Ultrasonic LTE
User Manual

Ultrasonic NB-IoT/CAT-M1 User Manual

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1. Product Description

The Ultrasonic 4G NB-IoT/CAT-M1 Sensor is a flexible and configurable battery-operated liquid level sensor with integrated Cellular modem supporting GSM (2G), LTE-CAT M1 & NB-IoT networks which uses ultrasonic technology to measure the liquid level of your tank and then communicates this data in a binary message to a remote server via a TCP connection.
The Ultrasonic sensor contains an internal temperature sensor which measures the temperature and a reed switch for activation and initiating manual measurements.

1.1 Abbreviations/Definitions

The following is a list of terms that may be found in this document.

Ullage	The unfilled space between the sensor and the top of the liquid being monitored
RSSI	Received Signal Strength Indicator
SRSSI	Sonic Received Signal Strength Indicator
SRC	Sonic Results Code
CRC	Cyclic Redundancy Check
RTC	Real Time Clock
HW	Hardware
FW	Firmware
Ack	Acknowledgement from the LoRaWAN network server
Message	The data packet / payload / datagram sent across the network
MSB	The Most Significant Bit is the left-most bit in the string
Payload	Data transmitted between sensor and LoRaWAN network
0x	Identifies the number as hexadecimal. Note: numbers are assumed decimal unless specified otherwise.
0b	Identifies the number as binary. Note: numbers are assumed decimal unless specified otherwise.
Unsigned byte	Will only allow you to represent numbers in the positive range
Signed byte	Will allow you to represent numbers both in the positive and negative ranges
Waveguide	A waveguide option allows the ultrasonic reading to be measured through a waveguide pipe inserted into the tank to avoid any obstacles/obstructions that may affect the standard ultrasonic reading
IoT	Internet of Things
Dormant	Dormant units are inactivated to ensure the longest battery service life
POR	Power Out Reset
BOR	Brown Out Reset

2. Configuring Device

2.1 Network Server Response

Every time a sensor makes an outgoing status connection to the gateway, the network server has the option to respond with configuration settings to alter the operation of the device.
Sending responses to the sensor is very useful for tasks such as changing the ultrasonic profile or the connection schedule. Care must be taken, as sending the wrong settings could render the device incapable of correct operation.

2.2 Message Types

The sensor transmits or receives several packet types.

The standard message is referred to as a message type 4 and is transmitted based on a schedule defined by S2 Schedule Configurator register.

For message type 4, the unit transmits only the updates to the 28-position log i.e. only those values that have changed since the last transmission.

In the event of an alarm condition, the unit transmits a message type 8 which transmits the contents of the faster buffer log as this is the data that will have triggered the alarm. The exception is a no change alarm which is based on the log values in that case a message type 4 (with all 28 values in the logger buffer) is sent as this is what will contain the relevant data.

Message Type	Description
Message 4	**Standard results from sensor.** (Most common Message type) The scheduled data upload is referred to as a message type 4 and will contain new logging buffer values since the last schedule upload, along with additional information.
Message 6	**Sensor Settings.** A message type 6 can be requested from the sensor with the command R1=02, R1 = 04 or R1 = 08. A message type sends the contents of the S registers (and may be truncated to 140 bytes if configured to send data via SMS). The response to R1=02 is the settings starting from S0, R1=04 is the settings starting from S12 and R1=08 is the settings starting from S19.
Message 8	**Similar to message 4 with alarms or sensor waking up.** A message 8 is transmitted when an alarm is activated or when the sensor is activated with a magnet. A message type 8 contains the ullage values contained in the sampling buffer (because these are the values used to trigger the alarm). The exception to this is a no change alarm in which case a message type 4 is transmitted (with the logger buffer values as those are the data points used for that particular alarm).
Message 16	**ICCID and modem information.** A message type 16 is sent to the server when the command R6=02 is received by the sensor. This message type also contains additional status information.
Message 17	**GPS details.** A message type 17 is related to GPS information

2.2.1 Header Message

The header of the message is always the same for all message types up to byte 16.
The following table contains the 16-byte header message.
**Please note that all Hexadecimal entries require CAPITAL lettering.*

2.2.1.1 Product ID reference

TEK #	PROD ID field
TEK 766	00
TEK 586	02
TEK 790	03
TEK 733	05
TEK 643	06
TEK 811	07
TEK 822	08
TEK 733A	09
TEK 764	255

Byte 15 highlights the message type and therefore how to interpret the rest of the message.

