Salient Features – AC10 Control for Slip-ring Motors

The majority of Class 4 and specialized cranes around the world operate on an AC supply and are powered by standard AC slip-ring motors. Whereas the combination of frequency drives and cage motors have made strong inroads, many users adopt a conservative approach, and hold a preference for a somewhat lower order of technology, but with a proven track record in severe industrial environments.

The measure of a successful system lies in it's adaptability to a large variety of industrial applications. It will have the following important qualities:

1- **Excellent control**: for both hoist (vertical) and travel (horizontal) drives.
2- **Modular construction**: with user-friendly format for power and control assemblies.
3- **High reliability**: simple rugged construction with effective zero maintenance.
4- **Safety of operation**: inherent protection against over-speed, tacho failure, and phase failure.
5- **Versatility**: application to any size and quantity of motor, and to all voltage ratings.
6- **Ambient tolerant**: insensitive to high ambient temperatures – 60^0C.

The above are features inherent in AC10 control from HP Resistor Control, in association with Saftronics (Pty) Ltd. The system is in extensive use in steel-plants throughout South Africa, as in steel-producing complexes in Brazil, India and Malaysia.

1.1 The AC10 Design

AC10 is a closed-loop primary thyristor system for control of machines driven by one or more slipring induction motors.

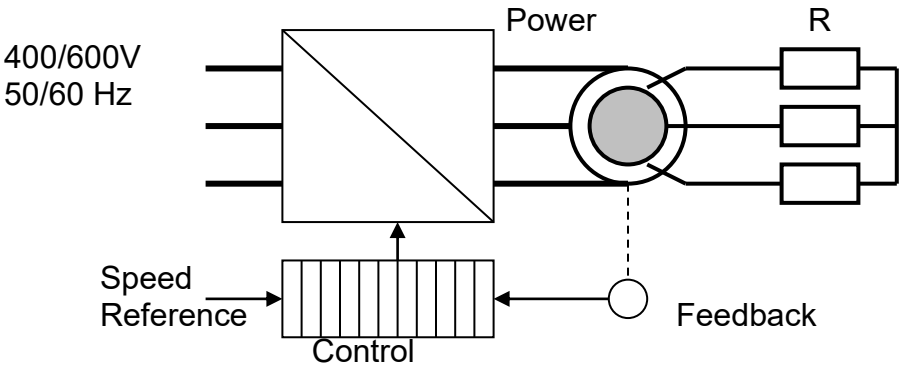


Fig 1-1

Fig 1-1 shows the principal AC10 components:

AC10 Control for Slip-ring Motors

1.2 Power Assembly- A1.

This is a 10-thyristor assembly to control both *magnitude and polarity* of power to the motor. For nominal motor ratings to 250A, the assembly is based on five Semipak units on a common heatsink. Each Semipak contains a forward and reverse thyristor. The heatsink assembly has a common temperature switch, and cooling fan. It has a high speed fuse in each input phase, as well as an R-C snubber plus zener klipsel protection circuit across each Semipak device.

For motor ratings higher than In = 250A, type SKT disc devices are employed. The assembly is then in the form of five identical plug-in cassettes within a frame. Each cassette is a heatsink onto which is mounted one forward and one reverse disc device. The frame carries two cooling fans. An 800C temperature switch is fitted on each heatsink. Standard ratings for this type of assembly extend to 4200A.

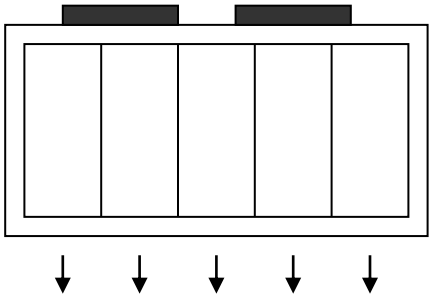
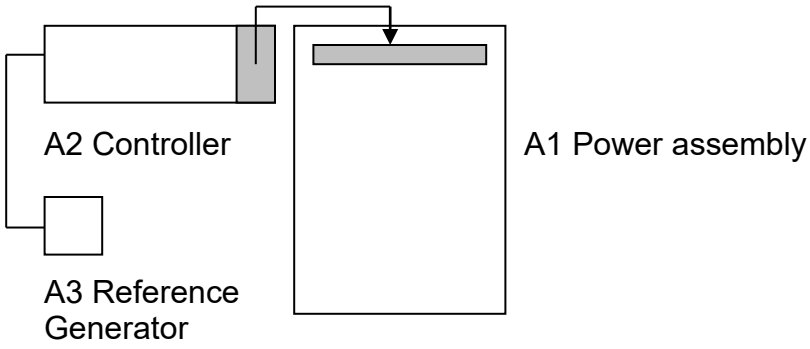


Fig 1-2 – Type SKT thyristor assembly

The A1 power assembly is complete with internal power connections and gate connections from the adjacent A2 Eurorack controller. All connections are correctly marked and color-coded. In the AC10 system, all of the stator energy to operate the motor is handled on a solid-state basis. The single isolation contactor remains closed when the system is in operation mode.

