

MARINE RADAR  
EQUIPMENT

RADAR 3000

FIELD SERVICE  
MANUAL

**JRC** *Japan Radio Co., Ltd.*

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# SECTION 1

## SPECIFICATIONS

### 1.1 GENERAL

- |                              |               |   |
|------------------------------|---------------|---|
| 1. Maximum range:            |               | 24 Nautical Miles   |
| 2. Minimum range:            |               | Less than 25 m on the. 125 NM range   |
| 3. Range scales              | Range<br>(NM) | Number of<br>Rings      Range ring<br>Interval(NM)  |
|                              | 0. 125        | 2      0.0625   |
|                              | 0. 25         | 2      0.125  |
|                              | 0. 5          | 2      0.25   |
|                              | 0. 75         | 3      0.25   |
|                              | 1. 5          | 6      0.25   |
|                              | 3. 0          | 6      0.5  |
|                              | 6. 0          | 6      1.0  |
|                              | 12. 0         | 6      2.0  |
|                              | 24. 0         | 6      4.0  |
| 4. Range discriminations:    |               | Less than 25 m  |
| 5. Range ring accuracy:      |               | Better than ; $\pm 0.9\%$ of maximum<br>maximum range of the scale in use,<br>or 8 m, whichever is the greater. |
| 6. Bearing accuracy:         |               | $\pm 1$ degree  |
| 7. Display device:           |               | CRT: 7" (640 x480 dots)   |
| 8. Environmental conditions: |               |   |
| Scanner unit                 | Temperature   | - 15° C to +55° C   |
|                              | Humidity      | UP to 95% at 35° C  |
| Display unit                 | Temperature   | - 10° C to + 50° C  |
|                              | Humidity      | UP to 95% at 35° C  |
| 9. Input power               |               | 10.2 V to 42V   |
| 10. Power consumption:       |               | 65 W  |
| 11. AVR                      |               | Floating AVR system   |

### 1.2 SCANNER UNIT

- |                           |            |   |
|---------------------------|------------|---|
| 1. Dimensions:            | Diameter   | 620mm   |
|                           | Height     | 275mm   |
| 2. Weight:                | Approx.    | 9.5 Kg  |
| 3. Polarization:          | Horizontal |   |
| 4. Beamwidth:             | Horizontal | 4° nominal                                    |
|                           | Vertical   | 25°   |
| 5. Sidelobes:             |            | -21 dB or greater                             |
| 6. Rotation:              | Approx.    | 27 rpm  |
| 7. Transmitter frequency: |            | 9410 $\pm$ 30 MHz                             |
| 8. Peak power output:     |            | 4KW   |
| 9. Pulse length/PRF:      |            | 0.08us/2250Hz (0. 125, 0. 25, 0. 5, 0. 75 NM) |
|                           |            | 0.35us/1500Hz (1. 5, 3. 6 NM)                 |

- |                    |                               |
|--------------------|-------------------------------|
|                    | 0.7us/750Hz (3, 6, 12, 24 NM) |
| 10. Duplexer:      | T-junction with diode Limiter |
| 11. Mixer:         | MIC frontend                  |
| 12. IF amplifier:  | Center frequency 60 MHz       |
|                    | Bandwidth 3/10 MHz            |
| 13. Noise figure   | Less than 6 dB                |
| 14. Characteristic | Semi-Log                      |

### 1.3 DISPLAYUNIT

- |                     |  |
|---------------------|--|
| 1. Dimensions:      | Width 276 mm   |
|                     | Depth 250 mm   |
|                     | Height 204 mm  |
| 2. Weight:          | Approx. 6 Kg   |
| 3. Mounting:        | Table, Overhead, or Flush mount  |
| 4. Video:           | 8 levels quantitized   |
| 5. Tuning:          | Auto/ Manual   |
| 6. Bearing scale:   | 360° scale graduated at intervals of 1°  |
| 7. VRM:             | 3 digit readout  |
| 8. EBL:             | 3 digit readout  |
| 9. Alarm:           | Audible alarm with zone mark   |
| 10. Off Center:     | 2/3 radius   |
| 11. Planned TX:     | Rotation period 10, 20 or 30 scans   |
|                     | Repetition period 3, 5, 10, 15 min.  |
| 12. LANGUAGE:       | English, Spanish, Norwegian  |
| 13. Features:       | VRM(2), EBL(2), Cursor with LL,<br>Interference rejection, Target expansion,<br>Target alarm, LL or TD readout, Waypoint<br>with LL, Offset, Timed TX, Target Trail,<br>Auto tune, Man Overboard |
| 14. External input: |  |
| NAV-AID             | NMEA0183 (RMA, RMB, RMC, GLL,<br>GTD, VTG, BWC sentence) NMEA0182  |
| Compass             | NMEA0183 (HDM, HDT, VWH, or HSC sentence)  |

