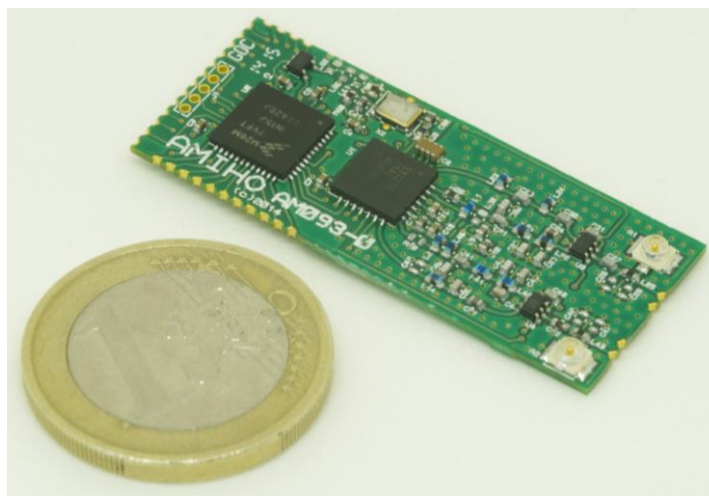**AMIHO technology**

Datasheet DS0011
AM093 Wireless Meter-Bus Dual Band 169/868MHz Narrowband Modem
Advance Information
Production Status – Production

Important Information – The information contained in this document is subject to change without notice. Please contact AMIHO Technology before using this information to design your product.

The AM093 Wireless Meter-bus (W-MBus) 169/868MHz modem uses the Freescale KL26 Kinetis ARM Cortex M0 microcontroller and a Semtech SX1276 Radio Transceiver to form a compact dual band 100mW module.

The AM093 is supplied optimised for peak power on either the 169MHz output (AM093-169) or 868MHz output (AM093-868).

The module uses an AT command interface and supports a very low current standby modes for battery powered applications. It is designed specifically for use in Wireless Meter-Bus applications and is supplied with an EN13757-compliant Wireless Meter-Bus software stack, but is also suitable for other ISM-band applications including KNX.

Features

- *Wireless Modem:* Use in stand-alone modem mode, or embed user application alongside stack.

- *RF modes:* Suitable for narrow-band operation at 169 MHz and 868 MHz and wideband operation throughout 868MHz ISM band

- *Hardware:* ARM ® 32-bit Cortex M0+ MCU with built-in 128kB Program flash, 16kB RAM and optional 32kHz RTC. High-speed precision ADC and DAC for audio and measurement applications, additional USB, UART and I2C.

- *Application Support*: Application notes for antenna selection and for meter and concentrator applications, including sample software. AE093 Evaluation Kit with example applications. Freescale CodeWarrior project files available on request.

- *Software Support:* Full low level platform, drivers and EN13757-4:2013 Wireless M-Bus RF stack level drivers provided plus utilities and sample application code.

- AM093-868 Supports S, R and T modes, and optionally C mode, as well as AES128 encryption.

- AM093-169 Supports N mode (sub modes a-f).

- *Software Upgrade:* Extension of software stack to include OMS and EN13757-5:2008 software modules.

- *Compliance:* The design complies with European Union radio standards (EN300220).

- *Tools:* Utilities available to help debug user application; supported by Freescale CodeWarrior

Specification

Microcontroller & RF transceiver	Freescale KL26Z128
Program memory	128kB flash
Data memory	16kB RAM
	Dataflash driver for user storage
Supply Voltage	1.8 – 3.6 V (min 2.4V for +20dB output power)
Maximum output power	+20 dBm intermittent
	+17 dBm continuous
Sensitivity	-123 dBm / 1.2 kbits/sec, FSK modulation
	-109 dBm / 38.3 kbits/sec, FSK modulation
	-95 dBm / 260 kbits/sec, FSK modulation
	* prefer to have 100kbps
	-148dBm / xx bps, spread spectrum modulation
Current Consumption (provisional)	17 mA / receive
	26 mA / transmit (7dBm)
	95 mA / transmit (+17dBm)
	130 mA / transmit (+20dBm)
	tbd uA / sleep (timed wake-up)
	tbd uA / deep sleep
Temperature range	-30 ^{O}C * / +85 ^{O}C

