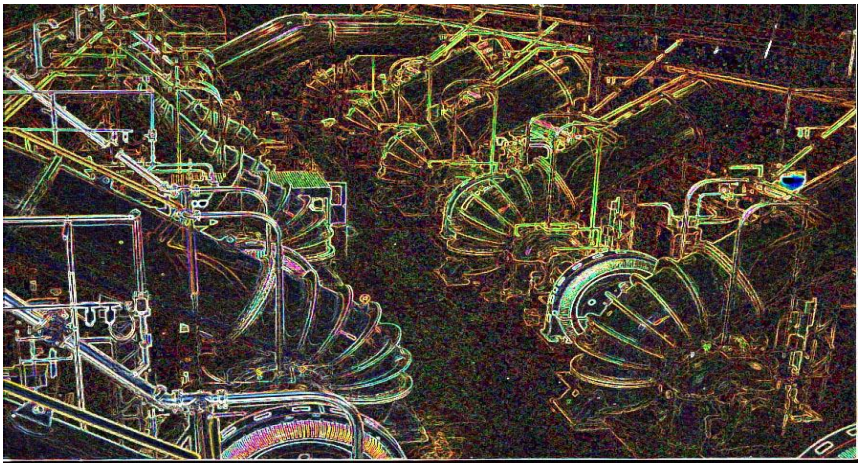
. *Kinetics Industries, Inc.*

Manufacturer Of:

One Manufacturer Source Solutions For

Synchronous Motor Field Excitation Systems

- **Synchronous Motor Application Questions & Answers**
- **Specification Regulated Exciter Rectifier**
- **Specification Solid State Application Circuit**
- **Specification Contactor Applied Application Circuit**
-



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Kinetics Manufacturer of:

Regulated & Non-regulated Rectifiers 1 to 2000Kw
Excitation Systems For Synchronous Machines

Kinetics Industries Manufacturer Of:

Excitation Systems For Synchronous Machines

Kinetics Industries has prepared this book to present common questions and requests for technical information that we receive concerning the application, service and trouble shooting of synchronous motor field excitation systems. The booklet highlights Kinetics' expertise and capabilities to design and manufacture excitation solutions for a wide range of motor designs, applications, power system management and application specific electrical and mechanical configurations.

Synchronous Motor Field Excitation Systems

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58 Specification: Totally solid state brush type motor field application panel & Kinetics' KinetSync-SR digital annunciation and logic module.

>> Typical large horsepower, steel mill, rolling mill, brush type synchronous motor under repair <<

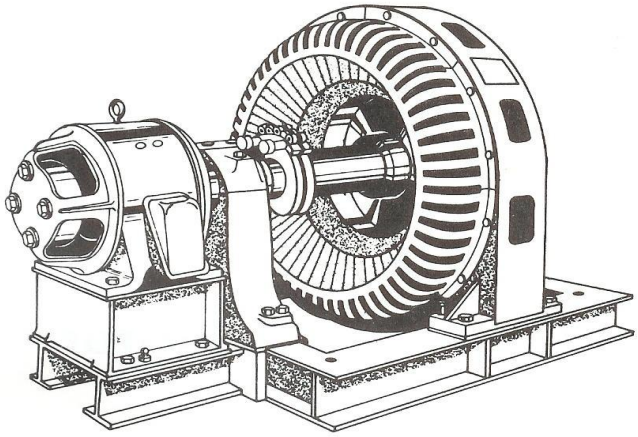


Fig. 1. Synchronous motor with a directly connected exciter.

Kinetics Synchronous Motor Field Excitation Systems

1. Questions & Answers: Who is Kinetics Industries:

Briefly, Kinetics Industries is a USA owned and operated, integrated, power systems manufacturing company, located in Trenton, New Jersey. Kinetics Industries was founded as S&M Electric Motor Repair, in 1939 by E. Paul Secrest. The company began as an electrical apparatus repair and service company for the region's heavy industrial customers. In the early 1960's Kinetics began working closely with "local" heavy industrial customers to design and manufacture diode rectifiers, SCR rectifiers and DC motor drives for the retro-fit of motor generator set and mercury arc rectifier and new solid state power conversion systems for plant automation. The company added capacity to manufacture dry type transformers in the late 1960's. During the mid-1970's a complete sheet metal fabrication facility was added for the manufacture of enclosures, panels and buss work.

Kinetics' roots within the motor service industry made the company well suited to develop rectification products for crane motors, lifting magnet, traction power system and excitation systems for synchronous machines.

Kinetics has developed experience working closely with various motor oriented production processes, such as, floor material manufacturers, steel & aluminum mills, rubber mills, pulp & paper mills and public utilities. From this heavy industrial experience, Kinetics has grown from a regional custom manufacturer to a world-wide manufacturer of a product line of standard and custom DC power supplies, SCR regulated rectifier and field excitation products for synchronous machines.

Kinetics' extensive customer list includes a wide spectrum of diverse industries, utilities, governmental agencies and geographical locations. Our diverse customer base has enabled Kinetics to develop a product line of

power system products that begins with a basic diode power supply to the sophisticated facility integrated production process solid state digital logic and control excitation system for a synchronous motor with data networking capabilities.

At Kinetics' single source manufacturing, plant located in Trenton, NJ, Kinetics' skilled staff designs and manufactures our own SCR and diode power control assemblies, dry type transformers from 1 to 2000 KVA, control and firing circuitry and sheet metal panels and enclosure fabrication. As a self-contained manufacturing facility, Kinetics brings the team concept to the manufacturing process. We work to consistently manufacture the highest quality power system products and provide the availability of the most comprehensive and accessible engineering support on the market.

>> Motor pump room at one of the many pumping facilities of Southwest Nevada Water Authority. Pumps driven by 2,500 Hp brushless synchronous motors. Excitation systems incorporate the use Kinetics regulated exciters and KinetSync-NB digital annunciation and control logic modules.

2. What is the difference between a brush and brushless synchronous motor?

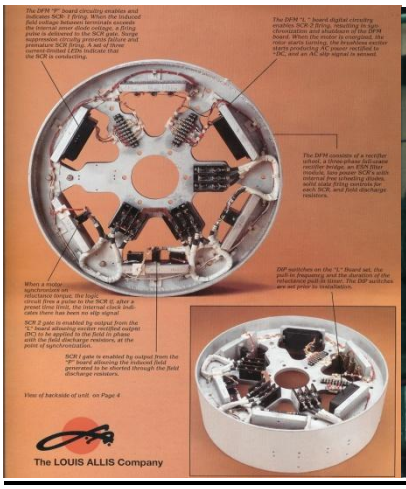
The motor theory and delivery of mechanical power is nearly identical for both type of motors. The major differences between motors is the method of "delivery" of the field excitation to the rotating field poles.

- A brush type synchronous motor incorporates the use of brushes riding against slip rings to deliver the full field current and voltage, power, field directly to the motor field. The DC power source for field excitation, field application logic, field application / discharge resistance application method and field discharge resistors are located external from the synchronous motor.
- A brushless type synchronous motor incorporates the use of a remotely located DC power source called a "pilot exciter" or "control power exciter". (Common value 125 VDC at 3 to 20 amps DC). The DC "control" power source

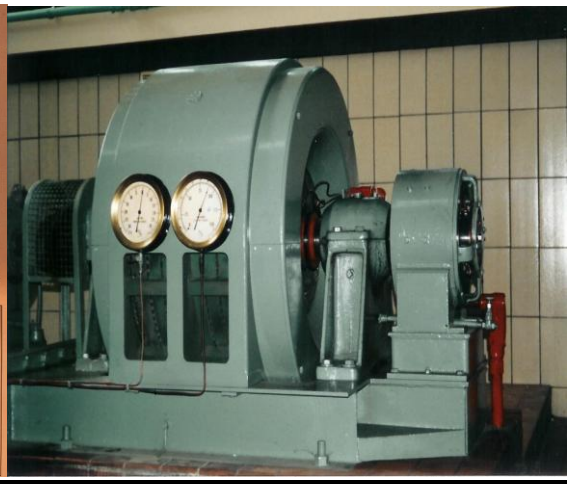
is applied to the motor's rotating rotor via an induced electro-magnetic field. The field application logic, power field exciter and discharge resistors are mounted to the motor's rotor. By increasing or decreasing the output of the "pilot" exciter, the rotating power exciter increases or decreases field strength. The motor manufactures promote that the elimination of brushes and slip-rings reduces the maintenance requirements of the motor.

Left: Off-shaft brushless motor excitation system
Right: Brush or slip ring motor excitation system

Typical rotating exciter assembly



Typical slip ring motor assembly



3. Brush type synchronous motor: what is needed to run the motor?:

1) AC main line power motor starter and / or switchgear.

2) CT's & PT's in quadrature on the AC main power feeds to the motor.

-> *Quadrature defined: A quarter of a cycle phase difference. If the angle of lag or of lead between two sets of alternating current waves be 90', or a quarter circle, the waves are said to be in quadrature with each other.*

3) DC power source for field excitation. DC for excitation can be supplied from several possible means:

- Common DC mill buss power.
- Motor generator set.
- Synchronous motor shaft mounted DC generator.
- Constant potential diode exciter.
- SCR regulated rectifier exciter.

4) Field application control and application logic. Old vs. modern methods

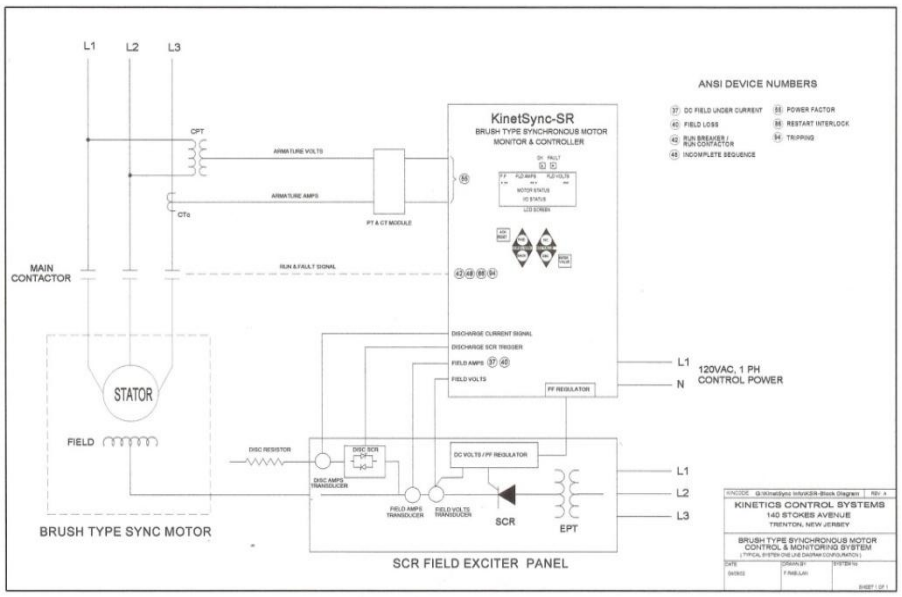
- Discrete components consisting of contactors, relays and timers (Pre-electronic panels)
- KinetSync-SR, solid state, micro-processor based, digital logic and annunciation control module.

5) Field application method: Two of the common methods are;

- Two normally open poles & one normally closed pole contactors with over-lapping contacts. Found in "older" vintage packages. Currently used when excitation power is supplied from a DC buss, constant potential exciter or existing exciter.
- Solid state field / discharge resistor application via SCR switching with latching crow-bar circuit. Solid state switching is the most desirable method of switching and is the modern standard. Solid state switching application circuits are only available when an integrated regulated exciter is supplied as a system.

6) Field discharge resistance grid.

7) Application specific features: Kinetics engineering is available to assist in application customizing features such motor "inching" control for ball mills and field forcing for steel processing rolling mills.



>> Typical brush type motor excitation system drawing

>> Typical "complete" excitation system: 5 KV input LBSF, regulated exciter, solid state application circuit, KinetSync-SR annunciation & logic module, discharge resistors all in a NEMA3R line-up enclosure.

4. Brushless motor: what is required to run the motor?

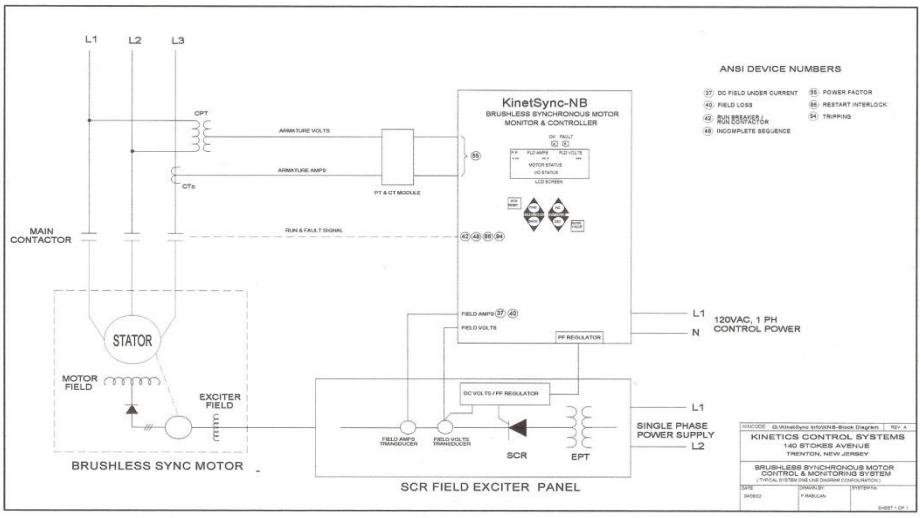
1) AC main line power starter and / or switchgear.

2) CT's & PT's in quadrature on the AC main line power feed to the motor.

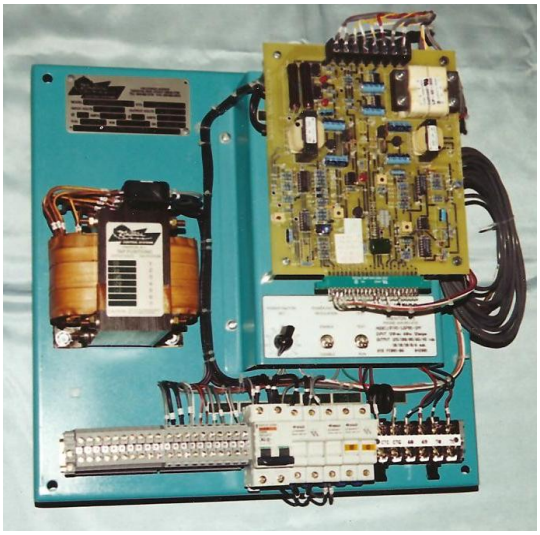
3) Constant potential or regulated output exciter.

4) For applications where controlling power factor, monitoring the motor, having a operational history registry or placing operational information on a communication network Kinetics recommends the KinetSyn-SR digital annunciation and logic control module.

5) Electrical drawings or a written description of the operational configuration of the rotating field excitation circuitry and the relationship to the off-shaft exciter.



>> Typical brushless motor excitation system drawing



Typical Brushless Motor Off-shaft Excitation Regulator

5. Off-shaft brushless exciter circuit design warning of potential failure when applied to a GE motor.

Off-shaft exciter system designs, when applied to GE brushless synchronous motors, must address the potential of rotating electronics damage if voltage suppression is not applied to the output of the exciter. Failure to provide adequate voltage suppression between the off-shaft exciter and the rotating exciter electronic can result in a failure to the rotating electronic package. A failure of the rotating exciter semi-conductor can produce an interaction that can result in failure of the off-shaft exciter due to voltage surges.

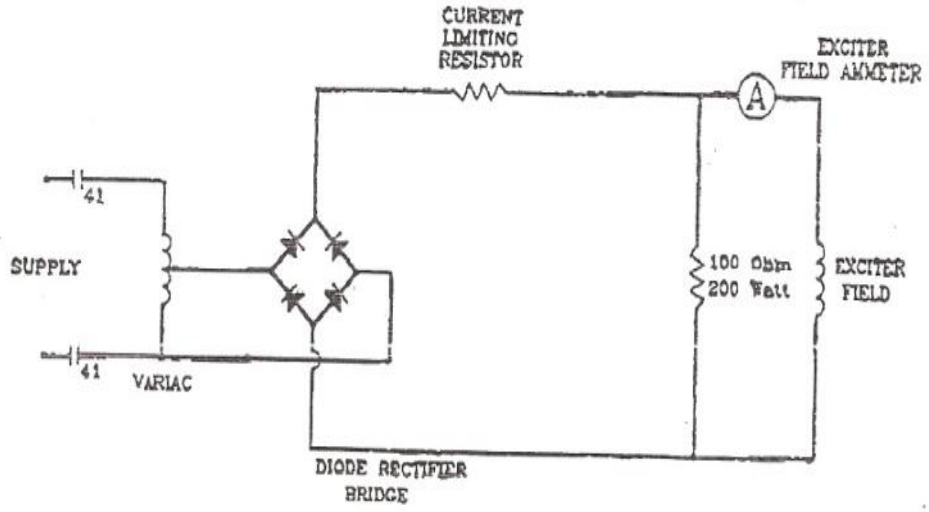
Specific to the GE brushless synchronous motor rotating electrics design, GE offers the following warning within their instruction manual concerning the off shaft exciter design and the need for circuitry voltage surge protection:

Caution: It is possible to develop a high induced voltage across the exciter field terminals during abnormal operation (Failure of a rectifier circuit component). To limit subsequent damage to the exciter field supply and control components, it is recommended that a 100 ohm, 200 watt, fixed resistor be placed across the exciter field terminals. If an ammeter is incorporated to monitor the field current, the resistor should be located on the supply side of the ammeter. Failure to observe these precautions may result in equipment damage.

Failure to provide a simple, common and inexpensive resistor, on the output of the off shaft exciter, when applied to a GE brushless motor, can result in an expensive motor failure. GE's manual highlights the potential of off-shaft exciter failure, however failure of the rotating exciter and circuitry is a far more expensive and time consuming event. It is not uncommon of one exciter to lead to the failure of the other if sufficient voltage suppression is not present.

Various manufactures deploy various configurations of rotating exciter circuitry that have pro's and con's for functional reliability, durability and operational / application flexibility. The designer and application engineer of brushless excitation systems must be on constant guard for the dangers of the improper exciter compatibility and / or inadequate system circuitry protections.

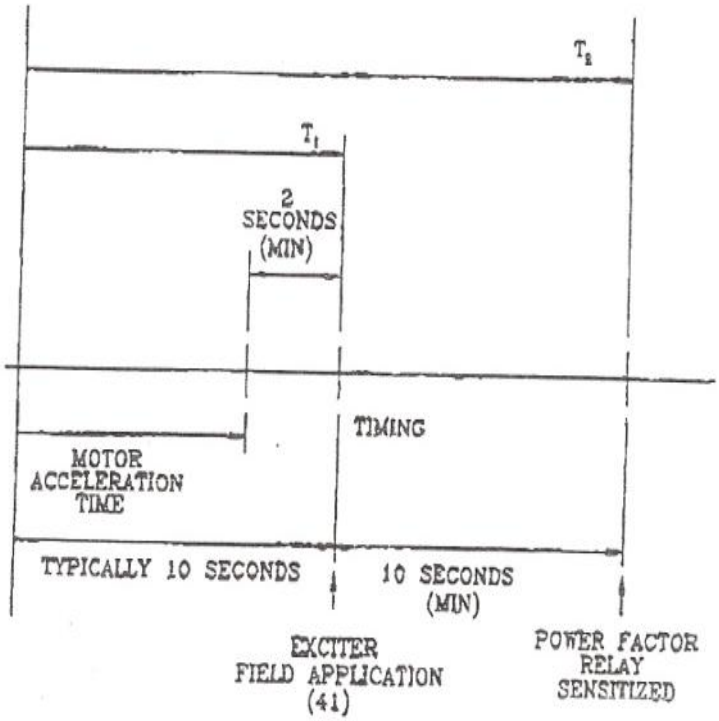
The instruction manual for GE brushless motors provides the following circuit drawings as recommended configurations of possible off-shaft exciter designs that incorporate the critical voltage suppression resistor across the exciter output.



Diode Rectifier PRV = 100 x $I_{Field\ Exciter}$ x 2.0

Example : $I_{Field\ Exciter}$ = 3.3 Amps For Full-Load Motor Operation

PRV = 660 Volts (min)

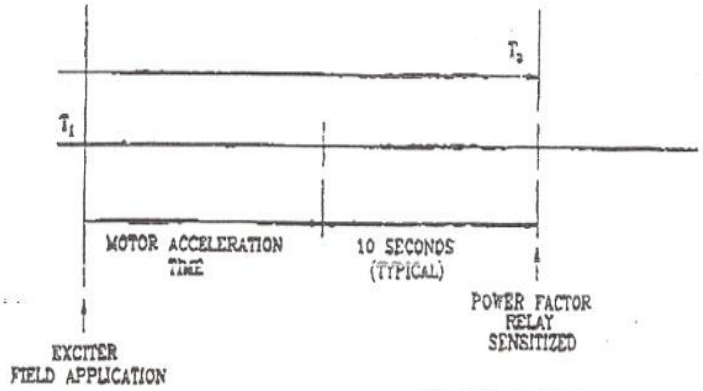


For Typical Applications

$T_2 = 2.0 \times T_1$

Fig. 5 Typical M-1 Circuit Application

For a typical M-2 circuit application the exciter field supply circuit is identical to an M-1 circuit. The timing diagram is different.

