TECHNICAL DESCRIPTION OF THE E3 / RESCUE 406 EPIRB

The E3 is a 406MHz float free satellite EPIRB with a built in 121.5MHz homing beacon and is used to locate a vessel or life raft in distress. When activated, encoded data is transmitted, enabling identification of the vessel and its position to better than 3Km. The EPIRB comes complete with an automatic release mechanism.

BEACON DESCRIPTION

The E3 consists of two mouldings, a transparent top dome made from Polycarbonate and a main body made from a Polycarbonate/ABS thermoplastic mix. The main body is internally sprayed with a conductive coating to achieve good EMC performance. The two mouldings are screwed together. A gasket made from Sarlink, which is a thermoplastic elastomer, is used to provide a waterproof seal.

The bottom molding contains the battery pack and a counter balance weight to give good buoyancy characteristics. On the rear of the moulding are two seawater switch contacts and two membrane switches. One membrane switch is labeled HOLD TO TEST/READY and the other is labeled ON. The ON switch is protected against inadvertent use by a plastic cover fitted with a tamper seal. The EPIRB cannot be manually operated unless the tamper seal is removed and the plastic cover slid across to the left of the moulding. The bottom moulding also houses the EPIRB electronics, which are contained on two printed circuit boards, configured in a ‘T’.

The top dome is transparent so that Xenon tube is clearly visible. The top dome also provides the mechanical fixing for the 406MHz/121.5MHz antenna. A recess in the moulding allows for aligning a light pen for infra-red data programming.

The E3 is programmed via an infra-red data link. This means that a vessel’s unique identity number can be programmed into the E3 via a RS232 interface. This data is then permanently stored in the EPIRB. This system enables swift and easy programming of the EPIRB without having to break the watertight seal.

RELEASE MECHANISM

The E3 is protected in a ‘floatfree’ two-part housing which provides safe storage for the EPIRB until it is required for use. The two-part housing is made from Acrylate Styrene Arylonitrile, which is a thermoplastic material. The bottom half contains the release mechanism and is designed to be bolted to a bulkhead.

The release mechanism consists of a stainless steel bracket to support the EPIRB, a spring and a hydrostatic release unit. The bracket containing the EPIRB compresses the spring, and is held in place by an acetal copolymer rod that passes through the hydrostatic release and is secured using a circlip at the base of the bottom housing. The top and bottom housings are then secured together with the aid of an R clip passed through the acetal copolymer rod which protrudes through the top housing. The hydrostatic release will operate at a depth of 1.5m-4m. Once activated the hydrostatic release cuts the acetal copolymer rod. This releases the spring and forces the two halves apart allowing the EPIRB to float to the surface.

E3/ RESCUE 406 EPIRB TECHNICAL SPECIFICATION

GENERAL

Approved to	COSPAS-SARSAT T.001 class1 RTCM SC110-STD Version 2 class 1 ETS 300 066 IEC 1097-2
Complies with	EN 60945 Part 80 of FCC regulations
Operating temperature range	-40ºC to +55ºC
Storage temperature range	-50ºC to +70ºC
Operational life	48 hours minimum at -40ºC
Battery type	9V lithium sulphur dioxide
Battery expiry	6 years from date of manufacture

ELECTRICAL

406.025MHz transmitter

Frequency	406.025MHz ± 5KHz
Output power	5W ± 2dB
Data encoding	Bi-phase L
Modulation	Phase modulation: 1.1 rads ± 0.1 rads
Transmission time	440ms ± 1%
Repetition period	50 secs ± 2.5 secs

121.5MHz homing transmitter

Frequency	121.5MHz ± 3KHz
Output power	50mW ± 3dB PERP
Transmit duty cycle	Continuous
Modulation format	3K20A3X
Modulation frequency sweep	1300Hz to 350Hz
Modulation duty cycle	38% ± 5%
Sweep repetition rate	3Hz ± 1Hz
Sweep direction	Programmable UP or DOWN

Antenna

Type	Flexible, vertical whip
Characteristics	Vertically polarised, omni-directional

Optical Homer

Type	Xenon discharge tube
Flash rate	20 to 23 flashes per minute
Light output	> 0.75 candela over ≥75% of the horizontal plane

EXTERNAL INTERFACES

Programming interface	Infra-red link via RS232 port on a PC.
Manual activation	Sealed membrane switch. Protected by sliding cover.
Automatic activation	Sea water switch contacts. Activation within 5 seconds of immersion.
Self test	Sealed membrane switch. Press and hold to activate self test. Confirmation of successful self test by 3 flashes of strobe light.