## SECTION 2

### TECHNICAL DESCRIPTION

#### 2.1 GENERAL

The theory of operation for the Radar Set RADAR 3000 is presented here with descriptions following the functional block diagram circuits Figure 2-2.

#### 2.2 RADOME ANTENNA UNIT

The Radome antenna unit consists of the RF PCB radiator, the motor/encoder assembly, radiator rotating mechanism, bearing reset assembly, and the transmitter/receiver units. These components are all housed within the 24.5" radome. The functional Block Diagram of Radome Antenna Unit appears in Figure 2-2.

##### 2.2.1 RADIATOR

The RF PCB radiator forms the main RF transmitting beam for the radar transmitter and becomes the receiving antenna during the receive cycle. The beam formed by the phased array styled PCB at half power points is 4° horizontally and 25° vertically. The direction of the beam (maximum radiated power) is essentially perpendicular to the radiator surface.

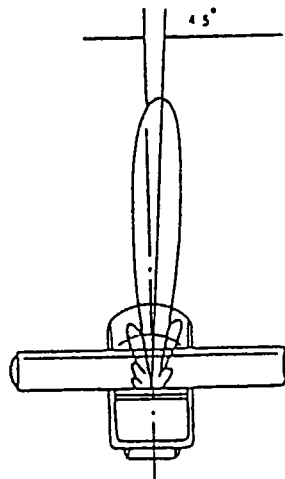


Fig. 2-1 RADIATOR PATTERN



### 2.2.2 RADIATOR ROTATING MECHANISM

The mechanical coupling between the PCB radiator assembly and the motor-encoder is effected by a reduction drive gearbox. The antenna motor normally rotates the radiator at approximately 27 rpm.

### 2.2.3 MOTOR-ENCODER

A 12 VDC motor operating at a regulated 12VDC is used to rotate the radiator. At the bottom end of the motor an encoder section produces bearing pulses used for sweep line generation, rotation synchronization of the sweep line within the display unit. A bearing sync pulse (BP) is generated for every 0.176 degrees of rotation (2048 pulses per each revolution) at 5 VDC amplitude. These pulses are sent through J1-9 down to the Bearing Pulse circuitry in the display unit.

### 2.2.4 BEARING RESET SWITCH

The bearing reset switch, or otherwise referred to as the "heading reference switch", produces the signal to reset the scan converter circuitry to "0" when the permanent magnet fitted on the main gear passes across the reed switch S102. The resulting signal (BZ) is sent down to the bearing reset circuitry in the display unit and synchronizes the scanner position to the display sweep. The BZ signal is sent down to the display together with the Tune indication signal at J1-6.

## 2.3 TRANSMITTER UNIT

The transmitter consists of the solid state modulator circuits, the power supply, and the 4kW magnetron.

### A. Modulator

A solid state type pulsar design is used by the modulator and primarily consists of a pulse generator circuit, power MOSFET switch, and pulse transformer.

When setting the X-MIT/STBY key on the indicator control panel at the display unit to "ON", the transmitter trigger pulse is sent via the interunit cable from the transmit trigger generator circuit in the display unit to the base of TR2 in the modulator.

Simultaneously +12 VDC and -12 VDC is supplied to the modulator to operate the HV power supply for the transmitter. The switching regulator power supply provides +350 VDC to charge the capacitor (C21 and C22). In addition to the high voltage for the modulator, the power supply also provides the magnetron filament voltage and the operating Vcc for the PFN control circuits TR7-TR10.