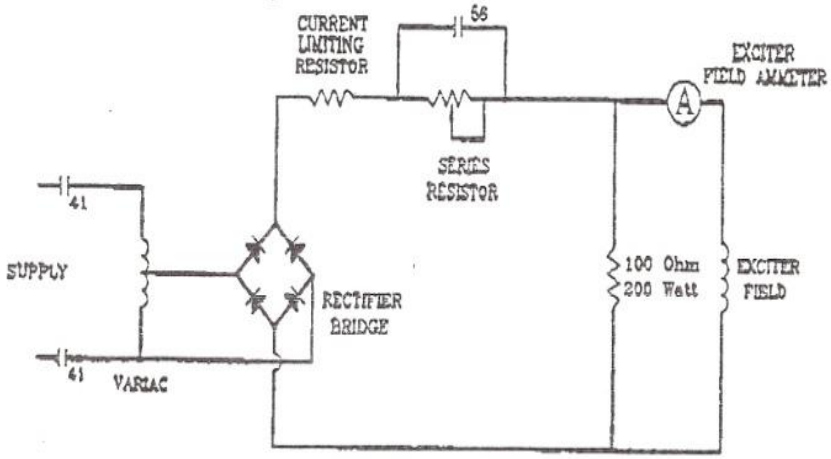


For typical applications

T2 = Motor Acceleration Time + 10 Seconds
T1 = 0. Seconds

Fig. 6. Typical M-2

In some applications of the M-1 Circuit (i.e., larger exciter ratings) it is desirable to apply the exciter field current in steps to prevent excessive heating of rectifier components during startup. To accomplish this, the following circuit arrangement is recommended:



Diode Rectifier PRV = 100 x $I_{Field\ Exciter}$ x 2.0

Example: $I_{Field\ Exciter}$ = 3.3 Amps For Full-Load Motor Operation PRV = 660 Volts

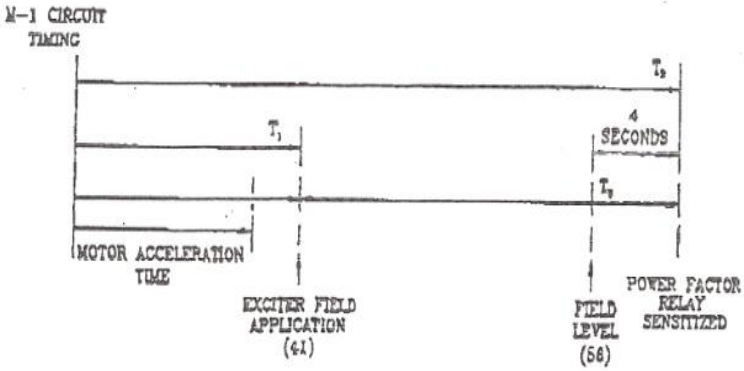


Fig.7. M-1 Circuit Application For "Stepped" Field Control

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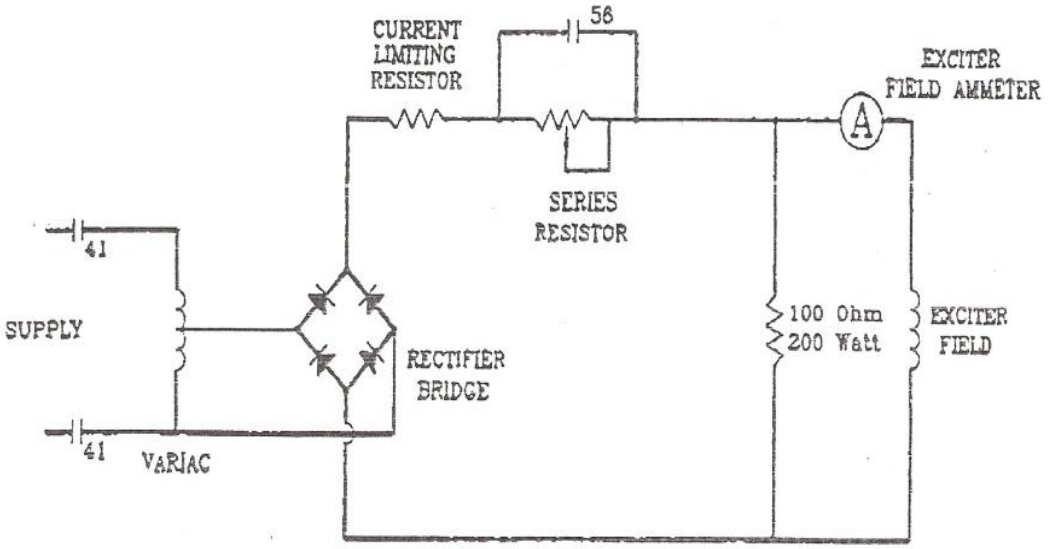
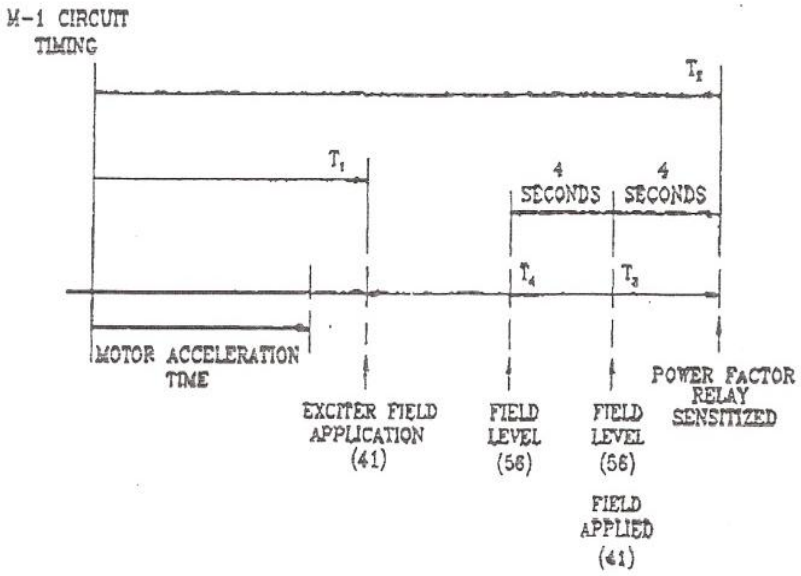
In some severe applications of the M-1 circuit (i.e., high inertia drives without initial loading provision) it is desirable to remove the exciter field current at the end of the starting sequence for a short time. It is possible this procedure will require a 2-step application of exciter field current. (56 Relay and Resistor)



Diode Rectifier PRV = 100 x $I_{Field\ Exciter}$ x 2.0

Example: $I_{Field\ Exciter}$ = 3.3 Amps For Full-Load Motor Operation PRV = 660 Volts



T_2 = 2.x motor acceleration time + 8 seconds

Fig. 8. M-1 Circuit Application For Field Removal Control.

6. What parts of a synchronous motor system does Kinetics manufacture or have the availability to supply with the excitation system?

- Kinetics is the one source solution for the manufacture of excitation systems and components necessary for "brush" and "brushless" synchronous motors.
- Kinetics can either manufacture or supply AC motor starters, of various types, up to 15 KV class.
- Components by various major manufacturers available upon request.
- Exciter power transformers, EPT: Kinetics manufactures dry type from 500 VA to 2000 KVA capacity and up to 15 KV class.
- DC field power sources, brush type motor exciters, with the feedback regulation loop closed various options, manufactured by Kinetics, to fit the application objective:
  - Current regulated - feedback loop closed on current.
  - Voltage regulated - feedback loop closed on voltage.
  - Power factor regulated - feedback loop closed using a vernier power factor monitoring circuit.
  - Remote signal regulated input of either 0 - 10 volt or 4 - 20 ma control signal supplied by other to terminal points at the rectifier.
  - Constant potential diode rectifiers with output voltage adjustment by manual tap changing. Taps commonly supplied 5% voltage increments below the nominal nameplate voltage rating.
- Exciters for brushless motors
  - Constant potential diode power supplies.
  - DC regulators / SCR regulated rectifiers.
- Solid state, digitally controlled annunciation & logic control modules.
  - KinetSyn-SR for brush or slip-ring motors.
  - KinetSyn-NB for brushless motors
- Field application panel systems for brush type motors by Kinetics:
  - Contactor applied field application panel system.
  - Solid state, SCR switching with latch crow-bar circuit field application panel.
- Inter-connection wire harnesses with quick-connect plugs for trouble free and highly reliable connections between the exciter / application panel & the KinetSync annunciation & logic module.
- Field discharge resistor banks.

- Data information highway digital communication interfacing.
- Application specific features and parameters of operation for interfacing with a given application.
- Open panel construction for mounting within the customer's enclosure or Kinetics manufactured heavy industrial enclosure types NEMA1, 3R, 4, 4X , 12 and IP 52 & 54.

>> Brush type synchronous motor excitation system for a 5,000 Hp water pump at electrical utility generation plant; 5 KV LBSF, regulated exciter, solid state application panel, KinetSync-SR annunciation logic module, discharge resistors in a NEMA4 enclosure.

7. A generator is similar in theoretical principal to a synchronous motor; can a generator excitation system be used on a synchronous motor?

Briefly, the designers of synchronous motors have the criteria of delivering mechanical load to a process as the paramount ultimate objective. Stating the obvious, a synchronous motor rotor is designed around the shaft to deliver mechanical load. A generator rotor is designed with the object of generating electrical power into a power grid. Although a synchronous motor can be run continuously with a leading power factor to act as a generator, the performance will always be marginalized when compared against a generator specifically designed as electrical power generator.

The same engineering principles hold for excitation systems. A generator excitation will "work" *but* a generator excitation is designed for the generation of power, regulating the quality of the power generated and synchronizing the generated power to a power system grid. A synchronous motor excitation system circuitry is designed for the production of dependable mechanical work through the motor shaft.

8. Exciter application guide, avoiding unit misapplication; necessary selection considerations when considering a diode, constant potential, rectifier verses a SCR, regulated output, limited range rectifier.

Application of Regulated and Non-Regulated Rectifiers to Synchronous Motor Field Excitation Applications

The use of rectifiers to supply DC power for synchronous motor field excitation is a common and recognized usage of rectifiers for both new installations and retro-fit. However, as in almost all cases of rectifier application there are application considerations that must be addressed to avoid the possibility of misapplication.

The new installation or OEM systems are usually the cleanest and simplest application. The customer generally has an engineering specification to meet and/or current un-modified system prints. The area most vulnerable to misapplication is the retro-fit of motor generator sets or older vintage rectifiers.

In simplistic terms there are two different types of existing installations. Illustrations 1 & 2 are one-line diagrams of these two general types of systems. The difference in the systems, from the reference point of rectifier application is whether or not a constant voltage diode rectifier, Kinetics models MVR & CVR, is adequate and desirable (diode units are lowest first cost) or if a SCR current regulated, ±1% of DC output setting, rectifier is required.

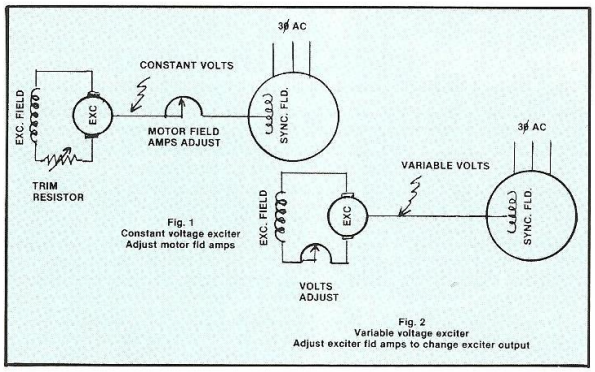
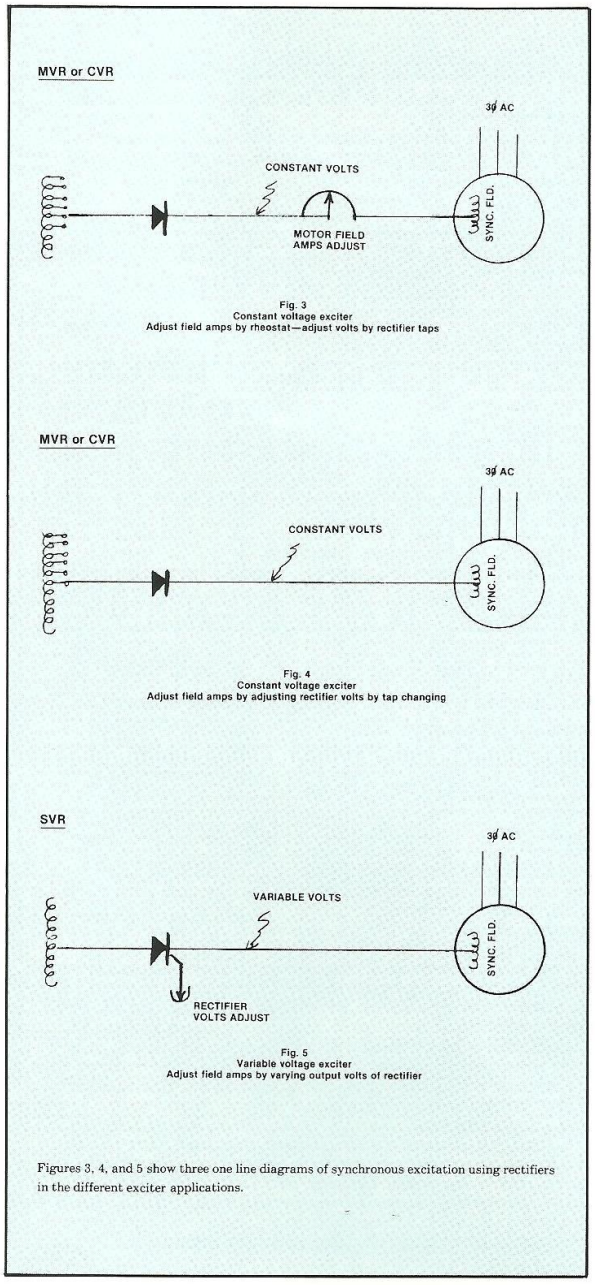


Figure 1 shows an exciter which is a constant voltage output, exciting the synchronous field with a large motor field rheostat in series with the constant voltage output to adjust the motor field current. This type of circuit is commonly identified by the size of the adjusting rheostat. This rheostat may have to be sufficiently large to carry the full field current. In this type of installation, a constant voltage diode rectifier, Kinetics model CVR and MVR, would be adequate for the job provided the customer is satisfied to retain the large rheostat control. Power rheostats can be a source of trouble to the user, a nuisance source of heat, provide "sloppy" control and require frequent adjustment by an operator. If the customer should have a desire to eliminate the rheostat, this can easily be done by use of Kinetics' SVRS SCR regulated rectifier.

Figure 2 shows a variable output exciter which is the biggest source of sales application problems. The motor field current is adjusted by adjusting the field strength of the exciter field and thus varying the output voltage of the exciter. This is an ideal application for Kinetics' SCR solid state regulated output model SVRS rectifier. The SVRS model has a higher initial cost than diode rectifiers but offers improved performance, ease of output adjustment and automatic output adjustment under varying operating conditions. A diode constant voltage rectifier may work but the customer must change taps on the units isolation transformer to adjust the DC output voltage. (The Kinetics model MVR comes standard with six 5% taps below rated output voltage.)



Figures 3, 4, and 5 show three one line diagrams of synchronous excitation using rectifiers in the different exciter applications.

Points to consider when selecting between a constant voltage diode rectifier or a SCR regulated output rectifier:

- Compare the above diagrams to determine the system you are working with. A regulated unit will meet all the application systems requirements. Diode, constant voltage units will only work in the specific cases detailed above without modification to the excitation control panel.
- The Kinetics SVRS system offers the user the greatest flexibility of operation. By providing a 4-20 ma signal the unit can be controlled from an external source, i.e., Power Factor leading and lagging and/or current regulated as opposed to voltage regulated.
- All rectifiers applied to AC synchronous motors must have semi-conductors rated with peak inverse voltage ratings exceeding six times the AC input voltage to the semi-conductor bridge. AC and DC surge suppression must be provided that is rated for "highly inductive loads" operation.
- Before installation and operation of a new solid state exciter we strongly recommend the field application circuitry be checked to make sure the system functions properly and that the timing circuit is set to the original specifications. It is common, in retro-fit applications, that the application circuits may be out of adjustment. If the timing circuit is out of adjustment; when the rectifier exciter is applied the field application contactor will machine-gun in and out. When the contactor cycles it produces extremely destructive spikes to both the rectifier and motor field.

9. When applying a regulated excitation rectifier, what rectifying configuration, 3 or six pulses, is "best" for the highly inductive load characteristics of a synchronous field?

In motor drive applications the usual consideration for using a six pulse or even 12 pulse, rectifier over a three pulse hybrid bridge (three SCR's and three diodes) is faster response time and lower semi-conductor ripple on the rectifier output buss. A synchronous motor field application is highly inductive and is a different type of load from a "motor drive" type of load.

The highly inductive nature of a synchronous motor field makes the need for a "fast" response a moot issue. The faster response of a 6 or 12 pulse system vs. a 3 pulse system can be a detriment to the excitation system performance. The field's current changing time constant, usually measured in seconds, is quite long in comparison to a SCR control response time that is measured in milliseconds and moving to "faster" regulator response can cause system instability. For synchronous motors, "slowing" the SCR control response time to match the motor's rotational inertia time characteristics while maintaining system "stability" is an application design parameter.

Due to the inductive nature of the synchronous motor field, it becomes almost essential to utilize free wheeling or commutating semi-conductors across the load to minimize current ripple. The three pulse system does not require the commutating device to function. A six pulse system does not require the commutating device to function but without it the field current ripple becomes very onerous as the rectifier voltage can actually reverse and produce regenerative effects with "high" ripple voltage and current spikes.

For exciters being applied to the motor field through power contactors, a 3 pulse exciter rectifier is normally selected due to its cost effectiveness, lower current ripple to the motor field, lower complexity and reduced number of components. Six and 12 pulse systems are utilized when special functions, such as negative field forcing, rectifier output reversal or solid state SCR switching is applied to the rectifier output. **Note: Kinetics' solid state field application system with SCR switching and latching crow-bar circuit incorporates the use of a six pulse SCR regulated exciter package.**

10. Does Kinetics offer a "small" synchronous motor, simplistic, excitation package, less than 250 Hp?:

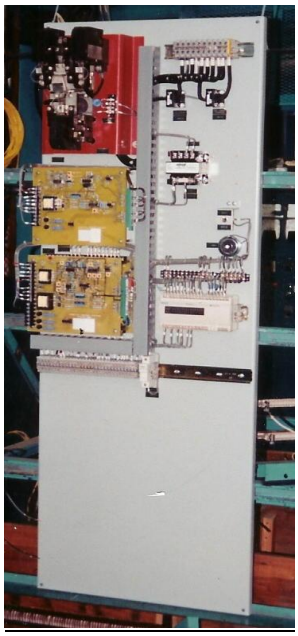
For "small" synchronous motors, non-critical operations or customer's desiring the least expensive means of synchronous motor field application; Kinetics does offer a combination tapped transformer / diode rectifier, motor ramp to synchronous speed timer and field application / discharge resistor contactor package, Kinetics model type SYNPTS. DC field voltage adjustment is by changing of taps on the diode rectifier isolation transformer.

A Full current capacity field rheostat is available as an option for manual on-line DC voltage adjustment. If the option of field voltage adjustment by a rheostat is being considered; Kinetics recommends that a SCR regulated rectifier, model type SVRS, also be considered. In many cases a SCR regulated rectifier is less expensive than a rheostat when cost factors such as delivery lead times, energy consumption, maintenance and operator attention for voltage adjustment are factored into the comparative cost analysis.

The most basic of field excitation packages, Kinetics model type SYNPTS, assumes that the motor's synchronous speed has been achieved when the timer has timed out and the DC field is applied. In the event of a system problem; the motor starter protective relays or overloads must be relied on to trip the system off line.

System status annunciation, motor life protection features and motor performance adjustments are not available with a functionally basic, SYNPTS type of system. Kinetics recommends the performing of a "down side" risk analysis when applying a first cost functionally simplistic system such as a SYNPTS vs. a SYNCHAPP-C with field contactors or KSR 100% solid state field application system with a KinetSync annunciation & logic system that offers motor and AC power system disturbance protection features.

