HF Series Generators

Advanced Service Manual (ASM)

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Line Powered HF Generator Theory

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SECTION 1 PURPOSE AND DESCRIPTION

1.1 COMPOSITION OF A GENERATOR

The generator is designed to supply X-Ray tubes in the conventional radiology.

The generator is composed of two main parts: Power Cabinet and Console.

The Power Cabinet contains:

- High Tension Tank (see note)
- IGBT's (Pulse Width Modulation) Power Module
- Low or High Speed Rotor Controller (LF-RAC or DRAC)
- Front Panel Assy. (Electronic Control)
- Back Panel Assy. (Power Input Line)
- Rectifiers Panel Assy. (Unregulated Power Supply)
- Input Line Panel Assy.
- Interconnection and Adaptation Panel (Adaptation for the different Options)

The Console contains:

- PCB, ATP Console (Console CPU)
- PCB, AEC
- PCB, Keyboard-Display

Note ☞ *Due to traceability reasons it has been considered three main parts in the generator (Power Cabinet, High Tension Tank and Console). Every part has its own serial number identified by the proper label. There is another label to identify the complete generator.*

1.2 REFERENCE DESIGNATIONS

POWER CABINET

- IGBT's Power Module:
  - Filter Capacitors C1–C4
  - Input Rectifiers CR1–CR3
  - Series Capacitor C9
  - Series AC Choke L1
  - DC Input Choke L2
  - Intelligent Power Inverter (IGBT's)
  - PCB, Charge /Discharge Monitor
  - PCB, IPM Driver

- Low Speed Rotor Control (LF-RAC)
  - Boost Autotransformer T3
  - Line Filter LF2
  - Solid State Relay K1
  - Shifting Capacitors C5.1–C5.2
  - LF-RAC Control

- High Speed Rotor Controller (DRAC)
  - Auxiliary Transformer
  - Main Transformer
  - PCB, Control DRAC
  - PCB, Interface DRAC-HF
  - Tube selection contactor KT1
  - DC Brake contactor K3
  - Fan voltage selection K1

- Front Panel Assy.
  - PCB, HT Controller
  - PCB, Interface
  - PCB, Filament Driver
  - Line Filter — LF3
  - Bridge Rectifier — BR1
  - Power Supply
- Back Panel Assy.
  - Input Autotransformer — T2
  - Charge contactor — K6
  - Precharge Resistor — R1
  - Input Fuses — F12–F13
  - PCB, Locks
  - CAR-T — LF1
- Rectifiers Panel Assy.
  - General Switch-ON Relay — K3
  - Bridge Rectifiers — BR1–BR2
  - Fuses — F2, F6–F8
  - Filter Capacitors — C6–C7
- Input Line Panel Assy.
  - Power Line Terminal Block — TS2
  - Tube Stators Terminal Block — TS2
  - Input Line Fuses — F3–F5
  - Room Fuses — F14–F16
  - Line contactor — K5
- Interconnection and Adaptation Panel (It depends on configuration)

1.3 CHARACTERISTICS

1.3.1 X-RAY RADIOGRAPHIC OUTPUT POWER

- Maximum Power .... 16 or 60 Kw
- kVp range .... 40 to150 kVp
- kVp accuracy .... $\pm$(5%+1 kV)
- mA range .... 10 to 800 mA
- mA accuracy .... $\pm$(5%+1 mA)
- Exposure Time .... 1 ms to 10 sec.
- Exposure Time accuracy .... $\pm$(1%+ 0.1 ms)
- mAs range .... 0.1 to 550 mAs
- Linearity .... (X1−X2) 0.1(X1+X2)
- Reproducibility (Coefficient of Variation) ... $\leq$ 0.05

1.3.2 HV SIGNAL CHARACTERISTICS

- kV and mA adjustment during X-Ray emission gives excellent exposure reproducibility.
- The very low kV ripple qualifies the generator as a constant voltage generator (IEC Standard) over most of its operating range.
- Minimum exposure time: 1 ms.

1.3.3 X-RAY TUBES

- The generator can supply two basic X-Ray tubes. Supply for a third tube is optional.
- These X-Ray tubes must be selected from the list given in the Service Manual.
- The rotation speed can be 3300 and 10000 rpm.

SECTION 2 THEORY OF OPERATION

2.1 GENERAL

The generator is designed to equip a conventional radiology room.

The generator provides the X-Ray tube/tubes (two tubes and a third on option) with:

- High voltage
- Filament heating current
- Anode motor control

The generator ensures dialog between the various pieces of equipment in the radiology room.

The generator is equipped with a control console, with an anatomic programming option.

2.2 GENERATOR OPERATION

See General Block Diagrams (illustration 1 and 2)

The Input Line Panel supplies the whole X-Ray Room, including the generator.

The Power Module rectifies and filters the line supply to provide the DC voltage for the IGBT's Inverter and also for the DRAC (from 300 to 750 v).

The inverter modulates at fixed frequency of 25 kHz. producing an AC voltage which supplies the HVT.

The HVT converts this AC voltage to high voltage which is rectified and filtered to give the high voltage (up to 150 kV) to supply the X-Ray tube/tubes.

The autotransformer T2, in the Back Panel, produces the voltages (DC or AC) for the whole generator.

The Front Panel controls the generator:

- Inverter control and regulation of the High Voltage (HT Controller)
- Filament heat current (Filament Control)
- mA regulation and control (HT Controller)
- Tube and Filament change (Interface)

The Filament Control produces the X-Ray filament heating current for the tubes (large and small focal spot).

The LF-RAC (low speed) or DRAC (high speed), is used to start up and brake the rotating anode.

The Interface board, is used to change the tube and the filament. Also is used to switch ON and OFF the generator.

The Console is used to control and monitor the generator (also via the anatomic programmer option). The console also controls all the compatibilities (Buckies, Tomo, AEC, Spot Film, etc.)

SECTION 3 FUNCTIONAL ANALISIS

3.1 POWER ON / OFF

The generator has a permanent power supply of 11 V, to switch ON and OFF the whole room (*see illustration 3*).

WARNING

AUTOTRANSFORMER T2 IS PERMANENTLY CONNECTED TO THE MAINS VOLTAGE, EVEN IF THE GENERATOR IS SWITCHED OFF. PERMANENT DANGEROUS VOLTAGE IS PRESENT IN THE INPUT LINE PANEL, BACK PANEL, RECTIFIERS PANEL AND INTERFACE CONTROL (IN THE FRONT PANEL).

When the "ON" push-button is depressed (in the console), Mosfet Q1 is activated (in the ATP Console board).

In the Interface Control board (Front Panel), K1 is energized trough Q1. A normally open contact of the same relay, keeps K1 self−energized.

A contact of K1 energizes K3 (in the Rectifiers Panel). K3 is the general Switch−ON relay, which supplies the power for the Front Panel (electronic control of the cabinet) and the Console.

The Console and the Cabinet microcomputers start to work, checking the whole system. The line contactor K5 is not yet activated, so the room still does n ot have power.

When the "ON" push-button is depressed (in the console), Mosfet Q2 is activated (in the ATP Console board).

In the Interface Control board (Front Panel), K1 supply is short-circuited to GND through Q2, de−energizing the relay K1. The general Switch-ON relay (K3) is also de-energized.

3.2 24 V DELAYED

The 24 V delayed is a security voltage which appears after the Switching-ON transient, in order to avoid a false (early) connection of the Filter Capacitors Bank (C1−C4 in the Power Module), through the Charge Contactor K6.

The 24 V delayed are present in connector P5−2 when, the relay K8 is energized. (*See schematic Interface Control board*)

To energize the relay K8 it is necessary fulfill two conditions:

- Capacitor C14 has to be charged through R33 (the time delay is equivalent to the time constant C14 and R33).
- The Line Contactor has to be already energized.

Once the relay K8 is energized, the 24 V delayed are present and the Charge Contactor K6 is allowed to be energized, to feed the Power Module.

3.3 ROOM AND POWER MODULE SWITCH-ON

After depressing the SWICH-ON, the Console and the Cabinet check the whole system. If everything its correct, the ATP Console (Console CPU) is ready to switch-ON the whole room through the Line Contactor K5.

If Watchdog is correct and the whole system is correct, the Console microcomputer activates Mosfet Q3.The network R12 and C52 produces a delay, to avoid a false (early) connection of the Line Contactor, during the Switching-ON transient. *(See illustration 4).*

Mosfet Q3 energizes K5. The contactor K5 supplies the whole room through fuses F14−F16.

The Bank Capacitors C1−C4 are soft charged (current limited) through LF1 (EMI filter) R1, Input Rectifier and L2.

The Capacitors charge is checked by the Charge/Discharge Monitor PCB. The HT Controller verifies the correct value of the charge

When the voltage in the Bank Capacitors is correct, the HT Controller energizes the Charge contactor K6, short−circuiting the resistor R1, allowing the current to flow directly to the Power Module (*See illustration 5)*.

3.4 SERIAL LINK

The Serial Link is a synchronous (fully isolated) communication between the Console and the Cabinet (*see illustration 6*).

The Console has all the intelligence of the generator (tube protections and system operation). The Cabinet executes the orders received from the Console. All the calibration data is content in the Cabinet (U3).

To transmit a data (from any side), there are two signals:

- Clock signal to interrupt the microcomputer and synchronize the data
- Data signal synchronized whit the clock.

There are two LED's to check the proper communication. One of the LED's (DS1) is located in the HT Controller. The second LED is located in the ATP Console (DS2).

The LED DS1 (HT Controller) start to light when the microcomputer receives the first data. DS1 keeps lighting until the microcomputer ends it's transmission.

The LED DS2 (ATP Console) start to light when the microcomputer sends the first data. DS2 keeps lighting until the microcomputer receives the last bit.

As a conclusion DS1 and DS2 are lighting when the Serial Link is busy.

3.5 ATP CONSOLE

The Block Diagram of the Console it is represented in the illustration 7.

The core is the microcomputer 8088 (U30).

The main program of the generator is stored in the 1 Mb EPROM memory (U24).

The EEPROM (U18) stores (the same data in two different memory locations, for security reasons):

- The backup copy of the APR data (*see Illustration 8*)
- The workstation configuration.
- Number of X-Ray exposures.

The NVRAM (U23) stores:

- The Heat Units accumulated in the X-Ray tube.
- The last Console selection (Exposure parameters, AEC and workstation) to be selected automatically, when the generator is Switched-ON.
- The operating copy of the APR. All the APR changes are stored in the NVRAM and later (in the next power-ON) copied into the EEPROM (U18).

Watchdog to avoid uncontrolled operation of the microcomputer is performed by U4.

The Keyboard is controlled by U25 and the Display is controlled by U11.

The Exposure Time Counter and General Purpose Timer is performed by U21.

The Synchro Serial Link was already explained before.

U29 is the Interrupt Controller to manage all the interruptions entering the microcomputer, which are the following:

- (IR0) AEC Stop, to finish the X-Ray Exposure through the Automatic Exposure Control (AEC).
- (IR1) the Transmission data interrupt, to control the output serial link.
- (IR2) the Exposure timer control.
- (IR3) the Fluoro data input serial link.
- (IR4) the HT Controller data input serial link.
- (IR5) the input for external synchro for Fluoro.
- (IR6) the general timer and Exposure Back-up Timer.
- (IR7) the UART (U16) RS232/422 serial link control.

U6, and U15 are general Input/Output ports to control the whole system.

The AEC Control is an option directly connected to the Data Bus of the microcomputer. Depending upon selected parameters (kV, density, film speed and calibration data) the microcomputer gives an analog demand which is compared with the output ramp of the Ionization Chamber in order to finish the X-Ray exposure.

3.6 HT CONTROLLER

The Block Diagram of the HT Controller PCB it is represented in the illustration 10. The core (U5) is the 89C55 (with program memory included in the chip).

The calibration data is stored (the same data in two different memory locations, for security reasons) in a non volatile memory (EEPROM) U3.

An ADC (U4) is used to monitor and control:

- Rotor current, to check the proper status (acceleration, run or brake) of the low speed LF-RAC (Line Frequency Rotating Anode Controller).
- Filament current, to check the correct heating value of the filament.
- kVp, to check the correct (actual) value of the X-Ray exposure.
- mA, to check the correct (actual) value of the X-Ray exposure and also to close the mA loop to correct automatically the variations.

The bi-directional Synchronous Serial Link it was already described.

Two D/A converters are used:

- U22 to produce the filament current demand. U21 converts the RMS current value to a DC value. Modulator U23 produces a 6,6 kHz. PWM to get the (proper and stabilized) heating filament current value.
- U17 to produce the kVp demand. Modulator U19 produces a 25 kHz. PWM to control the Power Module.

The general propose outputs are performed with open collector drivers.

The general propose inputs are performed with optocouplers.

3.7 PREPARATION AND EXPOSURE TIME CONTROL

Preparation and Exposure switches enter in the ATP Console microcomputer U30, through U25 (*see illustration 11)*.

The microcomputer U30 sends the preparation signal through U5 (if the watchdog U4 is activated) and U7 to the Cabinet.

The preparation signal reaches microcomputer U5 (in the HT Controller) through the optocoupler U1.

The microcomputer U5 selects the filament and starts the rotor. After a certain (programmable) time, U5 sends the READY signal to the ATP Console through the Serial Link.

When the microcomputer U30 receives the exposure order, two thinks happen at the same time:

- U30 load the exposure time in U21 (timer).
- U30 sends the exposure order to the Console through the gate U5 and enters in U7 (if the watchdog U4 is activated).

The exposure order reaches the cabinet microcomputer U5 (in the HT Controller) through optocoupler U2.

The modulator U19 sends the 25 kHz. PWM to the Power Module, starting the X-Ray exposure. The cabinet microcomputer U5 can abort the radiation through the input "*kV safety*" if any problem occurs during the exposure.

Once the exposure has ended, the timer U21 interrupts the microcomputer U30 through the interrupt controller U29.

U30 stops the exposure through U5, U7, and U2. The modulator U19 stops the PWM to the Power Module and the X-Ray exposure is ended.

3.8 CLOSED LOOP OPERATION

Refer to illustration 12 for the Closed Loop Block Diagram.

The generator has two different kind of loops, Hardware Loops and Software Loops.

The first Hardware Loop is the filament current. The microcomputer U5 sends the filament demand through U22 according to the calibrated data.

Modulator U23 generates a PWM of 6,6 kHz., keeping the filament current constant according to the demand received from U5. The converter U21 guaranties the stabilized RMS value in the filament (the proper value for heating).

The second Hardware Loop is the kV. The microcomputer U5 sends the kV demand through U17 to modulator U19, according to the exposure data sent by the Console.

Modulator U19 generates a PWM of 25 kHz. according to the demand received from U5 and the feedback received from the HVT. The PWM is sent to the Power Module to drive the HVT.

The first Software Loop is the mA. The microcomputer U5 reads the mA through U4.

If mA Closed Loop operation is selected (HT Controller SW2−4 in OFF position), the microcomputer U5 regulates the filament demand in order obtain the proper mA in the X−Ray tube. The mA Closed Loop operation is necessary to keep constant the mA value in long time exposures, due to the cooling effect of the filament when is emitting electrons to the anode.

The second Software Loop is the kV. The microcomputer U5 reads the kV through U4.

If kV Closed Loop operation is selected (HT Controller SW2−3 in OFF position), the microcomputer U5 regulates the kV demand to keep it constant.

It is advisable to keep the kV Loop OPEN (SW2−3 ON) for normal conditions, because the kV waveform is flatter. Only when the generator is connected to a single phase (and bad regulated) line is better to close the loop to have the best regulation.

3.9 LF-RAC (LOW SPEED ROTOR CONTROLLER)

The stator voltage is selectable High (330 V) or Low (220 V) for every tube position

The shifting capacitor is selectable (15 or 30 microfarads) for every tube position.

The fan voltage is selectable (220 or 115 V) for every tube position.

K1 is a solid state relay mounted in the panel. The propose of the relay is to allow acceleration relay K1 (mounted in the board) to commute from acceleration voltage to running voltage, without switching any current (*see illustration 13*). At time 1, relay K1 selects acceleration voltage (220 or 330 V).

At time 2 (50 ms later) solid state relay K1 is ON, flowing current through the stator coils. The current transformers T1 and T2 sense the current. In RTRI appears 3.2 V, which corresponds to the nominal acceleration current.

At time 3, solid state relay switches OFF to allow acceleration relay (K1) to commute, at time 4 (50 ms later), to running voltage (60 or 90 V).

At time 5, solid state relay switches ON again. The voltage in RTRI now is 1.6 V, which corresponds to the nominal running current.

At time 6, solid state relay switches OFF again, ending the running state.

At time 7 (50 ms later than time 6), relay K1 commutes to Braking or Accelerating voltage and K3 commutes to Braking position.

Between times 8 (50 ms later than time 7) and 9, the stator is braking with a DC voltage applied (to both coils) through CR6.

At the time 10 (50 ms later than time 9) acceleration relay commutes again to the low voltage position, ending the sequence.

There are several LED's to show the proper relay status. These LED's are the following:

- DS1 indicating high voltage applied to the stator (Acceleration or Braking state).
- DS2 indicating that the tube two is selected.
- DS3 indicating Braking state.
- DS4 indicating that current is flowing through **BOTH** stator coils. High luminous intensity means Acceleration state. Low luminous intensity means running state.

3.10 DRAC (HIGH SPEED ROTOR CONTROLLER)

The Block Diagram of the DRAC is represented in illustration 14.

The DRAC is a fully solid state converter, which generates digitally, the voltages for both stator coils (auxiliary and principal) shifted 90º. This characteristic gives two big advantages:

- The bulky shifting capacitors (for high speed, low speed, auxiliary coil and principal coil) are no longer needed, neither the contactors to switch them.
- Any combination of stator type can be selected for each tube position.

It is interesting to notice, that the generator will always try to make the exposure at Low Speed if it is allowed by the tube (in order to save unnecessary heat and mechanical fatigue for the bearings). This means the following:

1. During Fluoro, always Low Speed is selected.
2. During Spot Film, two modes of operation can be configured:
    a. Always High Speed (SW3−3 ON).
    b. High or Low Speed, according to the tube characteristics, heat units and exposure selected (SW3−3 OFF)
    c. During RAD, Low Speed is selected. Nevertheless if the exposure is not allowed by the tube at Low Speed, then High Speed will be selected automatically.