Physical / Hardware

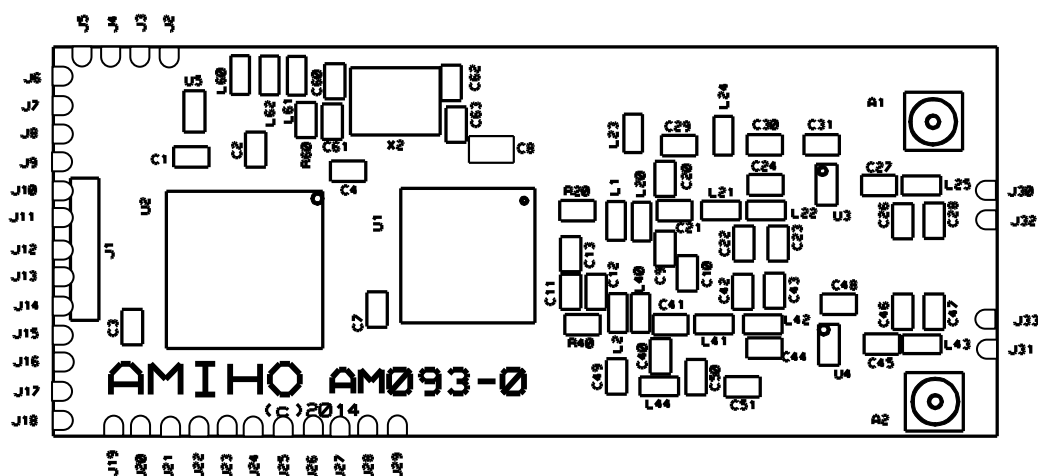|	
Dimensions	42.5 x 17.5 x 2.5 mm approximate size
Connections	1.27 mm pitch SMD edge connectors for PCB mounting
	CMOS-level UART interface
	12 x Analogue inputs/GPIO
	11 x additional GPIO, including special functions such I2C, USB, SPI and UART
Programming/debug	SWD debug interface

Software

EN13757-4:2013 wireless meter-bus stack

AT command interface for stand-alone modem operation

Built-in profiles for rapid mode switching

M-bus S, R, T, C and N mode packet interface

API to add higher layer M-bus protocols

API to allow other protocols to be added

Packet sniffer mode

Network formation mode

Pulse counter application

Power management

Example gas meter application

Ordering Information

| Part Number	Description
AM093-169	Base modem supporting N Mode
AM09x	Extended modem supporting Modes S, T and R2 and C according to EN13757-4:2013
AM09x	Extended modem with dedicated OMS application layer according to EN13757-4:2013
AM09x	915 MHz version with pseudo-W-Mbus modes
AE093	Evaluation kit for AM093 modems

1 Module Pinout

Application Connector

Edge connector is 1.27mm pitch half-holes, 0.75mm diameter.

Pin Number	Pin Name	Description	*KL26 Signal*
J1	Debug	Debug/Programming Header	See separate section
J2	USB_P	MCU on-chip USB P	USB0_DP
J3	USB_M	MCU on-chip USB m	USB0_DM
J4	I/O1	Spare GPIO / Analogue input	PTE20/UART0_TX/ADC0_SE0
J5	I/O2	Spare GPIO / Analogue input	PTE21/UART0_RX/ADC0_SE4a
J6	I/O3	Spare GPIO / Analogue input	PTE29/ADC0_SE4b/TPM0_CH2/ TPM_CLKIN0
J7	I/O4	Spare GPIO/Analogue Input/Output	PTE30/DAC0_OUT/ADCO_SE23/ CMP0_IN4/TPM0_CH3/TPM_CLKIN1
J8	I/O5	Spare GPIO / I2C	PTE24/TPM0_CH0/I2C0_SCL
J9	I/O6	Spare GPIO / I2C	PTE25/TPM0_CH1/I2C0_SDA
J10	VDD	System Power	VDD
J11	GND	System Ground	GND
J12	SWDCLK	Debug/Program/Spare GPIO	SWD_CLK/PTA0/TSI0_CH1/TPM0_CH5
J13	SWDIO	Debug/Program/Spare GPIO	SWD_DIO/TSI0_CH4/PTA3/I2C1_SCL/ TPM0_CH0
J14	RESET	Reset/Spare GPIO	Reset_b/PTA20
J15	I/O7	Serial Port 0_RX/Spare GPIO Default serial port for PCTool connection	PTA1/UART0_RX/TSI0_CH2/TPM2_CH0
J16	I/O8	Serial Port 0_TX/Spare GPIO Default serial port for PCTool connection	PTA2/UART0_TX/TSI0_CH2/TPM2_CH1
J17	I/O9	NMI/Spare GPIO	PTA4/TSI0_CH5/I2C1_SDA/TPM0_CH1
J18	I/O10	Serial Port 1_Rx/Spare GPIO	PTA18/EXTAL0/UART1_RX/TPM_CLKIN0
J19	I/O11	Serial Port 1_Tx/Spare GPIO	PTA19/XTAL0/UART1_TX/TPM_CLKIN1/ LPTMR0_ALT1

