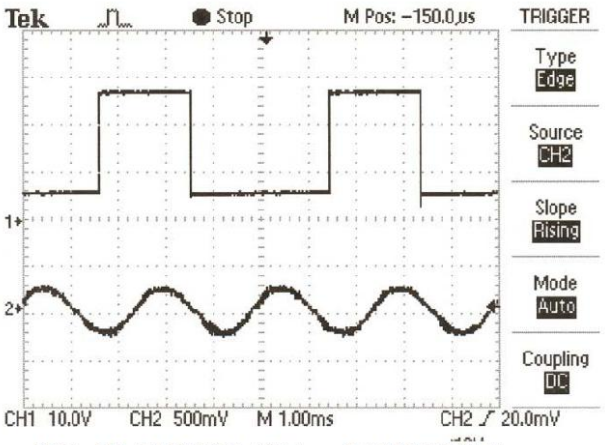
BC-6K TEST DATA, 800 HZ PRF



Output Current 10a/div

Input Current 50a/div

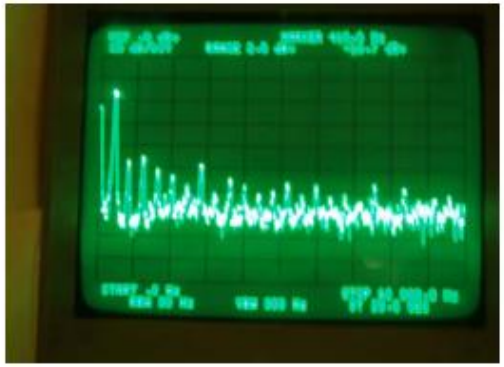
BC-6K TEST DATA, 400HZ PRF



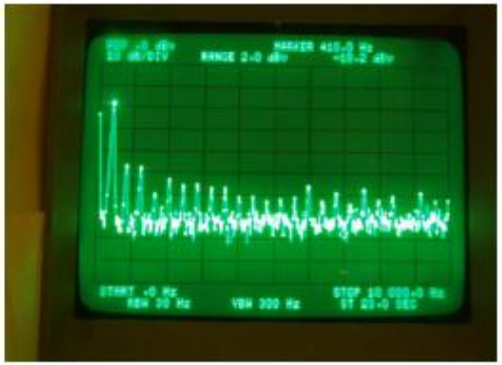
BC-6K TEST DATA, 200HZ PRF

BC-6KW Input Harmonic Line Currents

BC6KW TEST DATA
INPUT CURRENT SPECTRUM

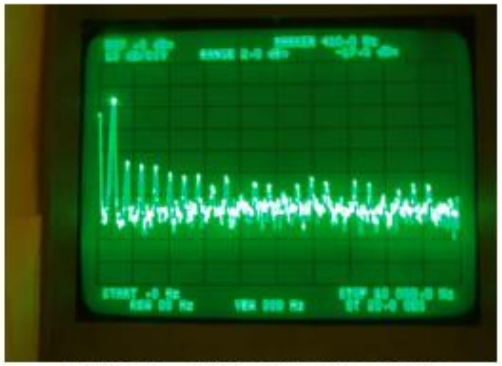


PHASE A INPUT CURRENT



PHASE B INPUT CURRENT

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



PHASE C INPUT CURRENT