       Note that an exposure (with exactly the same parameters) can be made in Low or High Speed, depending upon the actual anode temperature (heat units), this means that a series of exposures can be started at Low Speed and finished at High Speed.

The input command comes from the generator through the optocouplers OP1 and OP2 to the microcomputer U17.

Refer to schematic A3243−03. The signals used to control the DRAC are the following:

- ERROR DRAC. Is an output of the DRAC used to tell the Generator the actual status (J4−1 and J4−2).

  The errors can be disconnected (SW4−7 ON) in order to let the Service Engineer to do the Troubleshooting. WARNING, when the errors are disconnected (DL1 ON), the DRAC will always give the READY signal, even if the rotor is not running at the proper speed.

- ST (START). Is an input for the DRAC to start the normal acceleration (J4−19 and J4−20).

  With this input, the DRAC can enter in the “SELF−RUNNING MODE” (see Service Manual) in order to avoid overheating in the stator.

- FL (FLUORO). Is an input for the DRAC to start the acceleration from the Fluoro workstation (J4−15 and J4−16).

  The Fluoro hold over time (time that the rotor keeps running after the signal Fluoro is OFF) is programmed, from zero to 120 seconds, with SW2−1 to SW2−3.

- SF (SPOT FILM). Is an input for the DRAC to start the acceleration from the SPOT FILM workstation. (J4−13 and J4−14).

  The Spot Film hold over time (time that the rotor keeps running after the signal Spot Film is OFF) is programmed, from zero to 40 minutes, with SW4−1 to SW4−4.

  The X-Ray tube can start always at High Speed, if this feature is selected with SW3−3 ON.

- HS (HIGH SPEED). Is an input to the DRAC to select high speed operation (J4−17 and J4−18).

- TUBE 2. Is an input for the DRAC to select tube 2 (J4−23 and J4−24). The X−Ray tube type, is selected with SW2−4 to SW2−8.

- TUBE 3. Is an input for the DRAC to select tube 3 (J4−21 and J4−22). The X−Ray tube type, is selected with SW3−4 to SW3−8.

- To select TUBE 1, the input signals Tube 2 and TUBE 3 must be OFF. The X−Ray tube type, is selected with SW1−4 to SW1−8.

- READY. Is an output of the DRAC to tell the Generator that the rotor is running at the proper speed (J4−4 and J4−7).

  The output J4−5 can be used to drive an optocoupler.

  Although the rotor can be accelerated very fast, in a very short time, the READY signal can be delayed, in order to let the generator to heat the filament, to make the proper exposure. The minimum delay time for READY can be configured (SW1−1 to SW1−3) from zero to 3 seconds.

The microcomputer U17 make the calculations, generates and controls the logic sequence according to the configuration made in SW1 to SW4.

The voltage magnitude of both coils are controlled by PWM (Pulsed Width Modulation), sent from the microcomputer U17 to the logic control U16.

The logic control U16 decodes and generates all the signals needed for the Three Phase IGBT Inverter (PTR1). The logic control also limits the Inverter current through U11 (the output of the inverter is fully short−circuitable).

The ADC (Analog to Digital Converter) is telling the microcomputer four important thinks:

- The DC voltage in order to calculate the PWM, to apply the stator the proper voltage, despite the line variations (the voltage applied to the stator is kept constant with line variations from 320 to 550 VAC).
- The auxiliary wire current, to check the proper stator operation.
- The principal wire current, to check the proper stator operation.
- The common wire current (obtained with the difference between the auxiliary and principal wires) in order to check the proper 90º phase shifting.

The DRAC has a very powerful error detection with 43 different codes. That means a very helpful tool for the troubleshooting. As seen before, the errors can be disabled (SW4−7 ON) in order to do some measurements.

The error code is sent to the Generator through an asynchronous serial link.

There are 8 LED's in the DRAC:

- DL1 lighting when the DRAC errors are disabled with the switch SW4−7 ON.
- DL2 is connected to the DRAC ERROR CODE serial link. The microcomputer is sending the error status to the Generator, every 1.4 seconds so DL2 is flashing all the time, indicating that the serial link is operating properly.
- DL3 indicating rotor ready when is lighting.
- DL4 indicating selection of tube 1.
- DL5 indicating selection of tube 2. When neither DL4 nor DL5 is lighting, tube 3 is selected.
- DL6 indicating that the DC brake is operating.
- DL7 and DL8 indicating high voltage present in the power inverter.

The IGBT's power inverter output, is connected to 2 transformers (Auxiliary and Main) to adapt the voltage and isolate the stator from the input line (inverter power supply).

DANGER !

THE DRAC OUTPUT VOLTAGE CAN BE AS HIGH AS 1000 VRMS. FOR SAFETY REASONS (TO AVOID ELECTRIC SHOCKS), THE STATOR CABLE MUST BE SHIELDED. BOTH ENDS OF THE SHIELD MUST BE CONNECTED TO GROUND. DUE TO ELECTROMAGNETIC INTERFERENCE (EMI) PROBLEMS, THE IGBT'S HEATSINK IS NOT GROUNDED, IS CONNECTED TO THE NEGATIVE TERMINAL OF THE INPUT RECTIFIER. TO AVOID ELECTRIC SHOCK, BE SURE THAT THE INPUT LINE IS DISCONNECTED AND THE CAPACITOR BANK PROPERLY DISCHARGED, BEFORE MANIPULATE IN THE DRAC.

There are two braking modes (depending on the purpose), in the DRAC (*see Illustration 15*):

- **Active Brake**, applying an electromagnetic field, with the same magnitude, but in the opposite direction to the actual anode rotation (reverse electromagnetic field).

  This brake is to decelerate very fast the anode, in order to pass through the resonant frequencies as quick as possible, to avoid damage to the rotor bearings and to the glass insert.

  This braking mode can be compared to the one used to decelerate an aircraft, reversing the air flow of the turbines.

- **Passive Brake**, applying a constant electromagnetic field (DC current) in order to stop the rotor completely.

  This braking mode can be compared to the one used to brake and stop completely the aircraft wheels.

In the illustration 15 are shown the speed changes of the anode, controlled by the DRAC.

- From T1 to T2, the DRAC is applying the 3300 rpm. acceleration voltage.

  From T2 onwards the DRAC is applying the 3300 rpm running voltage, with the READY signal activated (if the minimum delay for READY is already completed).

- The Low Speed (3300 rpm) brake, can be completely disabled (SW3−1 ON), letting the rotor to run free.

  If the brake is allowed (SW3−1 OFF), from T3 to T4 the DRAC is applying the 3300 Active Brake (reverse electromagnetic field) to decelerate very fast the rotor.

  If the DC Brake is disabled (SW4−8 OFF), the rotor is running free at approx. 600 rpm.

  But if the DC Brake is allowed (SW4−8 ON), from T4 to T5, the DRAC is applying the Passive Brake (DC Brake) to completely stop the rotor.

  In any case, the READY signal is OFF, from T3 onwards.

- From T6 to T7, the DRAC is applying the 10000 rpm acceleration voltage.

  From T7 onwards the DRAC is applying the 10000 rpm running voltage, with the READY signal activated (if the minimum delay for READY is already completed).

- From T8 to T9, the DRAC is applying the 10000 Active Brake (reverse electromagnetic field) to decelerate very fast the rotor.

  If the DC Brake is disabled (SW4−8 OFF), the rotor is running free at approx. 600 rpm.

  But if the DC Brake is allowed (SW4−8 ON), from T9 to T10, the DRAC is applying the Passive Brake (DC Brake) to completely stop the rotor.

  In any case, the READY signal is OFF, from T8 onwards.

- From T11 to T12, the DRAC is applying the 10000 rpm acceleration voltage in order to go from low to high speed. The READY signal is OFF.

  From T12 onwards the DRAC is applying the 10000 rpm running voltage, with the READY signal activated (if the minimum delay for READY is already completed).

- From T13 to T14, the DRAC is applying the 10000 Active Brake (reverse electromagnetic field) to decelerate very fast the rotor.

  From T14 to T15, the DRAC is applying the 3300 acceleration voltage in order to go from high to low speed.

  From T15 onwards the DRAC is applying the 3300 rpm running voltage.

  The READY signal is ON all the time.

The switch SW4−6 is to check the actual tube selection:

- SW4−6 ON, the microcomputer U17 doesn't test the tube selection.
- SW4−6 OFF, the microcomputer U17 checks the actual tube selection.

The fan voltage is selectable (220 or 115 V) for every tube position.

3.11 THE POWER MODULE

In the illustration 17 is represented the Power Module Block Diagram.

AC input line is rectified in the Input Rectifier Board. The board also contains R−C networks for the diodes. There are also capacitors connected from line to ground to filter the conducted high frequency (EMI) noise.

Filter Capacitors C1 to C4 are charge through inductance L2, to avoid high di/dt currents (in the input lines), limiting the high frequency noise.

DANGER !

DUE TO ELECTROMAGNETIC INTERFERENCE (EMI) PROBLEMS, THE METALLIC PARTS OF THE POWER MODULE (CHASSIS) ARE NOT GROUNDED, ALL OF THEM ARE CONNECTED TO THE NEGATIVE TERMINAL OF THE INPUT RECTIFIER. TO AVOID ELECTRIC SHOCK, BE SURE THAT THE INPUT LINE IS DISCONNECTED AND THE CAPACITOR BANK PROPERLY DISCHARGED, BEFORE MANIPULATE IN THE POWER MODULE.

The two Charge/Discharge Monitor Boards have the following target:

- To equalize the voltage in the capacitors connected in series to avoid overvoltage in one of the branches.
- To obtain a fast discharge of the Capacitor Bank (C1 to C4) when the generator is switched-OFF.
- To show the Service Engineer the presence of high (very dangerous) voltage in the Capacitor Bank by means of LED's.
- To inform the HT Controller the proper charge of the Capacitor Bank.

Every IGBT module contains a half bridge inverter (one vertical). The IPM Driver converts the low voltage PWM (25 kHz. signal coming from the HT Controller) to the voltage needed for the IGBT module.

Also every IGBT module has an overcurrent and overheat detection, to protect the power stage from any damage due to an overload in the High Voltage Transformer (HVT). This protection sends the signal IGBT FAULT to the HT Controller who displays "*Generator Overload*" in the Console.

L1 is an air core inductance to match the input impedance of the HVT in order the obtain the maximum power from the IGBT Inverter.

C9 is a series capacitor to cancel the DC component in the primary side of the HVT. The capacitor avoids the HVT core saturation due to the elimination of the DC component.

The output cables of the Power Inverter are shielded (the shields are connected to the negative input terminal), to avoid noise problems. Both cables goes through an isolated metallic tube, which is also connected to the negative input terminal.

3.12 TUBE CHANGE AND FILAMENT CHANGE

The filament and tube change are performed in the Interface Control Board located in the Front Panel (see schematic).

The Tube 2 change order, comes from the ATP Console to the HT−Controller (through the Serial Link) and then to the Rotor Controller (LF−RAC or DRAC). Later is sent to the Interface Control (P4−18) activating the relay K5.

The relay K5 sends the order to the HVT solenoid in order to change the High Voltage Switch position.

The HVT sends back to the ATP Console the actual position of the High Voltage Switch (the signal HV–INTLK through connector J3–13) to check the proper tube selection.

The filament selection comes from the HT Controller (P1–13) to the Interface Control (P4–19), activating the relay K7.

C17, BR2, K11 and its associated circuitry detects the filament selection, sending back (through P4–22) to the HT Controller (P1–8) in order to check the correct operation.

Due to the physical structure of the High Voltage Switch (inside the HVT), Filament 1 has two different meanings, depending upon the tube selected:

- Filament 1 is Small Focus when Tube 1 is selected.
- Filament 1 is Large Focus when Tube 2 is selected.

L1, L2 and L3 are inductances to preheat the two filaments (only used for Rad and Fluoro generators).

SECTION 4 SCHEMATICS

1. System Block Diagram
2. Generator Block Diagram
3. Switch ON / OFF
4. Charge Circuitry
5. Switch ON Sequence
6. Serial Link
7. SEDECAL Console Block Diagram
8. APR Checking
9. Interrupt Controller
10. HT Controller Block Diagram
11. Preparation and Exposure Time Control
12. Closed Loop Block Diagram
13. LF-RAC
14. DRAC Block Diagram
15. DRAC Brake
16. DRAC Speed Control
17. Power Module Block Diagram
18. Tube Change
19. HV Transformer