Sample Payload: (Payloads are Hexadecimal)
072102018B0634086642503067213504 7B00018D03DC3C8201000A6328770A6328770000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
035C6

Byte#	Payload	Description	Notes	Result
0	07	Defines the product type	0x07 = TEK 811 *(See section 2.2.1.1)*	TEK 811
1	21	Defines the Hardware Revision Major 5 bits of Byte 1 = 4 -> BG96 Minor 3 bits of Byte 1 = 1 -> Pcb Rev1	0b00100001	BG96/pcb rev01
2	02	Defines the Firmware Revision Minor 5 bits of Byte 2 = FW Major Revision Major 3 bits of Byte 2 = FW Minor Revision	Minor 5 bits of 0x02 = 0b00010 = 2 Major 3 bits of 0x02 = 0b000 = 0	2.0
3	01	Defines the reason for contact *(See Section 2.2.1.1)*	0x82 = 0b00000001	Scheduled
4	8B	Defines the Status of Alarms *(See Section 2.2.1.2)*	0x86 = 0b10001011	Active/No Bund/Lim2/Lim1
5	06	Defines the CSQ result from Modem AT+CSQ query	0x06 = 6	CSQ=6
6	34	Defines battery & RTC status *(See Section 2.2.1.3)*	0x34 = 0b00110100 RTC Set Flag bit 6 =1 Batt lower 5 bits= (21 + 30) / 10	RTC Set Batt = 5.0 Volts
7	08	Defines the IMEI number	Concatenation of bytes 7 to 14	IMEI: 0866425030672135
8	66			
9	42			
10	50			
11	30			
12	67			
13	21			
14	35			
15	04	Defines the Message Type Minor 6 bits = Message Type	Minor 6 bits of 0x04 = 0b000100 = 4	Message Type 4
16	7B	Defines the length of the following payload (Bit5&Bit4 of byte 15 x 256) + Byte 16	• 0x04 = 0b00000100 = 0 • 0x7B = 123 (0 x 2^8) + 123 = 123	123

2.2.1.2 Contact Reason

Byte#3 Binary breakdown for contact reason:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Dynamic Limit2 Status	Dynamic Limit Status	TSP Requested	Reboot	Manual	Server Request	Alarm	Scheduled

2.2.1.3 Alarm/Status

Nyte#4 Binary breakdown for alarm status:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Active if Set	*Reserved*	*Reserved*	*Reserved*	Bund Status Set if closed	Limit 3 Set if alarm	Limit 2 Set if alarm	Limit 1 Set if alarm

2.2.1.4 Battery/Status

Byte #6 Binary breakdown for battery status:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	RTC set if true	Battery Status (BS) *(Battery Voltage =(30 + BS)/10 Volts)*				

2.2.2 Message Type 4 & 8

The following table is for a standard Message type 4 payload. Message type 8 will also follow this format.
This is a continuation of the preceding header message format, Section 2.2.1.
Sample Payload: (Payloads are Hexadecimal)
072102018B06340866425030672135047B00018D03DC3C82010F0A5B28770A5B28770A5B28760A5B28770A5B28770A5B28770A5B28770A5B28760A5B28760A5B28760A5B28760A5B28760A5D28770A5D28770A5D28770A5D28770A5D28770A5D28770A5D28770A5D28770A5F28770000000000000000000000000EEBA

072102018B06340866425030672135 is the message header, as defined in 2.2.1.