Generally the pulse width of the pulse generator circuit is controlled by the range key selections on the indicator front panel.

Three different pulse lengths: 0.08  $\mu$  sec, 0.35  $\mu$  sec and 0.7  $\mu$  sec (in accordance with the range scale or menu selections) can be provided. The pulse repetition frequency (PRF) always changes automatically to match the selected operating pulse length (See TABLE 2-1).

Upon receiving the positive trigger pulse, TR2 generate a differential waveform at C15, RV2, RV3, and RV4 setup the discharge period of this waveform to generate a short (80ns), medium (350ns), or long (700ns) gate to IC2-2. The pulse is amplified and applied to the gate of TR11 which will conduct for the selected pulse length drawing current through the primary of the Pulse Transformer (T2) generating a 3.7kV pulse to the magnetron cathode. (See Fig 2-3)

TABLE 2-1 RANGE, PULSE LENGTH, AND PRF RELATIONSHIPS

Range	Pulse Length	PRF
0.125, 0.25, 0.5, 0.75, 1.5 nm	0.08 $\mu$ S	2250 Hz
3.6 nm	0.35 $\mu$ S	1500 Hz
12, 24, 32 nm	0.7 $\mu$ S	750 Hz

#### 2.4 RECEIVER UNIT

The receiver unit consists of the passive diode limiter, the MIC Front End and the Receiver IF PCB (CAE-349-2).

The MIC Front End (E301, S-RX24) device consists of low-noise RF amplifier, a double balanced mixer, and the local oscillator. The received radar echo signals at 9410 MHz are first amplified by the low-noise RF amplifier. The signals are then sent into the double balanced mixer of the MIC. The MIC Local Oscillator, tuned by the adjustment of the operator's Tune control on the display unit front panel to be 60 MHz higher than the magnetron's operating frequency for maximum target detection, is also fed into the double balanced mixer. The balanced mixer output of 60 MHz echo signals is then coupled into the 60 MHz IF amplifier.

##### RECEIVER PCB (CAE-349-2)

The Receiver PCB includes the 60 MHz IF amplifier, bandwidth control circuits, video detector, tune circuitry, the GAIN/STC/MBS amplifiers and the video output circuitry.

IF Amplifier Circuit: The IF amplifier consists of low-noise gain controlled IC amplifiers IC1, IC2 and IC3, and bandwidth selector circuits TR1 and TR2.