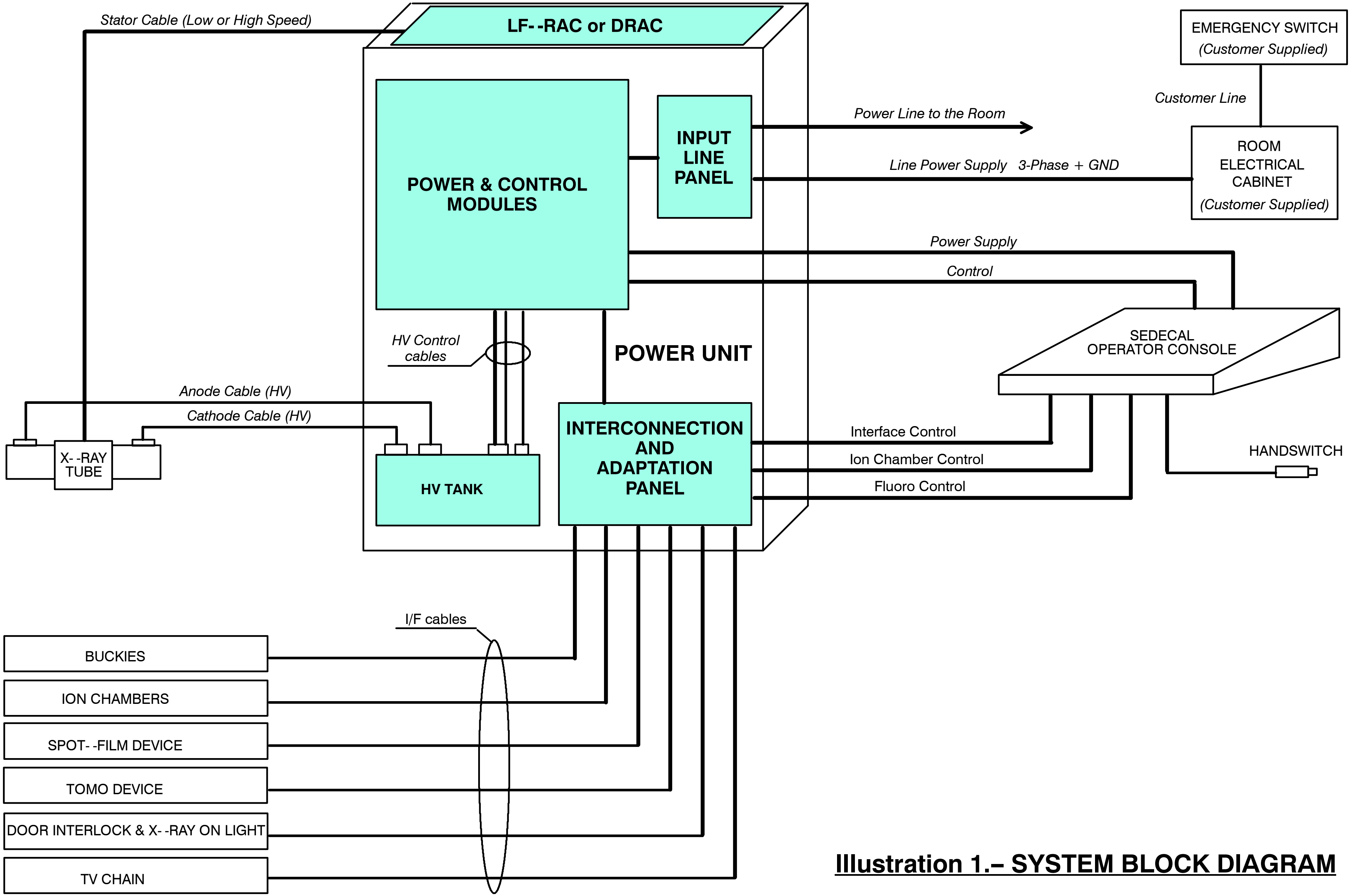


Illustration 1.– SYSTEM BLOCK DIAGRAM

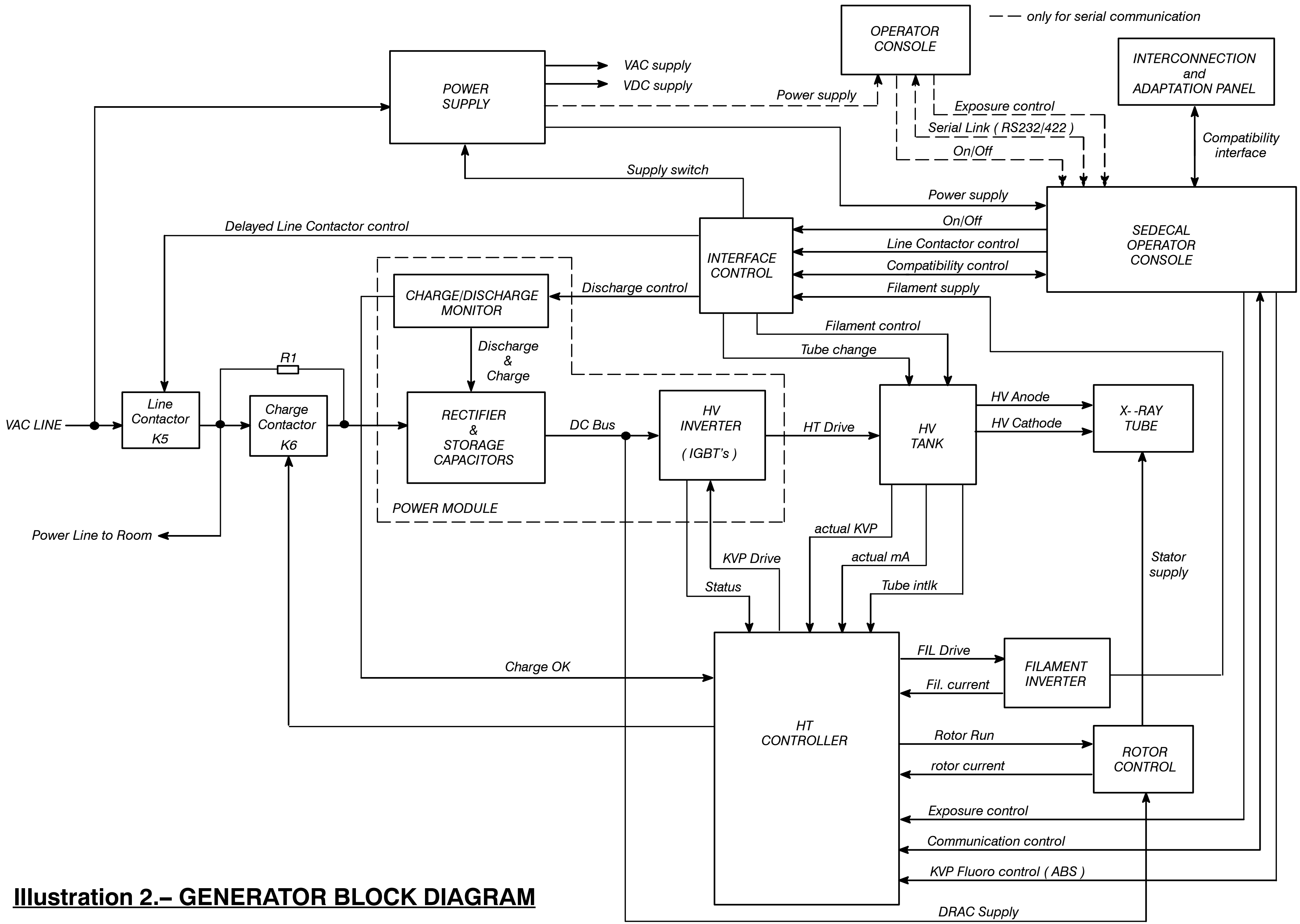


Illustration 2.– GENERATOR BLOCK DIAGRAM

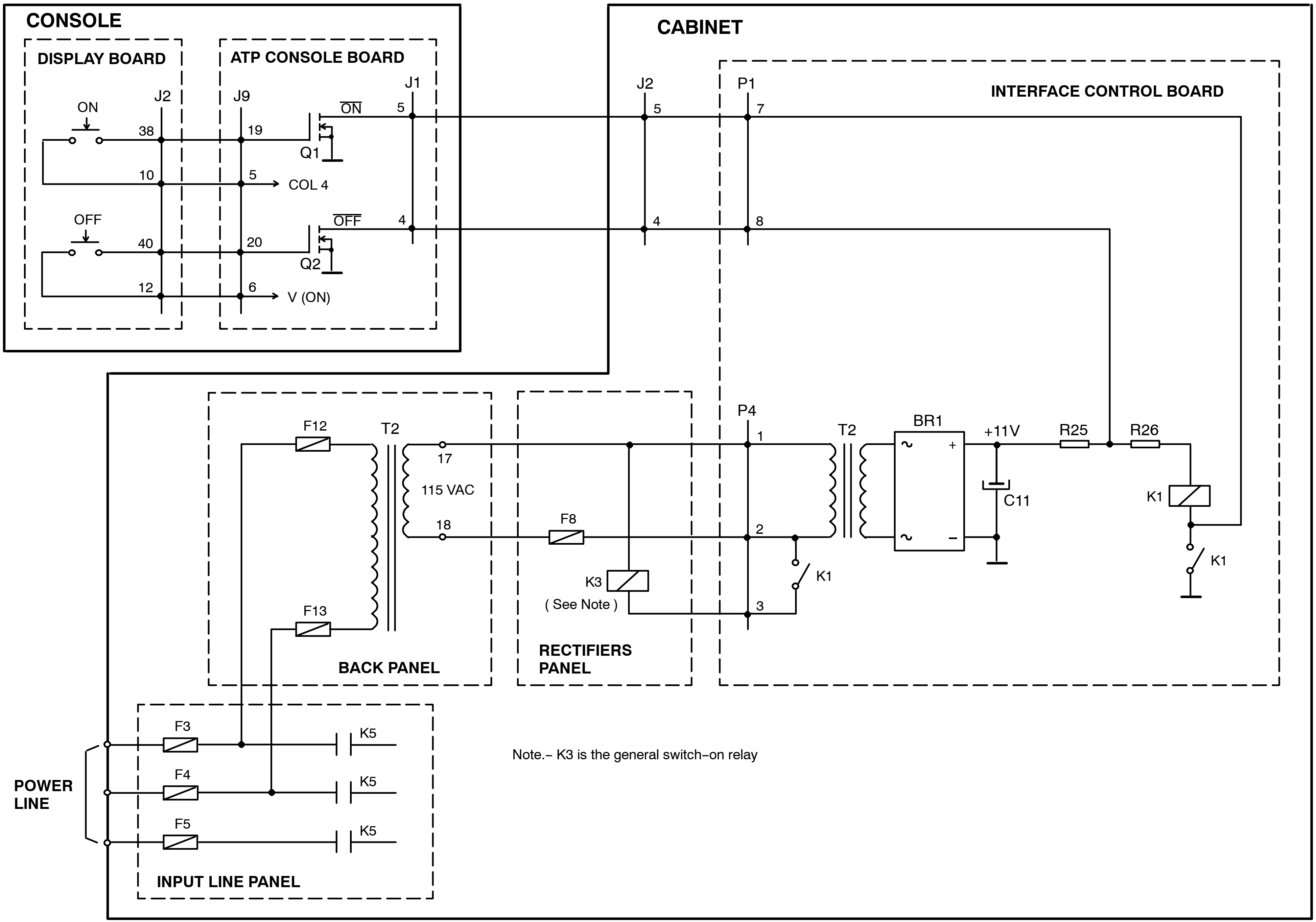


Illustration 3.– SWITCH ON–OFF

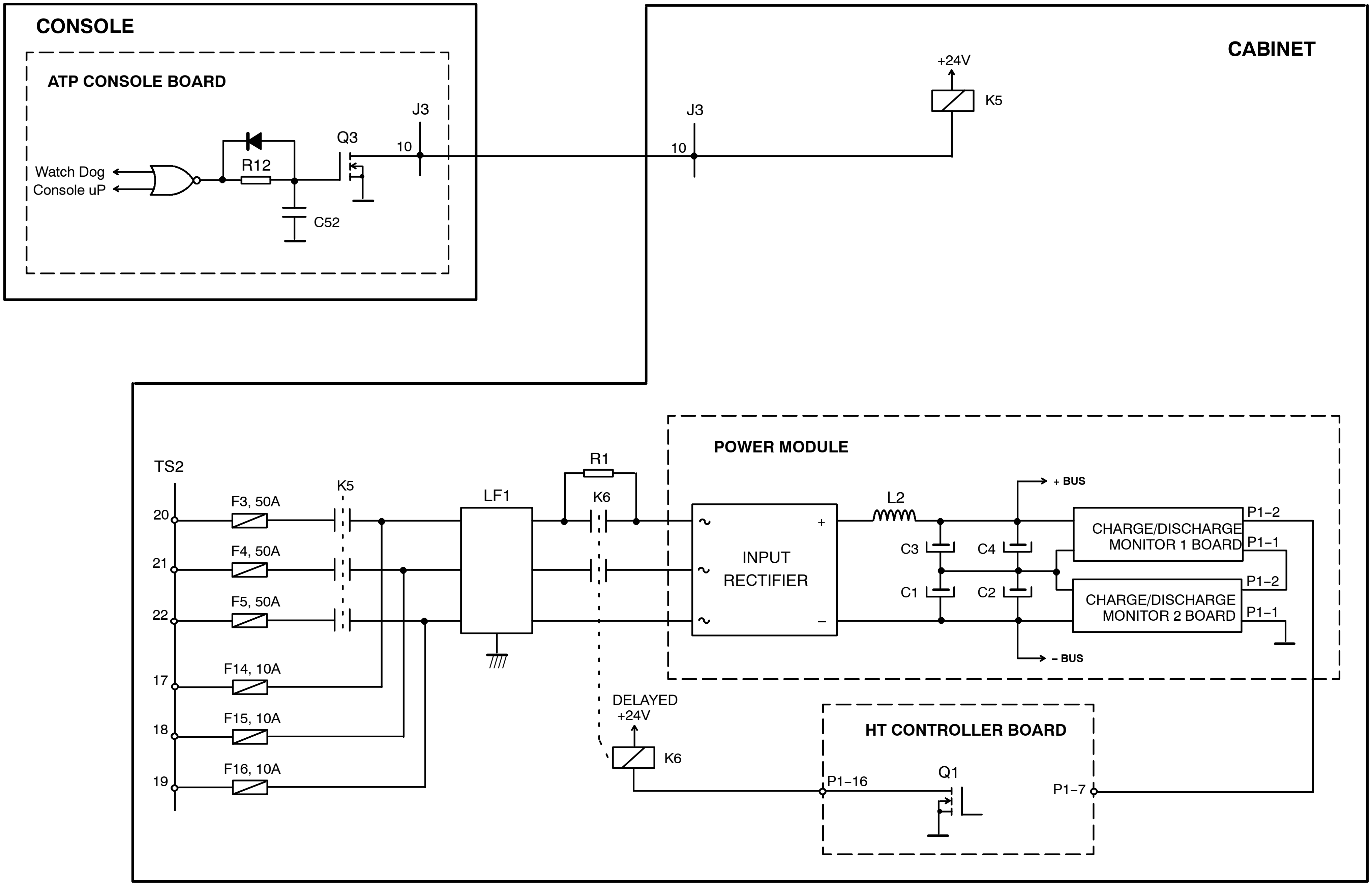


Illustration 4.– CHARGE CIRCUITRY

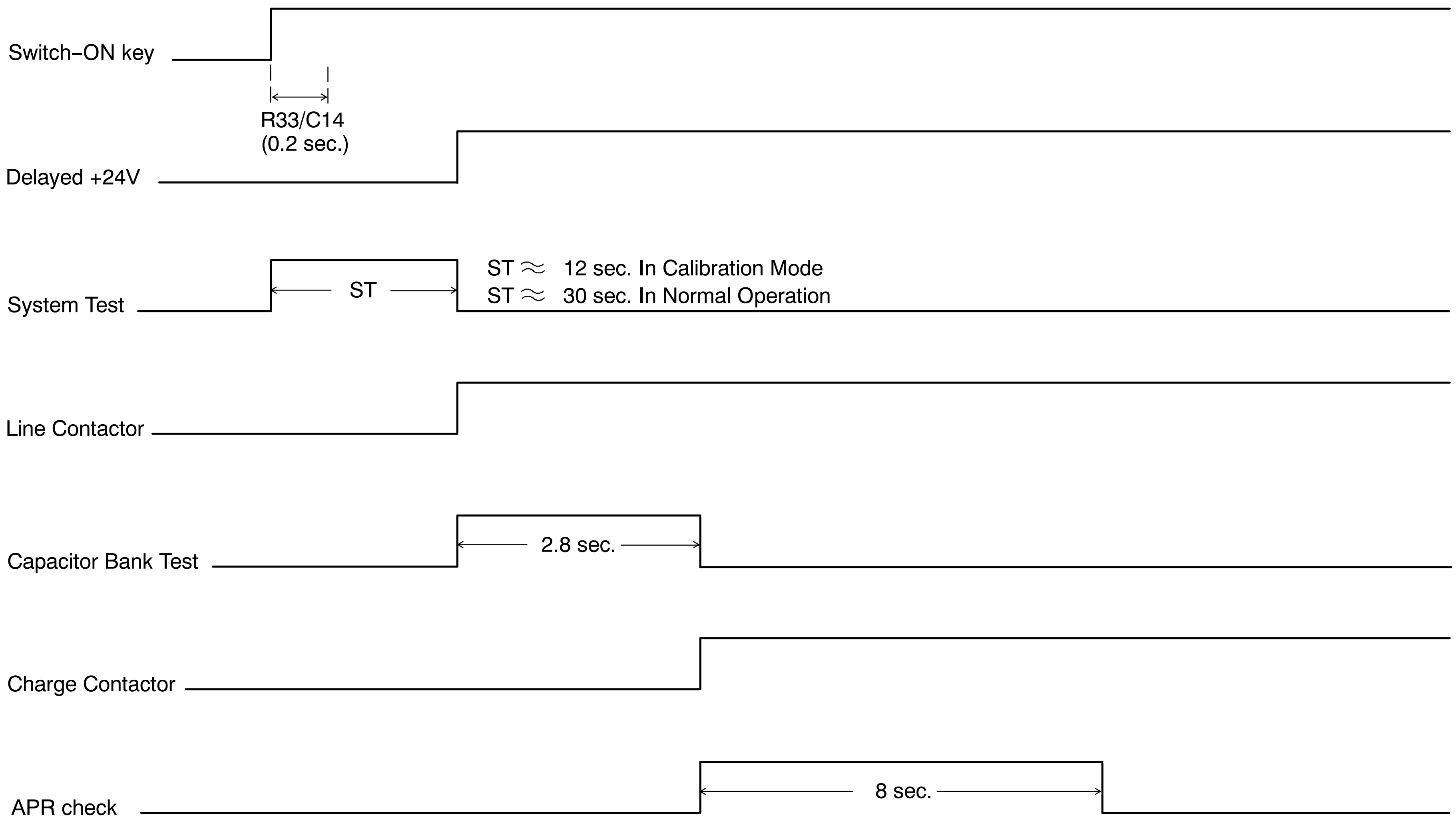


Illustration 5.– SWITCH-ON SEQUENCE

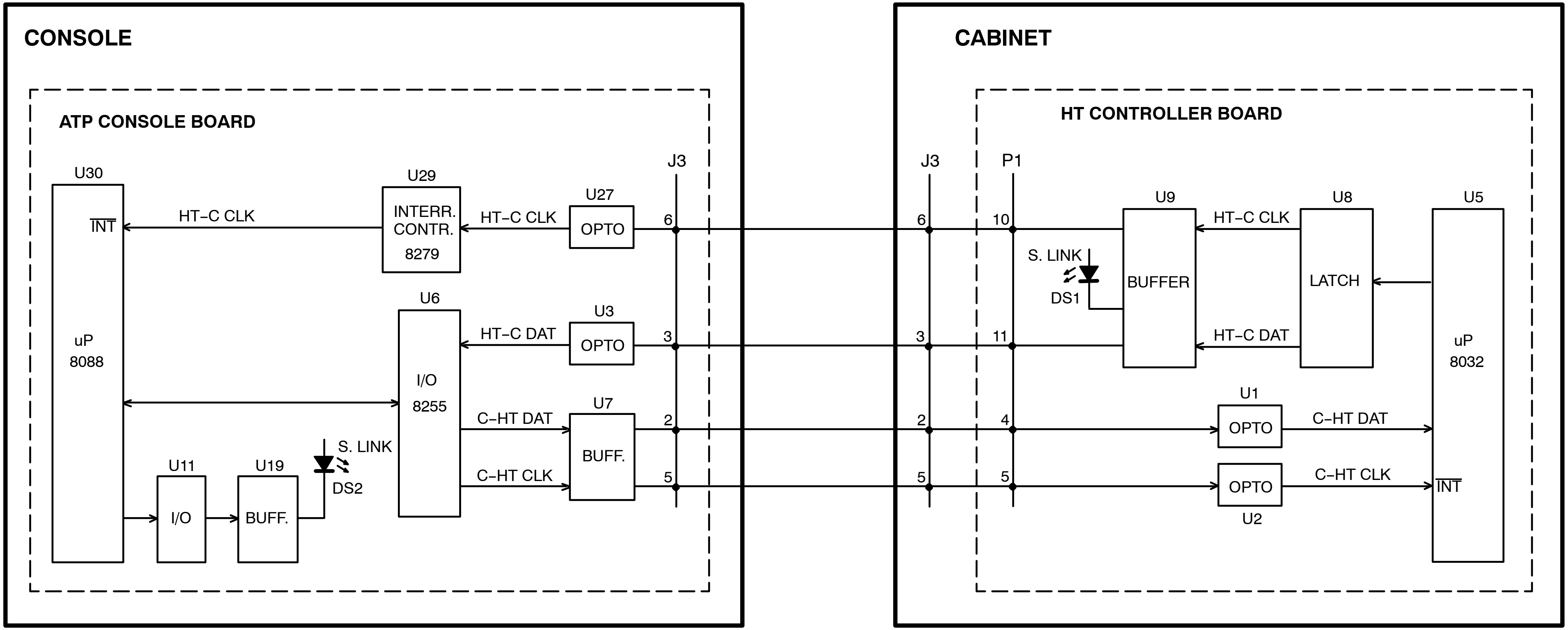


