Title: Technical Description, 406MHz COSPAS-SARSAT EPIRB MT400 Family

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1. PURPOSE & SCOPE

It is the intention that this document provides information to assist those personnel responsible for the manufacture, test, design support and through life service of the MT400 family of Emergency Position Indicating Radio Beacons (EPIRB).

The information contained herein is relevant to all variants of the MT400 EPIRB, but not those of the MT410 PLB.

Access to other design information such as circuit schematics, or the like is assumed. Accordingly no attempt has been made to reproduce such information within this document. Please refer to the 'Associated Documents' Section.

2. ASSOCIATED DOCUMENTS

Please refer to the 'TEST MANUAL CONTROL SHEET MODEL: MT400 SERIES EPIRB & PLB' (Drawing Number: 41929) which identifies documentation, drawings and software associated with this product.

In addition reference to the material identified in Table 2-1 below may also be required.

Title	Organisation	Identification Reference
Electrical Architecture – MT400	GME	41679
Specification for COSPAS-SARSAT 406 MHz Distress Beacons	C/S	C/S T.001
COSPAS-SARSAT 406 MHz Distress Beacon Type Approval Standard	C/S	C/S T.007
406 MHz satellite distress beacons Part 1 (EPIRB)	Standards Australia	AS/NZS 4280.1:2003
406 MHz satellite distress beacons Part 2 (PLB)		AS/NZS 4280.2:2003
EPIRB; technical characteristics and methods of measurement	ETSI	EN 300 066
COSPAS-SARSAT EPIRB	IEC	61097-2

Table 2-1 Associated Documents

3. PRODUCT DESCRIPTION

3.1 Item Description

The MT400 is a fully self contained, environmentally sealed distress beacon specifically designed for the marine environment. Normally stowed within it's mounting bracket when not in use, the MT400 can be quickly released when required for optimal deployment in water, or if adverse conditions exist elsewhere. A lanyard is provided to allow the unit to be retained.

MT401 and MT403 variant include a water sense switch and will when removed from the stowage bracket activate when placed in water.

MT401 & MT403 provided with the alternate auto-release housing are commonly referred to as'float free' models. These units have the benefit that the housing will release the EPIRB automatically when a pre-determined depth of submersion is reached. Consequently being out of bracket/housing and floating in water these units will activate.

A COSPAS-SARSAT approved data burst transmitter is used to provide global alerting and location capability. Each beacon is coded to be uniquely identifiable.

A key attribute of this transmitter is it ability to essentially eliminate any relative change in transmitted frequency, even when exposed to temperature change, including thermal shocks.

The beacon is fitted with an integral 121.5MHz homing transmitter and high intensity solid state strobe (which doubles as a bi-directional data programming interface).

"G" suffix versions also feature an integral GPS receiver so that the unit's location can be included within the data transmission.

3.2 Operational

(a) The MT400 includes the following safety related features:

i.) 406MHz COSPAS-SARSAT satellite beacon transmitter,
ii.) 121.5MHz low power local homing transmitter, and
iii.) Hi intensity flashing solid-state strobe light

(b) In addition other noteworthy features include:

i.) Simple operator activation,
ii.) Zero warm-up period, full performance at switch on,
iii.) Extended continuous operational life,
iv.) Self contained long storage life integral batteries,
v.) Internal self test capability,
vi.) External programming interface,
vii.) Highly resilient external antenna, and
viii.) Indication of prior activation.

3.3 Technical Specification

The product family has been design to comply with, and subsequently tested to the COSPAS-SARSAT documents T.001 and T.007, respectively. The requirements of these documents relate to the technical compatibility and operation of the beacon within the COSPAS-SARSAT constellation of Polar-Orbit and Geo-stationary Search and Rescue (SAR) satellites.

At present the MT400 design is approved as a Class 2 type which identifies it as having an operational temperature range of -20°C to +55°C.

In addition various region standards exist which specify the physical performance, construction, operation and miscellaneous other requirements which relate to emergency beacons (see 'Associated Documents'). These documents may also specify the performance of an included 121.5MHz homing transmitter and strobe light.