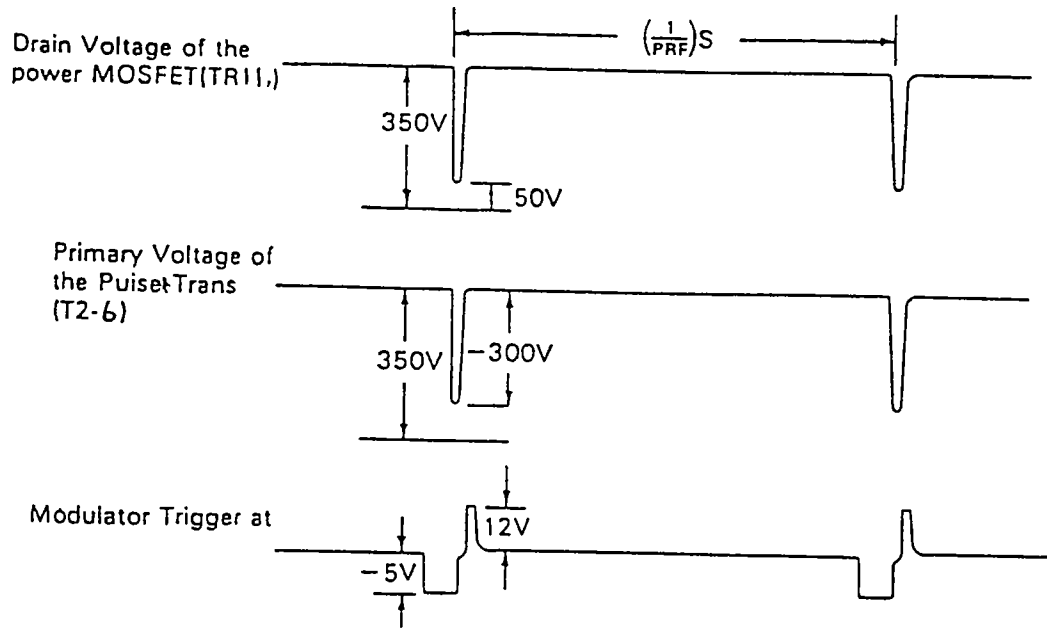


FIG. 2-3. TIME TABLE OF THE TRANSMITTER

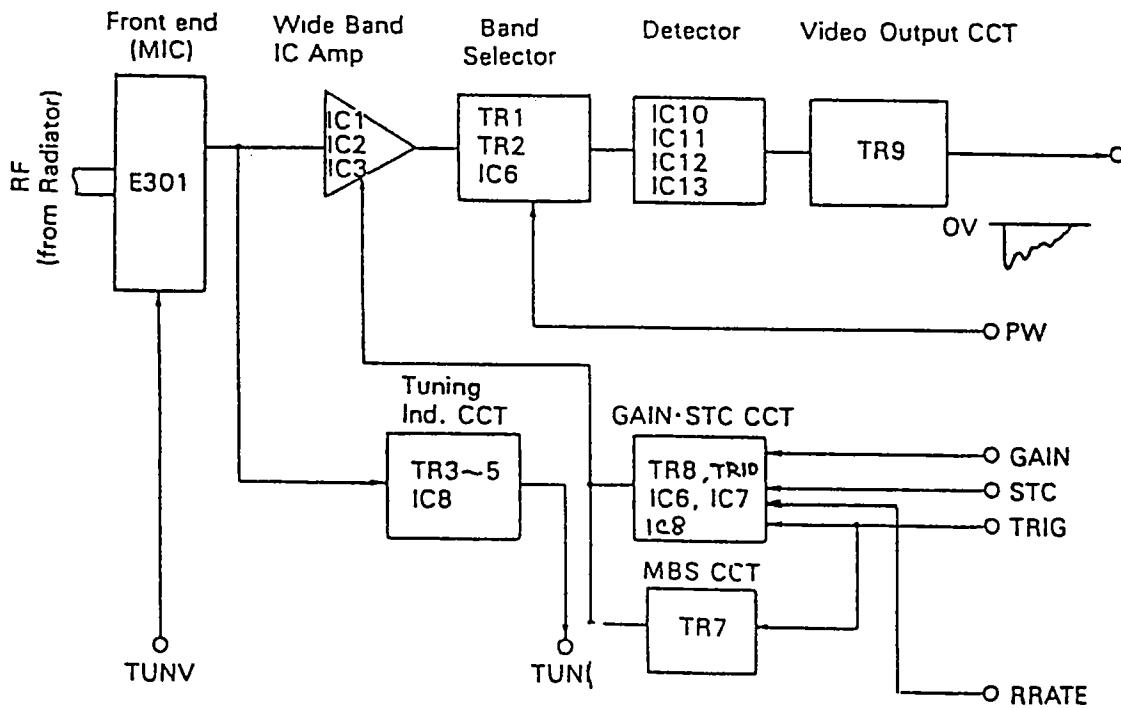


FIG. 2-4. RECEIVER UNIT BLOCK DIAGRAM

IC1 and IC2 are controlled by the gain and STC control signals generated by the TR8, IC6, IC7. Maximum gain is obtained when the voltage level at IC1-5 and IC2-5 reaches 4 volts.

The bandwidth selector IC6 enables components to be activated in the amplifier circuit so the receiver has either a 10 MHz or a 3 MHz bandwidth characteristic. The selection depends on the pulse length selector signal (PW).

When no pulse length signal is present, IC6 will be "OFF" and the gate voltage of TR2 will be 0 volts. In this condition, the pulse length in operation is  $0.08 \mu\text{S}$  and the bandwidth of the receiver is widened to 10 MHz. When the pulse length signal is other than  $0.08 \mu\text{S}$ , IC6 will be turned "On", the gate of TR6 will be -4V, and the bandwidth will become narrow at 3 MHz.