Illustration 6.– SERIAL LINK

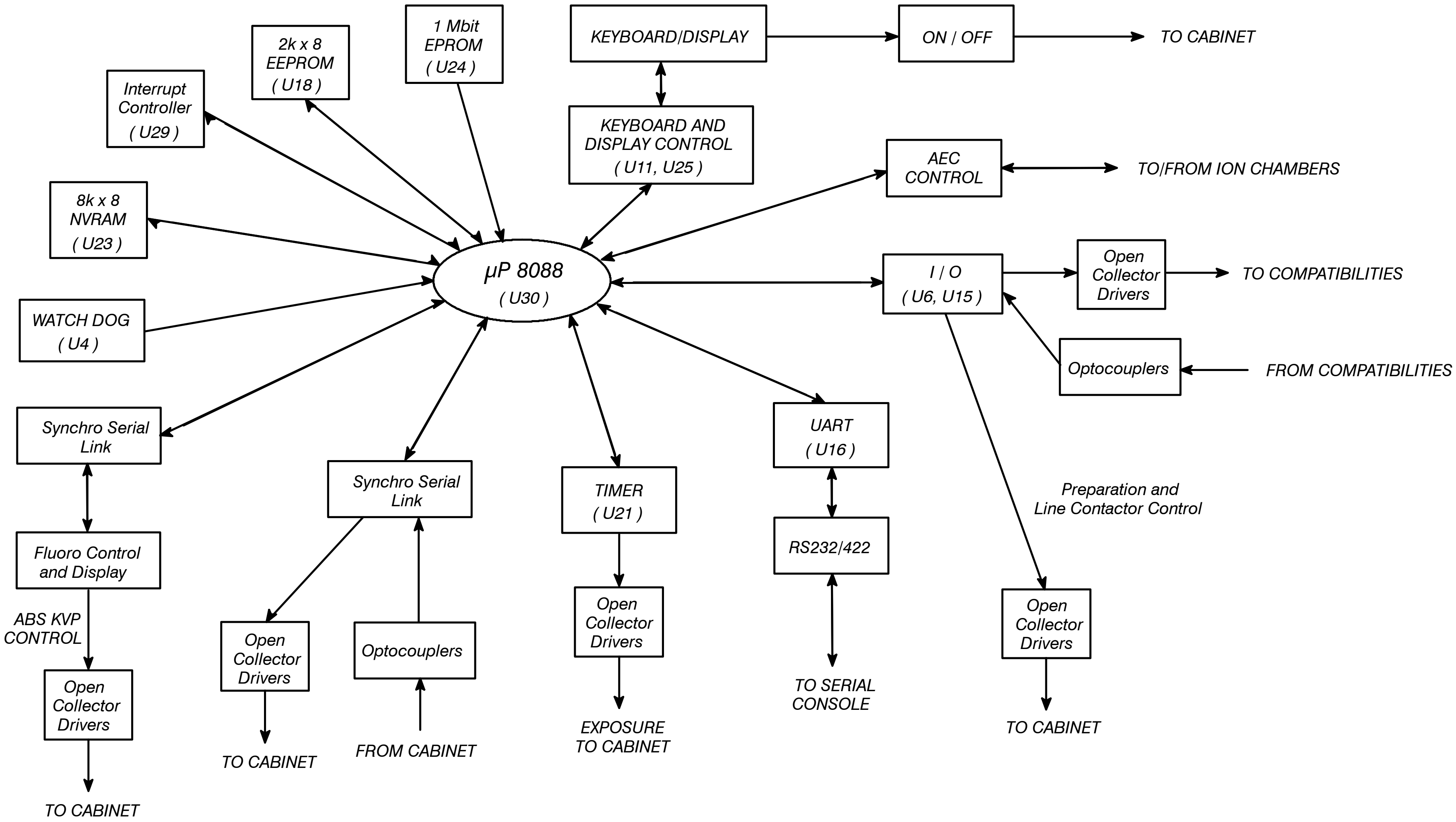


Illustration 7.– SEDECAL CONSOLE BLOCK DIAGRAM

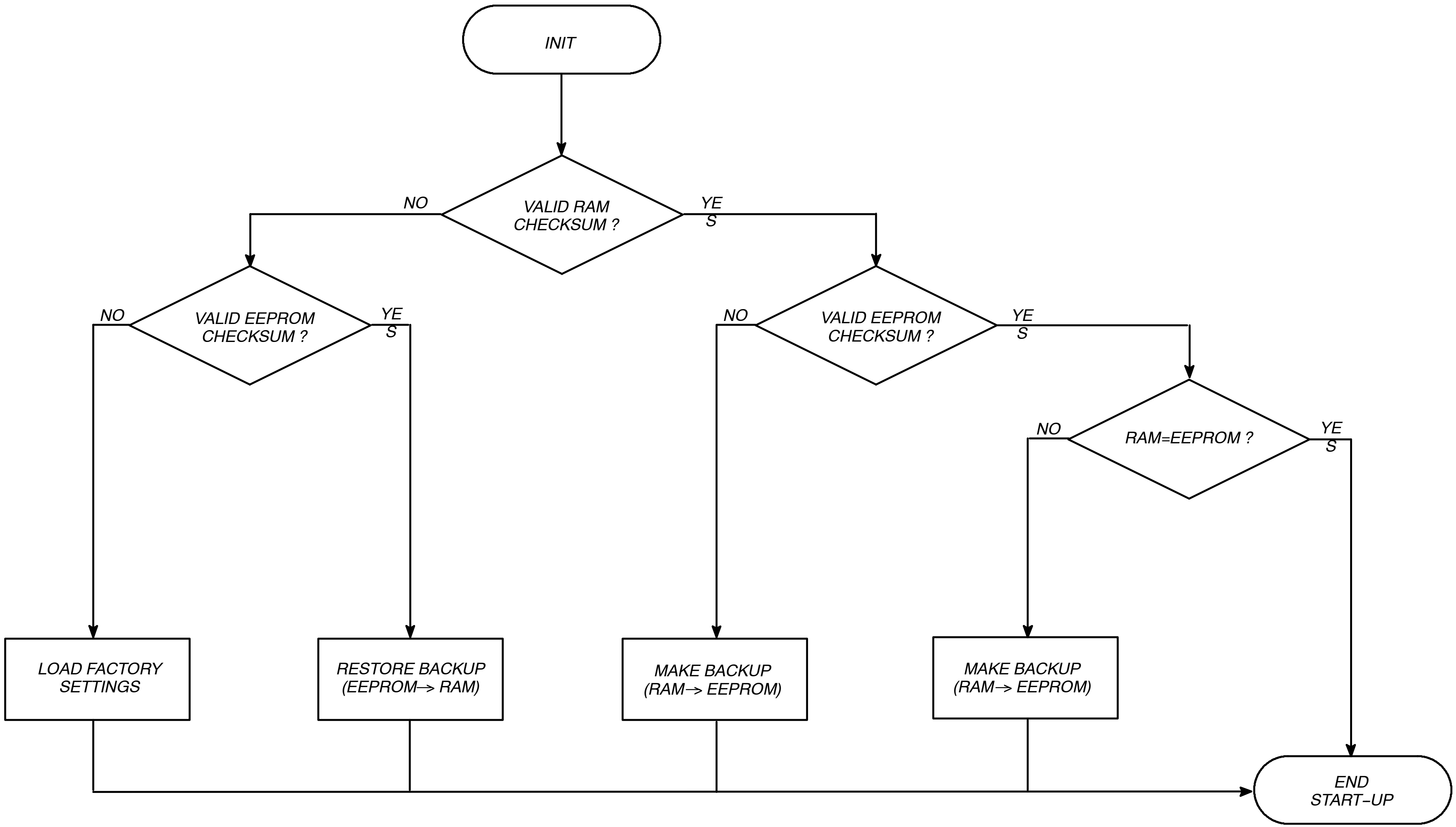


Illustration 8.– APR CHECKING

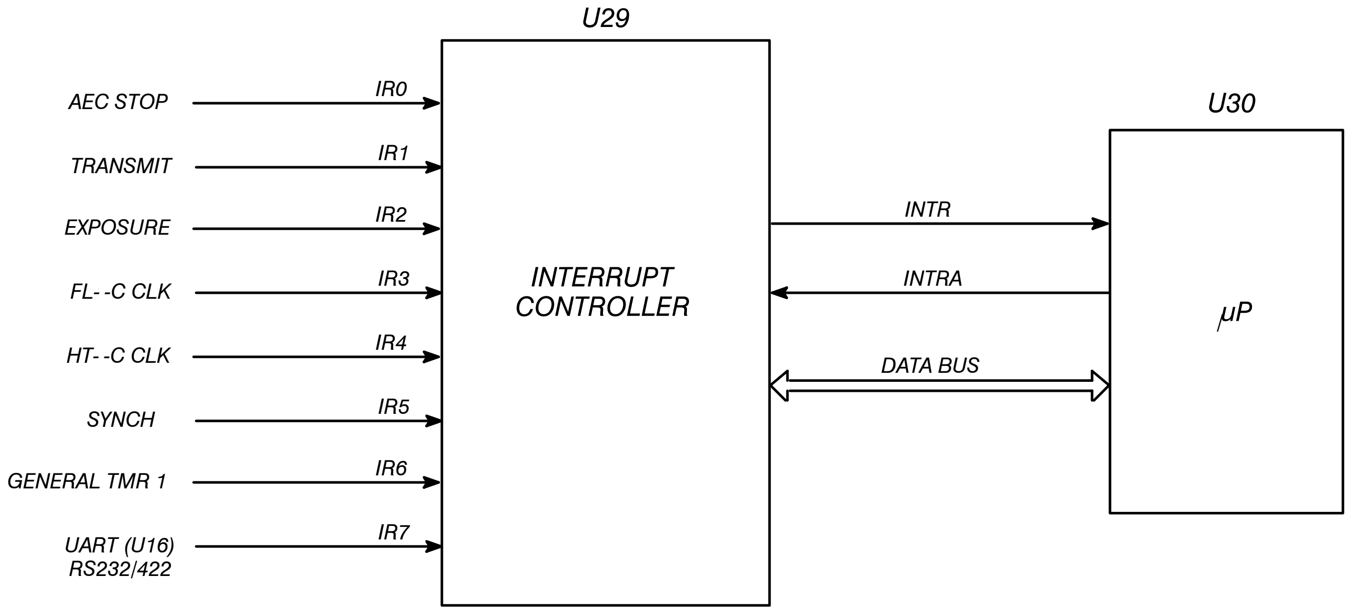


Illustration 9.– INTERRUPT CONTROLLER

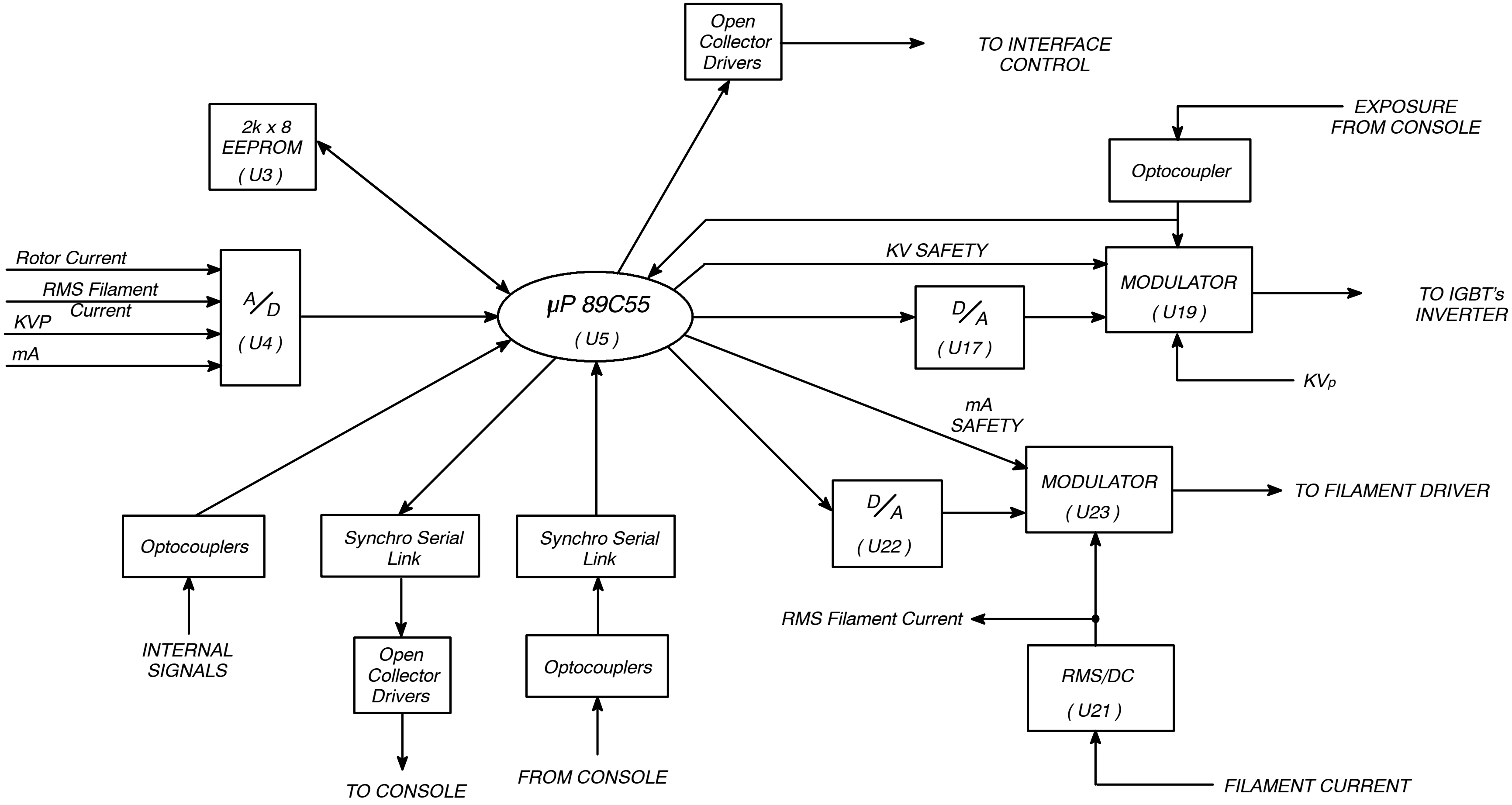


Illustration 10.– HT CONTROLLER BLOCK DIAGRAM

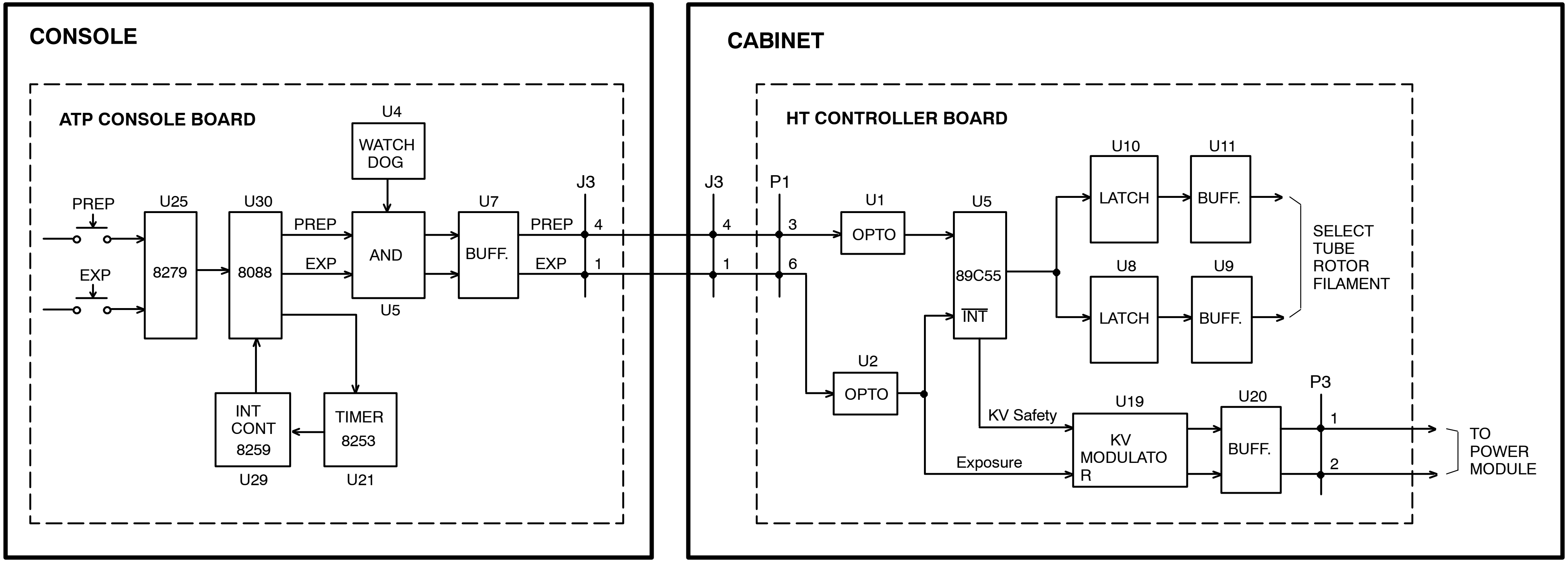


