Reinhold Environmental Ltd.

2009 APC Round Table & Expo Presentation

July 12-14, 2009, in The Woodlands, TX

Who Are We

- Paul Ford – President of Redkoh Industries. Redkoh has been manufacturing electrostatic precipitator controls since 1985. Control systems are sold internationally.

- Dan Steinhaur – President of Stein Industries. Stein Industries has been manufacturing precipitator transformers and power conversion equipment since 1992.

Stein Industries Inc.
19 Artisans Crescent
London, Ontario
Canada

Redkoh Industries Inc.
300 Valley Rd
Hillsborough, NJ
USA

Mid Frequency Power Supply Workshop

- Who we are.
- What is a Mid Frequency Power Supply.
- How does a MFPS work.
- What does a MFPS do for us.
- Where can we use an MFPS.
- System Flexibility.
- In Conclusion.

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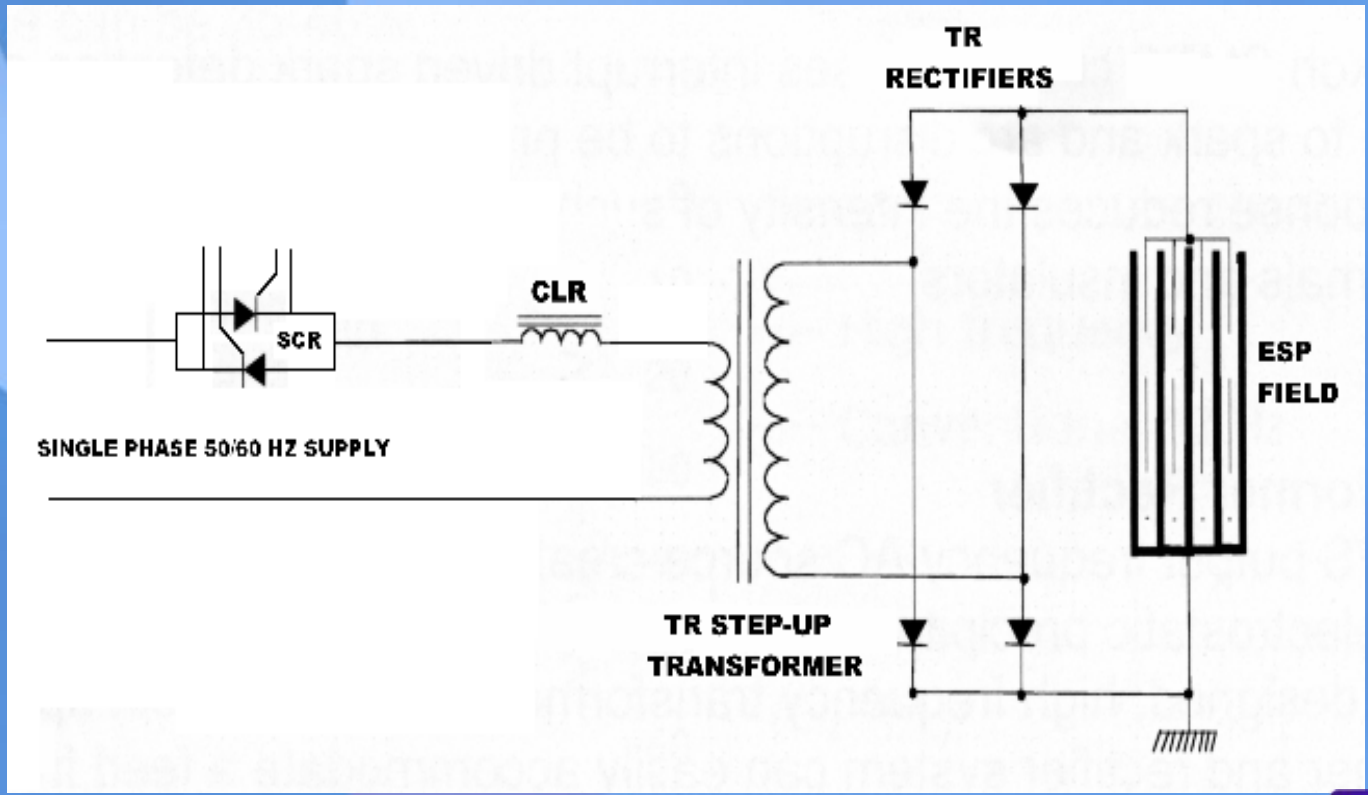
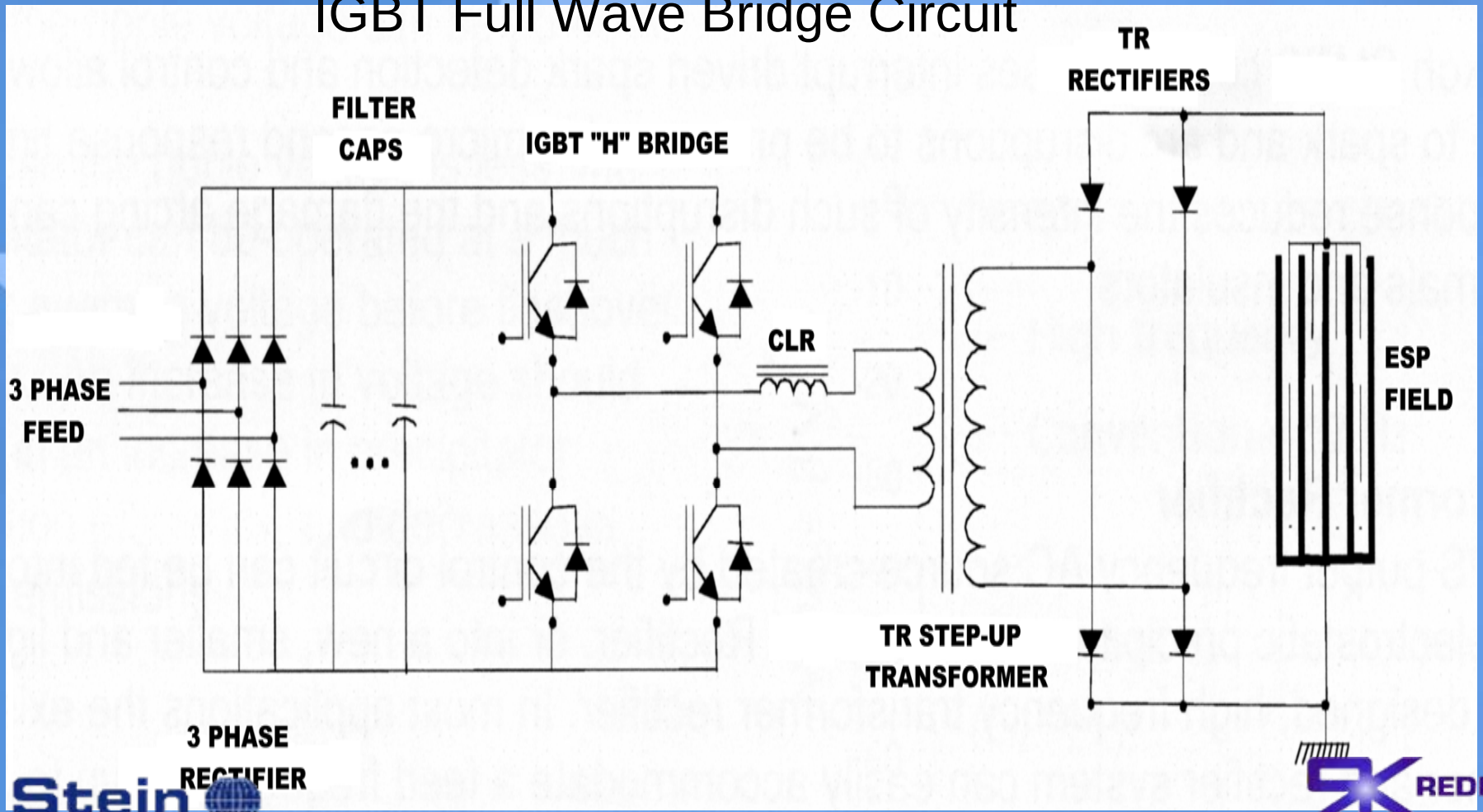
How does a single phase TR get its power?