Byte#	Payload	Description	Notes	Result
15	04	Defines the Message Type Minor 6 bits = Message Type	Minor 6 bits of 0x04 = 0b000100 = 4	Message Type 4
16	7B	Defines the length of the following payload (Bit5&Bit4 of byte 15 x 256) + Byte 16	• 0x04 = 0b00000100 = 0 • 0x7B = 123 (0 x 2^8) + 123 = 123	123
17	00	Defines the message count (Byte 17 x 2^8) + Byte 18	(0x00 x 2^8) + 0x01 (0 x 2^8) + 1 = 1	1
18	01			
19	8D	RTC_Hours in 5 lower bits: Try Tickets in 3 upper bits	Major 3 bits of 0x8D 0b10001101 → 100 = 4 Try tickets remaining Minor 5 bits of 0x8D 0b10010111 → 10111 RTC 13:00 hours	4
20	03	Energy used for last contact (Byte 21 x 2^8) + Byte 19	0x03DC = 988 Units mA - Seconds	988
21	CD			
22	3C	Reserved	Reserved	N/A
23	82	Defines the logger speed *(See Section 2.2.2.1)*	0x82 = 0b10000010 → 2 x 15 = 30 mins → 0 hours 30 mins = 00:30	00:30
24	01	Count of 10-second increments taken for registering to cellular network + seconds to connect to GPRS server	0x01 = 1 x10 = 10 seconds	10
25	0F	Real Time Clock of TEK811 Unit (hh:mm) Hours(Minor 5 bits of Byte 19) + Byte 25	Hours as determined by Byte 19 + Byte 25 = 13hr : 15 mins	23:15:
26-29	0A5B2877	Data 0	*See Section 2.2.2.2*	*See Section 2.2.2.2*
30-33	0A5B2877	Data 1		
34-37	0A5B2876	Data 2		
38-41	0A5B2877	Data 3		
42-45	0A5B2877	Data 4		
4649	0A5B2877	Data 5		
50-53	0A5B2877	Data 6		
54-57	0A5B2876	Data 7		
58-62	0A5B2876	Data 8		
62-65	0A5B2876	Data 9		
66-69	0A5B2877	Data 10		
70-73	0A5B2876	Data 11		
74-77	0A5B2876	Data 12		
78-81	0A5B2876	Data 13		
82-85	0A5D2877	Data 14		
86-89	0A5D2877	Data 15		
90-93	0A5D2877	Data 16		
94-97	0A5D2877	Data 17		
98-101	0A5D2877	Data 18		
102-105	0A5D2877	Data 19		
106-109	0A5D2877	Data 20		
110-113	0A5D2877	Data 21		
114-117	0A5D2877	Data 22		
118-121	0A5D2877	Data 23		
122-125	0A5F2877	Data 24		
126-129	00000000	Data 25		
130-133	00000000	Data 26		
134-137	00000000	Data 27		
138-139	EEBA	N/A		

2.2.2.1 Logger Speed

- If byte 23 = 00 then the result = 1 [*Note: Special test setting, not advised for normal use*]
- If byte 23 = 80 then the result = 15
- If byte 23 ≠ 00 & byte 23 ≠ 80 then use minor 7 bits of byte 23 and multiply the result by 15.
- Result in minutes, convert to hours and then to 24-hour format (hh:mm)

Example:

Byte 23 = 55

- 0x55 = 0b01010000 → 85
- 85 x 15 = 1275minutes = 21.25 hours = 21 hours 15 minutes = 21:15

2.2.2.2 Measurement

RTC	cm	SRC	RSSI	ºC
RTC (Data 0): This is the measurement timestamp of the scheduled measurement sample taken immediately before the payload delivery. **RTC: (Data 1 – 27)** Subtract the logger speed from the RTC (Data 0) time to get this measurement timestamp.	This is the ullage measurement taken by the sensor. Combine Bit3&Bit2 with Bit1&Bit0. Result in cm of the 10 minor bits of this combination. Example: Bytes 26-29 = 0x0A5B2877 (0x28 = 0b00101000) (0x77 = 0b01110111) Combo = 0b0010100001110111 → 0b0001110111 = 119cm	This is the SRC measurement reported by the sensor. 4 major bits starting at bit 5 of Bit3&Bit2. Example: Byte26-29= 0x0A5B2877 0x28 = 0b00101000 0b00101000 → 0b1010 = 10	This is the SRSSI measurement reported by the sensor. 2 major bits of the byte. Example: Byte26-29= 0x0A5B2877 0x0A = 10	This is the temperature reported by the sensor, measured in °C. Bit5&Bit4 divided by 2. Subtract 30 from the result. Example: Byte26-29=0x0A5B2877 0x5B = 91 91/2 = 45.5 45.5 - 30 = 15.5°C

Description	Byte#	Payload	RTC	cm	SRC	RSSI	ºC
Data 0	26	0A5B2877	23:15	119	10	10	15.5
Data 1	30	0A5B2877	22:45	119	10	10	15.5
Data 2	34	0A5B2876	22:15	118	10	10	15.5
Data 3	38	0A5B2877	21:45	119	10	10	15.5
Data 4	42	0A5B2877	21:15	119	10	10	15.5
Data 5	46	0A5B2877	20:45	119	10	10	15.5
Data 6	50	0A5B2877	20:15	119	10	10	15.5
Data 7	54	0A5B2876	19:45	118	10	10	15.5
Data 8	58	0A5B2876	19:15	118	10	10	15.5
Data 9	62	0A5B2876	18:45	118	10	10	15.5
Data 10	66	0A5B2877	18:15	119	10	10	15.5
Data 11	70	0A5B2876	17:45	118	10	10	15.5
Data 12	74	0A5B2876	17:15	118	10	10	15.5
Data 13	78	0A5B2876	16:45	118	10	10	15.5
Data 14	82	0A5D2877	16:15	119	10	10	16.5
Data 15	86	0A5D2877	15:45	119	10	10	16.5
Data 16	90	0A5D2877	15:15	119	10	10	16.5
Data 17	94	0A5D2877	14:45	119	10	10	16.5
Data 18	98	0A5D2877	14:15	119	10	10	16.5
Data 19	102	0A5D2877	13:45	119	10	10	16.5
Data 20	106	0A5D2877	13:15	119	10	10	16.5
Data 21	110	0A5D2877	12:45	119	10	10	16.5
Data 22	114	0A5D2877	12:15	119	10	10	16.5
Data 23	118	0A5D2877	11:45	119	10	10	16.5
Data 24	122	0A5F2877	11:15	119	10	10	17.5
Data 25	126	00000000	10:45	0	0	0	-30
Data 26	130	00000000	10:15	0	0	0	-30
Data 27	134	00000000	09:45	0	0	0	-30