>> Typical "simplistic" panel for mounting in customer's existing switchgear enclosure. Contactor applied system. Minimal annunciation – first cost purchase package.



11. Can units be supplied as open panels for mounting within existing enclosures or OEM switchgear or motor starter lineup enclosures?:

Kinetics has a complete sheet metal fabrication department at our Trenton, NJ plant to package open panel systems into the application's available space constraints. A very important feature of Kinetics' open panel excitation packages in combination with our enclosure door mounted KinetSync-SR digital annunciation and logic module product offering, is our exclusive, inter-connection cables with quick connection *Molex* plugs. Kinetics' electro-statically shielded, color coded, interconnection cables substantially reduce installation time and the possibility of wiring errors.

Systems are designed for modular change out of "major" assemblies. Safety electrical shock barriers and covers are provided for ease of service and separation of electronics from power compnentry.

Units provided in enclosures can be supplied with the same space variability and in NEMA classifications: 1, 2, 3R, 4, 4X, 12 and IP 2 & 54.

>> Pictured below: 600 ADC at 125 VDC regulated exciter, solid state field application package, KinetSync-SR digital annunciation and logic control module and interconnection wire harness with quick connect plugs.

12. Can an entire excitation system be packaged to fit into a "standard" medium voltage switchgear enclosure cell?


Brush type motor cell in cell modular assembly system designed to side into a signle standard switchgear cell.

Kinetics has designed a space efficient, economical package, to fit into a standard switchgear cell that we have termed a ***"Cell-in-Cell"*** construction packaging. The pre-packaged unit includes: medium voltage input fuses, EPT transformer, **KSR** exciter / application panel, inter-connection cables and **KinetSync-SR** annunciation & logic module. The Kinetics ***cell-in-cell*** unit is delivered to the customer ready to slide into the customer's switchgear cell. The Kinetics' cell-in-cell package provides the customer with the fastest an lowest installation cost retro-fit package available.

13. Does Kinetics manufacture a solid state applied field application panel?

Kinetics began manufacturing our first solid state field application packages in the early 1980's. The units have proven to be highly reliable and far more desirable then mechanically linked contactors. The Kinetics model type **KSR** incorporates the use of a power semi-conductor switching configuration and latching crow-bar circuit to provide a "solid state field application contactor" system. Kinetics newest system, the model type **KSR** is a fully integrated 100% solid state system with UL and CUL Listed mark approval. The **KSR** is only available as a packaged system, in combination with Kinetics regulated rectifier with 100% solid state circuitry, semi-conductor, field & discharge resistor switching circuit. Today, operating engineers and technicians tend to be quite comfortable with power semi-conductors and gate firing circuitry. Kinetics' SCR switching circuit has been designed and constructed to be serviced in the field. The system does not use "specialty" or difficult to locate components that would result in extended down-time should a component fail.

Inter-locking electro-mechanical contactors for field and discharge resistors have the disadvantage of being expense, long delivery lead times, produce corrosive off-gases from arcing and require significant panel space vs.

SCR switching built into the output side of the solid state regulated exciter.

The majority of exciter & field application packages that Kinetics manufactures today are of the 100% solid state design. In a 100% solid state system the exciter and application circuitry are required to be a coordinated and an integrated package, the timing of firing and turning off of SCR's is critical for a reliable system, it is not feasible to field install a solid state application circuit to an existing regulated rectifier. A solid state application circuit can't be added to a diode constant potential or motor generator set exciter due to the requirement that the DC from the exciter must be "off" for switching or a short circuit fault occurs. A diode CP exciter and MG set don't have the capacity be instantaneously turned off as can be achieved with a gate fired semi-conductor used in a SCR regulated exciter.

>> One of fives, 100% solid state excitation systems, manufactured by Kinetics, for a large paper mill and installed on 6,000 Hp "grinder" motors..

14. <u>Large field current capacity excitation systems in space efficient user friendly packaging configurations.</u>

Large motors, older vintage motors and motors designed to require relatively high field currents at reduced field voltages; introduce additional challenges of motor protection and field application circuitry to the designer of cost effective and reliable solid state field excitation systems. For some packagers of basic excitation systems, exciter capacity is limited by the standard allocated panel and enclosure space or the maximum rating of simplistic semi-conductor packaging. Above, approximately, 200 ADC, semi-conductor packaging changes from base mounted packaging to "hockey puk devices. The footprint of hockey puk rectifier bridges and SCR solid state switching assemblies are significantly larger then lower current capacity multi-device base mounted devices. Kinetics' engineers, drawing on 50 years of industrial power rectifier manufacturing experience in the 1 to 2000 kilowatt capacity range, have developed a space efficient multi-layered system, designed to fit into a standard switchgear cell, maintains ease of serving access while maintaining the highest electrical shock safety protection while servicing and simplistic modular major component change out.

The application specific requirements of EPT's, exciter power transformers, for "heavy current units are efficiently designed and manufactured at standard delivery lead times, by Kinetics' in-house transformer manufacturing capabilities.

The Kinetics ergonomic, space efficient, high current, BUBS-H design platform, permits complete excitation systems to be packaged in significantly smaller enclosures then systems constructed as "panelboard" type construction, single layer layout, units. Enclosure design footprint has been specifically designed to be within the common space restrictions of air freight and cargo containers for units being shipped to remote sites around the world for customer's requiring expedited delivery.

*>> Layered ergonomic construction design of Kinetics' BUBS-H, high current, solid state, model type **ESR** exciter and field application system.*
Left: hockey puk type SCR rectifier bridge – power section
Center: Enclosure door mounted KinetSync-SR module and excitation circuit and 120 volt control on hinged panel.
Right: BUBS-H platform mounted in a IP51 enclosure, complete packaged excitation system, suitable for air freight shipment

15. Field application contactors vs. solid state application via SCR switching and latching crow bar circuit.

A common point of misunderstanding concerns synchronous motor excitation systems is the selection of a field application method. If a product offering is selected from an on-going and regular manufacturer of synchronous motor excitation systems; the proposed product will be a system specifically designed for a brush type ***synchronous motor;*** the specification of a field application method is rather straightforward.

All the leading manufacturers of synchronous motor excitation systems in the United States, promote the use of solid state SCR switching and advise against using contactors as the field applications when a new regulated exciter is being supplied.

As a commercial note: system integrators and manufactures of generator exciters or DC motor drives commonly advocate using field contactors because contactors can be purchased and installed on the output of a rectifier, DC motor drive or generator exciter. The contactor method must be used because these companies have not invested in the product development engineering necessary to integrate an SCR switch circuit into a regulated rectifier or motor drive.

For applications using a common DC buss, MG set, diode rectifier, regulated rectifier or existing DC power source; field contactors must used.

The redundancy of contactors with a solid state SCR switch is not a practical or technically feasible design configuration and should not be used.

DC field breakers are used in generator system applications and are not suitable for synchronous motor applications due to cost of a three pole field breaker in relation to SCR switching, relatively slower switching speed and the mechanical fatigue due frequent to stopping and starting.

16. **Why does Kinetics manufacture two digital annunciation and logic modules for synchronous motors?**

- *KinetSync-SR for brush type / slip ring synchronous motors*
- *KinetSync-NB for brushless synchronous motors*

When Kinetics' engineers designed our digital annunciation and control logic modules, we asked our customers what they wanted in a system. The overwhelming request was for two units; one pre-programmed for characteristics of brushless motors and one pre-programmed for the operation characteristics of brush type motors.

The two unit approach offers:

- Reduced programming and learning curve time by engineers and technicians. KinetSync units are delivered pre-

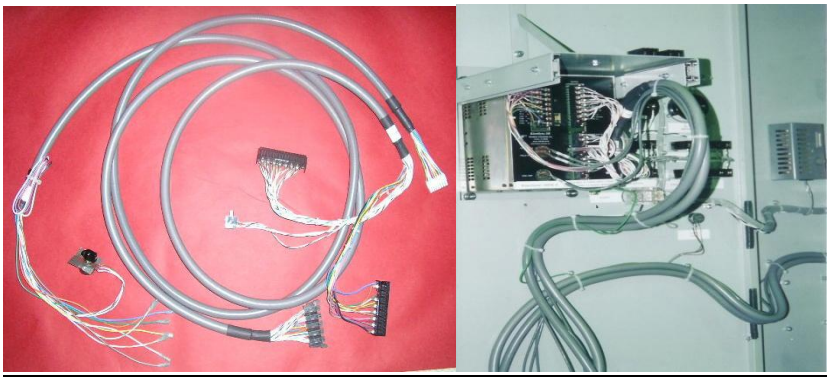
programmed ready for installation to motor's excitation system.

- Less confusion by installers and users understanding the product and features. The installer does not deal with sorting out which features apply to a given type of motor.
- Reduced cost; by eliminating non-applicable features and circuitry that are not required to be purchased in a one size fits all package.
- Motor type specific packages offer greater product hardware and programming flexibility that is tailored to the unique characteristics of the two motor types.
- Operational instruction manuals are easier to use and understand by directing the manual at a single motor of type of brush or brushless.

17. Are systems available that have the capacity to supply operating data and/or remote operating control via a computer network information highway?

Kinetics is continually working to provide systems that are state-of-the-art with the rapidly changing computerized plant automation systems. Kinetics does offer interface capabilities with several of the "major" data highway system language protocols such as Modbus and Profibus. All KinetSync annunciation and logic modules come with RS232, RS485 and UBS ports. Communication output of operation status and input of operating parameter adjustments via interface ports are standard features of the KinetSync-SR and NB modules. Kinetics offers a full range of communication input, output and control options to meet a customer's operational needs. Smart factory technology, central power management, un-manned motor room control and monitoring and operational process system integration via a communication network are all available options of a state of the art excitation system offer by Kinetics. For current specifics on data highway interfacing; contact your Kinetics sales representative.

18. **Why is the simple concept of a KinetSync module to the Kinetics exciter / field application system inter-connection cable w/ plug-in connectors such an important Kinetics product advantage over offerings by "others"?**



>> Kinetics exclusive wire harnesses. Photo on right shows connection of the wire harness plugged into the KinetSync. KinetSync mounted in a drawout carriage assembly

From our years of manufacturing experience of open panel systems; we have all too often serviced customers that had unit operational problems due to inter-connection wiring errors between the enclosure door mounted KinetSync and the exciter /application panel. Installation wiring errors due to lack of familiarity and the inability to test the wiring in the field increases the cost of installation and can result in damaged equipment. To eliminate the potential of wiring problems; such as missing wires, reversed polarities or wires to incorrect terminals, Kinetics developed an electro-statically shielded inter-connection cable with Molex quick connect plugs.

The Kinetics manufactured, electro-statically shieled, inter-connection wire harnesses are continuity tested for customer quality control assurance.

Kinetics is the only excitation system manufacturer to supply inter-connection cables with the product as a standard feature.

The cables provide the customer the following benefits:

- Maintain component testing integrity from Kinetics synchronous motor test stand to the using customer's final operational location.
- Reduced product installation wiring time.
- Reduction of front-end time to determine wiring requirements.
- Shield cables provide protection of "signal" integrity.
- Plug connections ease KinetSync and/or exciter / application panel change-out for quick servicing and minimizes down-time.

19. Can a stand-alone application panel be supplied for use with an existing DC power source?

>> Contactor applied field system for operation off a customer's existing DC plant buss.

Yes. Kinetics manufactures a contactor applied field application panel systems for this type of project. Kinetics' model SynchApp-C was designed for applications using existing excitation power from a common DC mill buss, MG set, constant potential diode rectifier or regulated output rectifier. The SynchApp-C system is the correct application panel for systems using rectifiers manufactured by a supplier other then Kinetics.

20. Monitoring and recording brush type motor acceleration and slip frequency:

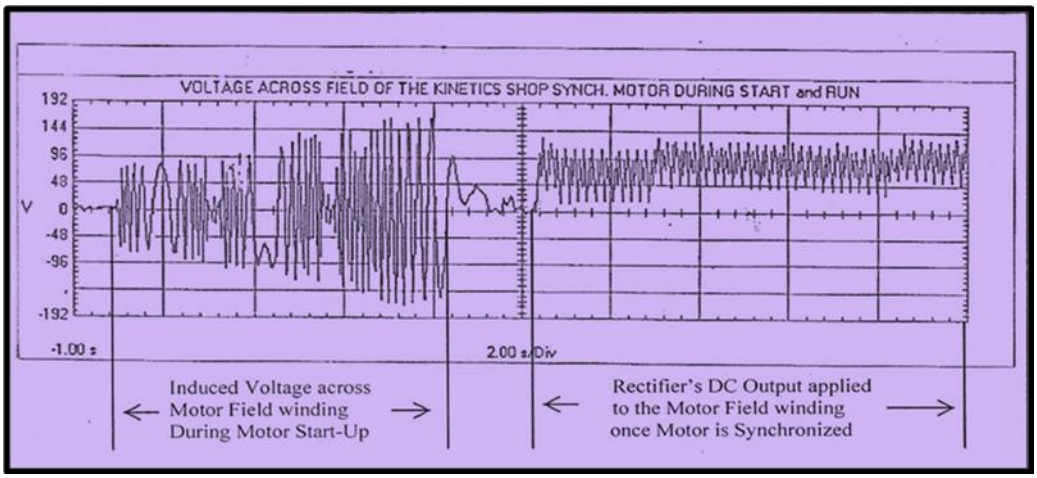
To analyzing the start of a brush type synchronous motor as it accelerates to near synchronous speed and the application of the field a effect means is to look at the slip frequency and voltage across through the discharge resistors with an oscilloscope. It is best to use a scope with the ability to record the event in memory since some motors come up to speed and synchronize in a few seconds. To properly analyze the starting event, the entire period of from 0 speed to post synchronization or trip, needs to be captured and reviewed.

To setup an oscilloscope to look at the field winding circuit Kinetics' engineer perform the following:

Caution! Risk of shock injury: Confirm that the oscilloscope leads are rated for a minimum of 1000 VAC. Never touch the scope leads while the motor is starting, the DC field not applied and the motor not synchronized.

1) Connect the "positive" lead of the oscilloscope to the positive field lead. This connection can be made at the output of the exciter or at the motor.
2) Connect the "negative" lead of the oscilloscope to the negative field lead. This connection can be made at the output of the exciter or at the motor.
3) Set the oscilloscope volts / division to 50 volts / division. This value may need to be changed depending on the amplitude of the induced voltage generated across the motor field.

4) Set the oscilloscope to 1 second / division. For “smaller” motors the time division may need to be “shortened” to less than 1 second, to capture a visually useful recording of the starting event.



21. <u>Are there common guidelines for sizing of brush type motor discharge resistors?:</u>

Based on Kinetics’ firsthand experience and information supplied from numerous synchronous motor OEM’s and design engineers, the safest approach for excitation system discharge resistance selection is to use the resistor sizing by the motor manufacturer / designer. Caution should be used when applying general parameters for selection because the motor designer can change the discharge characteristics substantially to alter the starting torques of the synchronous motor to match the design criteria or application process. It is Kinetics’ experience that the majority of discharge resistor issues and problems arise when the application, motor, starter or excitation system were not the original “system” and one or all of the items has been retro-fitted or applied to a “new” application or process.

The discharge resistor is a “balance” between motor starting acceleration time, via the short time of operation service factor duty amortisseur winding and holding the rotating transformer effect voltage “down” to a safe level so as to not generate voltage levels that can be dangerous and destructive to the motor field. This generated field voltage during the motor start, has significant voltage spikes and transients that need be respected or significant motor damage can result.

If the motor manufacturer’s specified discharge resistance value is ***<u>not</u>*** available, Kinetics has applies two different approaches to the selection of resistance and total resistance depending on the motor horsepower. Please remember these are rough calculations that should be used with a degree of cautionary jurisprudence. One should be on guard for the unusual motor, application or the motor to application combination that is retro-fitting the field application panel that had “problems”, that may have been the result of a “problem” associated with the auto-transformer effect voltage level, spike or transients on motor starting.

General discharge resistor sizing guide:

1) Smaller motors, defined as 75 to 1500 Hp with a stator voltage of 480 volts AC: total resistance of the discharge resistance bank in the approximate value of 3 times the motor field ohms (+/-10%).

2) Larger motors, defined as 1500 and larger and stator voltage of 2,300 to 15 KV volts: resistance is selected to limit the resistor bank voltage to a nominal rating of 1250 volts with the fully rated field current flowing (+/-10%).

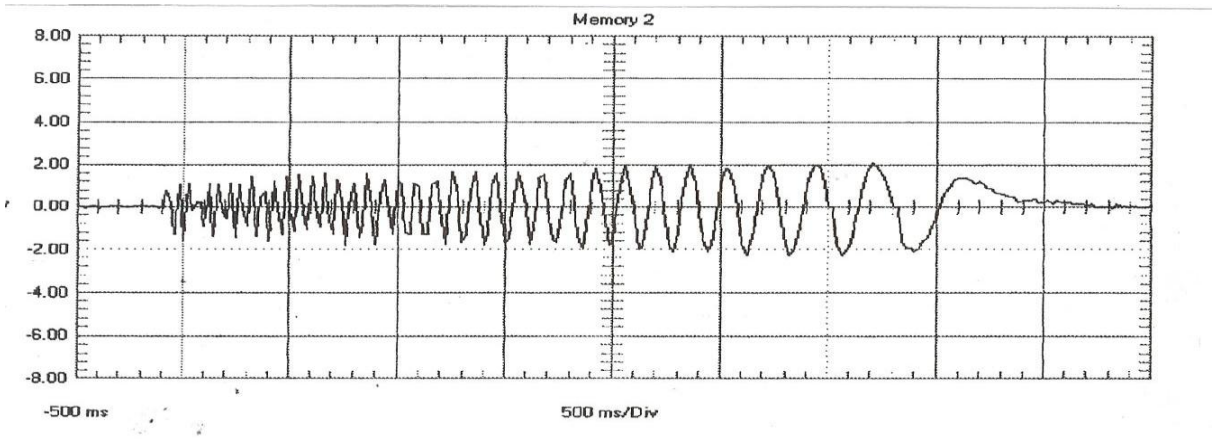
Example: 10,000 Hp motor with a field rated 200 ADC @ 230 VDC
Resistance bank ohms = 1250 volts / 200 ADC = 6.25 ohms.

Resistor wattage is a function of the length of motor start acceleration time and maximum temperature that the resistors can tolerate over a given time interval. The wattage value is determined by the selection of the type of resistor and specific resistor manufacture.

22. How can it be determined if the DC excitation circuit is being applied at the "correct" time?

One method, to determine if the field is being applied at the correct time, just below synchronous speed, is to connect a recording oscillograph across a portion of the field discharge resistor to obtain a tracing of the field discharge current during motor start-up. The "slip frequency", the frequency of the voltage induced onto the motor field by transformer action, decreases as the motor RPM increases. At synchronous speed this frequency will be essentially zero. The tracing shown in figure 22.a is a typical wave form of a properly timed application of the DC field to the motor.

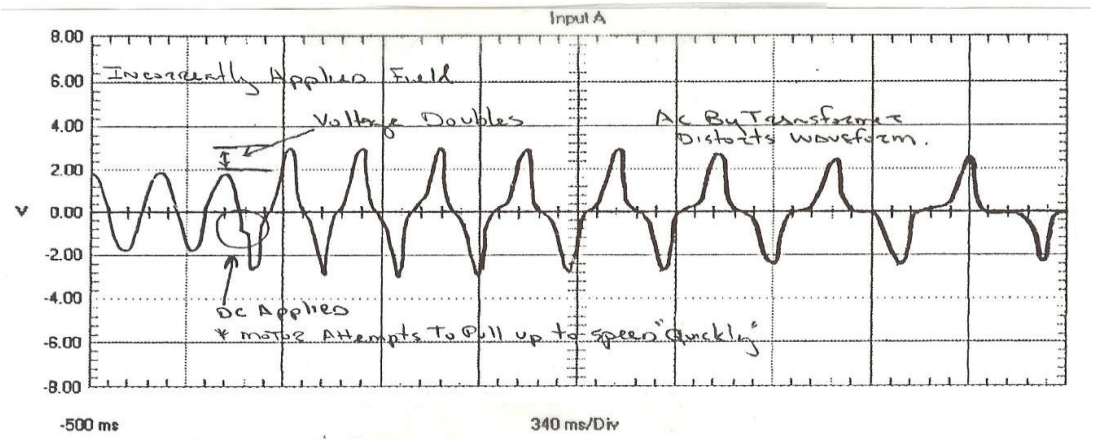
Caution - Safety consideration: Dangerously high voltages can be present on the field discharge circuit while the motor is ramping up to synchronous speed. Voltages of 3500 to 4000 volts are not uncommon. Proper safety, insulation pre-cautions and procedures for high voltage metering must be implemented prior to motor starting.