SCR Phase control Circuit

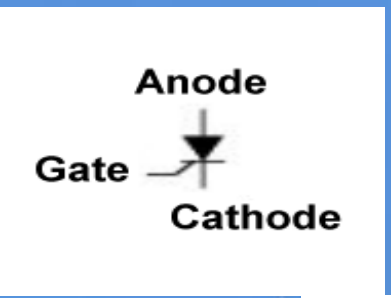


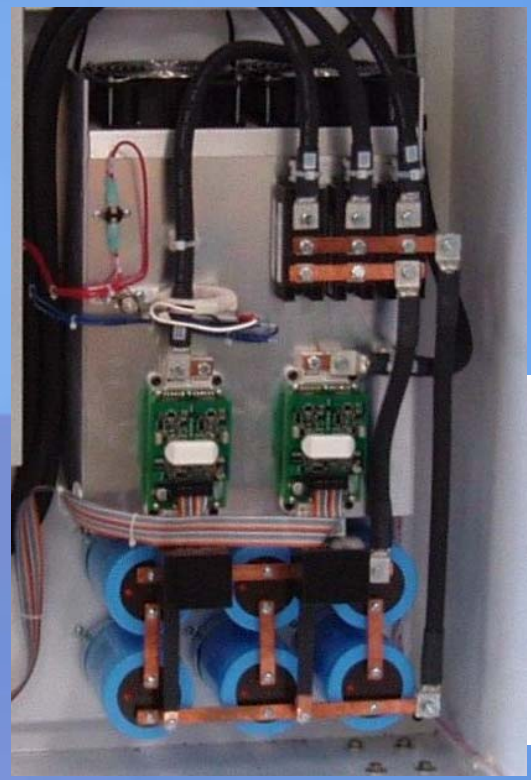
How does a mid frequency TR get its power

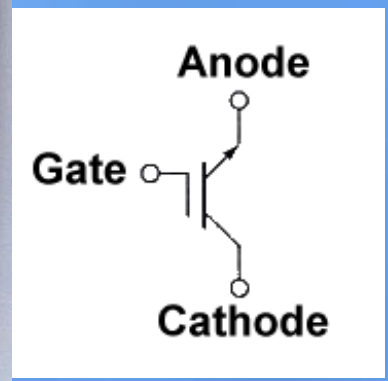
IGBT Full Wave Bridge Circuit



Silicon Controlled Rectifier vs. Isolated Gate Bipolar Transistor







Turns-on only every 8.3 ms.

Turns off at ‘zero crossing’

(SCR - 60 Hz Device)