J20	I/O12	Spare GPIO/Analogue Input	PTB0/LLWU_P5/ADC0_SE8/TSI0_CH0/ I2C0_SCL/TPM1_CH0
J21	I/O13	Spare GPIO/Analogue Input	PTB1/ADC0_SE9/TSI0_CH6/I2C0_SDA TPM1_CH1
J22	I/O14	Spare GPIO/Analogue Input	PTB2/ADC0_SE12/TSI0_CH7/I2C_SCL/ TPM2_CH0
J23	I/O15	Spare GPIO/Analogue Input	PTB3/ADC0_SE13/TSI0_CH8/I2C0_SDA TPM2_CH1
J24	I/O16	SPI_MOSI/Spare GPIO	PTB16/TSI0_CH9/SPI1_MOSI/UART0_RX/ SPI1_MISO/TPM_CLKIN0
J25	I/O17	SPI_MISO/Spare GPIO	PTB17/TSI0_CH10/SPI1_MISO/UART0_TX/ SPI1_MOSI/TPM_CLKIN1
J26	I/O18	Spare GPIO/Analogue Input	PTC0/ADC0_SE14/TSI0_CH13/EXTRG_IN/ CMP0_OUT/I2S0_TXD0
J27	I/O19	Spare GPIO/Analogue Input	PTC1/LLWU_P6/RTC_CLKIN/TSI0_CH14/ ADC0_SE15/I2C1_SCL/TPM0_CH0/I2S0_TXD0
J28	I/O20	Spare GPIO/Analogue Input	PTC2/TSI0_CH15/ADC0_SE15/I2C1_SDA/ TPM0_CH1/I2S0_TX_FS
J29	I/O21	Spare GPIO/Analogue Input	PTC3/LLWU_P7/TPM0_CH2/I2S0_TX_BCLK/ CLKOUT
J30	ANT_GND _868	RF ground for the antenna connection 868MHz output	
J31	ANT_GND _169	RF ground for the antenna connection 169MHz output	
J32	ANT_868	RF signal out 868Mhz	
J33	ANT_169	RF signal out 169MHz	