Illustration 11.– PREPARATION AND EXPOSURE TIME CONTROL

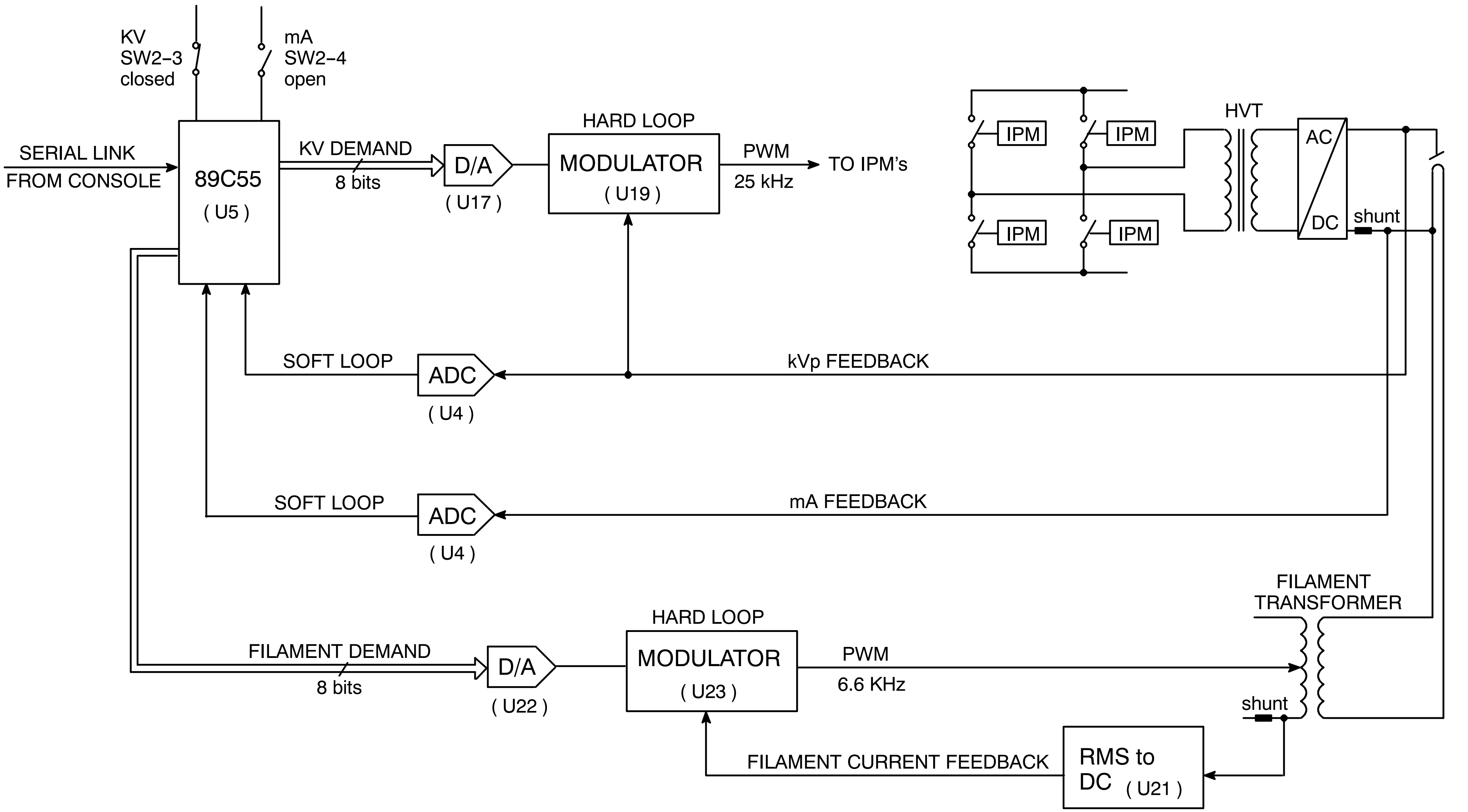


Illustration 12.– CLOSED LOOP BLOCK DIAGRAM

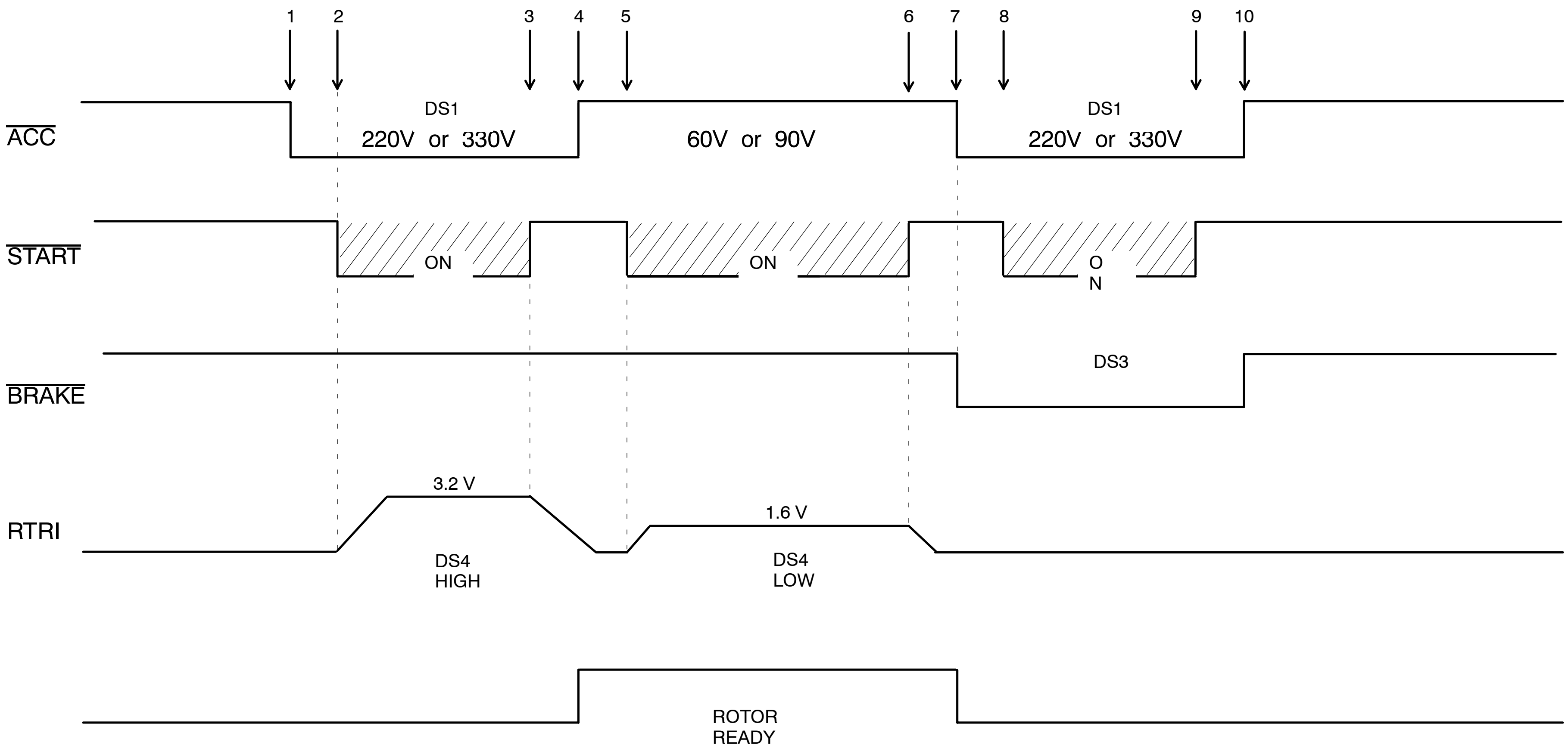


Illustration 13.– LF-RAC

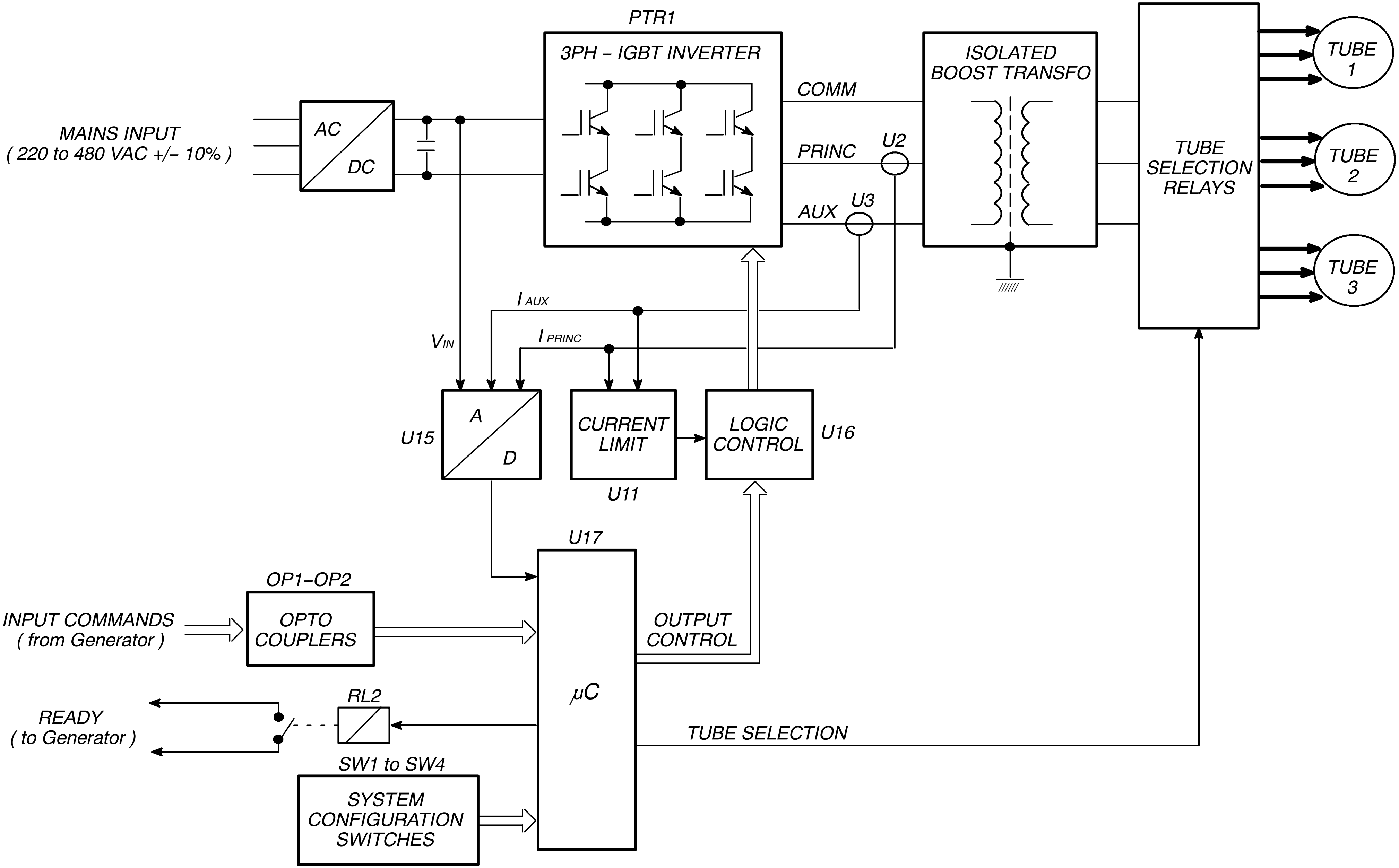
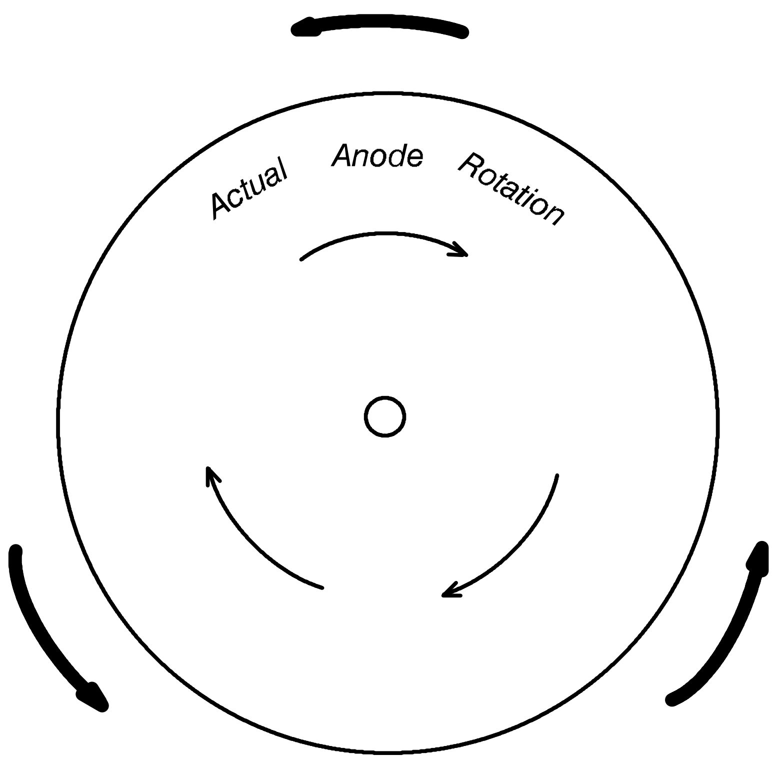
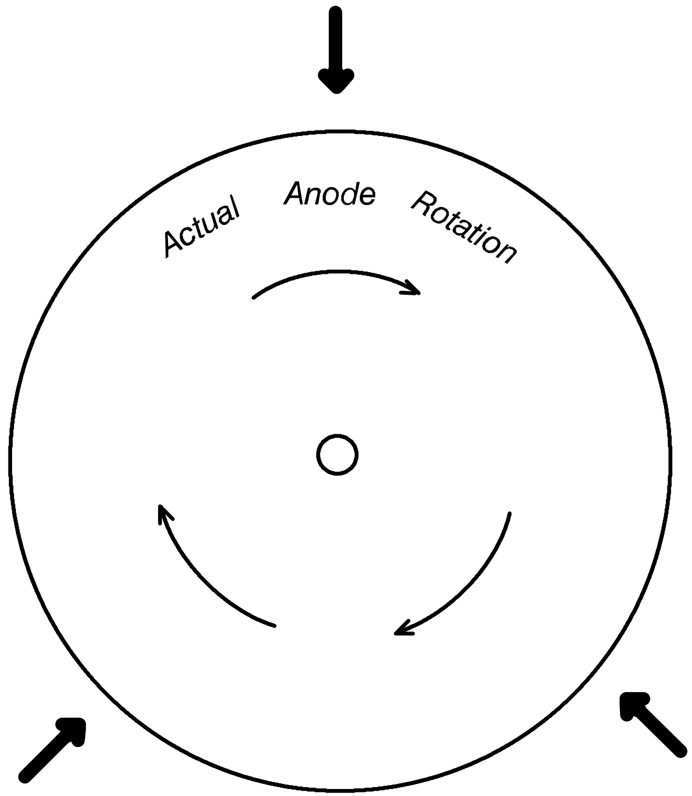


Illustration 14.– DRAC BLOCK DIAGRAM



Active Brake

(Reverse Electromagnetic Field)



Passive Brake

(DC Brake)