#### Video Detector Circuit.

The video detector circuits IC10, IC11, IC12 and IC13 operate as logarithmic amplifiers to remove the 60 MHz IF component from the incoming signals. The negative going signals appear across R76 where the IF component is removed by filter R14, L7. The detected signals, now at video frequency rates, are sent to the video output circuit.

#### Video Output circuit

The video output circuit consists of emitter follower TR9. The emitter follower operates strictly as an impedance transformer to drive the 50 ohms coaxial cable which carries the video signal to the display unit. The video signal is shown in FIGURE 2-4.

#### TUNING Indication Circuit

The tuning indicator circuit consists of amplifier TR3, detector TR4, and emitter follower TR5. TR charges C44 to the detected signal voltage. This voltage is sent to the display unit as a tuning indication voltage via buffer amplifier IC8. The range of the tuning indication voltage varies normally between +4V(detuned) and -0.7V(tuned in long pulse).

#### Gain-STC Circuit

The receiver includes GAIN and STC circuitry compressed of TR8, IC6 and IC7. The GAIN control voltage from the display unit is 12 volts for maximum sensitivity and 0 volts for minimum sensitivity. IC 6-6 controls the GAIN DC threshold at the summing amplifier TR6. RV4 sets the maximum gain level for the receiver when +12 VDC is supplied at the GAIN input.

The STC control circuitry consists of TR8 and IC7. The transmit trigger is coupled to the STC gate generator by C54. This circuit uses only the negative portion of the transmitter trigger to generate the STC pulse. The positive portion is removed by CD7. TR8 will be turned "ON" and C56 will charge. When the trigger pulse ends, TR8 will be turned "Off". C56 can then discharge back to 0V through R61 and RV3. The rate of C56's discharge will be determined by the time constants of R61, RV3, C56, C24 and R57. The STC signal resulting from C56 discharging is combined with the Gain control voltage at TR6 and applied to the IC1 and IC2.

#### Main Bang Suppression (MBS) Circuit

The main bang suppression circuit is intended to blank the nearby transmitter energy at the start of the display sweep. TR7 is used to generate the main bang suppression pulse. This circuit also uses only the negative portion of the transmitter trigger to make the MBS pulse. The positive portion is removed by CD8. TR7 will be turned "ON" with the receipt of the MBS pulse and C57 will charge. When the trigger pulse ends, TR7 will be turned "OFF". C56 will discharge to 0 V through R63. The discharge rate will be determined by the time constant of C57, RV2, and R63. The MBS signal is combined with the Gain control voltage and STC signal and applied to the IC1 and IC2.

## 2.5 DISPLAY UNIT

The display unit normally contains the Main Control PCB, the Power Supply PCB, the CRT and the CRT Display Control PCB, and the Control Panel PCBs.

### 2.5.1 SIMPLIFIED BLOCK DIAGRAM

FIG. 2-5 shows the fundamental circuits of the display unit in a simplified functional block diagram. Most system operations within the display unit occur primarily on the Main Control PCB (CMC-1008). It is on this PCB that most of the signal processing takes place. The following is a brief description of the main circuit functions of the display unit.

### 2.5.2 MAIN CONTROL PCB

#### 2.5.2.1 VIDEO INPUT CIRCUITRY

The incoming video signals from the receiver in the scanner are first routed through the FTC circuit components consisting of CD11 and C52.

The Varicap diode CD11 controlled by the voltage supplied from IC30-(8) which is determined by the front panel RAIN CLUTTER Control.