J1 – Single Wire Debug/programme header.
    In addition to the edge connectors, the module may be powered and programmed via this
    1.27mm pitch 5pin header.


```
Pin1 – Vdd
Pin2 – GND
Pin3 – SDW_clk
Pin4 – SWD_dio
Pin5 - nReset
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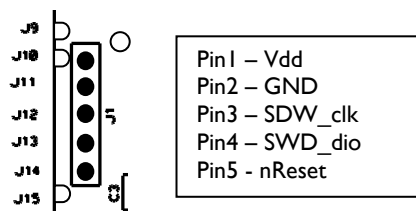
A1 – U.FL antenna connector, 169MHz RF.

A2 – U.FL antenna connector, 868MHz RF.

2   Module Description

The AM093 is a dual band 169 / 868 MHz narrowband modem with a 100mW transmission output, low-power, embedded module based on the Freescale KL26 Kinetis MCU and Semtech SX1276 RF transceiver.

The AM093 has been designed for maximum design flexibility and may be populated to generate its maximum output power on either the 169MHz port or the 868MHz port. Therefore there are two hardware variations of the AM093;

- 169MHz, 20dBm & 868MHz, 14dBm
- 868MHz, 20dBm & 169MHz, 14dBm

For both modules receive sensitivity is maximised on all RF ports.

Included on the module is discrete matching and filtering for the respective frequency of operation and associated matching network for a 50 ohm output impedance. For optimum performance the user must add any additional network components required to match the antenna to a 50 ohm impedance off-module.

The MCU handles the protocol, provides hardware interface and the software platform to run user application code. It also includes a dedicated data flash memory for system and application data storage.
The RF transceiver chosen is capable of both FSK/OOK modulation and Semtech's LoRa(TM) modulation scheme for increased range/sensitivity.

The transceiver provides the RF interface and low-level RF protocol handling as well as part of the network security. A programming / debug interface enables in-circuiting reprogramming and processor-level development and debug using the Freescale CodeWarrior IDE.

The AM093 is fitted with a temperature compensated oscillator (TCXO), for frequency accuracy, particularly at 169MHz and LoRa operating modes. The AM093 has provision for the TCXO and associated circuitry to be changed in order to assess operation with a standard crystal oscillator. Contact Amiho for adapted modules.

2.1 Functionality Overview

The integrated microcontroller is pre-loaded with an Amiho firmware image which hosts an AT command interface and supports very low current standby modes for battery powered applications. It is designed for use specifically in Wireless-MBus applications and is accompanied by a software stack to implement the low-level drivers, Wireless-MBus stack and core software platform.

The module may be used as a stand-alone modem, or as an embedded module which allows the user to run their application on the module.

The module design and software stack is also suitable to be used as a reference for embedding into a third party design.

The AM093 has the following features:

- A programming / debug interface enables in-circuiting reprogramming and processor-level development and debug using Freescale Code Warrior or other suitable software tool.
- Header pads along the edges of the module give access to the UART used for AT command modem control. Thus the AM093 may be used as a stand-alone modem, and according to application software may include a pulse counter and wake-up interrupt.
- Further analogue inputs and output, GPIO and processor peripherals are also brought out to header pads. These may be used in a custom module application.