There is a standard layout format for each AC10 system, regardless of the kW size of the drive. The A2 controller is always mounted on the left side of the A1 power unit. The physical distance between the gate driver card (on RH side of A2), and the A1 gate terminals is the shortest, and in a noise-free zone.



AC10 Control for Slipring Motors

1.3 Control Assembly-A2

In a rugged modular eurorack format, the AC10 A2 controller has many years of experience and development built into it. The original concept was modeled around crane hoist and travel drives. The application use of it has extended to industrial drives – such as plate and crop shears – which benefit from smooth starting and speed control.

The AC10 A2 controller has numerous important features in addition to the basic control function. They include:

1- **Over-speed trip**: the A128 Speed Loop Supervisor monitors the dc tacho feedback and trips in the event of over-speed. The trip set-point is Ns×1,2.

2- **Broken brake protection**: in a separate control function, the A128 SLS will respond to an unauthorized downward movement of the load. It will activate the AC10 system and lower the load at a controlled slow speed. It will then deactivate at ground level. A broken brake is any mechanical fault which prevents full application of brake torque.

3- **Broken tacho protection**: in a further separate function, the A128 SLS monitors the presence of the dc tachogenerator. If the circuit is not complete, the system will trip.

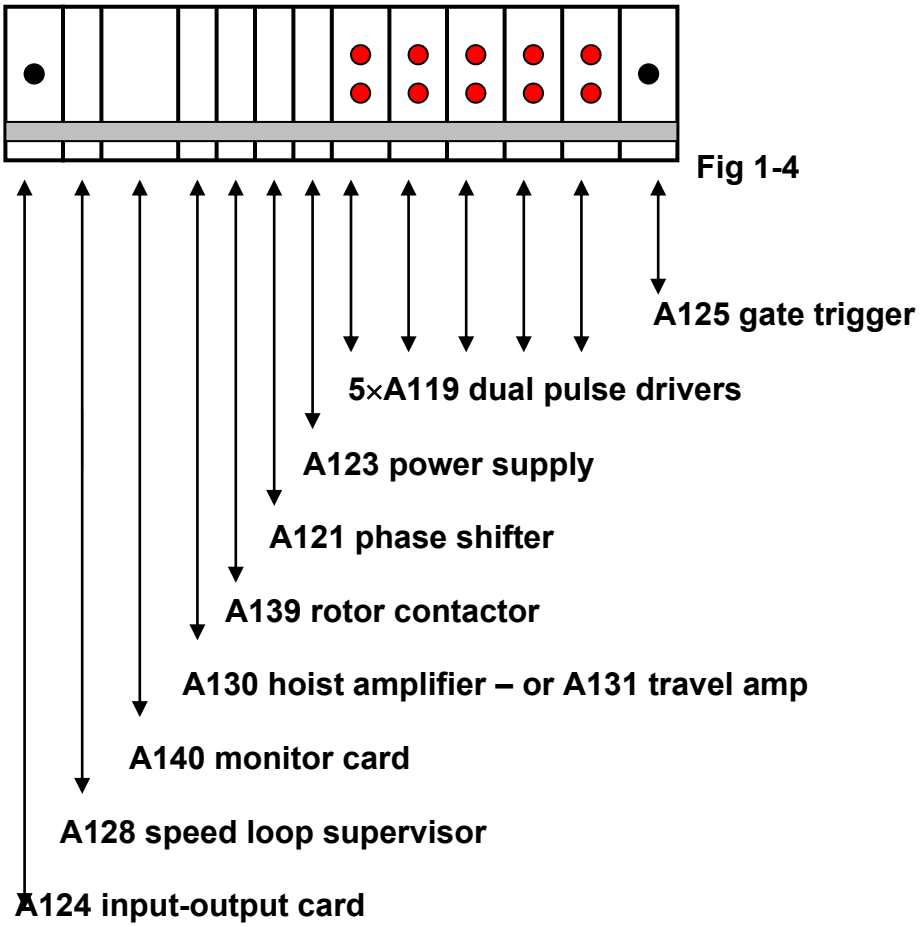
Fig 1-3. A2 modular eurorack AC10 controller.