4. ELECTRICAL ARCHITECTURE – MT400

4.1 Overview

Drawing 41679-X (where X is the drawing issue) identifies the main electrical functional blocks of the MT400. Each of the blocks within the drawing is detailed below.

	CAUTION: This equipment contains high energy Lithium cells. Service to be carried out only by suitably qualified personnel familiar with safe handling practices, procedures and precautions. Ensure that the assembly and operation of this equipment is fully understood before commencing service.
	CAUTION: The strobe within this equipment produces a regular and intense visible emission. Avoid looking directly at the strobe without protective eyewear.
	CAUTION: Radio Frequency (RF) energy is present when circuitry is operating. Handling precautions required.
	CAUTION: This equipment contains static sensitive componentry. Handling precautions required.

4.2 Functional Blocks

B1 Voltage Reference

General

Provides a known voltage output which is largely unaffected by changes in input voltage, temperature.

Circuit

'To be developed in future versions, if required'

B2 Temperature Sensor

General

The Temperature Sensor provides an output which is directly related to the temperature of the sensor itself. Typically a linear output of volts per degree is generated, although other formats are available. Based on a known output at a

reference temperature it is possible to determine the current temperature of the sensor.

For this application the sensor must provide a highly repeatable output that is unaffected by temperature cycling and component aging. Additionally the sensor must be able to resolve very small changes in temperature, be monotonic and exhibit minimal hysteresis characteristics.

Physically the sensor must maintain intimate contact with the Quartz Resonator (B11) through techniques conducive to high thermal conductivity.

During times of rapid temperature change the high thermal conductivity ensures that there is minimal thermal lag between the Sensor/Resonator pair.

Circuit

'To be developed in future versions, if required'

B3 Optical Interface

General

The Optical Interface supports two-way data communications between the beacons microcontroller and an external device. Whilst this interface may be utilised at various stages of manufacture, or during repair, its primary purpose is to allow communications with a fully sealed device. Such a capability is important at the very final stages of production or at the dealer level where environmental seals have been tested and must remain in tact.

An optical interface has the benefits of not requiring the addition of a connector, which also minimises case penetrations, a potential source of leakage.

The particular implementation of this interface uses the units LED user indicator as a data transmitter. With the inclusion of minimal additional circuitry this LED indicator functions as a data receiver.

B4 Audible Indicator

General

The Audible Indicator is provided to complement the Visual Indicator (B28) with the intention of positively alerting an operator that the beacon has been activated.

During both self test and activation, the presence of a periodic tone burst, separated by short periods of silence, qualifies that the unit is fully operational.

The beacon circuitry includes a highly audible transducer which is stimulated by a waveform generated by the units microcontroller. The transducers audible intensity is somewhat diminished due to the sealed nature of the beacon, but the result is considered more that sufficient to fulfil the intended purpose.

The transducer provides optimal output level over one or more narrow bands of frequency.

Circuit

'To be developed in future versions, if required'

B5 Battery Cells

General

Two types of cell chemistry and battery pack configurations are used within the MT400 series of EPIRB:

Chemistry	Configuration	Model Variants (+GPS &FF)
$LiSO_2$	1 battery pack with 2 cells wired in series with integral fuse	MT400, MT401
$LiMnO_2$	5 parallel packs each of 2 series wired cells. EachpPack provided with fuse and reverse current flow protection	MT402, MT403

Two high energy density lithium cells are mechanically arranged to form a self contained and replaceable battery pack.

Either after unit activation, or upon reaching the prescribed operational shelf-life (which-ever occurs first), the pack(s) are replaced prior to redeployment of the unit into service.

Note: the LiSO2 configuration is subject to transport restrictions as hazardous cargo.

Circuit

'To be developed in future versions, if required'

B6 EEPROM

General

The Electrically Erasable Programmable Read Only Memory (EEPROM) provides a non-volatile storage medium used to retain all executable code and configuration/user specific variables.

EEPROM allows for its data contents to be replaced or updated without physical replacement of any componentry. Both an external programmer and the units microcontroller have the capability to erase or write to memory locations.