Illustration 15.– DRAC BRAKE

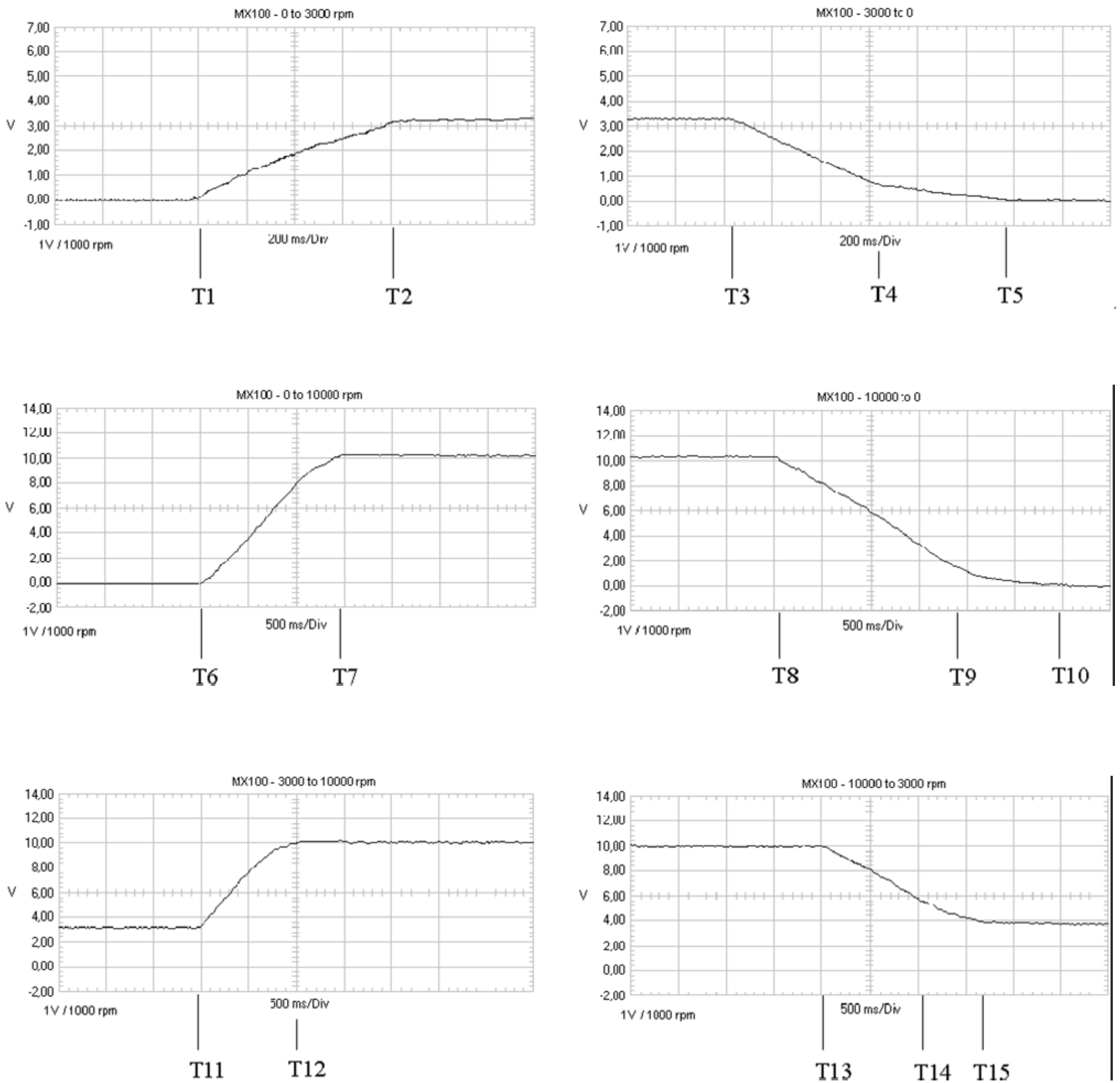


Illustration 16.– DRAC SPEED CONTROL

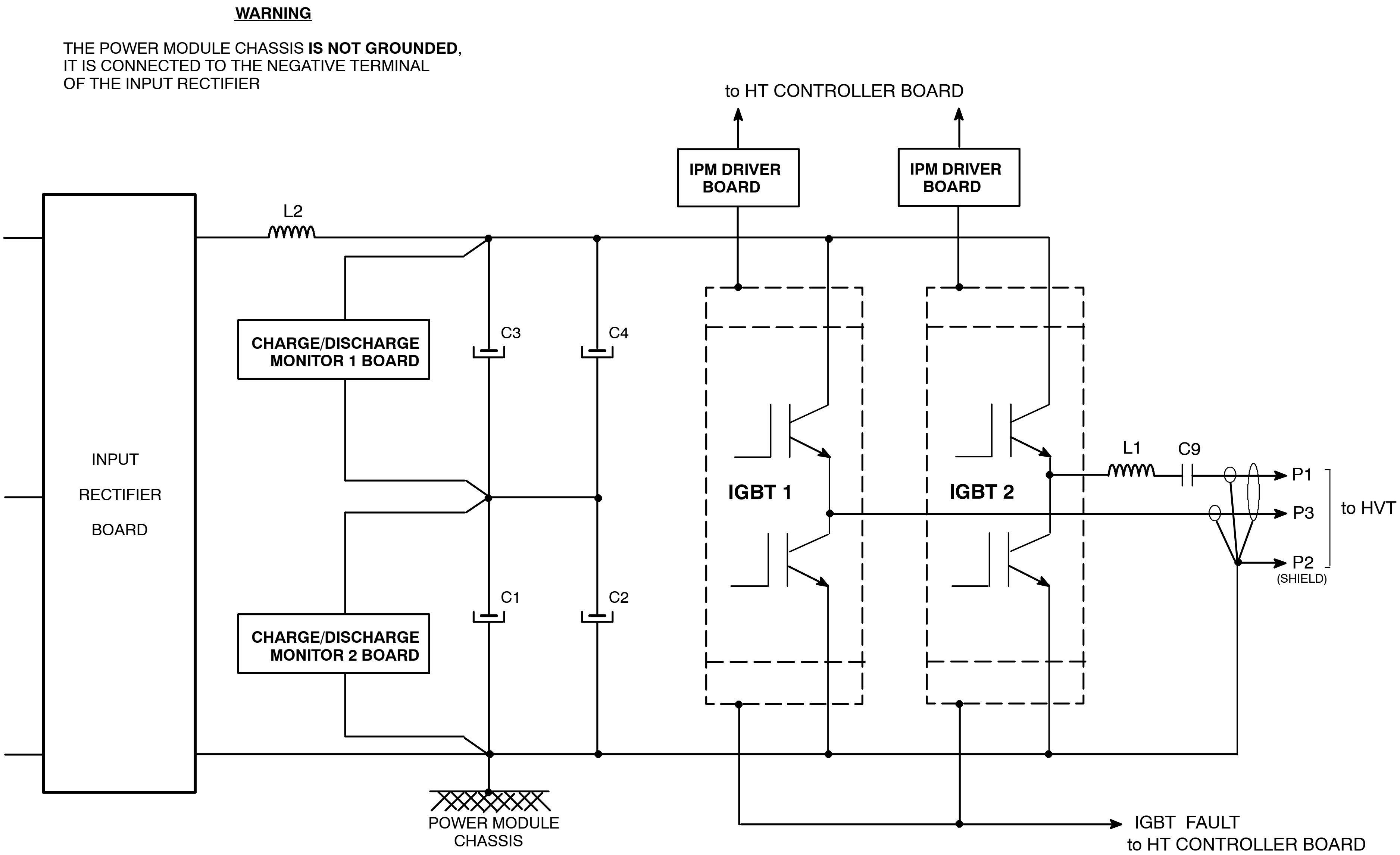


Illustration 17.– POWER MODULE BLOCK DIAGRAM

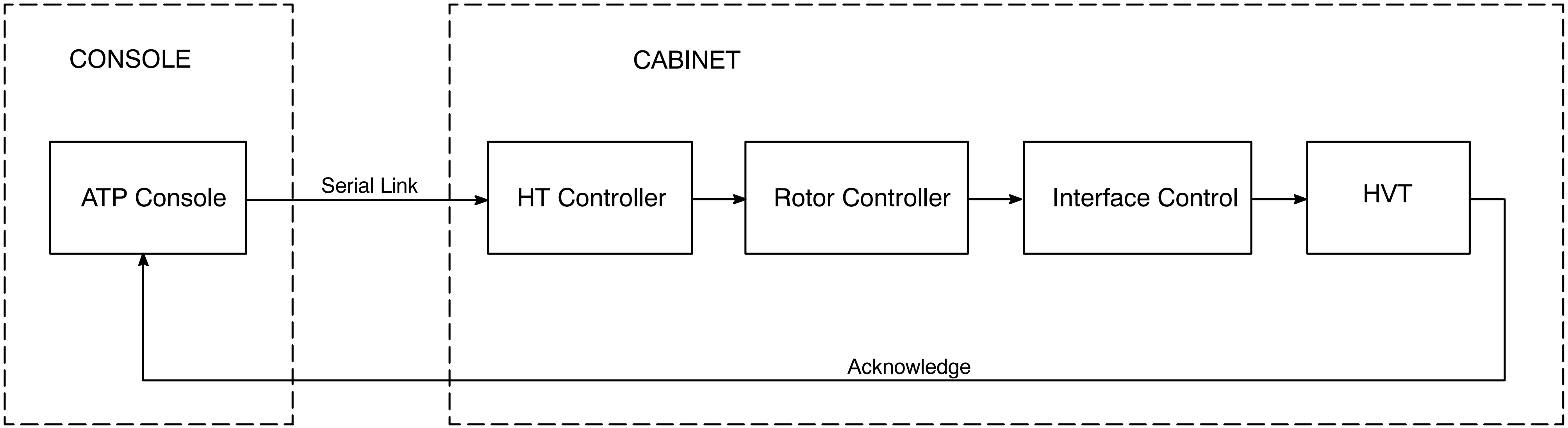
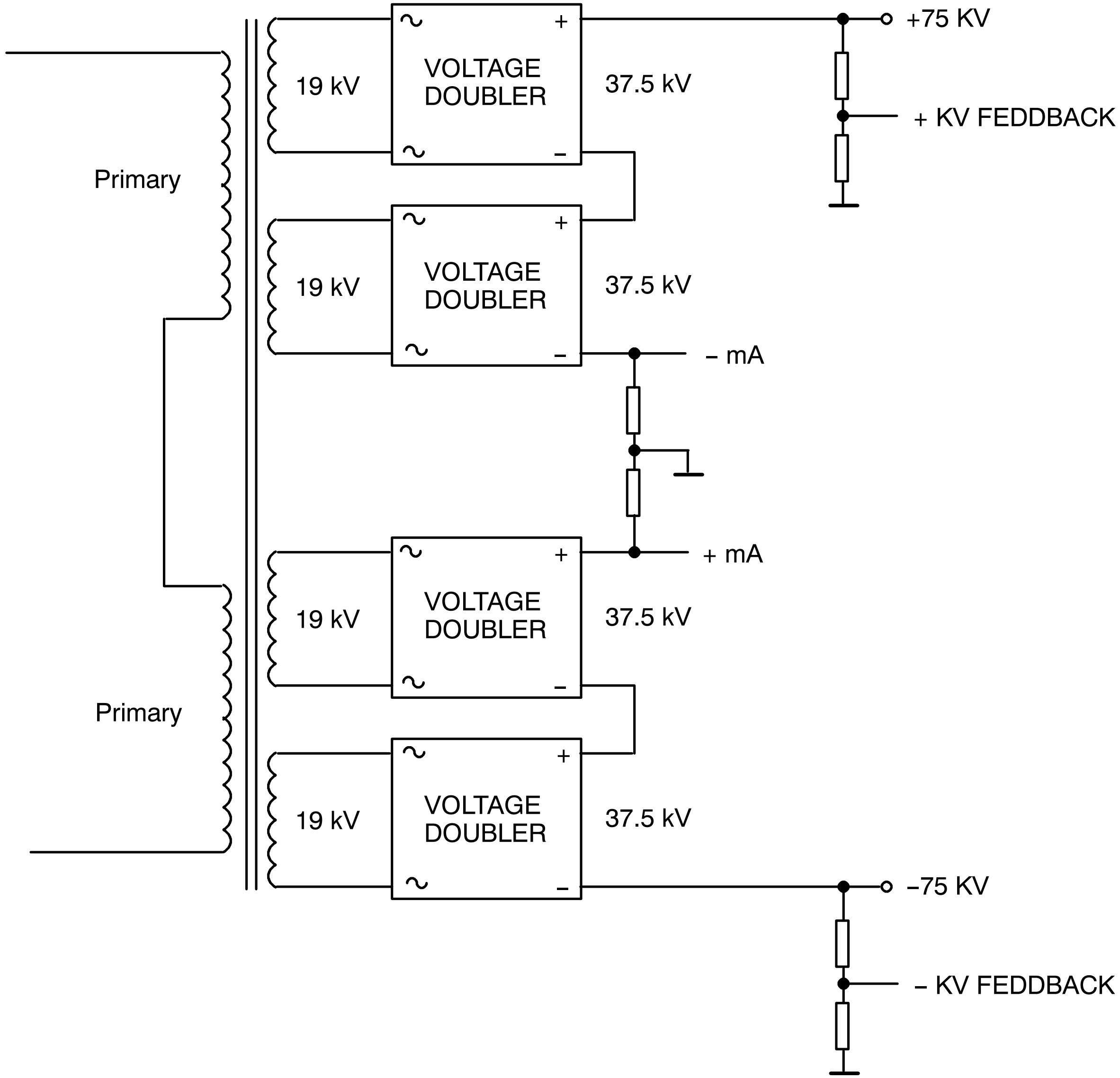


Illustration 18.– TUBE CHANGE



<u>Illustration 19.– HV TRANSFORMER</u>

SECTION 3 AEC OPERATION

3.1 AEC OPERATION FOR ION CHAMBER

The circuitry controls the four possible Ion Chambers to be installed in the System, and provides the voltage reference to switch OFF the exposure when AEC is ON (an Ion chamber area selected). Refer to Illustration 5.

When AEC is OFF (or the Generator is not provided with AEC), the exposure time is controlled by the Generator Timer which is determined by the mAs selected on console. When AEC is ON, the exposure time can be automatically controlled by sensing the exposure dose level at film using Ion Chambers.

AEC function depends on the action of Comparator U8 (Ramp and Reference inputs) with the AEC STOP output signal.

The voltage on the Reference input of the Comparator is a result of the value in Extended Memory (AEC Calibration number) thru a DAC (U3), which is function of Density, KVP, and Film Screen Speed selected on console. This Voltage Reference could require an additional adjustment with the potentiometer R22 (set jumper position B) when the Output Ramp of the Ion Chamber is too low (Ion chamber with low sensitivity).

The Ramp input of the Comparator is a ramp voltage developed in the Ion Chamber Pre−Amp (Output Ramp). When the ramp voltage equals the Voltage Reference, the AEC STOP signal on the Comparator output goes high logic and stop the exposure. The analog switch U5 selects the proper IC input according to the Ion Chamber selected

The ramp voltage must be close or equal to 0 VDC before to start of the exposure, because of the STRT DR (Reset) signal is resetting the Ion Chamber Pre−Amp. .Also, the area selection sent to the Ion Chamber thru Driver U6 is made according to the area selected on console.

Typical values of the Extended Memory (AEC Calibration number) range from 20 to 80 (higher values will run out of head room in the Comparator, and lower values have an effect on the AEC accuracy due to signal noise).

See Illustration 6 for waveforms in AEC operation with Ion Chamber.

Illustration 5.– AEC System with Ion Chamber

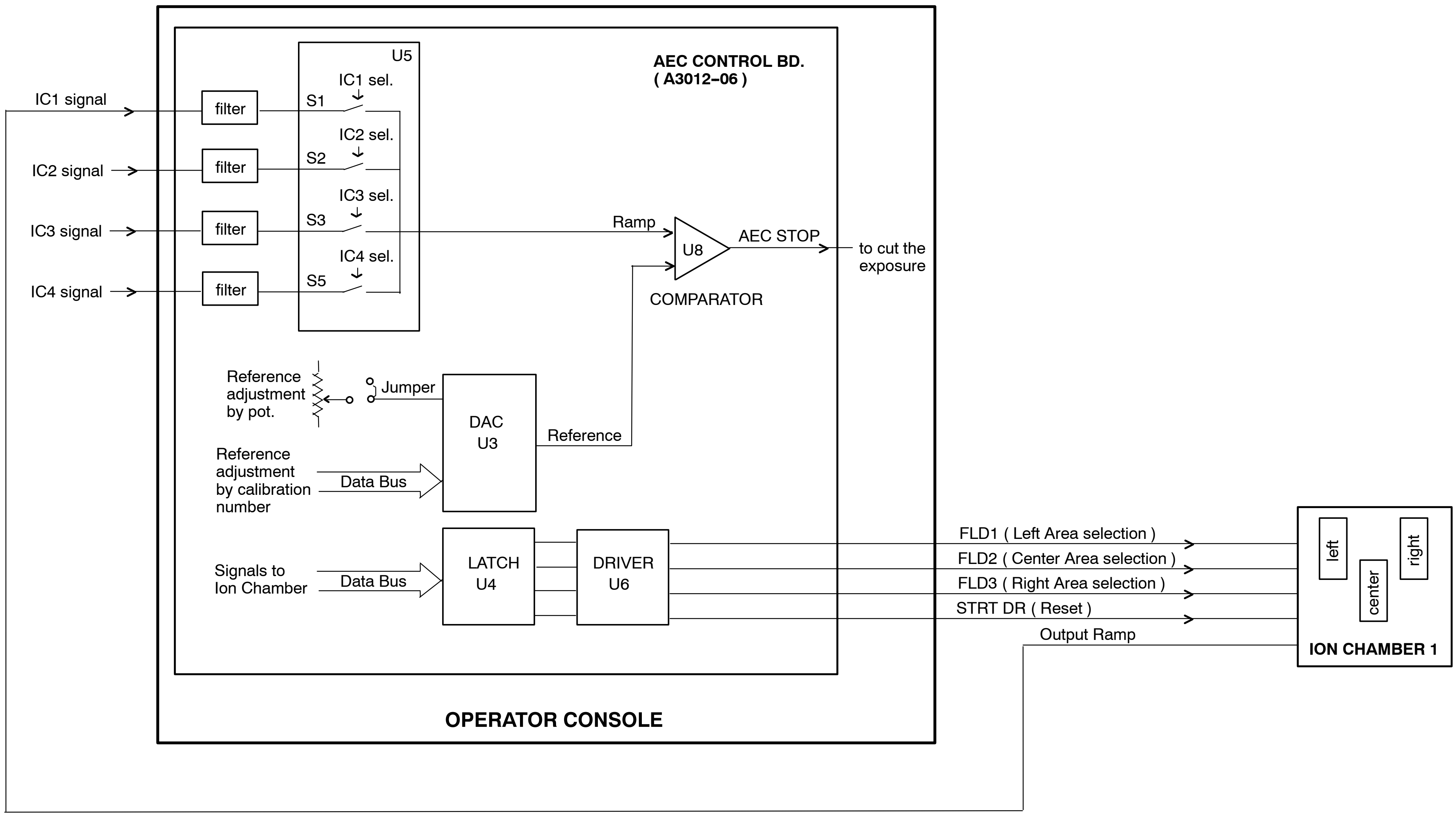
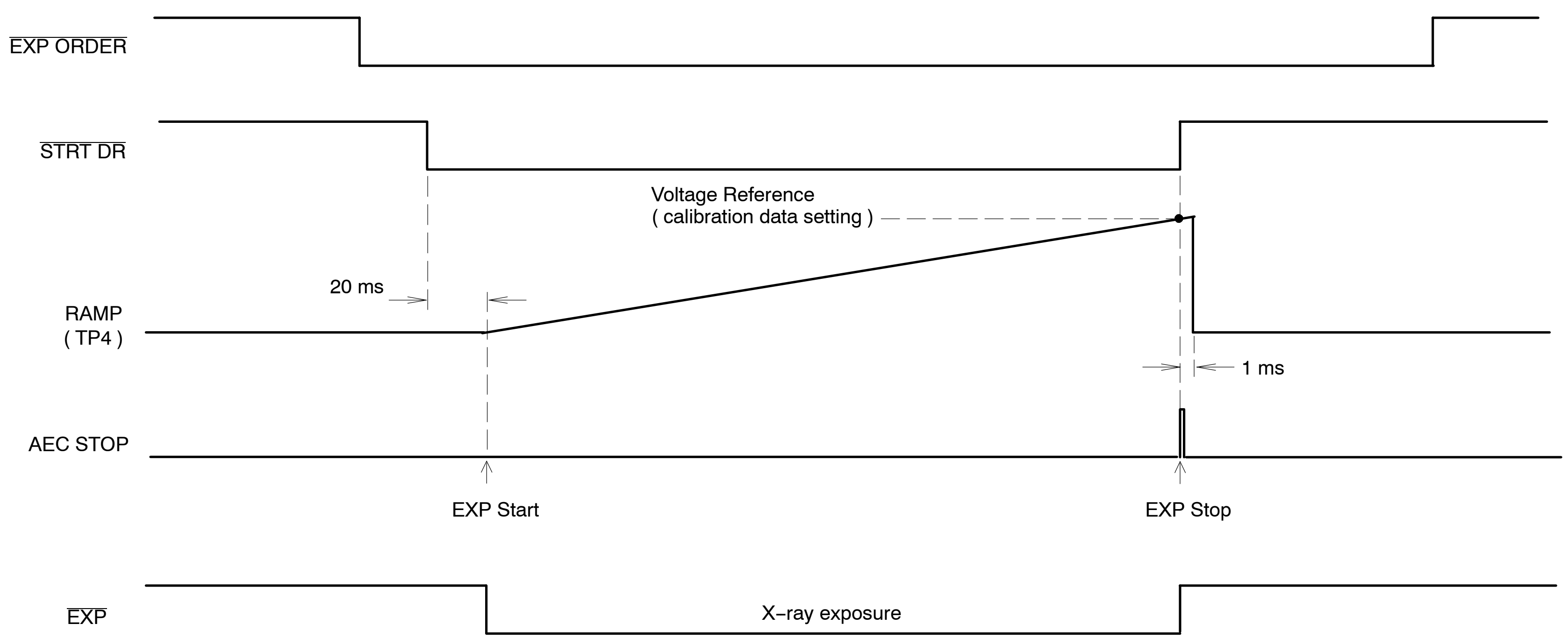


Illustration 6. – Waveforms for AEC operation with Ion Chamber



ASM Technical Publication

Modules Description of Compact Generator – 1 Tube LS (Mini)