4- **Phase reversal protection**. The A123 Power Supply card will trip the system if the sequence of stator supply is not R-W-B.

A number of the protection features inherent in AC10 are unique in the control industry.

AC10 Primary Thyristor Control for Slipring Motors

The AC10 controller is fitted with the following cards:



The red dots in the A119 dual pulse drivers represent high density LED's. They indicate active output to the thyristor driven by them. LED's are also fitted to A128, A130 (and A131), A123 and A139 cards. As a group, the LED's give a clear indication of the status of the driven machine. This, and the modular construction of the A2 controller, are important features of AC10 control.

The A2 controller is simple, straightforward, and easy to maintain. Yet it provides sophisticated control and protection. Individual cards are based on discrete electronics. They are tolerant to relatively high noise and temperature levels. With one of each card in stock, security of operation is high.

A separate specification sheet is provided for each AC10 card.

AC10 Control for Slipring Motors

1-4 AC10 Reference Generator-A3

To complete the AC10 proprietary trio, the A3 reference generator converts conventional digital inputs to a set-point analogue output, in the range 0 – 10V. This is also a modern solid-state design, in a robust insulated box. It is void of trim-pots, or other fragile components.

AC10 requires one digital input plus one discrete analogue input for each machine speed-direction. Consider an AC10 system for a horizontal travel drive. Slot 4 in the A2 controller will accommodate an A131 travel amplifier. The following speeds can be set:

Input F + 0V = full forward speed
Input F + 1.25V = 75% forward speed
Input F + 2.5V = 50% forward speed
Input F + 3.75V = 25% forward speed
Input F + 4.5V = 10% forward speed
Neutral + 5.0V = brake to stop
Input R + 5.5V = 10% reverse speed
Input R + 6.75V = 25% reverse speed
Input R + 7.5V = 50% forward speed
Input R + 8.75V = 75% reverse speed
Input R + 10V = full reverse speed

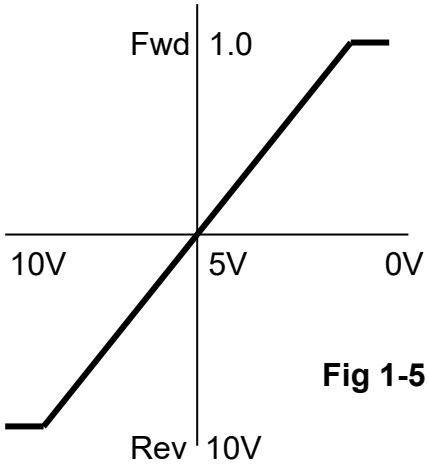


Fig 1-5

The reference-speed curve Fig 1-5 is typical only. Due to a rotor slip resistor, the A131 travel system is damped. Refer A131 spec' document.

1.5 The Complete AC10 Setup

The proprietary AC10 components - A1 power assembly, A2 controller and A3 reference generator - are supported by basic isolation, protection and control items:

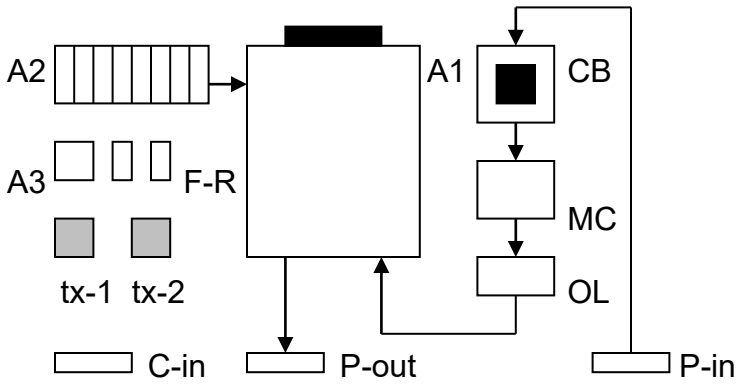


Fig 1-6. AC10 control layout for single motor travel drive

AC10 Control for Slipring Motors

This is the standard, practical layout for a single motor travel drive. The quantity of overload monitors OL will simply increase for multi-motor drives. For travel performance (controlled acceleration and deceleration), the A2 controller will accommodate the A131 Travel Amp. Because of the high level of protection in the A1 power assembly, circuit breaker CB can be a simple unit, with set-point current protection. MC is a main isolation contactor. F-R represent forward and reverse control relays, and tx-1 plus tx-2 control and synchronize transformers.