>> Figure 22.a Field applied after motor has reach "pull-up" speed <<

The voltage and current amplitudes across the field discharge circuit will, for most synchronous motors, increase as the motor speed increases. When the motor reaches its “pull up point” or maximum non-synchronous speed, the current across the field discharge current will drop precipitously. This point is typically in the 2 to 1 hertz slip frequency range. At this point, the motor has achieved the optimum synchronization point and the field can be applied with the minimum power circuit disruption.

If the field is applied before this optimum synchronization point is achieved, the motor attempts to “pull up” in speed and into synchronization when its slip frequency is too high. The motor’s rotor attempts to rapidly increase in speed causing a potentially destructive induced voltage spike back across the motor’s slip rings, through the brushes and into the DC field power source. This power spike is referred to as “flashing the rings” – a well selected term to describe the dramatic arc & flash produced when the spike travels across the slip rings to the brushes. Flashing the field can cause significant arc damage to rings, brushes, brush-holders and the exciter system. In most cases, a substantial AC power disturbance will also occur when the field is applied to early. The motor will attempt to accelerate to synchronous alignment, thus drawing high AC in-rush current type loading.

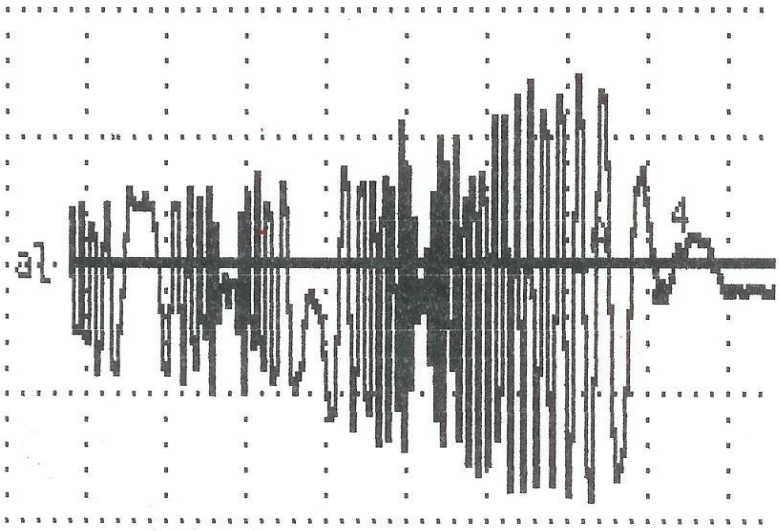


>> Figure 22.b Field applied prior to synchronous speed <<

The sample oscillograph, figure 22.b., shows a classic peak waveform with the motor field being applied **prior** to the motor having reached “pull up” or maximum non-synchronous speed. The denoted “glitch” in the waveform is the point where the DC field excitation voltage is applied to the motor field prior to the motor having reached synchronizing speed. The motor attempts to pull up to synchronous speed instantaneously. The attempted rapid acceleration forward of the motor combined with the injection of DC acting upon the remaining AC component from the less then synchronous speed transformer action of the field, causes the peaked wave shown on the oscillograph. The peaking voltage in the illustrated oscillopraph is nearly double the sinusoidal voltage prior to the excitation being prematurely applied.

23. Why is the wave form observed from a "small" synchronous motor discharge circuit not "uniform" and smooth as per the "textbook" and shown in 22.a?

Relatively small synchronous motors will accelerate rather quickly. The wave form will include; power system distortions due to motor in-rush, rotor and shaft mechanical inertia distortions and uneven motor acceleration. The wave form in figure 22.a is from a 22,500 HP motor with an acceleration time of nearly 30 seconds. A common waveform for a 500 to 1,000 HP motor would appear as show in figure 23.a. The acceleration slip frequency waveform show occurs over 3 seconds. The field is applied at the correct time. Note there is no peaking or waveform distortion is present after the field is applied.



>> Figure 23.a "Small synchronous motor slip frequency & correct application <<

24. What is "power factor" and how is calculated?

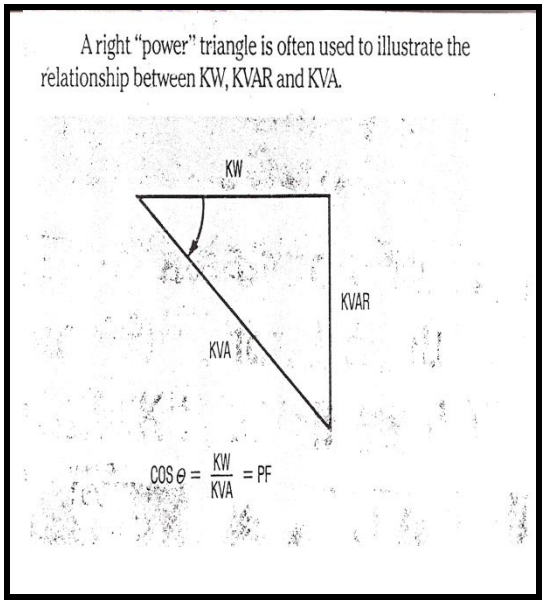
Most loads in electrical distribution systems are inductive in nature. Inductive loads need an electromagnetic field to operate. Inductive loads require two kinds of current:

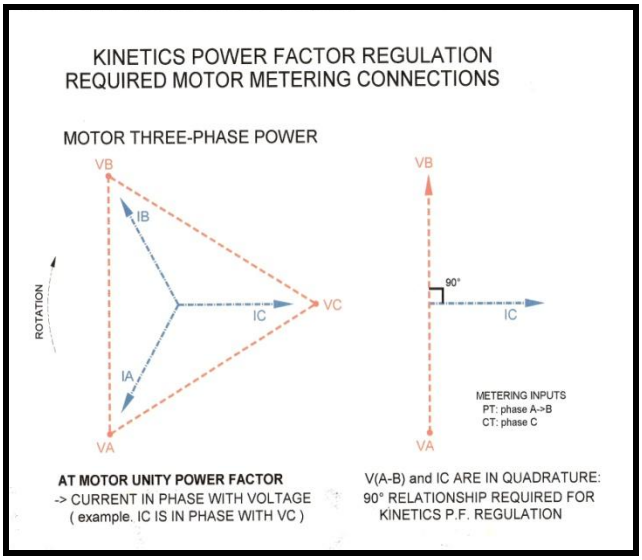
1. Working power, measured in watts, to perform the actual work of creating mechanical, thermal or light output.
2. Reactive power, KVAR, measured in kilo volt-amperes reactive, to sustain the electromagnetic field.

Working power consumes watts and can be read using a wattmeter in either kilowatts or watts. The reactive power component does not do useful "work" but circulates between the utility generator and the working load, Reactive power places a significant drain on the primary source of power as well the power distribution system. Working power & reactive power, together make up "apparent power" which is measured in, KVA, kilovolt amperes.

Power factor, PF, is the ratio relationship of working power to apparent power. Power factor measures how effectively electrical power is being used. A high power factor, ie 1.0, indicates an efficient power utilization rate, while a low power factor, ie 0.3, indicates s poor power utilization rates. Some electrical power utilities charge customers a penalty rate for not maintaining a specified power factor at their facilities.

To calculate power factor; divide working power (Kw) by the apparent power (KVA). In a linear or sinusoidal system, the result is also referred to as the cosine theta.





25. CT's & PT configuration and wiring for power factor regulation of synchronous motors.

Installation Caution – Warning: Connection of external CT's & PT to field excitation System

Failure to properly make connections can result in improper system function & failure

A **"CT"** is defined as a *current transformer* that monitors the stator current to a given phase and produces a secondary signal voltage in a proportional ratio to the current passing through the center opening of the device. A **"PT"** is defined as a *potential transformer* that monitors the stator voltage across two phases and produces a secondary signal voltage in a proportional ratio to the primary line voltage.

Excitation systems that incorporate the use of external CT's and PT, from within the motor starter or breaker, across the stator input, for power factor monitoring and regulation, **must** have the CT's and PT wired to the correct terminal points within the Kinetics excitation system and be in a quadrature configuration for the development of a power factor signal within the Kinetics excitation system.

The power factor signal generated within Kinetics' excitation systems is used for critical motor and field protection features, regulation of the exciter DC output to the motor field and producing of a power factor value on the KinetSync LCD screen and/or power factor meter(s).

Kinetics' excitation systems have circuitry designed to be **electrical isolated** from spike and surges and interactions that might be present from a general purpose, motor starter or switchgear, CT or PT, connection terminal point. The **electrical signal isolation** designed into Kinetics' PF signal generation circuitry, minimizes the potential of interaction from "other" components connected to the same motor starter CTs and PT terminals.

Failure to connect the CTs & PTs correctly to the Kinetics excitation system can potentially result in damage to the exciter, KinetSync-SR or NB or CT. At a minimum, incorrect wiring or selection of incorrect phase rotation, (CT-PT phasing relationship not in quadrature), will produce an erroneous power factor signal and reading or no reading at all, causing the field exciter to supply an undesirable output voltage and trip the motor off line.

The installing party has the following responsibility associated with CTs & PTs:

1) Verify the phase relationship of the CT's and PT within the motor starter or switchgear.
2) Verify the multiplier ratios of the motor starter or switchgear CTs & PTs match the values within the Kinetics instruction manual electrical drawings and scaling table.
3) Verify that "correct" CT and PT wires are correctly connected to the designated input terminal points within the Kinetics excitation system.

4) Confirm through a physical test, “ring-out”, that the CT and PT wires have not been omitted, confused, swapped, mismatched, incorrectly marked or connected to the incorrect terminal points.

5) The installer *MUST NOT* assume the phasing and wiring is correct without first a visual inspection of the CTs and PT, nameplates and performing a confirming connection test.

Installers, please be advised:

It is the installer’s sole responsibility to confirm that CT’s & PT signals provided to the *Kinetics* synchronous motor exciter are configured correctly & verified with the motor starter or switchgear phase scheme. If a Kinetics startup engineer is to perform unit commissioning, the installer still MUST verify the CT’s and PT wiring has been properly and correctly connected to the correct terminal points within the Kinetics excitation system.

Before unit commissioning can proceed:

As part of Kinetics established unit commissioning procedure; prior to performing a unit commissioning, a Kinetics engineer will seek confirmation from the installer that the CT’s and PT wiring verification requirement has been successfully completed, as part of our standard field commission procedure. Kinetics field commissioning engineers are not permitted to begin the unit commission procedures until the installer has completed the required verifications.

Correct configuration of CT’s and PT for generation of a power factor signal:

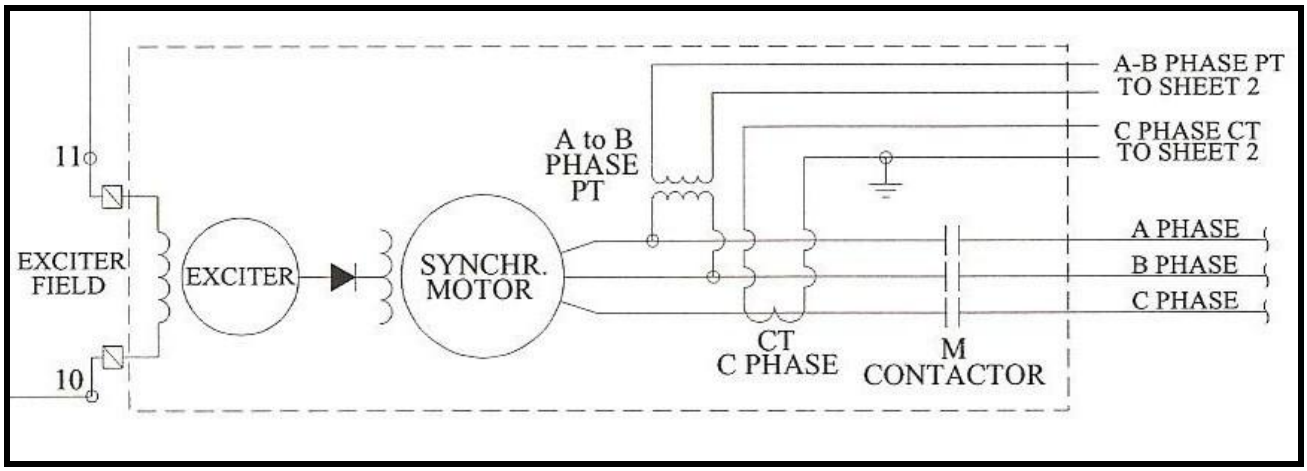
Several possible “correct” CT’s and PT connection configurations are possible for achieving the desired quadrature relationship that enables a power factor signal to be generated. The most common PT connection configuration is an “open delta” with the “B” phase grounded. A second, lesser used configuration is a “grounded wye” connection. Kinetics units have the capacity to use the “grounded wye” configuration if “set-up” to do so at the factory. When applying an excitation system to a “grounded wye” configuration, if the connection is not already specifically addressed within the unit’s instruction manual and drawings, please contact Kinetics’ factory support for technical assistance.

Possible quadrature configurations:

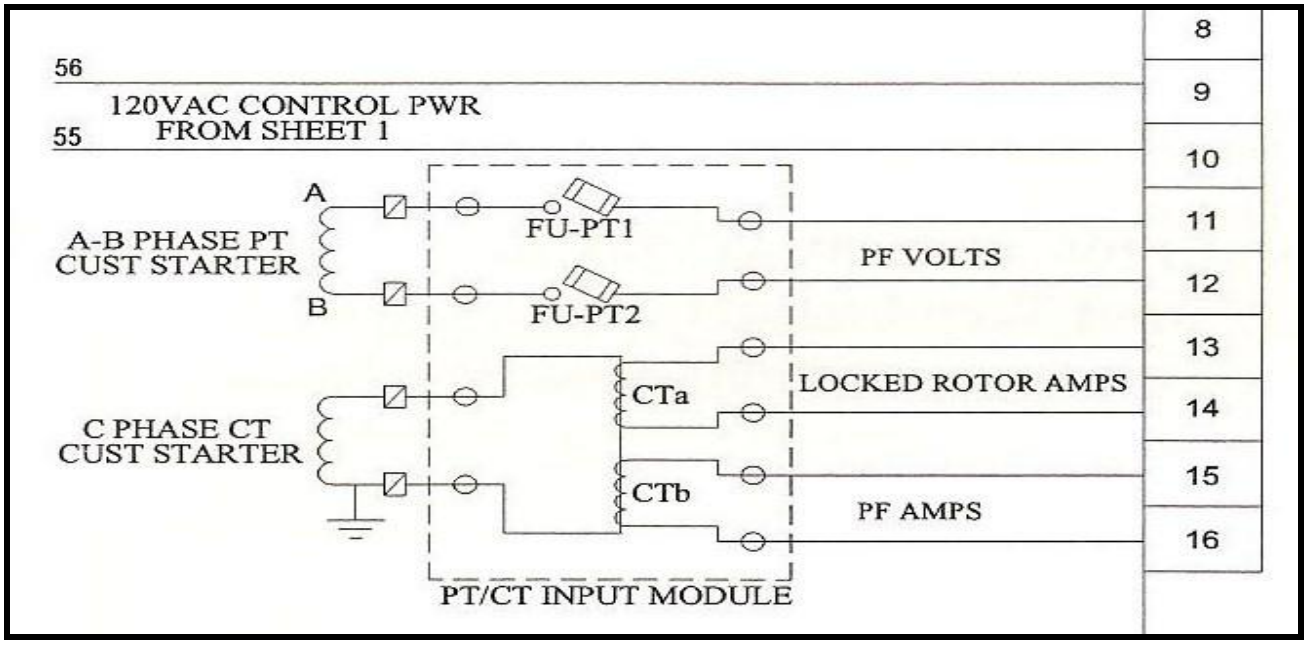
- **PT** signal from Phase **A** & **B**, with **CT** signal from Phase **C**

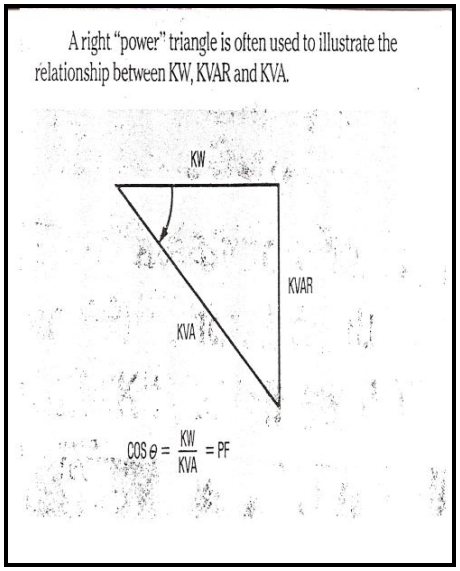
  (* Most commonly used connection configuration)
- **PT** signal from Phase **B** & **C** with **CT** signal from Phase **A**
- **PT** signal from Phase **C** & **A** with **CT** signal from Phase **B** ***

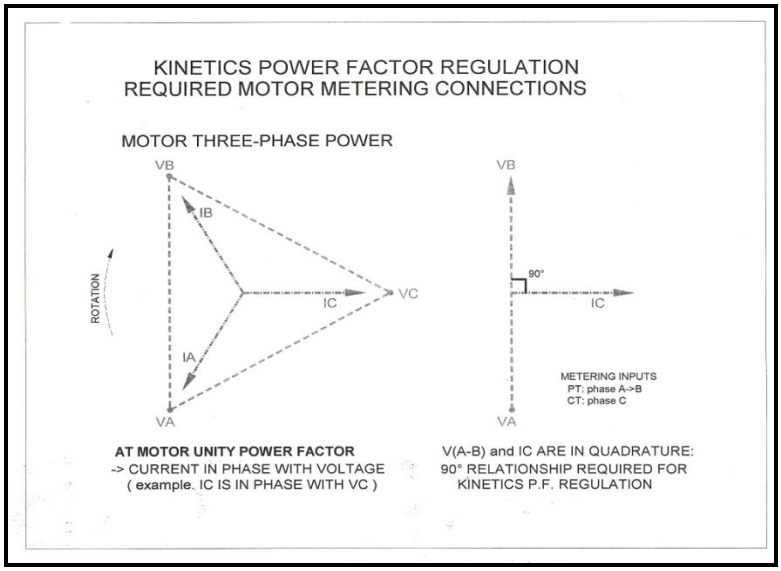
  (* Normally considered less then desirable due to possible distortion of “values” resulting from the unsupported open delta PT connection configuration)



Typical & desirable CTs & PT connections for power factor regulation and monitoring.







Kinetics excitation standard configuration requirement for PTs & CTs is:

PT: Motor stator primary voltage to **120VAC** (secondary)

CT: Motor stator maximum current to **5A** or **1A** (secondary)

Note: CT secondary current must be established at time of manufacture of the exciter circuitry. If the current rating is found to not match the factory documentation, the installer should contact Kinetics' engineering support prior to attempting to commission the unit into service.

CT & PT selection: System designers are reminded that the CT's and PT's, within the motor starter or switchgear, be selected within the mean value of operation so the secondary signal values produced are measurable and relevant with the scope of operation of the metering and exciter.

Burden on PT & CT by *Kinetics* excitation circuitry:

- **PT:** 0.03VA burden @ 120VAC
- **CT:** 0.02VA burden at 50/60Hz

Safety warning and cautions concerning CTs and PTs:

For **CT**: current transformers – dangerous, human risk of electrocution, shock hazard

- Do not open a CT circuit during Load.
- The secondary of a CT not in use should be **shorted** or dangerous high voltage can develop.
- CT ratio **>** Rated Full Load Current

For **PT**: potential transformers

- Do not "short" a PT circuit while under during load.
- The secondary of a PT not in use should be **opened.**
- Choose PT burden to Load

26. What is a synchronous motor V-curve pattern?

Per Audel – Electric Motors by Edwin P. Anderson and Rex Miller.

In the case of a synchronous motor pulling a constant load, a variation in the field current is followed by a variation in the stator current, giving the V-curve pattern. For a given load, there is a single value of field current that will give unity power factor at the motor terminals. Increasing or decreasing the field current from this value will give a power factor less than unity – increasing the field current will give a leading power factor, and decreasing the field current will give a lagging power factor. Stated another way, for a given load with constant voltage, if the field current is changed either way from the unity power-factor value, reactive current will be produced, causing the line current to increase, as shown by the V curves in the diagram below. This reactive current will be leading if the field excitation is increased, or lagging if decreased.