HF Series Generators

MODULE 3 – CONTROL MODULE

3A1	HT CONTROL board
3A2	INTERFACE CONTROL board
3A3	FILAMENT DRIVER board
3PS1	LVDC power supply
3LF3	LVDC filter
3K3	POWER INPUT relay
3BR1	SUPPLY rectifier
3BR2	+24V rectifier
3BR4	+12V rectifier
3F2	220V fuse
3F6	19V fuse
3F7	10V fuse
3F8	115V fuse
3F9	LVDC fuse
3C6	+24V capacitor
3C7	+12V capacitor
3TS1	INTERFACE OUTPUT terminal strip

MODULE 4 – STARTER MODULE

4A1	LF–RACK board
4LF2	START filter
4K1	START relay
4C5	PHASE SHIFT capacitor
4R4	DISCHARGE resistor
4R5	LOAD resistor
4RC1	RELAY filter
4TS2	TUBE terminal strip
4TS3	INTERFACE terminal strip

MODULE 5 – INVERTER MODULE

5A1	IPM DRIVER #1 board
5A2	IPM DRIVER #2 board
5A3	CHARGE/DISCHARGE MONITOR #1 board
5A4	CHARGE/DISCHARGE MONITOR #2 board
5A5	INPUT RECTIFIER board
5R2	DISCHARGE resistor
5C1	STORAGE capacitor
5C2	STORAGE capacitor
5C3	STORAGE capacitor
5C4	STORAGE capacitor
5C8	FILTER capacitor
5C9	HT Capacitor
5C10	FILTER capacitor
5C11	FILTER capacitor
5L1	HT Inductor
5L2	BUS Inductor
5IGBT1	IGBT
5IGBT2	IGBT

MODULE 6 – POWER INPUT MODULE

6T2	POWER INPUT transformer
6K5	LINE contactor
6K6	CHARGE contactor
6R1	CHARGE resistor
6NL1	POWER lamp
6J2	POWER connector
6J3–A	COMMUNICATION connector
6J3–B	COMMUNICATION connector
6F3	LINE L1 fuse
6F4	LINE L2 fuse
6F5	LINE L3 fuse
6F12	INPUT TRANSFORMER fuse
6F13	INPUT TRANSFORMER fuse
6LF1	INPUT filter

MODULE 7 – ADAPTATIONS MODULE

7A1	TOMO / BUCKY ADAPTATION board
7A2	AEC ADAPTATION board
7A3	LOCKS board

MODULE 9 – HT. MODULE

9HT1HT	TRANSFORMER

ASM Technical Publication

Modules Description of Compact DRAC Generator

HF Series Generators

MODULE 3 – CONTROL MODULE

3A1	HT CONTROL board
3A2	INTERFACE CONTROL board
3A3	FILAMENT DRIVER board
3PS1	LVDC power supply
3LF3	LVDC filter
3K3	POWER INPUT relay
3BR1	SUPPLY rectifier
3BR2	+24V rectifier
3BR4	+12V rectifier
3F2	220V fuse
3F6	19V fuse
3F7	10V fuse
3F8	115V fuse
3F9	LVDC fuse
3C6	+24V capacitor
3C7	+12V capacitor
3TS1	INTERFACE OUTPUT terminal strip

MODULE 4 – T.B.D

4TS3	INTERFACE terminal strip

MODULE 5 – INVERTER MODULE

5A1	IPM DRIVER #1 board
5A2	IPM DRIVER #2 board
5A3	CHARGE/DISCHARGE MONITOR #1 board
5A4	CHARGE/DISCHARGE MONITOR #2 board
5A5	INPUT RECTIFIER board
5R2	DISCHARGE resistor
5C1	STORAGE capacitor
5C2	STORAGE capacitor
5C3	STORAGE capacitor
5C4	STORAGE capacitor
5C8	FILTER capacitor
5C9	HT Capacitor
5C10	FILTER capacitor
5C11	FILTER capacitor
5L1	HT Inductor
5L2	BUS Inductor
5IGBT1	IGBT
5IGBT2	IGBT

MODULE 6 – POWER INPUT MODULE

6T2	POWER INPUT transformer
6K5	LINE contactor
6K6	CHARGE contactor
6R1	CHARGE resistor
6NL1	POWER lamp
6J2	POWER connector
6J3–A	COMMUNICATION connector
6J3–B	COMMUNICATION connector
6F3	LINE L1 fuse
6F4	LINE L2 fuse
6F5	LINE L3 fuse
6F12	INPUT TRANSFORMER fuse
6F13	INPUT TRANSFORMER fuse
6LF1	INPUT filter

MODULE 7 – ADAPTATIONS MODULE

7A3	LOCKS board

MODULE 9 – HT. MODULE

9HT1HT	TRANSFORMER

MODULE 10 – STARTER MODULE (FOR LF-RAC VERSION)

10A1	LF–RACK board
10LF2	START filter
10K1	START relay
10C5–1	PHASE SHIFT capacitor (for 330 VAC Stator option)
10C5–2	PHASE SHIFT capacitor (for 220 VAC Stator option)
10R4–1	DISCHARGE resistor (for 330 VAC Stator option)
10R4–2	DISCHARGE resistor (for 220 VAC Stator option)
10R5	LOAD resistor
10RC1	RELAY filter
10TS2	TUBE terminal strip
10J7	INTERFACE connector
10J8	ROTOR VAC connector
10T3	220/330 VAC Transformer (for VAC Stator ion)

MODULE 11 – DRAC MODULE (FOR DRAC VERSION)

11A1	CONTROL DRAC board
11A2	INTERFASE DRAC–HF board
11TS2	TUBE terminal strip
11J7	INTERFACE connector
11K1	TUBE relay
11K3	BRAKE relay
11K3	BRAKE relay
11KT1	TUBE contactor
11VR1	Varistor
11T AUX	AUXILIARY Transformer
11T MAIN	MAIN Transformer
11A3	CLAMPING board – Ferrite core

ASM Technical Publication

Modules Description of Compact ESM Generator

HF Series Generators

MODULE 1 – FRONT PANEL / BACK PANEL

1A1	STAND–ALONE board (BACK PANEL)
1TB1	LINE / TABLE terminal strip
1TB2	Terminal strip
1K22	Table Relay
1LF1	Filter
1SW1	Magnetothermic Automatic Breaker

MODULE 2 – BATTERY CHARGER MODULE

2A1	BATTERY CHARGER board
2A2	ENERGY GUARD board
2A3	LINE MONITOR board
2SN1	SNUBBER
2T1	BATTERY CHARGER transformer

MODULE 3 – CONTROL MODULE

3A1	HT CONTROL board
3A2	INTERFACE CONTROL board
3A3	FILAMENT DRIVER board
3PS1	LVDC power supply
3LF3	LVDC filter
3K3	POWER INPUT relay
3BR1	SUPPLY rectifier
3BR2	+24V rectifier
3BR4	+12V rectifier
3F2	220V fuse
3F6	19V fuse
3F7	10V fuse
3F8	115V fuse
3F9	LVDC fuse
3C6	+24V capacitor
3C7	+12V capacitor
3TS1	INTERFACE OUTPUT terminal strip

MODULE 4 – STARTER MODULE

4A1	LF–RACK board
4LF2	START filter
4K1	START relay
4C5	PHASE SHIFT capacitor
4R4	DISCHARGE resistor
4R5	LOAD resistor
4RC1	RELAY filter
4TS2	TUBE terminal strip

MODULE 5 – INVERTER MODULE

5A1	IPM DRIVER #1 board
5A2	IPM DRIVER #2 board
5A3	CHARGE/DISCHARGE MONITOR #1 board
5R2	DISCHARGE resistor
5C1	STORAGE capacitor
5C2	STORAGE capacitor
5C3	STORAGE capacitor
5C4	STORAGE capacitor
5C8	FILTER capacitor
5C9	HT Capacitor
5C10	FILTER capacitor
5C11	FILTER capacitor
5L1	HT Inductor
5L2	BUS Inductor
5IGBT1	IGBT
5IGBT2	IGBT

MODULE 6 – POWER INPUT MODULE

6T2	POWER INPUT transformer
6K5	LINE contactor
6K6	CHARGE contactor
6F1	BATTERY fuse
6R1	CHARGE resistor
6NL1	POWER lamp
6J1	DC-BUS connector
6J3–B	COMMUNICATION connector
6J2	POWER connector
6J3-A	COMMUNICATION connector
6J3-B	COMMUNICATION connector
6J4	ESM connector

MODULE 7 – ADAPTATIONS MODULE

7A1	TOMO/BUCKY ADAPTATION board
7A2	AEC ADAPTATION board
7A3	LOCKS board

MODULE 8 – BATTERY MODULE

8TRAY1	BATTERY TRAY(J1)
8TRAY2	BATTERY TRAY(J2)
8TRAY3	BATTERY TRAY(J3)
8TRAY4	BATTERY TRAY(J4)
8TRAY5	BATTERY TRAY(J5)

MODULE 9 – HT. MODULE

9HT1HT	TRANSFORMER

MODULE 10 – STARTER MODULE (FOR OPTIONAL LF-RAC VERSION)

10A1	LF−RACK board
10LF2	START filter
10K1	START relay
10C5−1	PHASE SHIFT capacitor (for 330 VAC Stator option)
10C5−2	PHASE SHIFT capacitor (for 220 VAC Stator option)
10R4−1	DISCHARGE resistor (for 330 VAC Stator option)
10R4−2	DISCHARGE resistor (for 220 VAC Stator option)
10R5	LOAD resistor
10RC1	RELAY filter
10TS2	TUBE terminal strip
10J7	INTERFACE connector
10J8	ROTOR VAC connector
10T3	220/330 VAC Transformer (for VAC Stator ion)

MODULE 11 – DRAC MODULE (FOR OPTIONAL DRAC VERSION)

11A1	CONTROL DRAC board
11A2	INTERFASE DRAC–HF board
11TS2	TUBE terminal strip
11J7	INTERFACE connector
11K1	TUBE relay
11K3	BRAKE relay
11K3	BRAKE relay
11KT1	TUBE contactor
11VR1	Varistor
11T AUX	AUXILIARY Transformer
11T MAIN	MAIN Transformer
11A3	CLAMPING board – Ferrite core

ASM Technical Publication

System Interconnection

HF Series Generators

SECTION 1 SYSTEM INTERCONNECTION SIGNALS

Note ☞ *For Generators with Serial Communication (RS-232 or RS-422) keep in mind that the Console CPU PCB is located inside of the Power Module as ATP Console PCB. Refer to this PCB during System Interconnection procedures.*

Note ☞ *Refer to System Interconnection Schematics in this document.*

The generator is designed to easily interface with most X-ray Tables, both R&F and RAD. All input signals are active low. This means that the inputs must be pulled to ground (chassis ground of the generator) thru relay contacts, by a transistor or other switching device. The current requirement of the switch is less than 10 mA.

CAUTION ***Do not apply 115 / 220 VAC logic signals to any of the logic inputs. If 115 / 220 VAC logic signals are used in the X-ray table (i.e. fluoro command), these signals must be converted to a contact closure by a relay.***

The outputs signals from the generator to the subsystem devices are usually active low (switched to chassis ground of the generator). The output are open collector transistor drivers with a maximum current of 1 Ampere.

Table 1-1
System Interconnection Signals

SIGNAL NAME	SIGNAL DESCRIPTION
ABC OUT	This analog input is the output from the ABC Adaptation Board or from TV Camera. A DC level signal is used for system that uses a TV Camera for the Brightness level. When a DC level is used, an input range of 0 to 10 volts is required. The stabilized value of the input will be between 5 and 7 volts.
−ABC	This signal selects the Fluoro operation mode: a low signal selects Automatic Brightness Control, a high signal selects Manual Mode.
−ACT EXP	This low going signal indicates the Actual Length of Radiation.
ALOE	This high going signal indicates the Actual Length Of Exposure. This signal is used to interface to some Spot Film system and is used to advance the Spot Film device to the next position when multi-exposure are made on the same film.
−ALOE	This low going signal indicates the Actual Length Of Exposure. This signal is used to interface to some Spot Film system and is used to advance the Spot Film device to the next position when multi-exposure are made on the same film.

Table 1-1
System Interconnection Signals

SIGNAL NAME	SIGNAL DESCRIPTION
–AUTO OFF	This signal only applies to generator systems with the Stand-alone option. When the generator is operating in Stand-alone mode (Power Line off), the Auto Off signal shut off the power from the Battery Generator cabinet if the Control Console is not actuated after 5 minutes.
AUX BUCKY SPLY	External voltage supply required for the Bucky motion, when this voltage is not +24 VDC.
–BEEP	A low signal energizes the Fluoro buzzer.
–BUCKY 1 DR CMD	A low signal to the Interface Control PCB as a command to output a Bucky-1 (normally the Table Bucky) drive signal.
–BUCKY 1 MOTION	This low going signal from Bucky-1 indicates Bucky-1 in motion, and therefore the exposure is enabled.
BUCKY 1 DR	This signal is originated from the Bucky supply of the Power Module when an exposure order. It starts the Bucky.
–BUCKY 2 DR CMD	A low signal to the Interface Control PCB as a command to output a Bucky-2 (normally the Vertical Bucky Stand) drive signal.
–BUCKY 2 MOTION	This low going signal from Bucky-2 indicates Bucky-2 in motion, and therefore the exposure is enabled.
BUCKY 2 DR	This signal is originated from the Bucky supply of the Power Module when an exposure order. It starts the Bucky.
–BUCKY EXP	This low going (0 volts) signal starts the Bucky exposure. The signal originates on the Interface PCB
BUCKY SPLY	Voltage supply required for the Bucky drive command.
CAM SYNC	Sync. signal from TV Camera. This signal is used for timing in the generator.
–CAM FL EXP	This signal interfaces to any Video Camera. A low signal tells the camera that the generator is making a Fluoro exposure and the Camera should unblank.
C–HT CLK	Serial data clock to the HT Control PCB. This clock synchronizes the C–HT DATA signal.
C–HT DATA	Serial data to the HT Control PCB. This data is synchronous with the C–HT CLK signal.
–COLLIMATOR	This low signal indicates that NO EXPOSURE HOLD condition exists at the Collimator. This input is read only when the Radiographic Tube is selected.
–COMP	This low signal indicates that Compression Device is selected. This input changes original density to the appropriate density for Compression selection.
–DOOR	This low signal is the interlock for the Door of the X-ray room.
–DSI SEL	This low going signal from a DSI device indicates that the DSI has been selected and will be used for the next exposure.
–EXP	Low going Expose signal to the HT Control PCB. If –PREP is low then a Spot Film or RAD exposure is made, else a Fluoro exposure is made.
FL DSI	Sync. signal from the DSI device. This signal is used for timing in the generator.
–FL EXP	This is the EXPOSURE COMMAND input when the Tube-2 (Fluoro / Spot Film) is selected. If the –SF PREP input is open then a Fluoro exposure is started, and if the –SF PREP input is low then a Spot Film exposure is made.
–FLD1 DR	A low signal to select the right field in the Ion Chamber.
–FLD2 DR	A low signal to select the left field in the Ion Chamber.

Table 1-1
System Interconnection Signals

SIGNAL NAME	SIGNAL DESCRIPTION
−FLD3 DR	A low signal to select the center field in the Ion Chamber.
−FT SW CMD	This low going signal indicates the Fluoro exposure command. It is needed for Pulsed Fluoro at variable rate.
HT−C CLK	Serial data clock from the HT Control PCB. This clock synchronizes the HT−C DATA signal.
HT−C DAT	Serial data from the HT Control PCB. This data is synchronous with the HT−C CLK signal.
−HT INL	This signal is low when the switch in the high voltage transformer is in the RAD position. This is a safety interlock which prevents an exposure if the high voltage switch (in the HV Transformer) is in the wrong position.
HV PT CRL	This analogic signal controls the output of the HV Power Supply on the Interface Control PCB. This signal originates on the optional AEC Control PCB. Plus 5 volts programs the output to be 0 volts, and 0 volts programs the output to approximately −1200 volts.
IC GND	GND for the IC SPLY.
IC1 INPUT	This input is the output of the Bucky 1 Ion Chamber (normally the Table Ion Chamber).
IC2 INPUT	This input is the output of the Bucky 2 Ion Chamber (normally the Vertical Bucky Stand Ion Chamber).
IC3 INPUT	This input is the output of the Spot Film Ion Chamber.
IC SPLY	Power supply for the Ion Chamber. This output should be within the range of 500 to 800 volts.
−kV DWN	A low signal is a command for the HT Control PCB to drive the Fluoro kVp DOWN when during a Fluoro exposure in the ABC mode.
−kV UP	A low signal is a command for the HT Control PCB to drive the Fluoro kVp UP when during a Fluoro exposure in the ABC mode.
−LINE CONT	A low signal energizes the main line contactor K5 in the Power Module.
LINE SYNC	Signal synchronous with the AC line. This signal originates on the Interface PCB and is used to synchronize Fluoro exposures with the AC line.
−MAG 1	A low signal selects Magnification-1 mode on the Image Tube.
−MAG 2	A low signal selects Magnification-2 mode on the Image Tube.
−MEM EN	A low signal enables a frame grabber function in some Video Camera.
−MEM GATE	A low signal enables a record function in some Video Camera. Some time it can be used to start a VCR or other recording device not integrated into the Video Camera.
−NORM	A low signal selects Normal mode on the Image Tube.
−PREP	Command to the HT Control PCB to boost X-ray Tub Filament to the value of mA selected and to start the X-ray Tube Rotor is RAD Tube is selected.
PT INPUT	This analog input is normally the output of the Photo Multiplier Tube in the Image System and is used for Automatic Brightness Control. A DC level signal can be used for system that uses a solid state pick-up device or the TV Camera for the Brightness level. When a DC level is used, an input range of 0 to 10 volts is required. The stabilized value of the input will be between 5 and 7 volts.
PT SPLY	Power supply output for the Photomultiplier. The level of this signal is controlled by the HV PT CRL.