Turns On/Off at will

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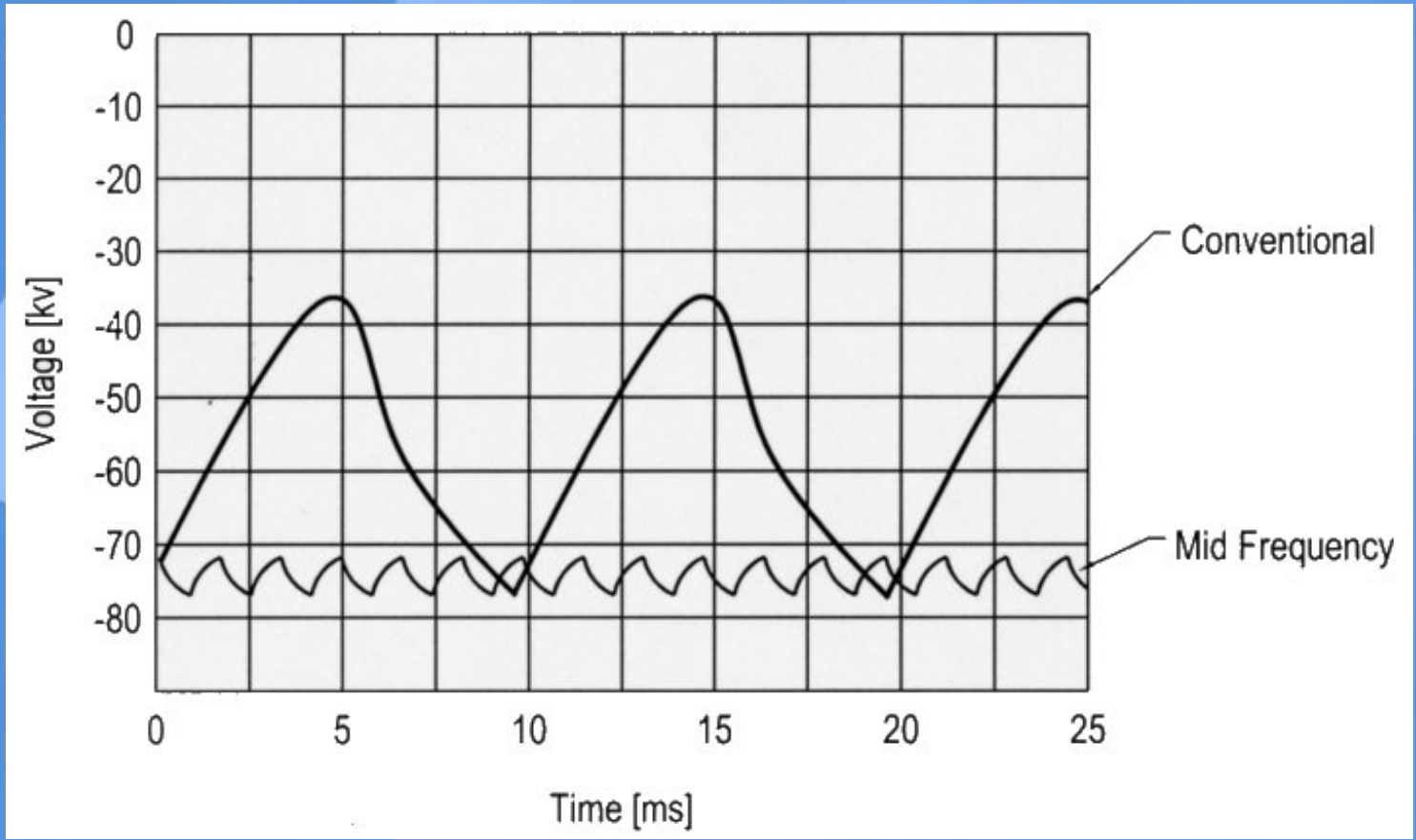
What does an MFPS do for us.

- The use of a higher frequency ESP field Power supply can result in dramatic improvement of performance
- The improvement in performance is a result in a 10% to 20% increase in Field KV
- A 10 % increase in field KV typically results in a 20% to 30% increase in field power

How Does MFPS Increase Power ?