For vertical movement drives, the A2 controller will accommodate the A130 Hoist Amp. This has a sharp gain, as needed for hoist control. The two control relays will be HR for hoist, and LR for lower. The noted change will be to the rotor. Whereas for travel drives, each rotor has a fixed slip resistor (as Fig 7/1), the rotor in each AC10 hoist system will incorporate at least one contactor. This is to ensure correct performance for hoisting duty.

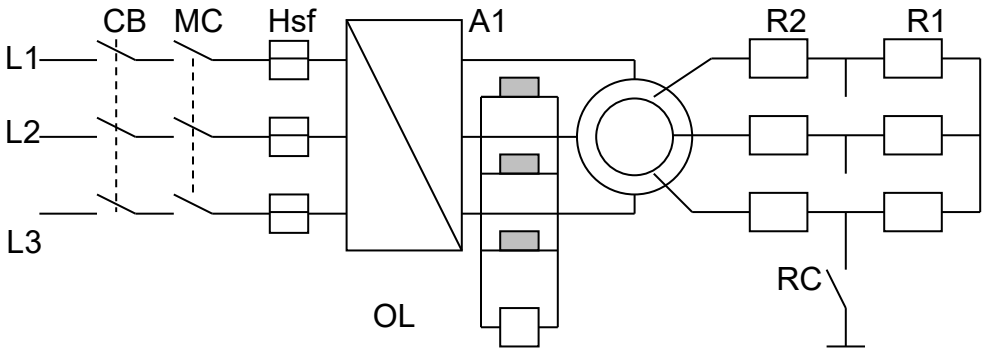


Fig 1-7 AC10 hoist power circuit

Closure of contactor RC is automatic at Nn×0.75 (75% speed). This is a fixed set-point. Refer to spec A139 Rotor Card.

AC10 Control for Slipring Motors

1.6 Performance Curve-with A130 Hoist Amplifier

The following is a speed-torque curve for AC10 hoist control with one RC and five fixed controller notches:

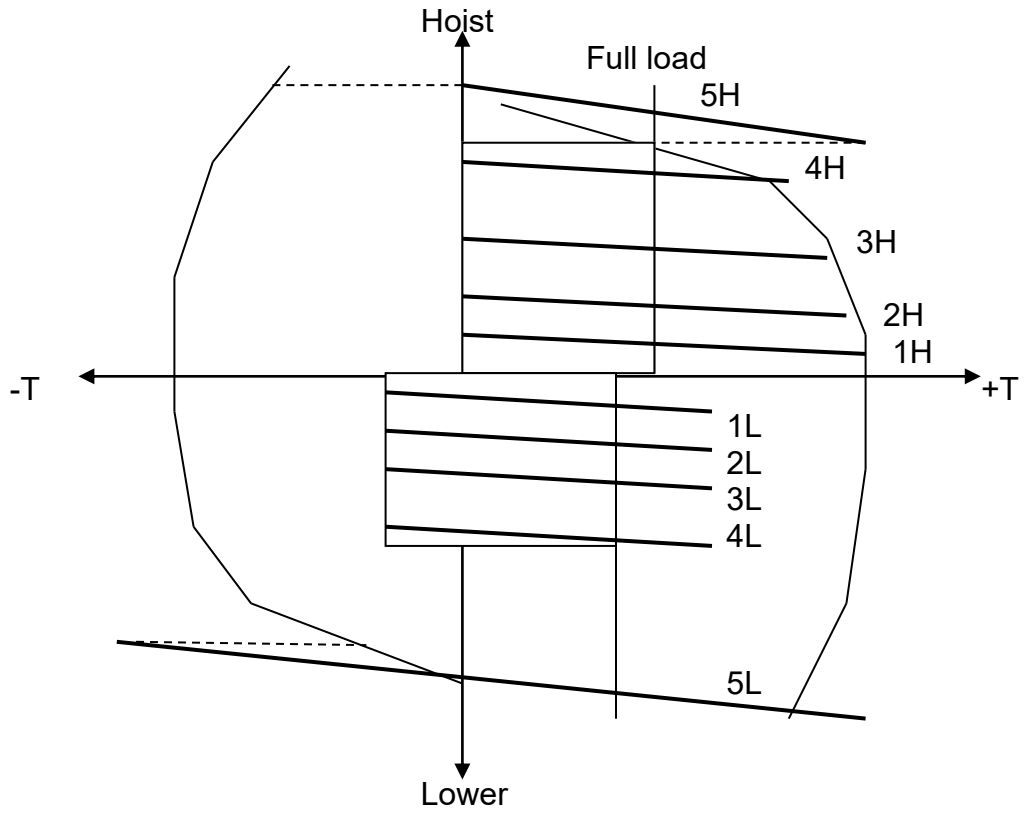


Fig 1-8. AC10 hoist performance curve

Fig 1-8 is a four-quadrant speed-torque curve. It represents the four combinations of speed and torque which the motor will go through during a hoist-lower cycle. The outer limits of torque are set by the rotor resistor. This is sometimes referred to as an electrical box. Motor performance is contained within the box.