PHYSICAL CHARACTERISTICS

Weight	730 grams nominal
Height	210mm to base of antenna.
Width	110.5mm at maximum

CIRCUIT DESCRIPTION

The E3 EPIRB is powered by three 3V Lithium Sulphur Dioxide batteries connected in series, which gives a nominal voltage of 8.4V. The battery pack is protected by a 2A fuse. The battery pack is designed to last for at least 48hours at –40ºC and be capable of supplying 1.8A pulses every 50 seconds.

Refer to drawing 82-100C

ACTIVATION

The EPIRB is activated by energising Q13, this can be done by either pressing the ON membrane switch, the READY membrane switch, or via the seawater switch contacts.

The seawater switch operates when the resistance across the contacts is less than 60K ohms. This allows IC9d output to switch high. IC9c will switch low after a delay of 2 seconds due to the time constant formed by R65 and C55. This enables D4 to conduct and Q13 to turn on. In this state, the unit may only be turned off by removal from water. C55 will discharge through R78 causing Q10 to switch off after a delay of 6 seconds.

The combination of IC9a and IC9b form a set-reset bistable. When the ON membrane switch is pressed, the output of IC9b switches high and is latched by IC9c switching low. D5 conducts, turning Q13 on. In this state the latch may only be reset by pressing the READY switch.

When the READY membrane switch is pressed and held, D6 conducts allowing Q13 to turn on. The TST line to the microcontroller will also be pulled low via D3, causing the self-test routine to be initiated.

Self Test

1) LED 1 illuminates.
2) The 121.5MHz homer performs three sweeps. The output of the RF detector is checked to ensure the correct power level.
3) The LCK line is checked to ensure that the PLL is locked.
4) After 5 seconds a 406MHz test message is made. The output of the RF detector is checked to ensure the correct power level.
5) If the levels are correct, the strobe flashes three times to indicate correct performance.

MICRO-CONTROLLER

The E3 EPIRB is controlled by IC1, an 8-bit microcontroller, which has internal EEPROM. The microcontroller is responsible for all board operations. The microcontroller is powered by a 3V5 regulator, IC3, and run by crystal X2. The micro-controller may be programmed during self-test with the data to be encoded in the 406 message. Data is input to the RX line from an infra-red phototransistor Q11, and stored in internal EEPROM. In operational mode the micro-controller provides the following control signals:

1) Every 2.6 seconds pulses the strobe trigger line high to flash the strobe
2) Flashes a LED every 2.6 seconds to indicate normal operation.
3) Sets the PLL line high to enable the 121.5 MHz oscillator.
4) Generates frequency swept square waves on the MOD line to modulate the 121.5MHz transmission.
5) Every 50 seconds makes a 406MHz transmission.
6) Sets the PLL line low to enable the PLL and VCO circuits.
7) Loads division ratio data to the PLL via the LAT, DAT and CLK lines.
8) Sets the PA line high to enable the 406MHz PA.
9) Holds the DAT and CLK lines static for 160ms to generate unmodulated carrier.
10) Pulses the DAT and CLK lines for 280ms to phase modulate the carrier with encoded data.

STROBE CIRCUIT

Q15, T1 and C54 form an astable oscillator, running at 8KHz to 15KHz. The output waveform of the secondary of T1 is rectified by D8 to 300V and clamped at 270V by D11. Capacitors C69 and C70 are thus charged to 270V (and so is C68 via R79). The strobe trigger line is pulsed high for 2us every 2.6 seconds, forcing SCR1 to conduct. This causes C68 to discharge through the primary of T2, which generates a 3KV voltage across the Xenon tube, which causes the strobe to flash. Once C69 and C70 are discharged, the charging cycle repeats until clamped by D11.

121.5MHz TRANSMITTER

The transistor Q4 forms part of a modified crystal controlled Colpitts oscillator, IC6 is a programmable regulator which supplies the oscillator with a regulated 5V supply. The oscillator is switched on and off by the microcontroller via D1 and R7.
FET Q5 is a modulator/buffer. Amplitude modulation of the 121.5MHz signal is generated by the microcontroller. Modulation is in the form of a square wave, swept down from 1300Hz to 350Hz, with a nominal duty cycle of 38%. The FET modulator/buffer produces an output power of 8dBm that drives the power amplifier Q8.
The power amplifier is operated in Class C mode and produces an output level of 20dBm. The second harmonic at 243MHz is notched out by an elliptic filter formed by L10, C42, 43, 44 and 47. The filtered output signal is fed to a diplexer comprising of C59, 62 and L14. The diplexer acts to combine the 121.5MHz signal with the 406MHz signal which is then output to the antenna

via the antenna tuning unit, (A.T.U). This is formed from the network comprising L17, 18 and 15 with C73, 75, 83 and 84.
The 121.5MHz output power level is detected and converted to a DC level by the network C67, L15 and D9. This level is monitored during the self-test sequence to confirm the correct operation of the 121.5MHz circuit.