Table 1-1
System Interconnection Signals

SIGNAL NAME	SIGNAL DESCRIPTION
–READY	This low going signal indicates the system is ready to make an exposure (Prep cycle completed). This signal is used to interface to some Film Changers, etc.
–ROOM LIGHT	This low going signal indicates the X-ray preparation or exposure. This signal is used to interface to the Room X-ray warning light.
–SFC	This low going signal from a Spot Film camera indicates that the Spot Film camera has been selected and will be used for the next exposure.
–SF PREP	This low going signal indicates the system to boost the filament to the level required for the mA selected on the Control Console and prepares the system for a Spot Film. This input is read only when the Tube-2 (Fluoro / Spot Film) is selected.
–STRT DR	A low signal to indicate the start of an exposure to the Ion Chamber.
–THERMOSTAT-1	This signal from X-ray Tube indicates the overheat of the Tube-1.
–THERMOSTAT-2	This signal from X-ray Tube indicates the overheat of the Tube-2.
V SYNC	Vertical Sync pulses from the TV Camera. In Fixed Rate Pulsed Fluoro the X-ray tube is pulsed at line rate. However, with the Variable Rate Pulsed Fluoroscopy option the X-ray tube is pulsed at rate selected by the operator, the rate is driven from the V Sync signal (it is obtained by dividing the timing frequency of the V sync).

ASM Technical Publication

Disassemble / Reassemble Procedures

HF Series Generators

SECTION 1 DISASSEMBLE / REASSEMBLE PROCEDURES

1.1 JOB CARDS LIST

1. **GENERATOR CONSOLE:**

   a. Display board. Job Card 1.1.

   b. ATP CPU board. Job Card 1.2.

   c. Control AEC board. Job Card 1.3.

2. **POWER CABINET:**

   a. HT Controller board. Job Card 2.1.

   b. Filament Driver board. Job Card 2.2.

   c. Interface Control board. Job Card 2.3.

   d. Power Supply Board. Job Card 2.4.

   e. Low Speed Control Board. Job Card 2.5.

   f. Tomo Bucky Interface Board. Job Card 2.6.

   g. AEC Interface Board. Job Card 2.7.

   h. IGBT Module. Job Card 2.8.

   i. Charge / Discharge Monitor Boards. Job Card 2.9.

   j. IPM Driver Boards. Job Card 2.10.

   k. Locks Board. Job Card 2.11.

   l. High Speed Control Board (DRAC). Job Card 2.12.

3. **HIGH VOLTAGE TANK ONE & TWO TUBES. Job Card 3.1**

Job Card 1.1

SUBASSEMBLY: DISPLAY BOARD: CONSOLE

PURPOSE: REPLACEMENT OF BOARD.

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET.

1. Remove all connectors of the board. Note their position.
2. Remove the twenty three screws and nuts with washers used to secure the board in the Console.
3. Replace the old board for the new one.
4. Replace the twenty three screws.
5. Replace all connectors previously removed.
6. Power ON the Electrical Cabinet and Power ON the Console.
7. Make a functional check of the Equipment. A functional check is a complete check of Displays, mAs, kVp, mA and Time. Also included are the push-buttons etc.
8. Note on the Log Book the cause and the date of the replacement and fix an adhesive label beside the new board indicating the date and the name of the field engineer in order to give the maximum information.

Job Card 1.2

SUBASSEMBLY: ATP CPU BOARD: CONSOLE

PURPOSE: REPLACEMENT OF BOARD.

CAUTION

TURN OFF THE ELECTRICAL CABINET.

1. Note the actual setting of all jumpers and switches of the board. Note also the label of the EPROM U24 (Console Program).

2. Remove the memories U23, U24 y U39.

3. Remove all connectors of the board. Note their position.

4. Remove the five Allen screws used to secure the board in the console.

5. Using the anti-static protection device replace the old board for the new one. Install memories U23, U24 and U39 previously removed in Step 2. (If AEC option exists, the AEC Control Board should be removed. So, remove all Allen screws and take it off).

6. Replace the five Allen screws.

7. Replace all connectors previously removed.

8. Set all jumpers and switches in their original positions *(see Step 1).*

9. Check if the RAM U23 and EPROM U39 (APR data) are present. Also check if EPROM U24 is on the new board; if not, remove the old one and put on the new board (Do not forget to use the anti-static protection).

10. Power ON the Electrical Cabinet and Power ON the Console. Check if the Extended Memory Data Have not been lost or modified. Compare it with Tables of the Calibration Chapter in the Service Manual. Make a functional check of the Equipment. This means a complete check included all options such us Tomo, AEC, APR, etc.

11. Note on the Log Book the cause and the date of the replacement and fix an adhesive label beside of the new board indicating the date and name of the field engineer in order to give maximum information.

Job Card 1.3

SUBASSEMBLY: ATP CPU BOARD: CONSOLE.

PURPOSE: REPLACEMENT OF BOARD.

CAUTION

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET.

1. Remove the Allen screw used to secure the board on the CPU board.
2. Replace the old board by the new one . Exits a flat cable to the CPU board and is connected through a socket directly on the CPU board, Be sure the pins 1 and 2 of J1 match with pins 1 and 2 of J12−B on CPU console.
3. Replace the Allen screw.
4. Power on the electrical cabinet and power on the console.
5. Make a functional check of AEC. This means a complete check of the Ion Chambers in the installation.
6. Make a functional check of the equipment.
7. Note on the log book the cause and the date of the replacement and fix an adhesive label beside the new board indicating the date and name of field engineer in order to give maximum information.

Job Card 2.1

SUBASSEMBLY: HT CONTROLLER BOARD (CABINET).

PURPOSE: REPLACEMENT OF BOARD.

CAUTION

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET.

1. Note the actual setting of all jumpers and switches of the board.
2. Remove all connectors from the board. Note their position.
3. Remove the four Allen screws (one metallic and three of nylon used to secure the board in the Cabinet.
4. Using the anti–static protection device replace the old board for the new one.
5. Replace the four Allen screws.
6. Replace all the connectors previously removed.
7. Set all jumpers and switches in their original positions *(see Step 1).*
8. Check if the EEPROM U3 (Calibration data) and the microprocessor U5 (Cabinet Program) are present on the new board; remove both and install the old ones on the new board (do not forget to use the anti-static protection).
9. Power ON the Electrical Cabinet and Power ON the Console. Check if the Extended Memory Data have not been lost or modified. So compare with tables of the Calibration Chapter in the Service Manual.
10. Connect the mAs meter on the H.V. Tank and put the non invasive meter on the table under the X-ray beam.
11. Make several exposures with different technic settings in order to check if the parameters are correct.
12. If is not correct make a full calibration. If is correct, remove the Test Equipment and note the new memory data.
13. Note on the Log Book the cause and the date of the replacement and fix an adhesive label beside the new board indicating the date and name of the service engineer in order to give maximum info.

Job Card 2.2

SUBASSEMBLY: FILAMENT DRIVE BOARD (CABINET).

PURPOSE: REPLACEMENT OF BOARD.

CAUTION

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET.

1. Note the actual settings of jumpers on the board.
2. Remove all connectors of the board. Note their position.
3. Remove the four Allen screws used to secure the board in the cabinet.
4. Replace the old board for the new one.
5. Replace the four Allen screws.
6. Replace all connectors previously removed.
7. Set jumpers in their original position *(see Step 1)*
8. Power ON the Electrical Cabinet and power ON the Console.
9. Connect the mAs meter on the H.V. Tank and put the non invasive meter on the table under the X-ray beam.
10. Make several exposures with different technic settings in order to check if the parameters are correct.
11. If they are not correct, make a full calibration. If they are correct, remove the Test Equipment and note the new memory data.
12. Note on the Log Book the cause and date of replacement and fix an adhesive label beside the new board indicating the date and name of the field engineer in order to give maximum info.

Job Card 2.3

SUBASSEMBLY: INTERFACE CONTROL BOARD (CABINET).

PURPOSE: REPLACEMENT OF BOARD.

CAUTION

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET.

1. Note the actual setting of jumpers on the board.
2. Remove all connectors of the board. Note their position.
3. Remove the four Allen screws used to secure the board in the Cabinet.
4. Replace the old board by the new one.
5. Replace the four Allen screws.
6. Replace all connectors previously removed.
7. Set the jumpers in their original positions *(see Step 1)*
8. Power ON the Electrical Cabinet and Power ON the Console.
9. Connect the digital Voltmeter on TB1−9 and TB1−1 (GND) and calibrate with Pot R29 to obtain 230 VDC for BVM (CGR) Ion Chambers and 300 VDC. for GE Ion Chambers. Remove the Voltmeter.
10. Make several exposures with different technic settings of AEC in order to check if the density is correct comparing with previous results.
11. If not correct make an AEC full calibration and note the new memory data.
12. Note on the Log Book the cause and date of the replacement and fix an adhesive label beside the new board indicating the date and name of the field engineer in order to give maximum info.

Job Card 2.4

SUBASSEMBLY: POWER SUPPLY BOARD (CABINET).

PURPOSE: REPLACEMENT OF BOARD.

CAUTION

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET.

1. Remove all connectors of the board. Note their positions.
2. Remove the four Allen screws used to secure the board in the cabinet.
3. Replace the old board for the new one.
4. Replace the four Allen screws.
5. Replace all connectors previously removed.
6. Power ON the Electrical Cabinet and Power ON the Console.
7. Connect the digital Voltmeter on the board and check the Voltages: If the +5 V, +12 V and −12 V are not OK, calibrate the correct potentiometer.
8. Make a functional check on the equipment.
9. Note on the Log Book the cause and date of the replacement and fix an adhesive label beside the new board indicating the date and name of field engineer in order to give maximum info .

Job Card 2.5

SUBASSEMBLY: LOW SPEED BOARD (CABINET).

PURPOSE: REPLACEMENT OF BOARD.

CAUTION

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET.

1. Note the actual setting of jumpers on the board.
2. Remove all connectors of the board. Note their positions.
3. Remove the four Allen screws used to secure the board in the Cabinet.
4. Replace the old board for the new one.
5. Replace the four Allen screws.
6. Replace all the connectors previously removed.
7. Set jumpers in their original position *(see Step 1).*
8. Power ON the Electrical Cabinet and Power ON the Console.
9. Make a functional check about the acceleration, running and braking times and check directly on the window the rotation of the anode.
10. Make a functional check of the equipment.
11. Note on the Log Book the cause and date of the replacement and fix an adhesive label beside the new board indicating the date and name of the field engineer in order to give maximum info.

Job Card 2.6

SUBASSEMBLY: TWO BUCKY INTERFACE BOARD (CABINET).

PURPOSE: REPLACEMENT OF BOARD.

CAUTION

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET.

1. Note the actual setting of jumpers and switches on the board.
2. Remove all wires on the terminal strips of the board. Note their positions.
3. Remove the four Allen screws used to secure the board in the Cabinet.
4. Replace the old board for the new one.
5. Replace the four Allen screws.
6. Replace all wires previously removed on the terminal strips.
7. Set jumpers and switches in their original positions *(see Step 1)*
8. Power ON the Electrical Cabinet and Power ON the Console.
9. Make a functional check about the Tomo and Buckys selection and Tomo Times (if of application).
10. Make a functional check of the equipment.
11. Note on the Log Book the cause and date of the replacement and fix and adhesive label beside the new board indicating the date and name of the field engineer in order to give maximum info.

Job Card 2.7

SUBASSEMBLY: AEC INTERFACE BOARD (CABINET).

PURPOSE: REPLACEMENT OF BOARD.

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET.

1. Note the actual setting of jumpers on the board.
2. Remove all connectors of the board. Note their positions.
3. Remove the four Allen screws used to secure the board in the Cabinet.
4. Replace the old board for the new one.
5. Replace the four Allen screws.
6. Replace all connectors previously removed.
7. Set jumpers in their original position *(see Step 1).*
8. Power ON the Electrical Cabinet and Power On the Console.
9. Make several exposures with AEC different technic settings in order to check if the selection is correct.
10. Make a functional check of the equipment.
11. Note on the Log Book the cause and date of the replacement and fix an adhesive label beside the new board indicating the date and name of the field engineer to give maximum info.

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Job Card 2.8

SUBASSEMBLY: CHARGE/DISCHARGE MONITOR BOARD (CABINET).

PURPOSE: REPLACEMENT OF BOARD.

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET. BEFORE MANIPULATE THE BOARDS MAKE SURE THERE IS NOT VOLTAGE PRESENT IN THE CAPACITORS BANK.

1. Remove All connectors of the board. Note their positions.
2. Remove the four Allen screws used to secure the board in the Cabinet.
3. Replace the old board for the new one.
4. Replace the four Allen screws.
5. Replace all the connectors previously removed.
6. Power ON the Electrical Cabinet and Power ON the Console.
7. Make a check about the correct operation (Led ON) and check 0 VDC in the resistor R4 when the equipment is ON, and more than 200 VDC right after the equipment is Powered Off.
8. Make a functional check of the equipment.
9. Note on the Log Book the cause and date of the replacement and fix an adhesive label beside the new board indicating the date and name of field engineer in order to give maximum info.

Job Card 2.9

SUBASSEMBLY: IGBT MODULE (CABINET).

PURPOSE: REPLACEMENT OF MODULE.

CAUTION

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET. BEFORE MANIPULATING THE BOARDS MAKE SURE THERE IS NOT VOLTAGE PRESENT IN THE CAPACITORS BANK.

1. Locate the rear cover on the Cabinet used to gain easy access to the IGBT Module. Remove the four Allen screws and take off the cover.
2. Remove the following wires: (Remove the plastics cover first). Big wires to the Primary in the HV Tank marked P1, P2 and P3. Through the window the wires go to AC1, AC2 and AC3 on the input rectifier board (these wires are not marked and must be identified before being removed). Ground wire located on the Cabinet frame.
3. Remove the four connectors (two in each IPM Driver board). These are not marked and must be identified before being removed.
4. Remove the two white wires of the L2 Choke. (These are not market and must be identified before being removed).
5. Remove the four connectors (Two in each Charge/Discharge Monitor boards). (These are not market and must be identified before being removed)
6. Remove the four nuts located in the rear of the Cabinet used to attach the Module to the Cabinet.

CAUTION

This Module is heavy and must be removed through the front of the Cabinet.

7. Install the new Module and attach it with the nuts removed. Replace the previous wires and connectors previously removed in Steps 2 To 5.
8. Once the connections are check, power ON the Electrical Cabinet and the Console.
9. Check the voltage on the Capacitor Bank *(see ASM Manual).*
10. Connect the mAs meter on the HV Tank and put the non invasive meter on the table under the X-ray beam and check a few mA and kV settings in order to be sure the Inverter is working properly. Make a functional check of the equipment.
11. Install the rear cover with the four Allen screws in the Cabinet.
12. Return the defective Module to factory to be repaired.
13. Note on the Log Book the cause and date of the replacement and fix an adhesive label beside the new board indicating the date and the name of the field engineer in order to give maximum info.

Job Card 2.10

SUBASSEMBLY: IPM DRIVE BOARDS (CABINET).

PURPOSE: REPLACEMENT OF MODULE.

WARNING

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET. BEFORE MANIPULATING THE BOARDS MAKE SURE THAT THERE IS NOT VOLTAGE PRESENT IN THE CAPACITORS BANK.

1. Remove all connectors of the board. Note their positions.
2. Remove the two Allen screws used to secure the board in the Cabinet.
3. Replace the old board for the new one.
4. Replace the four Allen screws.
5. Replace all connectors previously removed.
6. Power ON the Electrical Cabinet and Power ON the Console.
7. Make a check on the correct operation.
8. Make a functional check of the equipment.
9. Note on the Log Book the cause and date of the replacement and fix and adhesive label of the new board indicating the date and name of the field engineer in order to give maximum info.

Job Card 2.11

SUBASSEMBLY: LOCKS BOARD (CABINET).

PURPOSE: REPLACEMENT OF MODULE.

CAUTION

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET.

1. Remove all wires of the board. Note their positions.
2. Remove the four screws and nuts with washers used to secure the board in the Cabinet.
3. Replace the old board for a new one.
4. Replace the four Allen screws.
5. Replace all wires previously removed.
6. Power ON the Electrical Cabinet and Power ON the Console.
7. Make a check about the good operation of the Locks, of tube stand, etc.
8. Make a functional check of the equipment.
9. Note on the Log Book the cause and date of the replacement and fix an adhesive label beside the new board indicating the date and name of the field engineer in order to give maximum info.

Job Card 2.12

SUBASSEMBLY: HIGH SPEED BOARD (CABINET).

PURPOSE: REPLACEMENT OF BOARD.

CAUTION

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET.

1. Note the actual setting of jumpers on the board.
2. Remove all wires and connectors of the board. Note their positions.
3. Remove the four Allen screws used to secure the board in the Cabinet.
4. Replace the old board for a new one.
5. Replace the four Allen screws.
6. Replace all wires and connectors previously removed.
7. Set jumpers in their original position *(see Step 1)*
8. Power on the Electrical Cabinet and Power ON the Console.
9. Make a functional check of acceleration, running and braking times and check directly on the window the anode rotation.
10. Make a functional check of the equipment.
11. Note on the Log Book the cause and the date of the replacement and fix an adhesive label beside the new board indicating the date and name of the field engineer in order to give the maximum info.

Job Card 3.1

SUBASSEMBLY: HIGH VOLTAGE TANK (ONE TUBE &TWO TUBES)

PURPOSE: REPLACEMENT OF TANK.

CAUTION

TURN OFF THE GENERATOR IN THE ELECTRICAL CABINET

1. Remove all wires from the Tank. Take note of their positions.
2. Save the varistors device installed.
3. Remove the two or four high voltage cables.
4. Replace the old tank for a new one.
5. Replace the wires previously removed in Steps 1 to 3.
6. Replace the varistors on the connection points Ma+ and Ma−.
7. Remove the ventilation screw and check the oil level.
8. Power ON the Electrical Cabinet and Power ON the Console.
9. Make a check in a few mA and kV settings (both filaments).
10. Make a functional check of the equipment.
11. Return the defective tank to factory.
12. Note on the Log Book the cause and date of the replacement and fix an adhesive label beside the new board indicating the date and name of the field engineer in order to give the maximum info.