The detailed use of the GPIO and peripheral functionality of any pin of the AM093 is fully specified in the Freescale datasheets and reference manuals for the KL26. Refer to these for further technical details.

2.2 Firmware Overview

The AM093 is pre-loaded with the AMIHO Wireless-Mbus stack and by default will start automatically from power-up and run an AT-command set modem interface on the UART serial lines.

For further information about the interface protocol, firmware and the use of the module for Wireless-MBus applications, please refer to the following AMIHO documents:

TD0014 AT Command Set
TD0015 for information on the use of W-Mbus.

The default serial link is:

- RS232 at CMOS level. Full Duplex
- KL26 Uart0, on port lines PTA1, PTA2
- 57600 baud
- 8 bits
- No parity
- No flow control

2.1.1 Configuration

Configuration data for the module is stored in the non-volatile data flash on the microcontroller. This holds the network addresses, encryption keys and module behaviour including radio profiles transmission modes, transmission times etc.

Unreserved space is available for the user application.

2.1.2 Wake-Up and Data Available

The modem is designed to use a single pair of UART RX/TX lines for handshaking and control.

Wake-Up
By default the modem uses a CLI command (a null character) to wake up from sleep. Optional configuration enables the modem to be woken on a GPIO line.

Data Available

By default, the modem uses a store and forward methodology, and the host polls the modem to check for new data, allowing the host to sleep or do other tasks until it is ready to read the message. This is the recommended method. Optional configuration options allow the modem to signal that a message has been received either by asserting the *data available* line or placing a dummy character on the UART RX line. It is also possible to enable the modem to output message data on the UART RX line immediately.

2.1.3 Configuration Rebooting

The module is expected to run continuously, entering a low-power state when not transmitting or receiving. The unit may be rebooted deliberately by re-powering the unit, or by issuing a software reboot command.

Diagnostic information, including 'up-time' is held in the unit.

2.1.4 Re-programming

Access is given, via the edge connectors and J1 to the Freescale SWD pins for debugging purposes. The user may reload the AM093 with custom firmware using a suitable software development environment. AMIHO may additionally undertake the development of alternative firmware under a customer contract.

3   Operating Characteristics / DC Electrical Characteristics / AC Electrical Characteristics

Absolute Maximum Ratings

Parameter	Min	Max	Unit
Supply Voltage	-0.3	3.8	V
Voltage on any pin	-0.3	VDD + 0.3V	V
Input RF level		10	dBm
Storage temperature	-55	115	^{O}C

Recommended Operating Conditions

Parameter	Min	Max	Unit
Supply Voltage	1.8	3.6	V
Logic Input Voltage Low	-0.3	30% VDD	V
Logic Input Voltage High	75% VDD	VDD	V
Logic Output Voltage Low (Imax = -1 mA)	0	10% VDD	
Logic Output Voltage High (Imax = 1 mA)	90% VDD	VDD	
Input RF level		10	dBm
Operating temperature	-40	85	^{O}C

4   Mechanical Specification

The AM093 module is a 0.8mm thick PCB-based radio-modem design. It is suitable for SMD PCB mounting and is designed to be operated without additional electrical screening or mechanical protection.

4.1 Module Dimension

The overall module size is 42.3mm x 17.5mm x 2.5mm, with components only on one side of the board.

5   Mounting