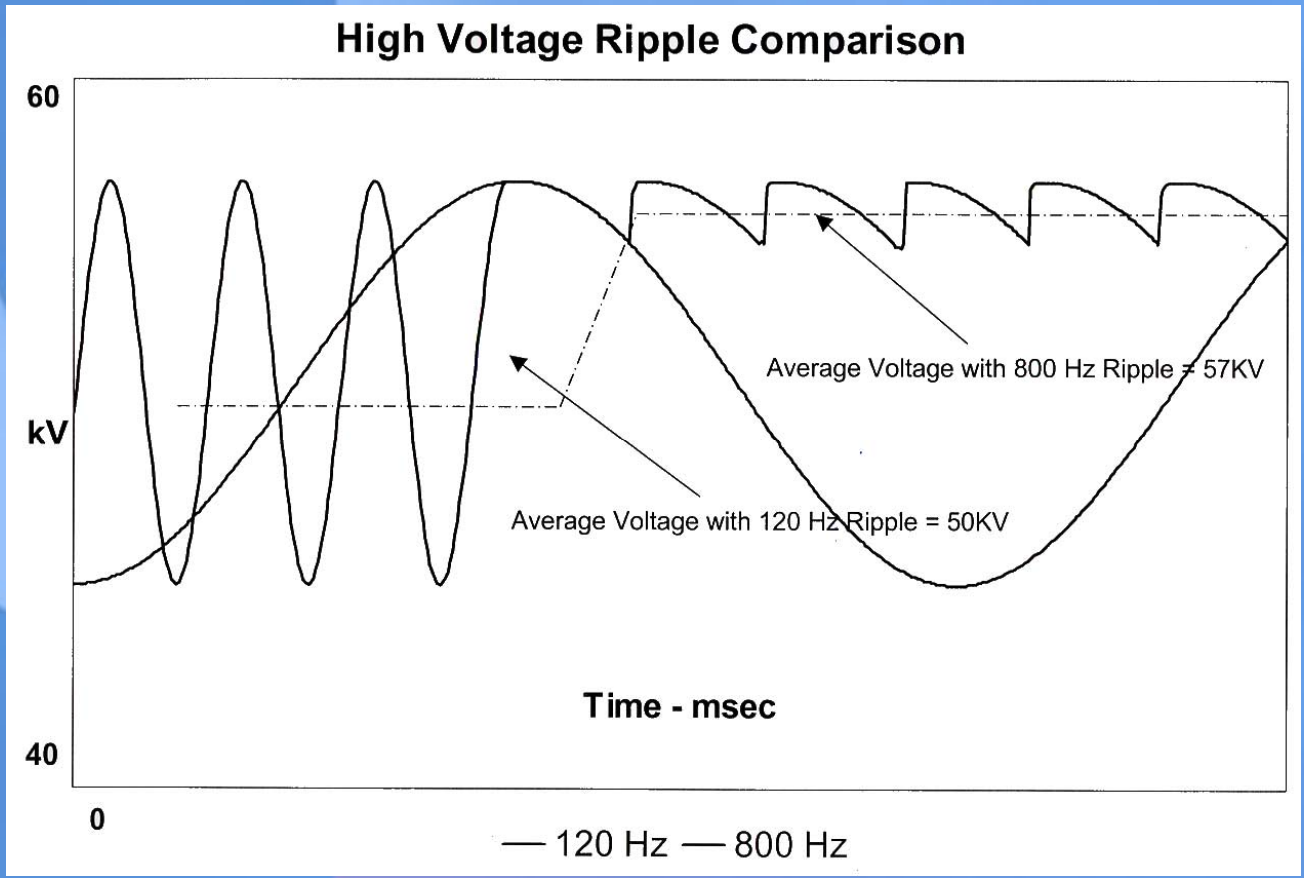
- The key to performance improvement lies in the ability on MFPS to reduce KV ripple and therefore operate at greater field KV
- The magnitude of such improvement is a function difference between the Ripple Voltage level of the 60Hz SCR Power Supply and that which can achieved with a 400 Hz Power Supply

Reduction of ripple results in increased voltage.



How does MFPS compare to higher frequency SMPS

- Increased performance by either tech. is a result of lower ripple and higher average voltage
- The amount of ripple is a function of the Power Supply frequency and the field Time Constant
- For typical ESP Field time Constants there is negligible difference between 400 Hz and multi Kilo-Hertz