406MHz TRANSMITTER

During normal operation of the E3 EPIRB, all 406MHz circuitry, except for the 5V supply to the ovened oscillator OSC1, is shut down. The 406MHz transmission sequence starts when pin 8 of IC1 switches LOW. This enables regulator IC4, powering the 406MHz synthesiser and VCO circuits.
A short time later, the 406MHz PA is enabled by pin 1 of the microcontroller switching high. At the end of the 440ms transmission, the PA, synthesiser and VCO circuits are shut down.

406MHz synthesiser

The 406MHz phase locked loop comprises of a high performance programmable synthesiser, IC2, and a discrete VCO, (Q6 and associated components).
Internal frequency division ratios are programmed into the synthesiser via the LAT, DAT and CLK lines which are output from the microcontroller.
OSC1 is used as the reference oscillator for the phase locked loop. This is an ovened oscillator with high phase stability characteristics. It is powered continually to maintain the internal reference crystal at a near constant temperature. This runs at 12.688281MHz and is divided down by 6 within the synthesiser to set the internal reference comparison frequency to 2.1147135MHz. A portion of the VCO output is applied to the input of the PLL prescaler at pin 8 of IC2. After appropriate division, the frequency is compared to the internal reference frequency. Deviation from the reference will result in a change in voltage at the charge-pump output at pin 5. This voltage is applied to a varactor diode in the VCO and will drive the VCO to the correct frequency. Phase lock is indicated by Q1 being turned on and applying a logic high signal to the LCK input on the microcontroller.

The VCO is based on a modified Clapp oscillator configuration. The oscillation frequency determining network is formed by D2, C19, C20, C22 and TL1, a strip-line inductor. Variable capacitor C20 is adjusted to centre the varactor drive voltage at mid-rail. Frequency control is then achieved by the synthesiser applying a correction voltage to varactor diode D2. The nominal tuning range of the VCO is 380MHz to 420 MHz for a control voltage swing of 3.5V.

Q2 and associated components act as a phase modulator. By drawing additional current from the synthesiser charge pump output, the relative phase of the 406MHz signal is shifted. The LAT and DAT lines from the microcontroller output the encoded message data to Q2 via the scaling network R8, 9, 49, 80 and VR1. The resultant base drive voltage will result in current being drawn from the charge-pump output thus phase modulating the

406MHz signal. The magnitude of the peak modulation is adjustable by VR1.This is adjusted for a nominal modulation of $\pm$ 1.1 radians. Diodes D14 and D13 act to provide temperature compensation for the modulator over the range -40˚C to +55˚C.

406MHz Power Amplifier

The VCO output is buffered by pad R32, 33 and 37, and provides a drive of 0dBm to Q7. Q7 generates 12dBm drive at the power amplifier module input. The PA is turned on by the PA line switching high. This turns Q10 on, which switches on Q14, applying 8.4V to the PA DC supply input.
The PA output power is set by adjustment of VR2 which varies the output of regulator IC7, which provides the bias voltage to the PA module. The output level of the PA is set to 37dBm $\pm$ 0.2dB.
Q9, 10 and 14 also act as a shut down circuit that monitors the power amplifier to limit the duration of a 406MHz transmission. The switched supply rail to the power amplifier is fed to the base of Q9 via the time constant formed by R56 and C78. If the power amplifier is on for typically 5 seconds, sufficient voltage will be developed across C78 to turn on Q9. This will result in Q10 and Q14 switching off thus removing the DC supply to the power amplifier.
The 406MHz signal is then fed to a diplexer, then to the antenna via the antenna tuning unit (A.T.U). The 406MHz output power level is detected and converted to a D.C. level by network C67, L15 and D9. This level is monitored during the self-test sequence to confirm the correct operation of the 406MHz circuit.

Antenna Tuning Unit

The network comprising L17, 18 and 15 with C73, 75, 83 and 84 match the 50 ohm output from the diplexer to the antenna impedance at both 121.5 and 406MHz.