With AC10 control, the drivers controller can be manipulated from full speed hoist to full speed lower, and from full speed lower to hoist, without detriment. The system is rated for continuous operation at any speed. There will however, be a restriction on the motor. This will depend on it's duty cycle rating. The four operating quadrants are:

Quadrant 1 = positive torque; positive speed. This is the main quadrant for lifting any load at any speed.

AC10 Control for Slipring Motors

Quadrant 2 = negative torque; positive speed. This is a transitional quadrant. It operates when reference input changes from hoist to lower. Motor torque reverses from positive to negative to drive the load down.

Quadrant 3 = negative torque; negative speed. This is a semi-transitional quadrant. A light empty hook or empty rope-drum (before roping), will operate in quadrant 3.

Quadrant 4 = positive torque; negative speed. If the load drops with the service brake released, it will operate in quadrant 4 in a lower notch. Notch 5L is a regeneration notch. The motor operates at a speed just in excess of synchronous speed. Electrical energy equivalent to mechanical energy – minus losses – is pumped back into the supply system.

1.7 Performance Curve – with A131 Travel Amplifier

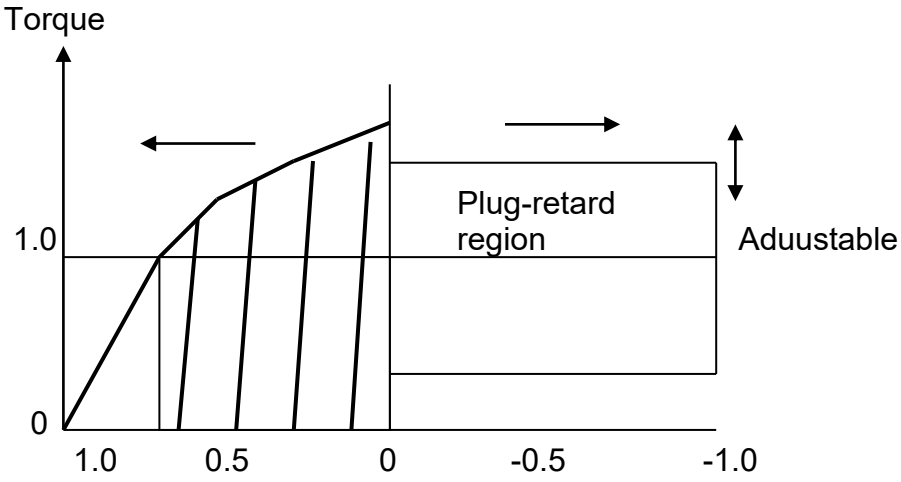


Fig 1-9. Performance curve for AC10 travel drive-with A131 amplifier

The speed-torque curve is for AC10 travel control, with five fixed speed points in each direction. It represents travel in one direction, and braking from the other direction. The same curve (inverted), can be used for operation in the opposite direction.

Due to the fixed rotor slip resistor (value rotor k×0.25), the motoring curve is highly damped. The effect on a travel drive is small. Once the inertia has been accelerated, nominal motor power is needed to overcome rolling resistance.

AC10 Control for Slipring Motors

1.8 Application of AC10 Control to Various Cranes

The AC10 control system is in use in every size and category of steel-production crane. The applications list extends from 250 and 350t Hot Metal Cranes, to several semi and fully automatic cranes for slab-manipulation, as well as slab piling and de-piling.

Whereas a clean, cool environment is a strong recommendation for any electronic system, the majority of applications are unavoidably hot and dusty. In some, such as the pot-room at Alusaf, ambient temperatures of 60^0 are exceeded. The temperature on the cranes is unbearable. AC10 has operated in this environment for many years.

AC10 is the principal control system for slip-ring motor-driven crane drives at the following plants:

ISCOR Vanderbijlpark
ISCOR Pretoria
Saldanha Steel
Columbus Stainless
CMI Lydenburg
Steelforge Pretoria– A division of ISCOR Vereeniging
International Harvester Services – 14 4t wharf crane hoists – CT
ISPAT – Bombay (4×250+350t hot metal cranes)
CST – Brazil (14 steel production cranes)

Also at Asecita Brazil (2×140t cranes) and AMSTEEL Malaysia (2×350t hot metal cranes).

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