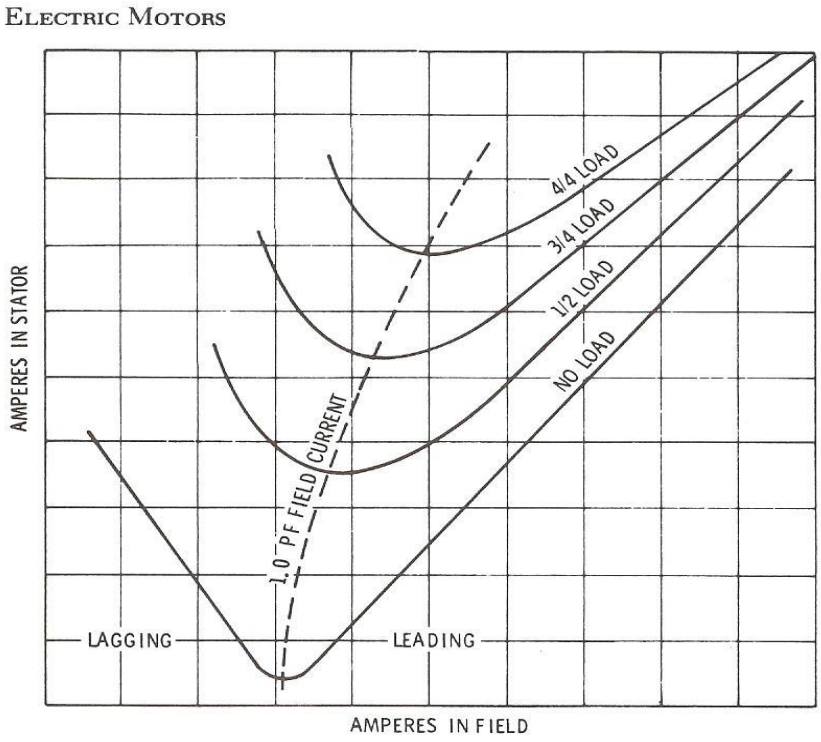


Fig. 4. Typical V-pattern characteristics of a synchronous motor.

27. How much power factor correction can be obtained from a given motor?

The motor manufacturer develops a set of performance curves based on the design relationship of the rotor field to the stator. As a general guide the curves below with basic equation will give a general indication of leading reactive KVA in percent of rated HP of the motor vs. percentage of motor loading.

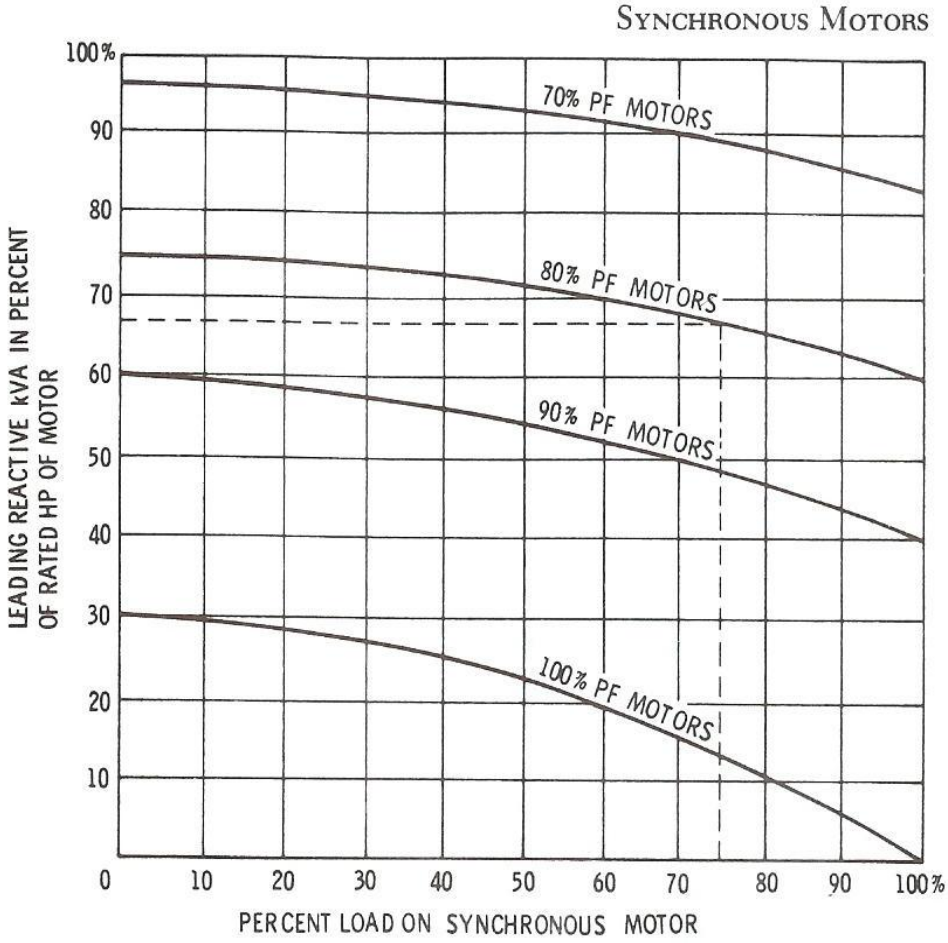


Fig. 5. Approximate leading kVA drawn by high-speed synchronous motors operating at partial loads and with full-load excitation maintained.

$$\text{stator current for desired PF} = \frac{\text{minimum stator current}}{\text{desired PF}}$$

28. How is the speed, RPM, of a synchronous motor established?

The speed of a synchronous of a synchronous motor is determined by the frequency of the supply current and the number of poles of the motor. Thus, the operating speed is constant for a given frequency and number of field poles. All motors are built with an even number of poles. The equation for the determination of motor speed is:

***** Revolutions/min = frequency * 120 / poles**

ELECTRIC MOTORS

Table 1. Synchronous Motor Speeds (r/min)

POLES	60 HERTZ	50 HERTZ	40 HERTZ	25 HERTZ
2	3600	3000	2400	1500
4	1800	1500	1200	750
6	1200	1000	800	500
8	900	750	600	375
10	720	600	480	300
12	600	500	400	250
14	514.2	428.6	343	214.3
16	450	375	300	187.5
18	400	333.3	266.6	166.6
20	360	300	240	150
22	327.2	272.7	218.1	136.3
24	300	250	200	125
26	277	230.8	184.5	115.4
28	257.1	214.3	171.5	107.1
30	240	200	160	100
32	225	187.5	150	93.7
34	212	176.5	141.1	88.2
36	200	166.6	133.3	83.3
38	189.5	157.9	126.3	78.9
40	180	150	120	75
42	171.5	142.8	114.2	71.4
44	163.5	136.3	109	
46	156.6	130.5	104.3	
48	150	125	100	
50	144	120	96	
52	138.5	115.4	92.3	
54	133.3	111.1	88.9	
56	128.6	107.2	85.7	
58	124.1	103.5	82.8	
60	120	100	80	
62	116.1	96.8	77.4	
64	112.5	93.7	75	
66	109	90.8	72.7	
68	105.9	88.2	70.6	
70	102.8	85.7		
72	100	83.3		
74	97.3	81		
76	94.7	78.9		
78	92.3	76.9		
80	90	75		
82	87.8	73.2		
84	85.7	71.4		
86	83.7			
88	81.8			
90	80			

29. What conditions could prevent a synchronous motor from reaching synchronous speed or pull-up speed that would prevent the field to be safely applied?

Failing to reach synchronous speed and extended operation of the motor below this level, without the field applied will cause significant damage to the motor. The motor manufacture will specify the maximum time that the motor can operate from the amortisseur winding and below synchronous speed. A timer function within the excitation system should always be present to prevent extended operation and motor damage.

Common causes of the motor not accelerating to synchronous speed:

1) Open field circuit / incomplete circuit due to no exciter power to the field. Possible causes: problem with the exciter, loose cable to the field or brushes not making contact to the slip ring.
2) Open or shorted field windings.
3) Extended AC main power line voltage drop.
4) Excessive mechanical load greater then the squirrel cage or amortisseur winding has capacity to carry. The majority of synchronous motors are designed to start with “no-load”.
5) Mechanical problem with the motor.

30. Is there a “test” procedure to a brushless motor to determine if a rotating semi-conductor has failed?

The majority of the excitation systems on brushless synchronous motors are mounted on the rotating rotor shaft. Some synchronous motor manufactures do have visible annunciation lights on the rotating exciter to indicate an open semi-conductor. There tends to be a reluctance to accept a rotating LED indication as a definitive reason to open up these rather large motors for time consuming service. It is only natural, for there to be a desire, for the source of a problem to be “off motor” and not “believe” the indication of the rotating LED’s. To address this operator / user desire to have a cross check – and more definite direction to the source of a motor problem; Kinetics developed a circuit that can be added to the exciter to detect unbalanced semi-conductor ripple injected back into the exciter when a rotating semi-conductor is not functioning. By detecting the irregular semi-conduct ripple, this optional circuit feature, provides the user a higher level of confidence towards expeditiously locating the source of a synchronization “problem”.

31. Is a "load" required to properly set up an exciter to maintain a desired motor power factor?

Referencing back to the description on the "V curves" of synchronous motors, at minimum or lightly loaded conditions, the bottom of the "V curve", indicating unity, is narrowed, sharpened and dramatic in angular direction of change, at the point of unity, from leading to lagging power factor. A relatively small change in power to the field, supplied from the regulated rectifier with the feedback loop closed on motor power factor will have the maximum response from the motor. The sensitivity of the motor to a change in field strength at no or minimum load, results in the setting of the motor to run at a desired power factor "difficult to locate" and will "change" once the motor is loaded and at full operating temperature. Therefore, it is Kinetics' opinion and experience that if a system is going to be operated with the exciter feedback loop closed on a power factor signal, the motor must have load of greater than 50% to realistically and reliably set the exciter to maintain a desired motor power factor.

32. Can a Kinetics excitation system be used to regulate plant power factor?

If a synchronous motor is of significant size in relationship to the overall plant electrical utility load; the motor can be used to regulate plant power factor by the generation of VARs when the motor is operated with a leading power factor. A Kinetics SCR regulated excitation rectifier with the feedback loop closed on plant power factor can, be provided in a configuration that will produce VARs back into the plant power system to improve or regulate the overall plant power factor. Today's communication technology and computer controlled power management systems, in combination with regulated exciters, enable customers to maximize the power factor improvement and correcting capabilities of synchronous motors, resulting in significant reduction in utility surcharges from "poor" plant power factor. Kinetics works with customers to use synchronous motors in a purely synchronous condenser format and combination product work / synchronous condenser when in a dwell mode between product work loadings.

Potential application limitation: A synchronous motor has a fixed capacity; a combination of electrical VAR

generation and mechanical output. The sum of the parts will equal a total capacity for a given motor. Plant power factor can be regulated within the differential limit of the overall motor capacity and the load requirement to drive the designated mechanical load. When operating a synchronous motor with a leading power factor for VAR generation, the VAR vs. mechanical load must be balanced within safe limits so as to not overload the motor. To prevent the potential of overloading, the motor due to the combined sum of VAR generation and mechanical load exceeding the available KVA capacity of the motor; Kinetics strongly recommends incorporation of a Kinetics minimum / maximum excitation limiter circuit into the rectifier regulation control circuitry.

33. Are systems available for impulse loading or extreme differential of minimal load to maximum load to minimal load applications?

Yes. Kinetics offers systems with ***field forcing*** capacity & maximum load to minimum load / no-load protection.

As a brief variable loading / impulse load example; a common rolling mill application in a steel mill, is for a motor to be running lightly loaded when product is not in the mill. When a bar is fed into the mill, the motor first sees an impulse of loading and then loading tends to be relatively constant. As the end of the bar reaches the mill stand; the end of the bar may have cooled and be harder to roll. The exciter / motor system respond by providing an "over-voltage" to the field, forcing the field, for a short time duration in order to provide the additional torque required to pass the harder material through and out of the mill. As the bar exits the mill the Kinetics field regulator must quickly respond by phasing back to protect against motor "overshoot" and the pulling out of synchronization as a result of the motor going from maximum loading with a forced field to a minimal loading / no-load and waiting for next bar status. Kinetics has manufactured power factor regulated excitation systems for impulse and variable motor loading applications.

Briefly, the excitation regulation is a combination power factor and voltage regulated feedback loop system that limit system range by Kinetics' signal summing circuitry that includes a minimum and maximum time intervals for

system response and voltage excursion limits.

For information on impulse or variable motor loading application excitation systems, contact Kinetics' sales engineering at 609-883-9700 extension 111 or your local Kinetics' sales representative.

34. Can a motor starting lockout protection be provided within the excitation system that prevents damage to the motor amortisseur winding or squirrel cage winding from too frequent starting?

As a "standard" programming feature within Kinetics' SYNCHAPP-C, KinetSync-NB and KinetSync-SR field application panel micro-processor logic and annunciation controllers is a series of commands that establish a lockout of the AC motor starter from attempting a motor re-start for a programmed dwell time interval. The dwell time interval is determined by the motor manufacturer's design parameters for the operational specification of squirrel cage or amortisseur winding to thermally handle motors starts over a given time period. A motor's operational instruction manual should provide a recommended dwell time between attempted starts. A dwell time between motor starts is a very important motor protection feature in that it reduces the potential of damage or burnout failure of the motor's amortisseur winding due to the winding's service factor being exceeded as a result of excessive attempted motor starting. The dwell time between starts is one of the many motor life protection features designed into Kinetics' synchronous SYNCHAPP-C, KinetSync-NB and KinetSync-SR motor field excitation systems.

Example: 500 Hp motor: dwell time set at 30 seconds between attempted starts.

10,000 Hp motor: 10 minute dwell time between attempted starts and a maximum of 3 attempted starts over a one hour time period.

35. Does Kinetics manufacture retro-fit systems for prime mover synchronous motors that have a multi-exciter combination field control system?

Kinetics has the technical expertise and installation experience to provide several option proposals for the retro-fit of multi-exciter combination systems. A common multi-exciter would consist of; a "small" rotating regulating exciter set, (Kinetics refers to this type of exciter as a pilot exciter.), that excites and controls the field on a power amplifier rotating exciter set, that in turn excites the field on a "large" primary mover synchronous motor.

As an application example; a steel rolling mill has a 25,000 horsepower motor running a roughing mill stand. A 1 Kw pilot exciter is mounted on the shaft of the 25,000 horsepower motor. The pilot exciter excites the field on a 125 Kw rotating, MG set, exciter, that in turn excites the field of the 25,000 Hp synchronous motor.

Kinetics can manufacture a retro-fit package for only the pilot exciter or only the power amplifier exciter or a completely "new" excitation system that retro-fits both the pilot exciter and the power amplifier exciter.

A multi-exciter system and / or the marrying of rotating exciters with their physical constraints of rotational inertia time delays, with the near instantaneous response of solid state regulated exciters requires a unique control scheme to provide a stable and reliable motor control system. Kinetics has the technical personnel, factory testing facilities and installation experience for multi-exciter system retro-fit projects.

Solid state excitation systems can be provided that retro-fit only the pilot exciter, retro-fit only the power amplifier exciter or both the pilot exciter and power amplifier exciter.

36. Excitation Systems & Variable Frequency Drives (VFDs):

VFDs are applied to synchronous motors for reduced and controlled stator starting in-rush. When a AC variable frequency drive is used for starting, the VFD has the starting management responsibility. The VFD and the exciter must operate as a coordinated closed loop feedback system. At motor start, the exciter will operate as a regulated rectifier. The output of the rectifier is adjusted by a control signal supplied by the VFD. The field strength and exciter rectifier output are controlled by a VFD supplied signal to maintain the motor power factor at a desired value by the VFD, as the motor RPMs and input frequency from the VFD is increased toward the maximum line frequency of the utility power system. For motors operated at a variable speed, the VFD retains continuous control of the exciter rectifier. The exciter rectifier must include the system and field protections and control for motor shut down. For motors run at a fixed speed, at the point that the motor is at or just below synchronous speed, the exciter rectifier output control is removed from the VFD and assumed by the excitation system's KinetSync digital annunciation and logic module for power factor / voltage control of the motor field.

Synchronous motors designed for variable speed and operation in concert with VFD can have either AC or DC off shaft input excitation systems, depending on the motor design. Kinetics manufactures excitation systems for both AC and DC systems, brush and brushless motors.

37. Does Kinetics manufacture AC excitation systems for brushless synchronous motors designed to Require a variable AC off-shaft excitation system? :

Why employ an AC off-shaft excitation system to a brushless synchronous motor? The AC excitation system enables the synchronous motor to be started using a variable frequency drive, limit in-rush starting currents, and / or run as a variable speed synchronous machine.

Why use AC for excitation and not DC? A simple and brief explanation is that the brushless synchronous motor designer needs to have the ability to pass the excitation power thru the exciter to the on-shaft electronics at very low rotational speeds and at "very low" frequencies at the starting of the motor. If the motor has a mechanical load with a significant reluctance to allowing the motor to start rotation, producing a field at zero or near zero speed is necessary for motor starting but not possible with a DC induced control field of a brushless synchronous motor. Since, there is no induced voltage on a DC generator at zero speed, using a DC system is not possible as is the common design for a "conventional" or more commonly found brushless synchronous motor with a rotating DC generator. A common system configuration of a VFD started motor is to have AC excitation applied immediately upon motor starting and controlled by the VFD from 0 to 100% speed.

For retro-fit – modernization projects; an indicating flag of an AC excitation system would be a significantly higher current and voltage rating then a "traditional" DC brushless exciter. DC excitation systems tend to be 125 VDC at 2 to 15 ADC. An AC system would require 300 to 400 volts AC at 30 to 50 amps AC.

Various motor manufactures design brushless synchronous motors with the off-shaft exciters being an alternating current, AC, voltage regulator system. In the brushless motor, excitation power is supplied to the rotating motor field by means of a rotating transformer and shaft-mounted components which include a semi-conductor rectifier, electronic field application switching, field discharge resistance and control circuitry which senses and monitors operating conditions and initiates field control to satisfy operating requirements.

The off-motor shaft, AC excitation system for a brushless synchronous motor, interacts with the on motor shaft power excitation via an induced field to a rotating transformer that can best be described as a single-phase shell-type transformer with an air gap or in essence a wound rotor machine. The rotating transformer feeds the rotating rectifier and control circuitry.

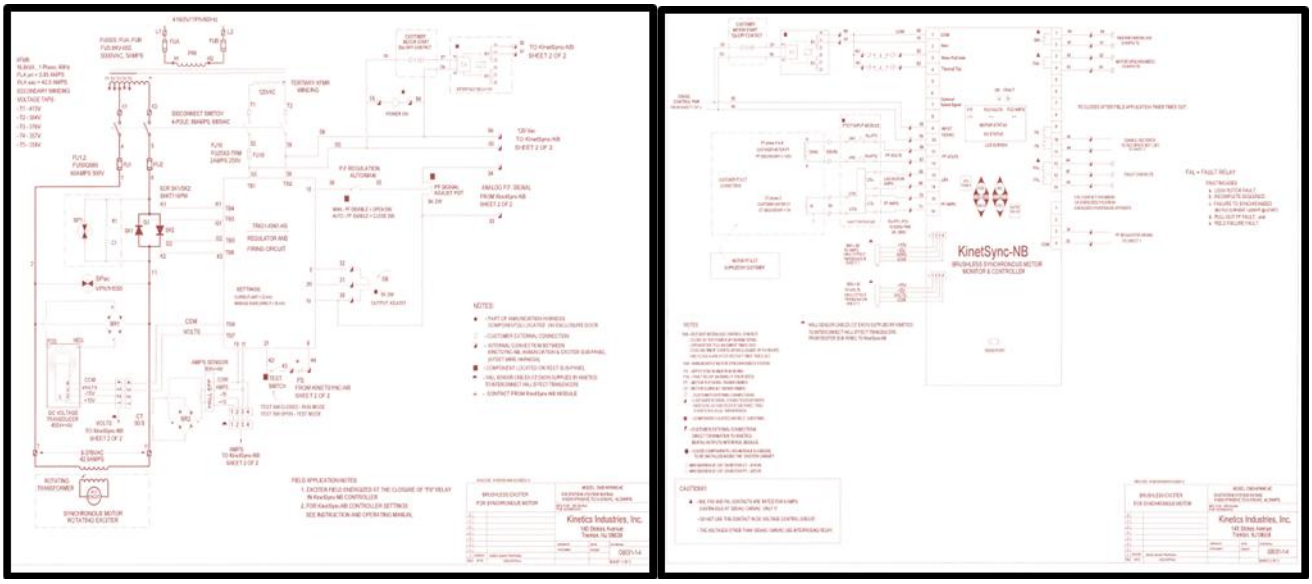
The rotating control circuitry is a protective monitoring and field excitation system. During starting conditions a semi-conductor is turned on allowing current to flow through the discharge resistor.