The AM093 is suitable for surface-mount pick and place operation. During assembly it is to be mounted onto the top side only of a customer PCB, unless special manufacturing precautions are taken.
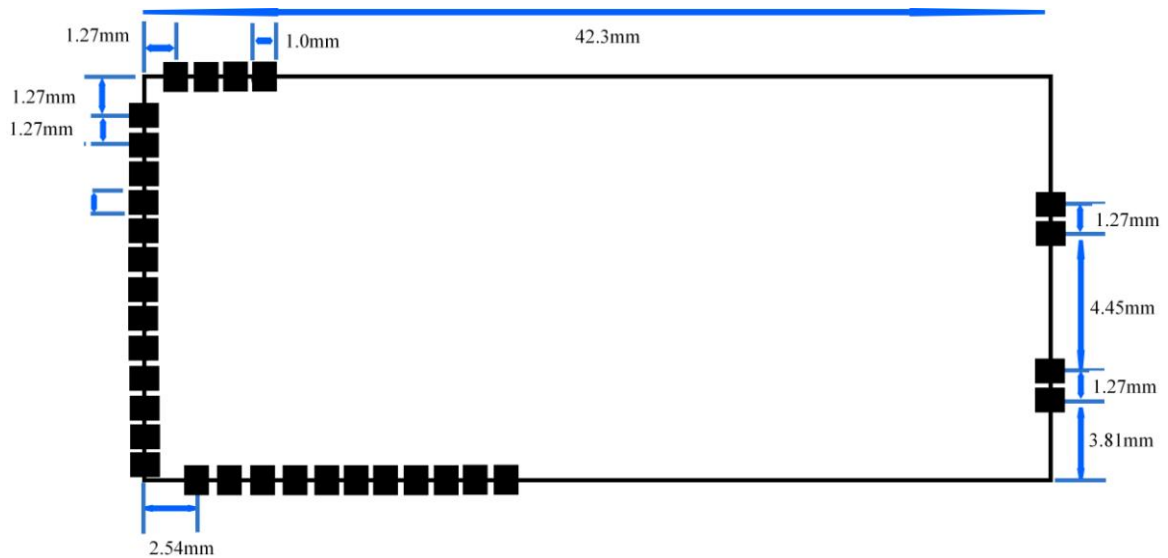
5.1.1 Soldering

The module MUST pass through a reflow soldering process with the components on the top side. Reflow-soldering the module upside down may result in damage to the module.
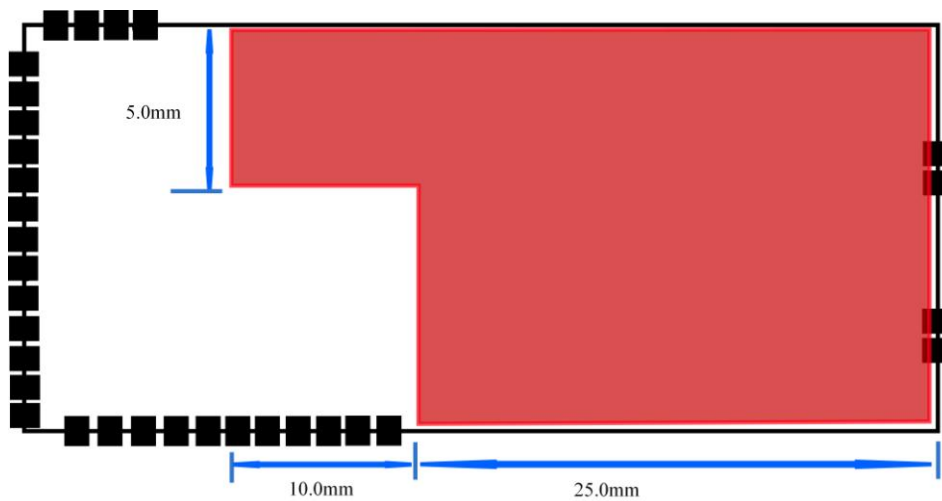
5.1.2 Module Detail
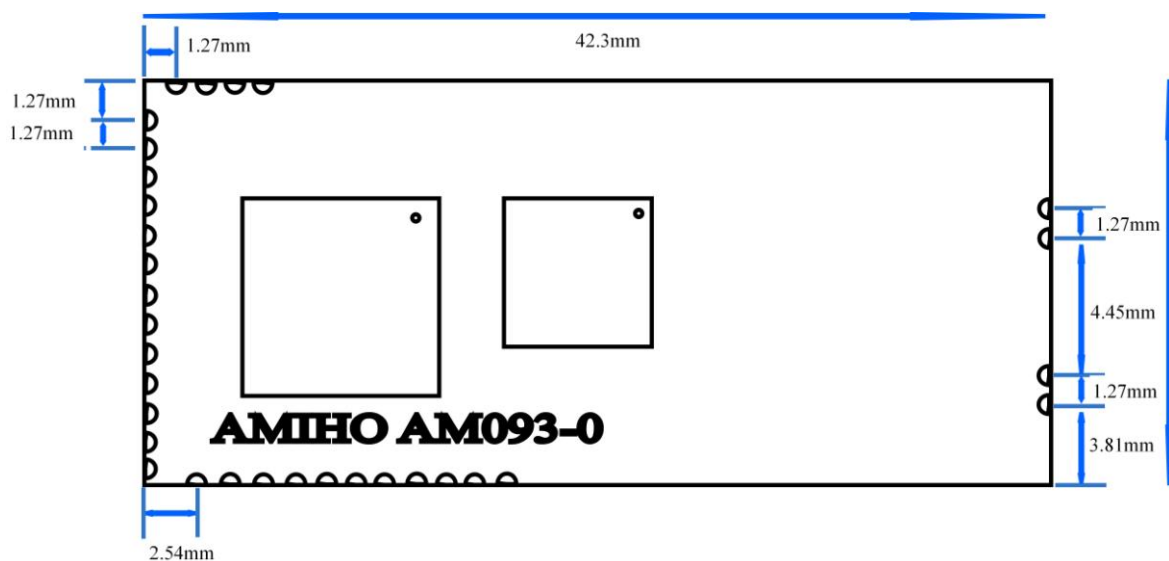
5.1.3 Recommended Solder Pad Pattern

5.1.4 Keepout Area

There must be no signals routed within the red keep-out zone on the top layer of the PCB to which the AM093 is mounted.

Any routing under the AM093 are to be low frequency signals only, unless the PCB is multi-layer and the layer immediately under the AM093 is a ground plane.

5.1.5 Power supply decoupling

There is local decoupling on the MCU power pins within the AM093. The power supply to the AM093 must be decoupled closely to the power connections. There must be a minimum of a low ESR 10uF capacitor is e.g.:

Murata 10uF 6.3V 0603 ceramic, part no. GRM188R60J106ME47D.

6   RF Layout

To ensure optimal performance from the module it is important that a good RF layout is achieved:

- The module ground pins must be connected to a solid ground plane.
- Connect the antenna ground to the ground plane with a single connection.
- Fill all unused PCB area around the module with ground plane.
- If the ground plane is on the bottom of the PCB only, then use several metal vias to connect the ground pins to the ground plane to minimise inductance.

6.1.1 Antenna connection

The AM093 has been designed with a 50 ohm output for direct connection to a matching impedance antenna. Amiho have matching circuits detailed for the use of other antennae – see application note TN0020.

7   Operating environment

- The AM093 is designed for operating temperature range:
  - -30 $^{\circ}$C / +85 $^{\circ}$C
- The AM093 would normally form part of a static installation and would either be incorporated into a larger unit or designed into the circuitry of a larger unit. Care should be taken to ensure that conductive materials mounted close to the board do not adversely affect the RF performance of the unit.
- The normal equipment environment for the product in use might be indoors or outdoors.
- The AM093 is suitable for both continuous and discontinuous operation.
- It is not expected to require servicing

8   Ordering Information

The AM093 series of modules are available in a number of customer build and software options – see the table on page 2 for current and planned versions e.g.:

AM093-00-01.01

i.e. EN13757-4:2013 Wireless-MBus stack; AT modem s/w release 1.01; 868MHz operation

Other versions can be built to order and may also be available off the shelf or with a short lead time. These include variations in software functionality and components fitted. The build options are defined as follows:

AM093-xx-yy.zz

where: **xx** *denotes the s/w type;* **yy** *is the major version,* **y** *is the minor version*

9   Standards and regulations

Radio stack and Data Interface: EN13757-4
Radio Approvals: EN 300 220 Pt 2
RoHS Compliance: Directive 2002/95/EC

10 Contact / Further Information

Contact AMIHO Technology for further information at:

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11 Document History

Revision	Date	Changes
0.1	27/01/2015	Draft
0.12	09/07/2016	Typos and voltage spec