2.2.3 Message Type 6

The Message type 6 will contain the header message, followed by the settings of the unit.
This is a continuation of the preceding header message format, Section 2.2.1.

Sample Payload: (Payloads are Hexadecimal)
0720620461171808664250300823844609
53303D38302C53313D30352C53323D3746303033382C53333D36342C53343D303831452C53353D383833322C53363D383834362C53373D30302C53383D30302C53393D2B333533383631373536333636342C5331303D2B333533383631373536333636342C5331313D54454B3733332C5331323D73747265616D2E636F2E756B2C5331333D73747265616D69702C5331343D73747265616D69702C5331353D38342E35312E3235302E3130342C5331363D393030302C5331373D303034393030323832382C5331383D3530302C5331393D303030302C5332303D30302C5332313D2C5332323D2C5332333D31332C5332343D30302C5332353D30302C5332363D31302C5332373D3838D9BA,Z=BBCB

07206204611718086642503008238 4 is the message header, as defined in 2.2.1

06A9 Message Type 6, 265 bytes to follow.

53303D38302C53313D30352C53323D3746303033382C53333D36342C53343D303831452C53353D383833322C53363D383834362C53373D30302C53383D30302C53393D2B333533383631373536333636342C5331303D2B333533383631373536333636342C5331313D54454B3733332C5331323D73747265616D2E636F2E756B2C5331333D73747265616D69702C5331343D73747265616D69702C5331353D38342E35312E3235302E3130342C5331363D393030302C5331373D303034393030323832382C5331383D3530302C5331393D303030302C5332303D30302C5332313D2C5332323D2C5332333D31332C5332343D30302C5332353D30302C5332363D31302C5332373D3838D9BA
Message Body

The Message Body is asci hex coded binary is simply converted to an ascii string.
Each 2-character pair converts to an asci character.
E.g., 0x53 converted to a decimal value = 83. Decimal 83 converts to character 'S' from asci tables.
http://www.asciitable.com/
Using online convertor such as https://www.rapidtables.com/convert/number/hex-to-ascii.html

Converted to ascii:
S0=80,S1=05,S2=7F0038,S3=64,S4=081E,S5=8832,S6=8846,S7=00,S8=00,S9=+353861756364,S10=+353861756364,S11=TEK733,S12=stream.co.uk,S13=streamip,S14=streamip,S15=84.51.250.104,S16=9000,S17=0049002828,S18=500,S19=0000,S20=00,S21=,S22=,S23=13,S24=00,S25=00,S26=10,S27=88

Which is the complete string of Settings for the unit, each setting parameter is delimited using a comma.

2.2.4 Message Type 16

The following table is for a standard Message type 16 payload.

Sample Payload: (Payloads are Hexadecimal)
0721A10060171B0866425030678884102822C383933353330323132303539303037323430314 62C424739364D415230324130374D31472C858D,Z=28ED

0721A10060171B0866425030678884 header message as defined Section 2.2.1.

1028 Message type 16, 40 bytes to follow

2C383933353330323132303539303037323430314 62C424739364D415230324130374D31472C858D.
Message Body.

The Message Body is asci hex coded binary is simply converted to a ascii string.
E.g., using online convertor such as https://www.rapidtables.com/convert/number/hex-to-ascii.html
Which converts to
,8935302120590072401F,BG96MAR02A07M1G,

Where 8935302120590072401F is the ICCID of the sim card, and
BG96MAR02A07M1G is the firmware version of the modem.

2.2.5 Message Type 17

Message type 17 payload delivers to the server GPS positioning.