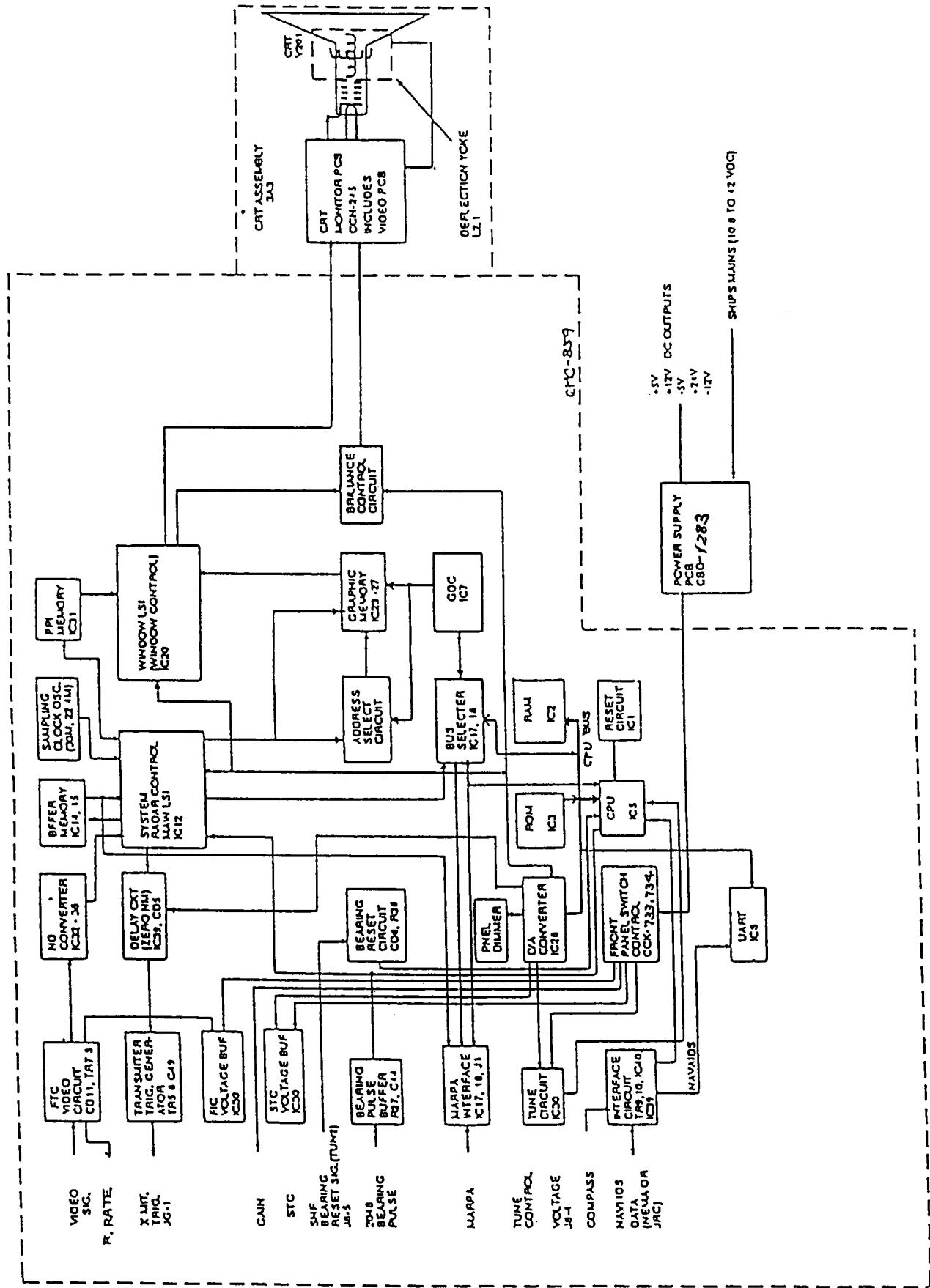


FIG. 2-5: BLOCK DIAGRAM OF DISPLAY UNIT

Maximum FTC occurs when the voltage level at CD11 cathode is 3VDC.

#### 2.5.2.2 A/D CONVERTER

The A/D converter changes the incoming video signal from analog video signals into 3 bit digital signals. The A/D converter consists of IC32-IC36. Since the conversion must occur at high speed, four comparator ICs are used. The MSB threshold level (brightest video) is set by RV2(Upper) located in the Main Circuit PCB. The digitized video output (RVDPO-3) is then sent to IC12, the Main LSI and Video Processor for storage into the video buffer memory.

#### 2.5.2.3 MAIN LSI/VIDEO PROCESSOR

The Main LSI, IC12 receives the bearing pulse signals(BP) generated by the antenna motor/encoder assembly to synchronize the timing of the scan converter and to control the various clock inputs and outputs for the video memory and display. When the bearing pulses are received, IC12 also generates the radars transmit trigger at TIYLOU. The trigger signal is sent over to IC27 where the ONM delay timing adjustment is applied. The output at IC37-12 and IC37-13 provide complementary drive signals to TR5 and TRD6. These amplifiers boost the output transmit trigger(TI) level to +12 VDC in amplitude.