The rotating circuitry senses the induced field current during motor starting conditions. Since the induced field current frequency decreases as the motor accelerates, the circuitry monitors the slip frequency. When the slip frequency decreases to a predetermined level suitable to allow pull up when excitation is applied, commonly about 97% slip of synchronous speed or 3% slip, field excitation is applied by the rotating on-shaft components to bring the motor into synchronization . The rotating control circuitry then seeks the proper phase relationship in the current wave to achieve maximum pull-in torque. When the proper phase relationship is sensed, the isolation semi-conductors are turned on, excitation current begins to flow and the motor synchronizes.

In cases where a VDF is used for motor starting, the rotating excitation circuitry must have the capacity for bypassing the on-shaft application control by monitoring of slip-frequency and permit the field to be applied at the time of motor starting.

After synchronization the motors power factor can be varied and regulated by adjustment of the induced voltage from the AC off-shaft exciter, similar to a DC field exciter.

The AC excitation system permits the system to function via a variable frequency drive. Using an anti-parallel SCR closed loop regulator allows the AC into the primary of the rotating transformer to be regulated and maintain a preset power factor of the machine as loading varies.



Representative Kinetics AC Brushless Synchronous Motor Excitation System

38. I have an "unusual" type of synchronous motor, can you help me?

Kinetics hopes we can help by developing an economically viable product proposal that fits your application requirements and budget. Kinetics has developed a wide range of knowledge on "special" purpose motors such as a dual speed consequent pole configuration motors and high starting torque wound rotor configuration switched to a synchronous motor winding configuration once the motor is up to synchronous speed and reverse directional rotating stator motors.

Kinetics' goal is to be specialists on all types of synchronous motors systems to best serve all our customer's synchronous motor excitation system applications.

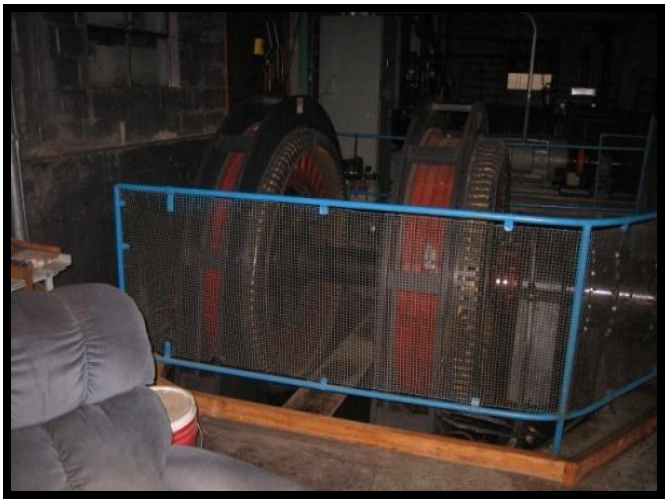
6000 Hp, 1950's vintage, paper mill chipper motor excitation retro-fitted with solid state excitation system

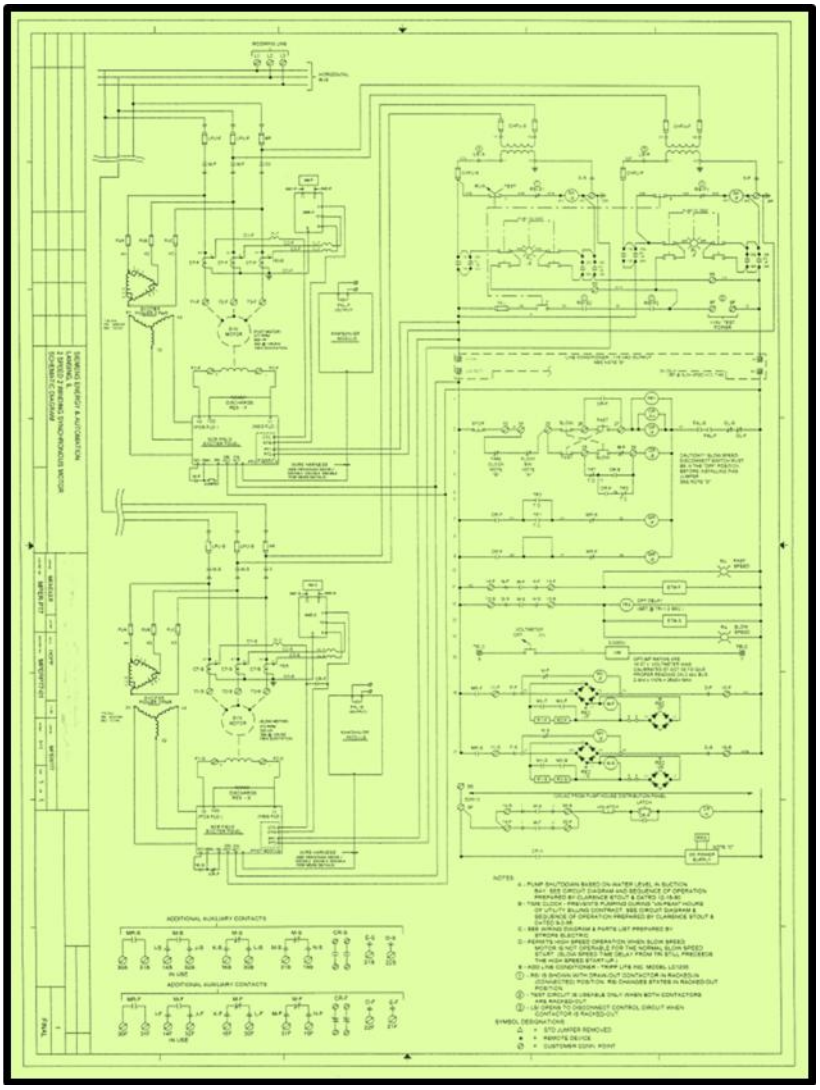
39. What is s super synchronous motor?:

This specialty type of synchronous motor is applied to applications with large starting loads that can / will produce heavy starting in-rush to the utility power system. This "older" vintage motor is most commonly found in grinding and ball mills or rotary kilns. For starting the motor, the motor's rotor is restrained by the load and the stator, on a separate set of bearings, is free to counter revolve around the rotor. When the motor is up to speed, a brake is applied to the stator keeping it from rotating and the rotor is free to turn at near synchronous speed. The excitation system monitors the slip frequency and field is applied at or just below synchronous speed, pulling the motor's stator and rotor into synchronous operation. These "older" vintage motors and starting configurations, were an electrical/mechanical approach of a "soft starter" that limited the starting in-rush current and disruption to the utility power system.

40. Two Speed Synchronous Motor – Two "Motors" On A Common Shaft:

Prior to solid state variable speed motor control, motor designers devised various electro-mechanical motor designs and control for applications requiring a given torque and speed characteristic. The two speed synchronous motor is just such a design. The complete motor is actually a "system" consisting of two independent motors on a common shaft. The two rotors have a different number of field poles. The number of poles determines the motor's RPMs or speed. Only one motor, stator and rotor, are energized and synchronized via the excited field at a time, thus setting the motor's speed. The excitation system must be designed to apply to either field for starting, switch from low speed to high speed and back without stopping the motor, interrupting the load process and perform a safe and orderly motor shutdown from high or low speeds. This design tends to be found under 1000 Hp.





System schematic drawing for a consequent pole motor

41. <u>Consequent Pole, Two Speed, Synchronous Motor:</u>

Larger two speed synchronous motors, larger than 1000 Hp, tended to be design as single motor-consequent pole machines. These motors are unique in that both the armature and the field structure can be reconnected in a 2:1 ratio pole configuration, while running under load, giving speeds in a 2:1 ratio. The reconnection of the field poles is switched while the motor is running under load. Other than the reconnection of the windings, the excitation system and switching of the control functions similarly to the two rotors on a common shaft speed-two motor system, previously described. The switching of the pole ratio tends to be found in applications where the material being processed changes in elastic properties while the process is being completed. The changing of pole configurations motors tend to be applied to applications such as a banbury mixers, common in the rubber and plastic industry.

42. Prime Mover For Starting Large Synchronous Motors and / or Heavy Coupled Mechanical Loads:

Starting large synchronous motors is commonly constrained by the limits of the utility service or the economic demand factor penalties applied by the local electrical utility. Prior to the introduction of solid state starting technology, such as VFDs and soft-starters, motor system designers would incorporate pony motors or prime movers to bring a large motor up to speed. This could include devices such as a steam turbine, diesel engine, or a clutch system from a starting motor. The excitation system for the motor field, is applied to the synchronous motor, when the motor has been brought up to synchronous speed by a pony device. The exciter configuration and control, in these applications, tends to resemble putting a synchronous generator on line. When the machine is near full speed, the field is applied and the motor actually operates as a voltage controlled generator during this time. The synchronous machine's voltage is controlled by the exciter, and the machine's frequency is controlled by the speed of the pony device. The synchronous machines volts and frequency are compared to the utility line voltage and frequency. When the volts and frequency of the synchronous machine matches the volts and frequency and phase angle of the line; the AC input main line breaker is closed and the synchronous machine is now on line and fully synchronized. The "matching" is most commonly accomplished using a device called a synchro-scope. After the matching has been achieved, the exciter takes over control of the synchronous machine and the synchronous machine is now a operating as a synchronous motor. In many applications, the pony device is de-activated or un-coupled from the motor after synchronization has been achieved.

43. **What is a wound rotor – synchronous motor and how does the system work?**

This specialty motor combines the starting and running benefits of two distinct large motor designs into a common motor. The motor incorporates the benefits of a wound-rotor motor for starting and when the motors is at "full", DC is applied to the field enabling the motor to synchronize as a synchronous motor for running the motor with the constant speed and torque benefits of a synchronous motor.

Retro-fit of MG set & control with a static excitation system:

A combination wound rotor – synchronous motor is a hybrid motor, which utilizes the high torque properties of a wound rotor motor to start a very high inertia load and then is converted to a synchronous motor when it comes up to speed to utilize the efficiency and constant speed properties of a synchronous motor.

The electro-mechanical control utilizes the inherent characteristics of the wound rotor motor and a DC self

excited motor – generator set for “control” power to the motor.

Basic principles applied and incorporated in the system design:

1. The secondary voltage & frequency of the wound rotor motor are an inverse function of the slip of the motor.
2. Excitation of a self-excited DC generator is the same voltage as applied across the DC generator armature.

The prime mover of the DC generator is turned on when the AC armature (power winding) is energized. Typically this would cause the DC generator to generate DC power. However, when the armature of the wound rotor motor is energized, line frequency AC voltage is induced into the motor secondary (rotor), which is much greater than the DC generated by the DC generator. AC power is impressed across the self-excited generator creating AC current flow in the DC generator field thus effectively turning off the DC generation. The DC generator circuit now becomes, during acceleration towards synchronous speed, only a low impedance path for one phase of the secondary winding.

The accelerating contactors are closed on a fixed time step basis allowing the AC motor to accelerate towards its synchronous speed. When the last accelerating contactor is closed, the motor is effectively running as a squirrel cage motor at low slip, thus the secondary (rotor) induced voltage is both low frequency and low voltage amplitude. This allows the DC generator to renew generation of DC power, which now naturally pulls the motor into synchronization and the motor runs as a synchronous motor.

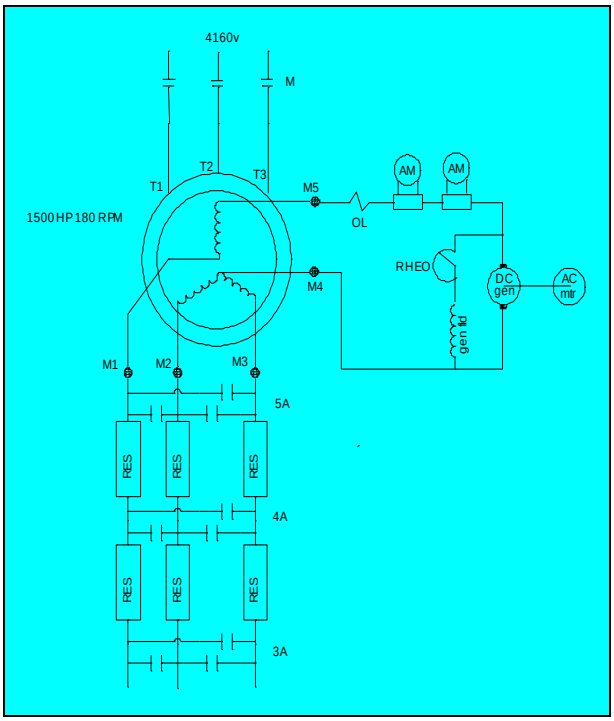
Alternate designs apply a control scheme of a combination of relays, contactors and a DC power source, such as a magnetic amplifier power supply, regulated SCR rectifier or shop DC bus power supply, in place of the self exciter generator system previously described.

To replace the DC generator with a solid state excitation system would require the excitation rectifier to be able to emulate the natural control functions of the self excited generator to apply synchronizing power at the end of the wound rotor acceleration. A solid state retro-fit excitation system would replace the MG set and include system interface monitoring for development of signals to control the DC current and voltage applied to the motor during start as a wound rotor motor and when at synchronous speed, the motor field is synchronized and operated as a synchronous motor. The exciters for these specialty motors are commonly “low” DC volts, in the 20 to 50 VDC range, and “high” in current, 400 to 800 ADC. Kinetics’ flexible manufacturing system and versatile excitation control circuitry enables Kinetics to manufacture an application specific, state-of-the-art, solid state excitation system to retro-fit older vintage special electro-mechanical control excitation systems.

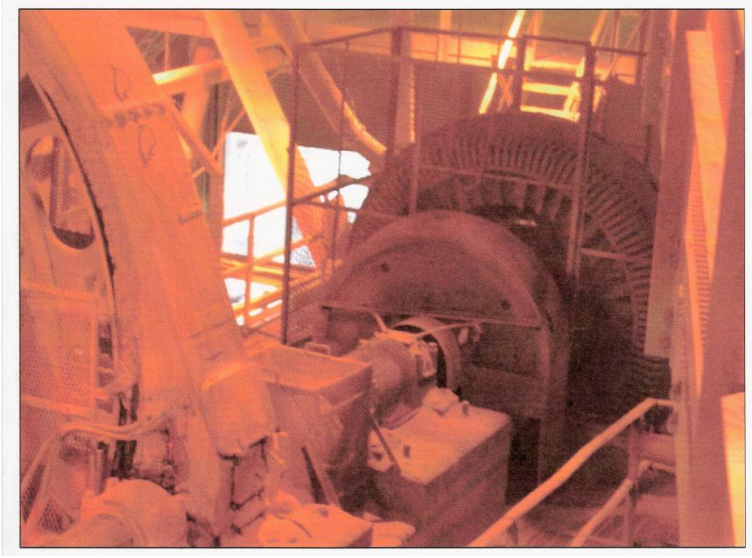
Wound Rotor – Synchronous Motor

Partial - Representative Power Schematic

Motor, Starting Resistors & MG Set Excitation



Kinetics Industries, Inc.



Kinetics Industries, Inc.
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e-mail: info@kinetics-industries.com
609-883-9700 ext 111

44. Brush type synchronous motors – brush hydroplaning causing separation of slip rings and brushes on motor start resulting in an open circuit, motor protection trip:

In applications and environments with high ambient humidity or the potential for condensation to accumulate on the slip rings; a combination of equipment and environmental factors can come together to cause difficulty obtaining successful motor starts and synchronization on the first motor start attempt, after a motor has been sitting idle. The motor starts and successfully starts and synchronizes on the second or third attempt, once the slip ring has been wiped “dry”.

When a brush type synchronous motor’s slip rings are not in use and in a high humidity or damp environment, such as a paper mill or water pumping plant, the rings can accumulate a condensation buildup, commonly referred to as “sweating”. If the brush spring tension is not properly set to hold the brush firmly on the ring surface during motor starting, the brush can be pushed away from the ring, by a thin firm of condensation moisture, that accumulates while the motor was off line and “sweating”. Other possible reasons for insufficient brush tension to the slip rings are; improper brush material, brush dimension not correct for the brush-holder or damaged rings that are pitted, groved or rutted rings, rings out of round or have an etched burn spot.

The sensitively and enhanced protections of solid state excitation systems have the capacity to detect the momentary interruption(s) of the field discharge path when the brush is lifted from the ring by the hydrostatic pressure generated by a bead of water between the brush and slip ring during motor starting / acceleration to synchronous speed. After the first motor starting attempt, the slip rings have been wiped clean of the condensation and the motor accelerates with the brushes in continuous contact with the slip ring.

Detection of the lifting of a brush from the slip ring is “good motor protection” and should not be considered a nuisance trip or failure of the excitation system. By the auto-transformer effect of the rotating field during motor starting, if the discharge resistors are not in the circuit, potentially dangerous and destructive high voltage spikes can generated within the field. The momentary lifting of a brush can cause a high voltage spike that can pit the slip ring and / or cause insulation failure within the motor field resulting in catastrophic damage within the field windings. The most common solution to trips caused by hydroplaning brushes is to increase the brush holder spring tension. If the problem still persists, consult the brush manufacturer or motor service provider.

Public water pump room – note blue fan blowing on rings to reduce potential of brush hydroplaning

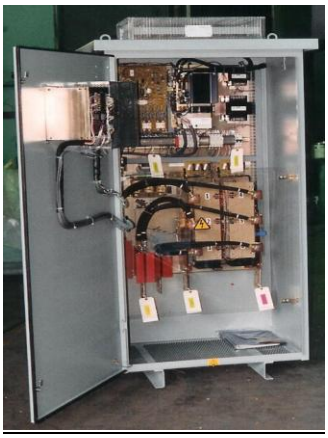
45. What standards and codes do Kinetics manufactured units meet or exceed?:

Kinetics has Underwriters Laboratory, UL and Canadian Underwriters Laboratory, CUL, **Listed** marks for our KinetSync-NB & KinetSync-SR digital annunciation and logic modules, KNB1 brushless exciter regulator panel and KSR brush type exciter & field application panel system.

Kinetics' manufacturing facility maintains a UL508 program for custom industrial control panels product marking. Maintaining a UL508 program enables Kinetics to NRTL "mark" product with application and customer specific features and parameters or operation.

Transformers, rectifiers, control panels, electronics and wire sizing and techniques, will meet or exceed all applicable NEMA, ANSI, IEEE, JIC, OSHA, EPA, NFPA and CSA standards and codes.

Kinetics is a U.S. Department of Labor and State of New Jersey approved apprenticeship facility for the electrical / electronic and sheet metal fabrication trade skills.



>> Units supplied to European steel mill for slip ring motors requiring 500 ADC at 50 VDC excitation. Systems included Kinetics regulated exciter with solid state field application, KinetSync-SR digital logic and annunciation module and discharge resistors. Unit tested and certified by Kinetics to CE and CSA standard for steel mill application in Italy.

46. How will the excitation system be tested?:

All Kinetics manufactured exciters are load tested by use of a highly inductive reactor bank to simulate the inductive field characteristics, including spikes & surges associated with collapsing fields of a synchronous motor.

Kinetics' field application panel systems are tested by operation of one of several synchronous motors within Kinetics' operational / loading testing facilities.

Standard testing of Kinetics' manufactured transformers include: high potential test, open circuit ratio test, excitation and short circuit regulation tests. Testing will conform to ANSI/IEEE standards C57.12.01 for dry type transformers.

Kinetics welcomes customers to visit our plant to witness the operational testing of their order prior to shipment. Kinetics does not charge a fee for customers to witness product testing.

Critical element to Kinetics QC is our motor & generator load test standing that includes a heavy industial synchronous motor. All systems are given operational testing by application to the motor & generator load test stand to varify operational performance.

47. Product documentation, operational maintenance manuals & software provided with Kinetics product.

Kinetics' engineering department is committed to supplying, technical submittals and operational manuals that are useful to all level of users, comprehensive in information and user friendly. All manuals include; system & circuit descriptions, installation instructions, parameters of operation settings, enclosure or panel mounting / installation drawings, component layout / location drawings, system drawings, circuitry drawings, trouble shooting guide, parts list with recommended spare parts. Manuals and drawings are available in electronic format upon request.

Kinetics maintains an engineering library on all systems we have manufactured back to the early 1960's. Replacement manuals are available for a minor fee to cover retrieval, reproduction and handling costs.

48. Why purchase a Kinetics excitation system?

1) From Kinetics' founding in 1939 as a motor maintenance company, we have stayed focused as a "motor oriented state of the art, world class, control manufacturer to US and international standards".

2) Kinetics is the *only* one source solution manufacturer, manufacturing all the critical component sections of an excitation system specifically designed and rated for synchronous motor field excitation. Kinetics takes the design, manufacturing, test, documentation and servicing responsibility for the critical elements in-with a chain of a complete excitation system. Kinetics manufactures, under one roof, all our own transformers, control and SCR firing circuitry, sheet metal enclosures or open panels and power semi-conductor rectifying assemblies. Being an integrated manufacturer enables Kinetics to maintain strict control of the products design parameters, assembly workmanship, testing and engineering startup support.