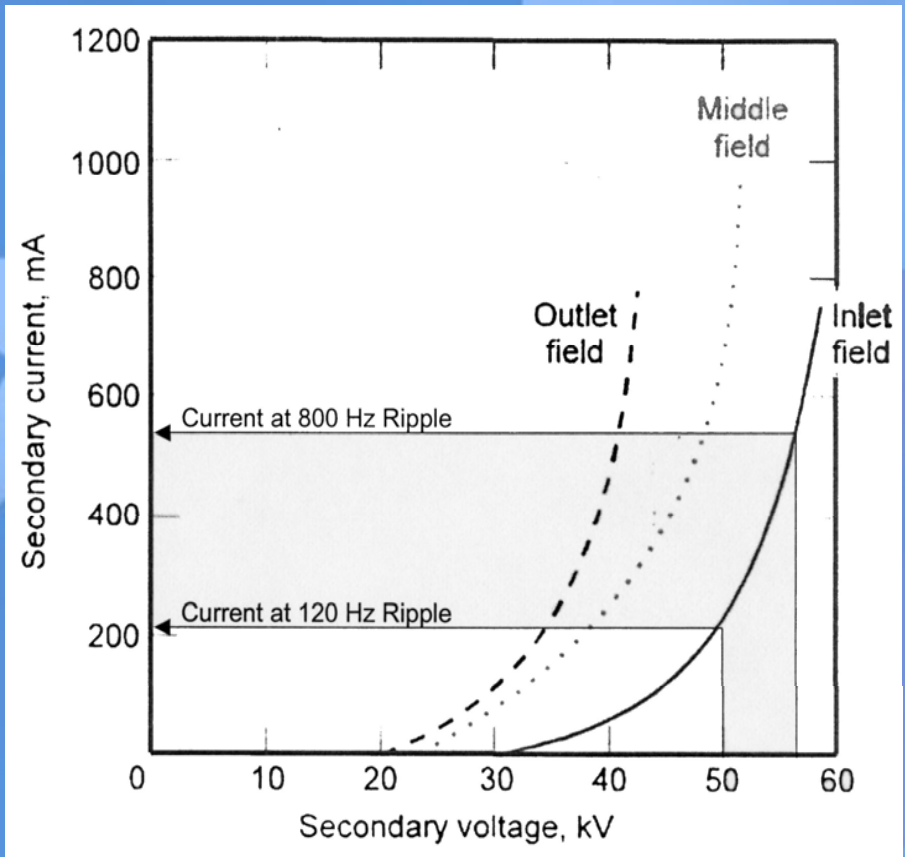

High Voltage Ripple Comparison
60
kV
40
0
Average Voltage with 800 Hz Ripple = 57KV
Average Voltage with 120 Hz Ripple = 50KV
Time - msec
— 120 Hz — 800 Hz

MFPS VS 20 KHZ SMPS

- Both technologies employ IGBT “H” bridge for power switching
- Resonant mode used for Kilo-Hertz SMPS use 20 KHz systems that require forced cooling to remove the heat generated.
- 20 KHz designs are smaller and require that Switching electronics to be mounted very close to the transformer
- 3 Phase power for SMPS must be available at the TR location

Increased voltage results in increased current.

Electrical field efficiency is related to power delivered.



Secondary voltage change of 8 KV produces a secondary current change of 350 mA.

Where Can the MFPS be Applied?

On any electrostatic precipitator, however, it will be of benefit if:

- Controls are operating below TR nameplate rating.
- Power is limited by spark rate.
- Controls are experiencing current suppression.
- Feeder power factor needs to be improved.
- Internal alignment can not be maintained.

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How can a MFPS be Applied to a Precipitator?

- As a new control with existing TR and CLR and existing wiring.
- As a new control with new TR
- As a new control integrated with an existing control and TR to preserve existing communication networks, power management, power down rapping, remote control, etc.
- As a new control integrated into a Transformer for ESP roof mounting

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What About the TR's?

- **Existing TR may be re-used.**
  - It is recommended that using a 60 Hz TR at 400 Hz can be done up to 50% of its nameplate milli-amp rating.
  - The 50% de-rating results in the unit operating within its design temperature limits.
  - Using the TR above 50% may be possible but it is recommended that temperature rise tests be conducted prior to long term use at such higher ratings.
  - *PRECIPITATOR POWER SUPPLIES, USE OF 60 Hz TR's at 400 Hz by H. J. DelGatto 2009*
- **New 400 Hz TR.**
  - New TRs may be required if existing TRs are operating at current limit.
- **New 400 Hz MIPS**
  - New TR with integrated controls on new plant or where 3 phase power is available to ESP roof.