Certain protection mechanisms are available to protect against the inadvertent alteration of EEPROM contents, and restrict access to executable code contained therein.

Operational data and temporary variables may use RAM provided separately within the microcontroller.

Circuit

'To be developed in future versions, if required'

B7 ADC

General

The Analogue to Digital Converter (ADC) provides a coarse resolution numerical digitisation of the analogue voltage output by the RF Detector (B26). This value is then made available to the microcontroller.

Primarily provision of the ADC allows the unit to verify that RF power levels are within acceptable limits during self-test operation.

Other uses are possible such as demodulation of the RF envelope or implementation of a power control feedback loop. Initially it is not proposed to include the afore mentioned features.

Circuit

'To be developed in future versions, if required'

B8 Solid-state Switch

General

The Solid-state Switch consists of a series pass MOS device inserted into the battery positive supply line. Whilst the beacon is inactive the MOS gate is held to the battery voltage thereby placing ensuring a very high series resistance. Battery load in this state is negligible.

When the gate is pulled to ground, the MOS device conducts and allows current to pass. This is the beacon active state.

The ON/OFF push button switch can be used to enable beacon power. Closure of the switch immediately pulls the gate low and thereby allows the MOS device to conduct (*on/off-2*). When the contact opens the gate is released after a time delay attributable to the inclusion of an RC circuit, and beacon power is then disabled.

Another input (*on/off-3*) is provided an operates in a fashion identical to 'on/off-2'. This control accepts input from the Water Activation Sense circuitry (B33) provided on model variants so equipped.

During normal activation, a mechanical slide mechanism keeps the contacts closed by holding the switch in a depressed state.

A second activation mechanism involves the Microcontroller (B17) asserting a control line (*on/off-1*) which drives a transistor switch placed electrically in parallel with the push button switch contacts.

For self-test operation, the push button is momentarily depressed, which in turn enables beacon power. The Microcontroller (B17) then asserts on/off-1 to ensure continuity of power. After completion of the self-test function, the microcontroller releases on/off-1. If the push button has been released then the unit power will be removed. If power remains for a specified period, the Microcontroller (B17) assumes that beacon activation is required. Thereafter, the release of the push button switch causes the unit to power down.

Circuit

'To be developed in future versions, if required'

B9 Switchmode PSU

General

The Switchmode PSU (Power Supply Unit) is a high efficiency step up supply capable of delivering high currents from a battery source.

Its output is use to supply the Radio Frequency (RF) power amplifier stages.

The design has been optimised to provide good performance during the short but regular periods of high current demand by the PA Driver [406] (B19) and Power Amplifier [406] (B23), whilst also achieving acceptable performance at much lower current levels necessary to support extended operation of the Power Amplifier [121] (B24).

To minimise the presence and amplitude of switching sidebands on the RF envelope the PSU circuit has been developed to keep the switching frequency above 30kHz under all operational conditions. Extremely low ESR (Equivalent Series Resistance) filter capacitors have been adopted within the design.

During normal operation the battery input voltage is always lower than the supplies 7.2V nominal output. Input levels above 3.6V enable the PSU to delivery at least 1.8A at its nominal output voltage.

Applied input voltages should not exceed 8.0V to avoid damage to follow on power circuitry, as the PSU does not provide any protection in this respect. For inputs above approximately 7.4V, the input appears at the output, less a diode induced voltage drop, and switching operation halts.

Circuit

'To be developed in future versions, if required'

B10 Linear Regulator

General

The Linear Regulator accepts an input voltage and produces a stable fixed output voltage which is largely independent of load and temperature. The Linear Regulator also rejects input noise to achieve a very clean output.

This is an Ultra Low Drop Out (ULDO) type ensuring operation at rated load down to within 100mV above the nominal output of 3.3V DC.

Circuit

'To be developed in future versions, if required'

B11 Quartz Resonator [S]

General

This is a high quality quartz crystal element. It has been optimised to eliminate/reduce the occurrence of activity dips and micro-jumps.

The Quartz Resonator [S] and Temperature Sensor (B2) enjoy a tight thermal coupling.