3) We listen to your application specifics. Our manufacturing concept is to remain flexible in the systems we design in order to meet the parameters of operation for the customer's application.

4) Kinetics designs our products to be flexible. Kinetics strives to match the scope of a customer's project objectives with the level of product offering. Kinetics' products are designed to offer customers the option of integrating system segments with existing segments or segment products offered by other suppliers.

5) Kinetics offers customers open access to our design and product support engineering staff.

6) Kinetics is an award winning and established power systems manufacturing company. Kinetics began manufacturing motor oriented power rectification products in the early 1960's. In 1995 Kinetics' dedication to product and organization excellence was recognized when Kinetics was selected as a "New Jersey Top 20 Growth Company".

7) Kinetics excitation system experience of successful projects covers a wide range of customer types, industries and application environments. Customer references and testimonials are available upon request.



>> Complete excitation system with power factor correction regulation and customer request motor protection / switchgear relays. One of several units installed on reciprocal compressors at an automotive engine foundry compressor room

49. <u>Kinetics engineering start-up services and training.</u>

Kinetics has a staff of factory engineers available for start-up and training classes at a customer's location. Our engineers may also be contracted for field engineering services or P&M work on Kinetics manufactured systems out of warranty.

Please contact Kinetics for a quotation and a copy of our established published rate sheet. Kinetics' engineering services rate sheet has been posted on the company web site in a downloadable format.

>> Photo show two of six 800 Hp brushless synchronous motors in a waste water roundhouse. Pumps motors are operated in pairs; one motors is a fix speed pump second motor incorporates an eddy current clutch for adjusting pump output. As a retro-fit project to the existing obsolete control, Kinetics manufactured new excitation that included digital communication and new eddy current clutch regulated rectifiers.

50. When comparing quotations & proposals; important standard features of the Kinetics excitation system that separate Kinetics from the competition.

- How many different manufacturers are involved in the various excitation system segments? Kinetics is the only manufacturer who directly designs and manufactures all the critical system segments.
- Who will service the product and each system segment? A Kinetics excitation system requires Kinetics to be 100% responsible for all service and product support.
- Who controls the operational logic software? As a one source solution manufacturer, Kinetics is responsible to the customer for maintaining support of software, micro-processors, bridging hardware and software transfer from one generation to the next and technical product support for past and present systems.
- Are you getting a “bucket of parts” or a manufactured product with the details covered that minimize installation cost, time and potential for “problems”? A prime example is Kinetics’ exclusive interconnection wire harnesses that efficiently and reliably connect two critical component sections in a user friendly manner.
- Has an EPT been included and has the EPT been designed and manufactured for regulated rectifier duty? Since Kinetics has manufactured all our rectifier transforms in the 500 VA to 2000 KVA range for 40 years, you can be assured of a properly designed and manufactured EPT.
- Is the system being proposed specifically designed for the application of a synchronous motor field excitation system? DC motor drives, discrete component panelboards and generator exciters may function but offer marginalized solutions because these products have not been specifically designed for the specific parameters of operation of a synchronous motor’s highly inductive load field with the demands of mechanical work load.

51. What information is necessary to obtain a quotation:

The minimum data Kinetics' application engineers require to initiate a proposal is the following:

___ 1) Application that the motor is operating within.

___ 2) Is the motor a "brush" or "brushless" field type of synchronous motor.

___ 3) Section(s) of the motor control / excitation system that are required for the project.
ie. motor starter, field exciter, field application panel in a common NEMA1 enclosure.

___ 4) If a motor starter is required, method / type of motor
starter desired and is the motor starting at full volts, reduced voltage or under a load.

___ 5) Horsepower of the motor.

___ 6) AC input voltage to the motor.

___ 7) AC input voltage available for the exciter.

___ 8) Field excitation DC voltage and amps.

___ 9) Desired mode of exciter regulation feedback loop closure: volts, amperes, power factor, VAR's remote signal or none and intend to use a diode power supply or common DC bus?

___ 10) If the inquiry includes a field application panel; what is the field discharge resistor bank ohmic value specified for this specific motor or the what is the value of the existing resistor bank?

___ 11) Type of enclosure or open panel and any space constraints.

___ 12) Any other motor or system data readily available such as; nameplate data, a system schematic or motor design data.

52. Commercial contacts to receive an application proposal:

Sales contact can be made to either the local sales representative or call Kinetics Industries directly at:

609-883-9700 sales extension 111.

Hours of operation: 7:30 AM to 5:00 PM EST Monday - Friday

Sales fax: 609-883-0025

E-mail: info@kinetics-industries.com

Wed site: www.kinetics-industries.com

Shipping, mailing & UPS address: 140 Stokes Ave., Trenton, NJ 08638 USA

53. Operation manuals & drawings:

Standard operation & maintenance manuals include; feature descriptions, installation instructions, terminal point layout interconnection diagrams, system startup procedure, electrical system drawings, enclosure footprint drawings, circuit board schematics with component values, trouble shooting guide and a parts list with recommended spare parts. Kinetics will provide two manuals per unit in water resistant covers unless specified otherwise at the time of unit / system quotation.

Units supplied in enclosures will include a door mounted manual storage bin as a standard feature.

Unit installation and startup can be a significant cost percentage of a excitation project. Being sensitive to this economic fact; Kinetics' includes in our operation and instruction manuals a section with specific information for the equipment installer to assist in an expeditious equipment installation, interfacing with surrounding equipment, unit checkout prior to startup and the system startup.

54. When Comparing Quotes & Proposals; Features Of Kinetics' Field Application Panels :

1) Kinetics' **ESR** (brush type motor system), **ENB** (brushless type motor system) and **SYNCHAPP-C** (contactor applied field system) systems have the very important feature of providing "impending pullout of synchronization protection". By using the signals from the AC motor starter CT's and PT's; Kinetics' field application panel systems sense that a motor is pulling out of synchronization and shuts the motor down BEFORE the pull out of synchronization is completed. Pulling out of synchronization can cause damage to the motor and will produce significant disruption to the associated power system.

2) Kinetics' systems are "confirmed system status" operational. Kinetics' application panel systems continuously monitor / check for confirmation signals that all parameters of operation are functioning properly prior to motor startup, field application and in proper "running" condition. Kinetics' **ESR**, **ENB** and **SYNCHAPP-C** systems do not apply the field "blindly" after a fixed time interval under the assumption that the motor "should have achieved synchronous speed" or "after the fact" tripping of a switchgear type relay.

3) Kinetics' regulated rectifier exciters can be offered with either a "soft" ramping “on” of the output to the motor field upon application or a "hard" instantaneous full field voltage application. The ramping “on” of the exciter voltage after application provides a gentle pull into synchronization. "Soft" pull into synchronization is another feature within Kinetics system that is designed to protect the life of the motor and minimize power system disturbances.

55. **Basic Kinetics SCR Regulated Exciter Specification: Kinetics model type SVRS**

The Kinetics SVRS regulated output rectifier is a closed loop, solid state, fully controlled phase shifted, limited range, DC power supply specifically designed and rated for the demanding inductive loading characteristics of synchronous motor fields.

The feedback regulation loop of the SVRS is available with the loop closed on current, voltage, power factor or a remotely supplied control signal. The mode of regulation needs to be specified at the time of order.

The SVRS rectifier is designed to provide an economical and efficient means of converting AC power to DC power within a limited operating range of 80% to 110% volts at 100% current. Below 80% volts the units current capacity is reduced directly proportional with voltage reduction. 110% to 100% output voltage capacity is provided to accommodate low AC input voltage of up to -10% without loss of full rated output capacity. Units are available with extended ranges; below 80% and over-voltage field forcing with protective timed interval circuit.

The 100% current between 110% to 80% voltage capacity range is designed into the SVRS rectifier to comfortably handle the essentially constant impedance load of a synchronous motor field.

Standard excitation rectifier is a three pulse, SCR - diode hybrid bridge rectifier circuit with a free wheeling or commutating diode for low current ripple output. 6, 12 & 24 pulse systems are available for applications that require "tighter" regulation and or DC output with a lower semi-conductor ripple content.

Standard Parameter of Operation:

Design and Standard Codes: Transformer and rectifier system will meet or exceed all applicable NEMA, ANSI, NEC, JIC, OSHA, EPA & NFPA standards and codes.

Operation/Maintenance Manuals: A manual specific to each rectifier system is provided that includes: system/component description, trouble shooting guide, drawings of system and circuit boards to the component level and unit bill of materials with recommended spare parts list.

Standard DC Nominal Output Voltages: 125, 250, 500, 600, 750, 1100, 1500, "low voltage" 28.5, 32 & 40.

Standard Output Regulation: +/- 1% using voltage or current feedback over the regulated range from 10% to 110% load change and maximum AC line fluctuation of +/- 10%. Tighter regulation is available per the application, IEEE 421A and Mil Std. 704E.

Service Factors:1.15 load continuous at 40E C ambient.
1.00 load continuous at 50’ C ambient.
1.25 load for two hours at 40’ C ambient.
1.50 load for two minutes at 40’ C ambient.

Efficiency: 95% or better at 100% load, 100% volts for convection cooled units.

Power Factor: 95% at 100% load, 100% volts.

Ripple: 6% RMS at 100% volts, into a resistance load for a three pulse SCR-diode hybrid bridge system, non-filtered output. For applications requiring lower percentage ripple, or detailed data and definition of unit output voltage and current ripple parameters contact Kinetics' factory sales engineering. If rectifier is to be applied powering; DC chopper circuits, inverters, lasers or DC brushless motors consult Kinetics' engineering for proper rectifier wave form requirement specifications.

Response: Less than 50 milliseconds. IEEE 421A.

System Protection Features: 600 volt class units have an AC circuit breaker, under-voltage or shunt circuit breaker trip in units 20 Kw and larger, current limiting fuses for semi conductors, AC and DC surge suppression network, solid state current limit and immense overcurrent shut-off of semi-conductor circuitry and over temperature thermal protection of the transformer and convection aided type bridge assembly.

Parallel Operation: Kinetics regulated rectifiers have the capacity to operate on a common DC bus with other rectifiers or motor generator sets. Optional feature of current balance circuit can be added if desired to have controlled load sharing with other DC sources.

Transformer Testing: Kinetics manufactured transformers tests include: high potential, open circuit ratio, excitation, efficiency / losses and short circuit regulation. Tests to conform to ANSI/IEEE standards C57.12.01 for dry type transformers.

Rectification Testing: Operational feature diagnostics testing of all control functions, output regulation at no-load and load, percent of output ripple, system protective feature operational tests, wave form analysis comparison test. Full current at reduced voltage or full current at full voltage service factor heat run loading test performed as an option. If service factor testing is desired, the test must be specifically quoted in Kinetics engineering proposal of the system to be provided.

Standard SVR Product Features:

AC Line Protection: Standard voltage units (208, 230, 240, 460, 480, 575 volts, 3 phase, 60 Hz) are equipped with a thermal magnetic molded case power circuit breaker. Units 20 Kw and larger come standard with an undervoltage trip for electrical disconnect on the AC input to the rectifier.

Higher voltage units (2300, 4160, 6900, 7200, 13,200, three phase, 60 Hz.) have terminations provided from the rectifier protective trips for interface with AC switchgear electrical trip circuit. As an option Kinetics offers match and line unit switchgear units; load break switch and fuse or vacuum contactor.

Isolation Transformer: Kinetics manufactured, specifically designed and rated for semi-conductor application, industrial duty, dry type isolation transformer. Service factor to correspond with rectifier system service factor. Convection cooled with insulation class H (200EC), class F (155EC) operated. Over-temperature thermal protection against overloads and single phasing provided in each coil. Thermals interfaced with AC circuit breaker trip (under 600 VAC) or AC switchgear electrical trip circuit (above 600 VAC). Primary taps of one (1) 5% above and below nominal input voltage.

Rectifier Elements:

- Hermetically sealed, industrial rated in excess of NEMA standards, silicon rectifier devices in a three phase SCR (3) diode (3) hybrid system.
- Semi-conductor devices are mounted on oversized, corrosion resistant extruded heatsinks for proper heat dissipation.
- Each semi-conductor will be individual fused with silver sand fast acting current limiting semi-conductor fuses on the semi-conductors input.
- Semi-conductor peak inverse voltage to be conservatively rated for a given application. General duty units to have PIV ratings of 3 times the transformer secondary voltage. Mill duty units to be rated a minimum of 6 times the transformer secondary voltage.
- Thermal over temperature protection is provided on convection aided cooled rectifier bridge heatsink arms.

Free Wheeling or Commutating Diode: Used to reduce the current ripple into a highly inductive load, such as a motor or generator field.

Surge Suppression: Oversized, semi-conductor, transient surge suppression and R-C dv/dt snubber networks are provided on both the AC and DC output of rectifier elements. Continuous bleed resistance is provided across the rectifier output bus for the absorption of voltage surges and "light" regeneration on the DC bus.

SCR Control Circuitry: Systems incorporate the use of Kinetics' solid state electronics SCR pulse width modulation, SCR trigger and referencing, firing circuitry. Circuitry provides adjustable current limiting control and immense-over-current, firing circuit shutoff, protective circuitry.

DC Output Control: Standard unit has a control potentiometer mounted on the enclosure door. Option of unit output control from a 4-20 milliamp, 0-10 volt or computer/microprocessor generated

signal is available. Unit can be provided with a local or remote output control selection switch.

Cooling: Units come standard in NEMA1 or NEMA3R enclosures, designed and rated for convection cooling. Transformers are designed and manufactured with the capacity to operate convection cooled within the unit

service factors. The rectifier bridge assembly may have low CFM fans mounted on the base of the heatsinks to aid in moving heat from the semiconductors to and out the heatsinks. Air inlet and outlet filters, wind switches or air ducting are not required.

Enclosures: Indoor operation units are supplied in NEMA1 steel, freestanding, vented, convection cooled, rugged mill duty enclosures. Components to have single side access through a hinged full enclosure length door. Enclosures suitable for fork truck lifting. Standard paint is electro-statically applied Kinetics blue industrial enamel finish. (Other colors available per specification). Enclosure types of NEMA3R, 4, 4X, 12 and specific dimensions are available to meet the application.

Enclosure Grounding: An enclosure or panel grounding lug is provided with all units meeting applicable codes and standards. Enclosure doors include a hard wire bonding to the enclosure structure.

Annunciation: Standard unit has DC analog ammeter and voltmeter, power on indication light, fuse/semi-conductor open indication lights to identify position of open device (20 Kw and larger), on/off pushbutton and AC circuit breaker through the door operator. Annunciation is mounted on the enclosure door. Numerous annunciation options are available to meet the applications requirements.

Additional Features Available:

1. Customized Enclosures: Kinetics' in-house fabrication department manufactures NEMA1, 3R, 4, 4X and 12 classification mill duty enclosures. Fitting systems into a given enclosure footprint dimension or special profile is available.

1A. Open Panel: Unit can be provided on open panel assemblies for mounting within an existing installation enclosure or an enclosure provided by others. Kinetics' in-house fabrication facilities enable Kinetics to offer unit packaging that remains flexible to space constraints.

2. Strip Heater with Thermostat Control: For environments where condensation may be a problem (i.e. dockside or hydro-electric generation stations) or units having voltages of 600 volts and higher, enclosures can be provided with thermostatically controlled strip heaters.

3. Magnetic Primary Contactor: For application requiring remote actuation of an AC line connection from pushbutton or other pilot device.

4. DC Output Circuit Breaker: Manual or electrical trip, station or drawout DC switchgear enclosure can be provided on the output bus of the rectifier.

5. DC Bolted Pressure Switch: Manual or motor operated no-load operation can be provided to isolate the rectifier off the DC distribution bus. DC fusing of the switch can be added.

6. Motor Kit: Consists of addition of a loop contactor and field supply to make a limited voltage range motor drive or combination power supply and reduced voltage starter. Motor drive feature adders such as field rheostats, field regulators, dynamic braking or slow down and field loss relay are available.
7. Annunciation: Customized meters (digital or analog), alarms, unit status indication lights, terminal ports for remote annunciation/control, keypad/digital readout system and remote operation stations are available.
8. Ripple Filter: Output R-C DC ripple filters to meet the application requirements. For aircraft hanger support application Kinetics offers filtered systems that meet military standard 704E.
9. 6, 12 & 24 SCR Pulse Bridge Systems: For applications where "lower" DC output ripple is desired without the use of R-C DC ripple filters and "faster" regulation response time; consult with Kinetics engineering for a system to meet the application.
10. Ramp On and/or Off of Output: Linear adjustable time interval ramp control of rectifier output circuitry.
11. Micro-processor or Computer Interface: Interface ports for unit control and/or unit status annunciation.
12. Power Factor Control: Monitoring circuitry kit, circuitry regulates output of the regulated rectifier based on monitoring of load power factor.
13. Current Balance: Solid State control circuit balances current loading between other rectifiers or motor generators on a common DC bus network.
14. Extended Voltage or Field Current Range: If an operating range is required larger than 110% to 80%; Kinetics will provide a system designed to meet the applications requirements.

    ie. For impulse loads, such as a steel mill rolling mill, Kinetics offers upward extended voltage range field forcing, commonly 145% of the unit's nominal DC voltage for one minute. To protect the field from extended over voltage and burnout, Kinetics offers a field forcing timed interval system trip lockout circuit.
15. Regenerative Absorption Protection. For applications where the load has the ability to overdrive the power source or raise the buss voltage to excessive electrical parameters a regenerative absorption circuit is required to protect the rectifier and load. A well established industry and NEMA standard for specification of capacity is 10% of the rating of the rectifier kilowatts or if a single motor, 25% of the motor horsepower. Applications such as steel mill ladle cranes, elevators and rotating inertia machine tools may require larger capacity units, please consult Kinetics engineering for capacity and duty cycle sizing assistance.

56. Constant Potential, Diode, Exciter with Multiple EPT Taps: Kinetics model type MVR / CVR

Kinetics manufactures diode rectifiers from 1 to 2000 Kw. Line regulated, diode rectifiers are the lowest first cost method of providing DC to the field of a synchronous motor when either voltage adjustment by changing transformer taps or a full field current capacity rheostat is acceptable. DC voltage adjustment is 100% manual by either adjusting the field rheostat or changing the 5% increment taps on the power supply's transformer.

When applying a diode rectifier, users should be aware that the field application panel voltage adjustment rheostat may need regular adjustment to compensate for changes in AC input voltage variation and the changing resistance of the motor field as the motor warms to its operational temperature. The need to adjust the field rheostat as the motor warms and cools can be a nuisance and add operating man-hour costs. An SCR regulated, Kinetics' model type SVRS, does not require repeated adjustment and the energy consuming, resistance bleeding to obtain a voltage drop. The rheostat is eliminated from the system.

57. Brush Type Motor Field Application By Contactors : Kinetics model type SynchApp-C

Combination Regulated Exciter & Field Application Via DC Contactors

The Kinetics SynchApp-C is a state-of-the-art "confirmed motor and excitation system status" synchronous motor field application panel. The panel incorporates the use of solid state sensing of motor field characteristics, micro-processor sequencing control with micro processor logic protection features and mill duty, electro-mechanical power circuit contactors to provide a complete motor field application system operating in conjunction with an AC motor starter and DC power source. The SynchApp-C monitors the output signals from the AC motor starter current transformers, CT's, and voltage transformers, PT's, providing continuous motor status monitored, fault protection and operation annunciation.

Kinetics' design & manufacture philosophy of; building a product that is low in maintenance, conservatively rated, interactive with the production system and provides annunciation and diagnostic feedback the helps to minimize trouble shooting downtime, are included within every Kinetics SynchApp-C field application panel systems.

Kinetics manufactures regulated and constant potential excitation rectifiers and can provide AC motor starters, exciters and the application panel within a package system.

For digital annunciation and control with the capacity to place information on a communication network is available by addition of the **KinetSync-SR** digital annunciation and logic module.

The solid state logic controls of the application panel sense the synchronous motor rotor starting dynamics; apply the field excitation DC power and remove the field discharge resistance at the optimum time by the use of a properly sequenced mill duty DC contactor(s) with overlapping, two normally open and one normally closed, combination contact function system to meet the desired application requirements. On motor shut down, the motor field contactors apply the discharge resistance to the motor field and remove the DC field excitation power source

in the proper overlapping sequence for motor, control and system protection from the fields highly inductive load discharge.

The DC field excitation power for the Kinetics SynchApp-C panel can be provided from a Kinetics regulated rectifier, Kinetics constant potential diode rectifier, common DC bus or MG set.

The application panel does not come with the field discharge resistor as a standard. A resistor grid is an available option offered by Kinetics.

An integral part of the Kinetics application panel system is the a micro-processor logic and annunciation system that provides continuous readout of the motor starting sequence position, motor operation status, availability of excitation voltage and current, monitoring of motor power factor and starting sequence trip or system fault trip indication. The cause of a system trip is identified by illumination of a problem identification LED on the system logic micro-processor. Panels are provided with the provision for remote annunciation interface.