#### 2.5.2.4 SAMPLE CLOCK GENERATOR

The sampling clock oscillators generate the frequencies necessary to create the various timing signals including those used for controlling the processing of the digital video signals into the memories.

The Sampling Clock Generators consist of crystals CX2 and CX3, along with IC13 and IC10. The CX2 operates at 30MHz and CX3 operates at 22.3MHz. The 22.3 MHz frequency is used to determine the timing clocks used on the 0.125, 0.25, and 0.5 and 32 nm range scales, while the 30 MHz clock frequency is used to determine the clock timing on the remaining range scales.

The Video Processor is contained in IC12 (Main LSI) and can perform two additional processing functions on the video signal when activated in menu. They are: Interference Rejection Processing and Target Expander Processing.

The Interference Rejection Processing is performed by comparing the bit-by-bit content of the digital video stored from each successive radar transmission whenever the IR function is enabled by the operator. The Expander Processing is performed by extending the target digital video pulse

length up to 8 additional digital video cells whenever target expansion is enabled in the menu.

#### 2.5.2.5 BUFFER MEMORY

IC14 and IC15 are Buffer Memories capable of 2K word $\times$ 8 bit dual port input data and output data handling. The buffer memories are used to temporarily store the digitized video input signals according to the clock timing for the range scales in use for the video processor. Memory IC15 is used to store the IR processed video data memory.

#### 2.5.2.6 VIDEO MEMORY

The start of the data readout of the video buffer memory is triggered on the trailing edge of the bearing pulse from the scanner unit. This clock is used for data processing in IC12. The processed video data which has passed through IC12 is now transferred to the video memory IC31. IC31 is a DRAM consisting of 256K $\times$ 4 Memory planes which are used to produce the picture data, EBLs, VRM, video (including wakes) range rings, etc.

The address signals used to write into the read out of the video memory are generated in IC12. The output data from the video memory is entered into IC20, the video signal mixer/processor.

#### 2.5.2.7 CONTROL PCBS

The RADAR 3000 use a keypad control PCB assembly(CCK-781) to activate the radar system and control its functions. These keypad control PCBs interface directly into the Main Control PCB via connectors J6 and J7 to IC5(CPU) on the Main PCB.

CCK-781 contains 13 key switches and the jog dial controls for the TUNE, GAIN, FTC, STC and RANGE. Each panel includes LEDs for backlighting the keyboard panels and the LED intensity can be controlled in 8 levels of brightness by the menu selection via the DIM line. The operating voltage for the LEDs originates at IC29 and TR3 on the Main PCB.

#### 2.5.2.8 GDC(GRAPHIC CONTROL MEMORY)

This radar uses an 8 bit CPU(IC5), and a Graphic Display Controller(IC7) to principally control the graphic system of the on-screen display of VRM, EBL, Bearing Scale, Range markers, and other graphic characters. The CPU receives operating instructions from the 1 Mbit EPROM in IC3 and system setting stores data in the 64 Kbits of RAM available in IC2. The RAM memory has a battery backup through IC1 so that the settings of Range, EBL, VRM, CRT brilliance, EXP, and IR will be maintained in memory after each shutdown of power.

The DGC(Display Graphic Controller) paints the various character data, VRM, EBL, Range Marker, etc. under direction of the CPU to the graphic DRAM memories IC23-IC27 while performing processing of the data from bearing pulses, reset pulses and from the keys on the control panel.

The contents of the DRAM memories is read out by input parallel-serial converters located in IC12 and ultimately is sent to IC20.

#### 2.5.2.9 VIDEO OUTPUT

In IC20, data which has been written into the Video Mixer/Processor by the range and sample clock timing signals will now be read out to the CRT monitor in raster scan timing; that is, the Horizontal frequency of 15.750 KHz and 60 Hz Vertical frequency.