Circuit

'To be developed in future versions, if required'

B12 Oscillator [S]

General

The oscillators operational frequency is determined by the thermally monitored Quartz Resonator [S] (B11). The oscillator includes a first order of frequency/temperature correction based on the general characteristics of the resonator.

Circuit

'To be developed in future versions, if required'

B13 Direct Digital Synthesis

General

The Direct Digital Synthesis (DDS) function is a numerically controlled oscillator employing a phase accumulator, sine look-up table, DAC and RF output filter. Based on a reference input frequency, the DDS is able to produce a signal of specified relative frequency and phase, both of which can be precisely controlled in very fine increments.

Common usage of DDS involves provision of a high stability reference signal from which an output frequency can be synthesised with certainty and stability traceable to the reference.

Where both the temperature stability characteristics and temperature of the reference are known, it is possible to adjust the synthesis function in a manner which produces an output which is largely independent of temperature.

The synthesis function is controlled by the Microcontroller (B17).

Circuit

'To be developed in future versions, if required'

B14 ADC

General

Dual high precision 12 bit Analogue to Digital Converters (ADC) are to is provided to numerically digitise both the Voltage Reference output (B1) and the Temperature Sensor output (B2).

Both values are then made available to the Microcontroller (B17).

Circuit

'To be developed in future versions, if required'

B15 PLL Multiplier [406]

General

The PLL Multiplier [406] includes phase detector, voltage controlled oscillator, frequency divider and loop filter functions to produce an output which is precisely 64 times the input frequency.

RF output is disabled should an out of phase lock condition be detected.

Loop dynamics have be selected to achieve required phase modulation rise and fall times.

Circuit

'To be developed in future versions, if required'

B16 Quartz Resonator [H]

General

This is a standard quartz crystal specified for parallel resonance operation. It has defined accuracy, aging and temperature characteristics.

Circuit

'To be developed in future versions, if required'

B17 Microcontroller

General

The Microcontroller is responsible for executing the products firmware and interfacing with the provided peripheral devices.

It is a low current design and includes protective features including 'watchdog timer' and low voltage detect functions.

Circuit

'To be developed in future versions, if required'

B18 DAC

General

The Digital to Analogue Converter (DAC)provides a coarse (#bit resolution) voltage output which feeds the Power Amplifier [406] (B23) bias circuitry. The output level is under the control of the microcontroller.

The voltage is set during manufacture as part of the automatic alignment process and is not normally subject to change except during service of the unit.

Circuit

'To be developed in future versions, if required'

B19 PA Pre-Driver [406]

General

The PA Pre-Driver [406] is a single stage class C RF amplifier with narrowband 50ohm matched input and output impedances.

Circuit

'To be developed in future versions, if required'

B20 PLL Multiplier [121]

General

The PLL Multiplier [121] includes phase detector, voltage controlled oscillator, frequency divider and loop filter functions to produce an output which is precisely 32 times the input frequency.

RF output is disabled should an out of phase lock condition be detected.

Circuit

'To be developed in future versions, if required'

B21 PA Driver [406]

General

This is an intermediate stage of amplification which raises the RF power level to the amplitude required by the Power Amplifier [406], B23.

This is an intermediate amplification stage necessary to develop sufficient RF drive level into the.

It is operated as a Class C amplifier and therefore does not draw any bias current.

Circuit

'To be developed in future versions, if required'

B22 PA Driver [121]

General

The B22 is a broadband power amplifier and buffer which is driven by the VCO of the PLL Multiplier [121] (B20).

An analogue input is provided which can be used for gain control, including on-off (OOK) keying.

Circuit

'To be developed in future versions, if required'

B23 Power Amplifier [406]

General

This amplifier is capable of producing in excess of 5W of RF output power at 406MHz indefinitely when operated with an approximate duty cycle of 0.5s ON, 50s OFF.

> **NOTE1:** Whilst the amplifier design is capable of continuous operation the heat sinking provided has been dimensioned to support the low operational duty cycle requirements. This is an important point to consider during product servicing. Continuous operation should be limited to no greater than 5 seconds, with allowance for a cool down period before repeating the action.