Motor and/or application protection trip functions, particular to a specific installation can be interfaced into the Kinetics application panel with the addition of an interface trip function / annunciation micro-processor. For ease of service excitation system trip functions are kept separate from the load or external system trip function. When the interface micro-processor is added; the trip function is identified with an annunciation LED and one signal is sent to the application panel logic micro-processor, tripping the motor off line.

A 120 volt, 5 ampere external AC power source is required for the operation of the panels logic micro-processor.

Motor field currents are monitored throughout the starting, running and shut-down sequences to provide continuous sequence and operational protection and annunciation.

For the maximum protection of the synchronous motor; the Kinetics SynchApp-C panel is a "confirmed motor status" operating system. The line voltage, current and power factor for the motor and the DC power source voltage and current are continuously monitored for confirmed proof of the motor and excitation system's operating status. At no time does the system have "blind" spots of operation or is the field applied with the assumption that the motor has reached synchronization speed.

The "standard" SynchApp-C logic micro-processor annunciates and trips the motor off line in the event of a system malfunction:

- Exciter or DC field power not available trip.
- Locked rotor protection.
- Proof of field start.
- Proof of field discharge resistor current.
- Excessive time interval using the squirrel cage rotor protection.
- Incomplete sequence protection
- Failure of the motor to synchronize protection.
- Field loss or low field current protection.
- Pull-out-of-synch protection.

A system trip warning horn and horn silence pushbutton comes as a standard feature on all units.

An annunciation test of the logic micro-processor LED indication lights is provided on all units.

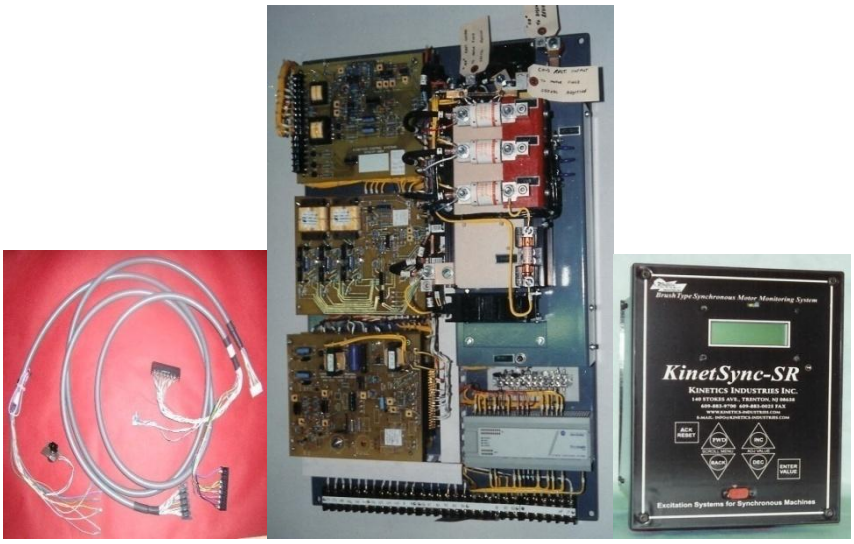
Enclosures: Systems can be provided in NEMA1, 3R, 4, 4X and 12 enclosures for floor or wall mounting. Standard enclosure has a full length, gasketted, hinged door with screw down industrial grade latch. The logic micro-processor is viewable through a plexiglass view window. All other annunciation and control are door mounted.

Open panels: System can be provided as open 12 ga. electrical panels for mounting within existing enclosures or an OEM panel with other equipment. Kinetics in house sheet metal fabrication can provide panels to give Kinetics flexibility to meet the applications specific space constraints.

58. **Brush Type Motor Excitation System: Kinetics Model Type *ESR***

Totally Solid State Brush Type Synchronous Motor Application Panel

With Excitation Rectifier & KinetSync-SR Digital Annunciation and Logic Module



The Kinetics ***ESR*** synchronous motor field application unit plus **KinetSync-SR** digital annunciation & logic module is a state-of-the-art "confirmed motor and excitation system status system" consisting of an integrated regulated rectifier and 100% solid state synchronous motor field application panel. The ***ESR*** exciter / application panel system incorporates solid state sensing of motor field characteristics, micro-processor sequencing control and protection via the Kinetics **KinetSync-SR** digital annunciation and logic module, regulated solid state rectification with a motor field and discharge resistor engaging and disengaging by means of Kinetics' high peak reverse voltage blocking capacity semi-conductor switching package.

Crowbar protection: sequencing protection to assure application of the field discharge resistors.

Kinetics' design & manufacture philosophy of; building a product that is low in maintenance, conservatively rated, interactive with the production system and provides annunciation and diagnostic feedback the helps to minimize trouble shooting downtime, are included within every Kinetics **ESR** field application panel systems.

The Kinetics ***ESR*** is designed to operate in conjunction with the AC motor starter. Kinetics can provide a motor starter system as an available system option.

An integral part of the ***ESR*** is the highly reliable, field proven, Kinetics regulated rectifier that is designed and rated for the highly inductive load operating parameters of synchronous motor field excitation. For a detailed specification on the rectifier section of the ***ESR*** see the model type **SVRS** description within this brochure.

The Kinetics excitation regulated rectifier component of the ***ESR*** system can have the feedback loop closed on either field current, field voltage, motor power factor, VARs or a remotely supplied signal by other. The mode of output regulation from the systems SCR rectifier must be selected at the time of order.

The **Kinetics *ESR*** with **KinetSync-SR** system monitors the output signals from the AC motor starter current transformers, CT's, and voltage transformers, PT's, providing continuous motor status monitor, fault protection and operation annunciation.

The solid state logic circuitry monitoring the motors operational status, in addition to continuously monitoring, the ***ESR*** with **KinetSync-SR** continuously monitors the motor's status; senses the motor rotor speed and applies the regulated rectifier output to the motor field at the optimum application point by the use of Kinetics' thyristor switching package.

For the maximum protection of the synchronous motor; the Kinetics ***ESR*** with **KinetSync-SR** excitation system is a "confirmed motor status" operating system. The line voltage, current and power factor for the motor and the DC power source voltage and current are continuously monitored for confirmed proof of the motor and excitation system's operating status. At no time does the system have "blind" spots of operation or is the field applied with the assumption that the motor has reached synchronization speed.

Motor field currents are monitored throughout the starting, running and shut-down sequences to provide continuous sequence and operational protection and annunciation.

Motor and/or application protection trip functions, particular to a specific installation can be interfaced into the Kinetics application panel with the addition of an interface trip function / annunciation micro-processor. For ease of service excitation system trip functions are kept separate from the load or external system trip function. The **KinetSync-SR** provides digital micro-processor logic for monitoring the motors operations status. If a "trip" function is detected, the trip function is identified on the liquid crystal display screen, recorded in the history registry and a trip signal is sent to the motor starter to trip the motor off line.

Control power required: A 120 volt, 5 ampere external AC power source is required for the operation of the panels logic micro-processor.

Advantages Of The Kinetics' *ESR* Solid State Field Application System:

* Maintenance demanding electro-mechanical field application
  contactors are replaced with a solid state, fast response,
  thyristor switching package.

* Solid state switching gives "faster" application and disengaging of the excitation power to the motor field and application or disengaging of the field discharge resistance.

* Solid state switching gives "faster"

* Physically smaller area footprint than contactor application panels.

* Lighter weight then contactor type application panels.

* Quieter DB then contactor systems / arc-less operation.

* Cleaner operation - no arcing gases as is associated with power contactors.

* Blackbox field maintenance of system components.

Standard AC input voltages to are available at 208, 240, 480, 575, 2300, 2400, 4,160, 6,900, 7,200, 11,500, 13.2 KV and 13.8 KV. 380 volts at 50 Hertz and 25 Hertz systems are also available.

Standard exciter output voltages are 125 and 250 volts DC. Systems with other then common voltages are available upon request. Kinetics in-house transformer manufacturing capacity enables Kinetics to offer "non-standard" input and/or output voltages to meet the applications requirements.

The Kinetics ***ESR*** with **KinetSync-SR** provides the following protective functions as standard:

- Exciter DC field power not available trip
- Locked rotor protection
- Proof of field start
- Proof of field/discharge resistor current
- Excessive time interval using the squirrel cage rotor protection.
- Squirrel cage rotor protection
- Incomplete sequence protection
- Failure of the motor to synchronize protection
- Field loss/low field current protection
- Pull-out-of-synch protection

A system trip warning horn and horn silence pushbutton comes as a standard feature on all units.

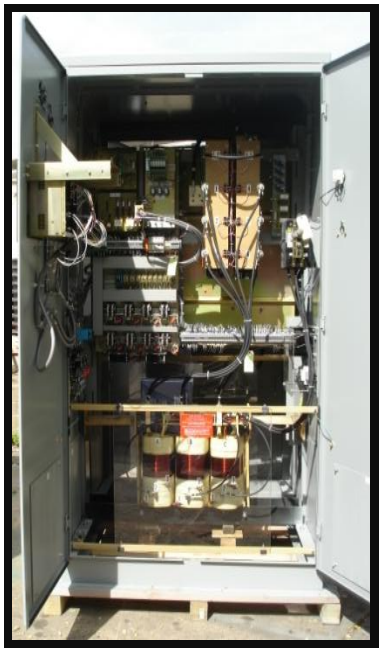
Annunciation via either a logic micro-processor with LED indication lights or **KinetSync-SR**. The **KinetSync-SR** provides word specific fault detailed on the screen and stored in history registry.

Enclosures: Systems can be provided in NEMA1, 3R, 4, 4X and 12 enclosures for floor or wall mounting. Standard enclosure has a full length, gasketted, hinged door with screw down industrial grade latch. The **KinetSync-SR** module is most commonly enclosure door mounted. All other annunciation, meters, indication lights and control are also door mounted.

Open panels: System can be provided as open 12 ga. electrical panels for mounting within existing enclosures or an OEM panel with other equipment. Kinetics in house sheet metal fabrication can provide panels to give Kinetics

flexibility to meet the applications specific space constraints.

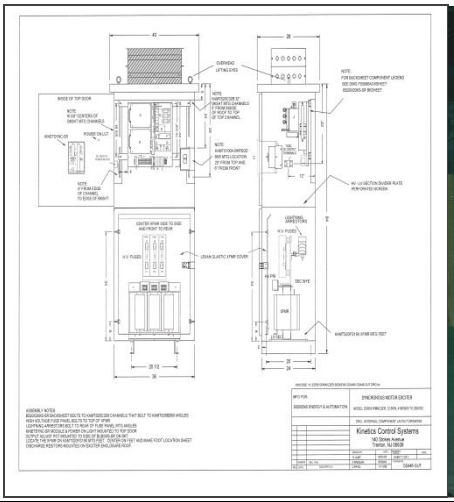
Power field discharge resistors are included as standard with the ***ESR*** control but can be provided deleted at the customer's request.



>> Complete synchronous motor rolling mill excitation system for a 12,000 Hp motor. Power factor regulated exciter with field forcing capacity, solid state field application system, KinetSync-SR annunciation and logic module, discharge resistors plus redundant application circuit to operate from a common DC mill buss.
Kinetics is the only on-going and regular manufacturer in the USA with the in-house manufacturing capacity to design, manufacture and test a system containing the state of the art technology specifically designed and manufactured for synchronous motors.

Sample Proposal: Complete Kinetics Excitation System

Application: Water pumping plant – pump motor.


One System:
Motor: Brush type 1,850 Hp pump
Primary feed 4160/3/60
Field rating: 125 VDC @ 120 ADC = 15 Kw

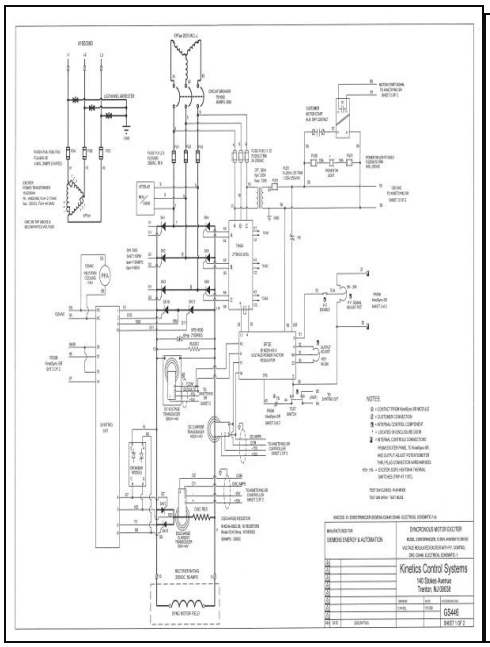
Kinetics, SCR, power factor / voltage regulated rectifier with solid state applied field synchronous motor field application panel system and KinetSync-SR digital logic and annunciation model mounted within a NEMA3R freestanding enclosure. The rectifier and synchronous field application panel model to be rated 15 Kw at 125 VDC, 1200 ADC. AC input to be 4,160/3/60. Rectifier system will be designed and rated for excitation rectifier application operation, Brush type motor.

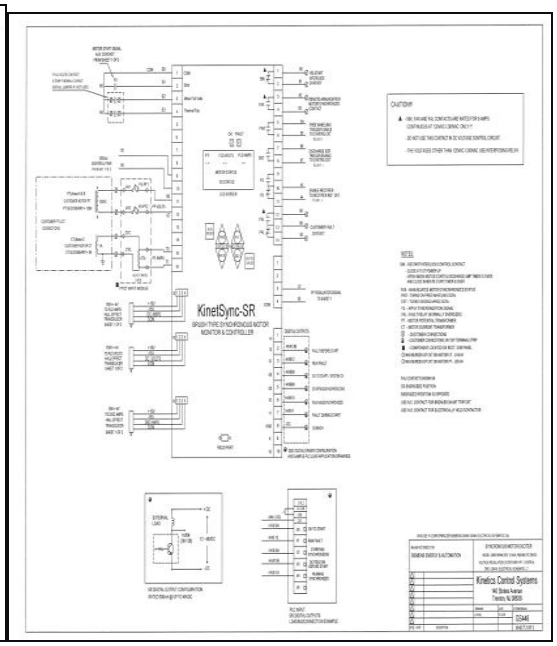
To order use model number: ESR015PMNF1ER

* Rectifier system will meet or exceed all applicable UL, CUL, NEMA, ANSI, NEC, OSHA, EPA & NFPA standards and codes. KinetSync-SR and KSR exciter / field application module are UL Listed product.
* Operational instruction manuals to be provided including system/component description, trouble shooting guide, drawings and spare parts list.
* System proposal is with the use of customer, or provided by other, AC motor starter CT's & PT's.
* Exciter with application will be tested using a synchronous motor within Kinetics test station.
* Kinetics to provide an inter-connecting wire harness for interconnection between the door mounted KinetSync and KSR exciter / application panel circuitry. (Eliminates the potential problem of “wiring issues” between the two key components and minimizes technician installation wiring cost.
* Control power from customer supplied 120 VAC. Control power input surge suppression network included.

System to include the following sections:

1) 5 KV fuse panel & three fuses
2) EPT isolation transformer
3) Isolation circuit breaker
4) SCR regulated exciter - Power Factor Feedback
5) Solid state field application panel
6) KINETSYNC-SR digital logic and annunciation control module.
7) Field discharge resistor bank.
8) Wire harness with Molex connector for connection of KinetSync to SVRS regulator.
9) NEMA3R enclosure, two cell configuration.
10) Fan cooling assembly mounted to base of KinetSync.





***** System Rectifier Specification Section *****

Kinetics, regulated power factor / voltage excitation rectifier rated 15 KW at 125 VDC at full load output of 120 ADC. AC input to be 4,160/3/60. Unit to have full current capacity from 110% to 80% volts DC. Below 80% volts, current capacity is proportional to volts. Rectifier system will be designed and rated for field excitation application duty.

** Primary mode of regulation is motor power factor. If, power factor can't be maintained the mode of regulation changes to a voltage regulated status. When the power factor range can again be maintained the unit automatically regulates power factor control.

***** AC Isolation *****

* 3 phase, 5 KV fuse panel assembly w/ three 5 KV line fuses.

***** Power Isolation Transformer (EPT) *****

* Isolation dry type 5 KV exciter power transformer designed and manufactured by Kinetics.
* Capacity 18.75 KVA.
* Conductor to be copper.
* Core steel to be grain oriented non-aging grain oriented electrical steel.
* Connection to be delta – wye.
* Class H insulation, class F rise.
* Designed for convection cooling, continuous operation in a 50'C ambient environment..

***** System Isolation *****

* One, three pole, thermal magnetic trip, insulated case circuit breaker located between the transformer secondary and input the KSR exciter panel.

***** Rectification / Exciter *****

* Three phase, six pulse, SCR, semi-conductor bridge using hermetically devices mounted on oversized extruded aluminum heatsinks for proper cooling.
* Free - wheeling SCR across rectifier output.
* Semi-conductor cooling to be convection aided.
* Semi-conductors to be rated 1600 PRV.
* Each semi-conductor to be individually fused with current limiting rectifier fuses.
* Fuse monitoring indication lights for identification of blown power semi-conductor fuse position.
* Transient surge suppression to be provided by metal oxide varistors (MOVs) on both the AC input and DC output sides of the rectifier.
* Heavy DC bleed resistance is provided to absorb small regenerative conditions and DC load spikes.

* DC output current adjustment by a control potentiometer. * Adjustable current limit control.
* Immense over current shut down protection control.
* Solid state SCR trigger circuit.
* Solid state SCR reference circuit.

***** Operating Parameters *****
100% load continuously at 50 degrees C ambient.
* Output regulation +/-1% based on 10% to 100% load variation and 0% AC line variation.
* Power factor 95% at 100% load.
* Efficiency 95% or better at 100% load.

***** System Status Monitoring *****
* Output control potentiometer mounted on the enclosure door.
* Auto / manual mode of operation selection switch.
* Enclosure door mounted analog DC ammeter and voltmeter.

***** Synchronous Field Application Specification Section *****
* Kinetics, solid state, synchronous motor field application system with Kinetics KinetSync-SR digital logic and annunciation application control module. Application power circuit to be Kinetics model KSR, rated 15 Kw at 125 VDC, 120 ADC for field application to a brush type motor.

** System to incorporate customer existing CT's & PT's within the motors AC motor starter.
* Excitation field application to be applied by Kinetics' high reliability, solid state application, SCR power switching, crow bar circuitry system.
* Solid state application to be integrated system with SCR field excitation regulator.
* Field discharge resistors to provide field swamp on start and field discharge on open and also to provide field frequency sensing path for field application controls to be provided by use of discharge resistors – *provided by Kinetics*.

***** KinetSync-SR Digital Application & Annunciation *****
* Heavy industrial grade digital logic control module with a LCD alpha - numeric display for operational status, faults, DC field volts & amps and power factor.
* Fault resister for motor trouble shooting evaluation.
* Touch - pad parameter adjustment and status strobe.
* Key pad access security functions.
* Front mounted RS232 interface port for parameter adjustment while motor on or off line.
* KinetSync-SR module to provide digital solid state field discharge sensing circuitry for power field application control to sense and apply field at the proper time.
* In event of a sequence / unit operational problem the AC synchronous motor starter interface relay trips taking the motor off line. The event causing the trip will be indicated on the KinetSync-SR LCD back-lit screen. Faults / trips will be recorded within the unit's fault registry memory.
** KinetSync-SR provide the following protective features:
- Prior to pulling from synchronization an orderly shutdown of system trip function.
- Excitation circuits not ready.
- Locked rotor protection.
- Proof of field start / discharge resister current.
- Squirrel cage rotor protection.
- Incomplete sequence protection.
- Failure to synchronize
- Field loss / low field current protection.
- Pull-out-of-synch protection.
** All faults / trips are displayed on a back-lit liquid crystal display module. Provides alpha - numeric readout of unit operational status.
** Fault / trip history register records event of fault / trip, date and time. System service assistance feature.

***** Enclosure *****

* Enclosure to be a 5 KV input class, NEMA3R, convection cooled, steel, freestanding industrial enclosure.
* Single side access to all components.
* Lower cell compartment to house the EPT transformer and 5 KV line fuses. Hinged door access. Bolted closed and will have a kirk-key interlock to prevent access while energized.
* Top cell to house the excitation rectifier and solid state application circuit. KinetSync to be door mounted. Top cell door to be hinged and have a screw down latch.
* Discharge resistors to be enclosure roof mounted.
* Enclosure grounding lug provided.
* Enclosure suitable for fork truck or overhead crane lifting.
* Enclosure dimensions: 95”H x 40”W x 28”D
  241cm x 102cm x 71cm
* Approximate weight: 1,000 lbs., 455 kg.
* Paint color to be ANSI 61 gray.