The 3 bit digital video signals are re-converted by IC20, into analog video signals having 8 levels and outputted to the buffer amplifier TR2. The graphic data is input to TR2 via CD1 and IC20. When the brilliance control is changed in the function menu, the brilliance control signal is outputted from IC28 and applied to TR1. The CRT brilliance will be varied in 8 steps. The combined video signals(radar targets and display graphics) along with the horizontal(HS) and vertical(VS) synchronization signals are sent to the monitor display.

#### 2.5.2.10 DISPLAY MONITOR

The display monitor receives its operating supply voltage from the +12VDC supplied by the power supply PCB. The video signal is sent to TR4 and TR5 amplifiers before coupling to the CRT cathode. RV1 sets the contrast level of the video for the CRT.

The horizontal sync signal operates the horizontal oscillator IC1. The oscillator provides the drive via TR6 to run the HV flyback transformer and generate the operating voltages for the CRT as well as the horizontal deflection coil.

The vertical sync signal operates the Vertical oscillator IC3 via IC2. The oscillator output at VOUT drives the vertical deflection coil.

Traditional adjustments are provided to set the focus, CRT brightness, vertical hold, size, and linearity, horizontal hold, and the video contrast.

The CRT is mounted and arranged in the "portrait" mode in the radar. Therefore, the horizontal adjustments will effect the vertical picture and vice-versa, the vertical adjustments will effect the horizontal aspects of the picture.

### 2.5.3 OPTIONAL INPUTS

The RADAR 3000 can receive various input signals from Navaid and Flux Sensors.

If more than one data type is present at the radar inputs (for examples; flux sensor and NMEA) a system priority has been established in the radar's software to respond to the inputs in driving the features. The assigned priorities are set in this manner:

HEADING: 1. Flux Sensor (NMEA 0183 "HDM, HDT, HSC" sentences)  
2. Sea Talk Data (Heading via Autopilot compass)  
3. Navaid Data (NMEA 0183 "RMC, RMA, VTG" sentences)

POSITION: 1. Navaid Data (NMEA 0183 "RMC, RMA, GLL, GTD" sentences)  
2. Sea Talk Data

SPEED: 1. Navaid Data (NMEA 0183 "RMC, RMA, VTG, VHW" sentences)  
2. Sea Talk Data

WAYPOINT: 1. Navaid Data (NMEA 0183 "RMB, BWC" sentences)  
2. Sea Talk Data

The NAVAID input is connected at J403, Pins 1 and 2. The signal is coupled via J9-1,2 to section 1 of IC40 (Optical Isolator), to Inverters 1 and 2 of IC39, to the data selector IC38, to UART IC6, and finally to the CPU IC5.

The HEADING data input essentially follows a similar route. The signal is connected at J403 Pins 3 and 4, coupled via J9-3,4 to section 2 of IC40 (Optical Isolator), Inverters 3 and 4 of IC39, to the data selector IC38, to UART IC6, and finally to the CPU IC5.

### 2.5.4 POWER SUPPLY (CBD-1283)

The Power Supply converts the ship's DC input voltage to the necessary DC voltages to operate the radar system. These output voltages include regulated +12 VDC, -12 VDC, +5VDC, -5VDC, and +24VDC.

The power supply can begin operation when the STBY/OFF switch is pressed on the Control (Right) PCB. The STBY signal toggles IC5-2 output and TR8 conducts. This enables the Vcc supply to the AVR converter circuit. IC4 is the 90 second timer and its output at pin 3 via IC2/2 becomes the OPE signal to put the radar into the Transmit mode. When the XMIT/OFF key is pressed, IC5-12 operates TR7 and IC2/2 to enable the OPE output.

The AVR converter consists of IC1, IC2, and IC3, as well as TR3, TR4, TR5, and TR6. IC1 controls the switching of the power FETs TR5 and TR6. Sensing of the AVR output occurs from the +12VDC line, sampled via RV1, compared at IC3 and controlled via IC2/1 to the AVR. RV1 is normally set by monitoring the +5 VDC output at TP1 and adjusting for +5VDC, +/- .1 VDC with a volt-ohm meter.

When both the POWER and XMIT/STBY keys are pressed together, IC6 resets IC5 outputs and disconnects the Vcc from the AVR IC1. This will turn the power supply and the radar system to OFF.