Bias current is set by a voltage input provided specifically for this purpose. Being a Metal-Oxide Silicon (MOS) device the bias input draws very little DC current. The amplifier draws negligible current when the bias input is held near 0V potential.

Circuit

'To be developed in future versions, if required'

B24 Power Amplifier [121]

General

The Power Amplifier [121] is a single stage class C RF amplifier rated for 100% duty cycle.

Circuit

'To be developed in future versions, if required'

B25 Combiner/Matching

General

The Combiner/Matching circuitry enables two discrete power amplifier stages to feed the single Dual Band Antenna (B1) via the RF Detector (B26).

All impedance transformation and antenna matching is performed by this part of the circuitry.

Circuitry

'To be developed in future versions, if required'

B26 RF Detector

General

The detector rectifies the AC (RF) voltage present at the antenna feed point and passes it through a low pass filter. The output voltage level is a time integrated representation of the absolute magnitude of the RF envelope.

Circuitry

'To be developed in future versions, if required'

B27 Dual Band Antenna

General

The antenna electrical design is a basic monopole end fed with respect to the units internal chassis screening. In turn, that part of the screening lining the inner face of the chassis and which is below the water line, capacitively couples into the surrounding water. Accordingly the surrounding water surface and monopole form the complete RF radiator.

The monopoles length has been selected to achieve the required (and specified) radiation pattern at 406MHz. At 121.5MHz the monopole is electrically quite short.

The monopole does not include any integrated impedance transformation features, however the feed capacitance at the base of the antenna has been minimised. This is to assist in achieving an acceptably broad impedance match to the respective Power Amplifier [121], B24.

Circuitry

'To be developed in future versions, if required'

B28 Visual Indicator

General

The unit includes a high intensity flashing strobe which is visible above the water line through the opaque cap assembly.

Depending upon the model configuration either 1 or 3 high intensity Light Emitting Diodes (LED) are fitted.

Circuitry

'To be developed in future versions, if required'

B29 Oscillator [H]

General

This is a low frequency Colpitts oscillator. It uses the Quartz Resonator [H] (B16) to accurately control the frequency of operation. The output is suitable for feeding a phase detector.

Circuitry

'To be developed in future versions, if required'

B30 GPS Receiver]

General

A low power GPS 16 channel (min) macro module is employed for this function. Interface with the EPIRB microcontroller (B17) is via bidirectional serial interface.

The GPS module includes a low noise front end compatible with a passive antenna.

The GPS operates as a slave to EPIRB microcontroller commands.

Circuitry

'To be developed in future versions, if required'

B31 High Pass Filter

General

The high pass filter has a cut-off frequency of approximately 400MHz. Its primary function is to reduce homing transmitter fundamental and low order harmonic energy reaching the GPS Receiver (B30) front end. The presence of such energy can affect the GPS receiver's ability to receive satellite signals that are low in level.

Circuitry

'To be developed in future versions, if required'

B32 Quadrifilar Helix Antenna

General

A passive quadrifilar helix GPS antenna is employed. The reduced near field performance of this antenna makes it highly immune to detuning effects potentially caused the presence of obstructing objects in contact with the EPIRB, and the presence of water film over part of the chassis radome structure.

Circuitry

'To be developed in future versions, if required'

B33 Water Activation Sense

General

The water sense circuit detects the presence of a conductive path between two external sense contacts. The sensitivity of the circuit is such that activation in fresh water will also occur. Additional features include:

- Activation defeat. The presence of a magnetic field is used to disable this function whilst the EPIRB is stowed in it mounting bracket/housing. Whilst defeat is active, voltage potential between the sense contacts is removed to avoid electrolytic damage.
- A monostable circuit is employed to hold the activation output on during short interruptions to the conductive path. This is to ensure continuity of operation should wave motion toss the EPIRB out of the water from time to time during normal operation.

The Water Activation Sense provides input to the Solid State Switch (B8) *on/off-3*.

Circuitry

'To be developed in future versions, if required'