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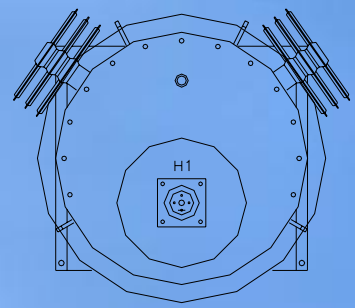
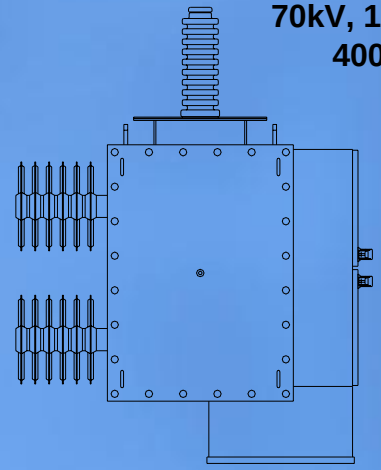
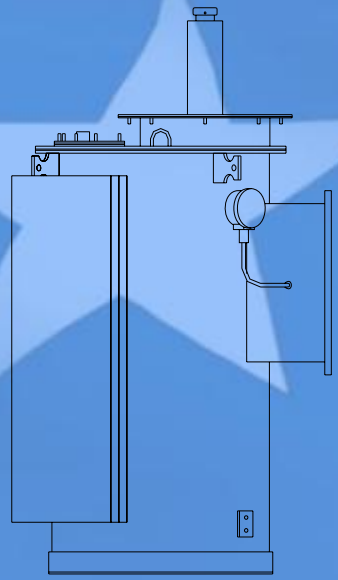
70kV, 1000mA
60Hz



70kV, 1000mA
400Hz





70kV, 1000mA
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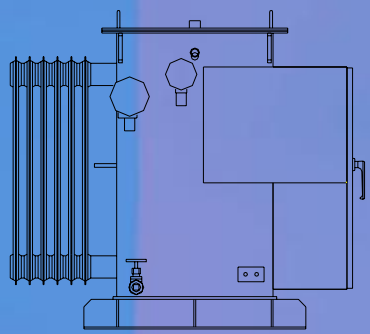
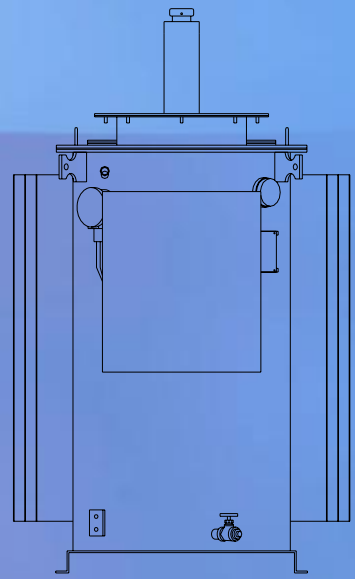


70kV, 1000mA
400Hz



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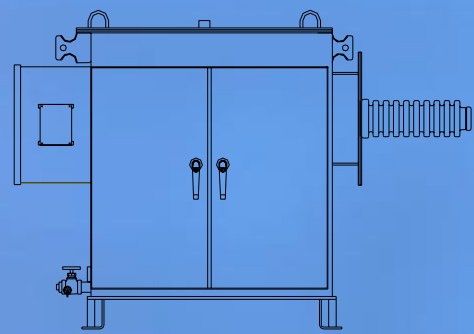

70kV, 1000mA
400Hz

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Integrated TR & Control

- Optional configuration with IGBT Switches and control electronics mounted with TR
- Remote control and monitoring via communication link
- Compatible with many existing ‘Third party’ 60Hz TR controls in use.
- Typically requires 3 Phase Power available at TR location.
- No fans ‘on roof’ required !

Reliability/Maintainability

- 400 Hz designs used for decades on Military applications requiring space/weight reduction
- TR design employs tried and proven materials and designs
- No pumps, fans or air filters required on the TR assembly typically in difficult environment.
- Controls and power switching may be located remote from TR in climate controlled area
- Equipment construction similar to that of industrial power systems

System Flexibility

- Distance between the TR and the field load is not a critical consideration
- TR configurations with any bushing location and orientation
- TR mounting compatible with existing duct Ground switches and buss work.
- Mix n’ Match
- Create a solution rather than design around a product

In Conclusion

- This concept offers a robust and flexible solution to powering an ESP