Sample Payload: (Payloads are Hexadecimal)
0721DF04830B380866425030679882114A2C34352C3131323330342E302C353330352E363231384E2C3030373533
2E35393537572C312E302C36322E302C322C3134322E34352C302E302C302E302C3039303531392C30392CE998

0721DF04830B380866425030679882 is the 15 byte message header, as defined in Section 2.2.1.

114A Message Type 17, 74 bytes

Message Body.
2C34352C3131323330342E302C353330352E363231384E2C30303735332E35393537572C312E302C36322E302C32
2C3134322E34352C302E302C302E302C3039303531392C30392CE998 message body.

The Message Body is asci hex coded binary is simply converted to an ascii string.
Eg, using online convertor such as https://www.rapidtables.com/convert/number/hex-to-ascii.html
Converts to:
,45,112304.0,5305.6218N,00753.5957W,1.0,62.0,2,142.45,0.0,0.0,090519,09,

The GPS location data consists of a series of comma delimited fields. (quoted from GPGGA sentence).

45	GPS	Time to Fix
112304.0	UTC	hh:mm:ss.s
5305.6218N	LAT	dd 00-89 (degree).mm.mmmm 00.0000-59.9999 (minute).
00753.5957W	LONG	dddmm.mmmm E/Wddd 000-179 (degree).
1.0	hdHop	
62.0	Alt	
2	Fix	GNSS positioning mode(quoted from GNGSA/GPGSA).
142.45	Cog	Ground heading based on true north. Format: ddd.mm
0.0	SpKm	Speed over ground. Format: xxxx.x, unit: Km/h
0.0	SpKn	Speed over ground. Format: xxxx.x, unit: knots,
090519	Date: dd/mm/yy	UTC date when positioning. Format: ddmmyy
09	nSat	Number of Satllites.

Note: The results string is separated by commas which are represented in the payload structure as ‘0x2C’.

3. Description of Data Transmission

3.1 S-Parameters (Settings)

The sensor is configured using the following S parameters. Blank values are undefined and can lead to inconsistent operation.

S-	Parameter	Description
S0	S-Logger Config	• How often a unit should store a reading. • How often a measurement is taken.
S1	GSM listen Config	• How long the unit remains active after powering up (Multiples of 5 minutes, Max of 155 minutes)
S2	Schedule Config	• Set schedule for when unit is to log data to server
S3	Control configurator	• Access Technology: (NBIOT/CATM1/GSM) • CRC checking • Bund Alarm
S4 & S5 & S6	Static alarms	• Alarm if measurement is higher or lower than a selected height.
S7 & S8	Dynamic alarms	• Alarm if measurement is rising or falling at a rate greater than selected.
S9	Primary Server SMS Phone number	• SMS fall back phone number.
S10	Reserved	• N/A
S11	Unit Password	• Password required in order to update or change settings to unit.
S12	GPRS APN (SIM card)	• Access Point Name. Name of the gateway to the server.
S13	GPRS APN Username (SIM card)	• GPRS APN Username. (SIM card)
S14	GPRS APN Password (SIM card)	• GPRS APN Password. (SIM card)
S15	Destination Server IP address or URL	• IP address or URL for server that unit is required to issue data to.
S16	Destination Server Port number	• Port number for server that the unit is required to issue data to.
S17	Ultrasonic measurement settings	• Determined by tank size and type.
S18	Tank height	• Height of tank in cm.
S21	MCC MNC (Network Operator Short Code)	• Mobile Country Code / Mobile Operator Code
S22	Operating Band Code	• LTE only
S23	Message deliver try configurator	• How many attempts to make data drop before falling back to SMS. • Time between attempts.
S24	Schedule delay	• How many minutes of a delay from the schedule set as S2.
S26	Control2 configurator	• Reserved Functions
S27	Sonic quality filter	• RSSI & SCR filter – Quality of ultrasonic measurement taken.

Note: Reserved- S19, S22, S25

3.2 Data recording – S0

The ultrasonic sensor is sampled and stored at various rates and stored in 2 different buffers, referred to as "Logging buffer" (Message type 4) and "Sampling buffer" (Message type 8).
The rate at which the sampling buffer is filled is the sampling period and can be set at once per minute or once every 15 minutes (set by the MSB of S0). The sampling buffer has 10 positions so will fill in either 10 minutes or in 2 hours and 30 minutes, depending on the setting of S0.
The rate at which the logger is filled is referred to as the logger speed and the rate at which it is filled can be set from once every 15 minutes up to once every 31 hours (in increments of 15 minutes) using the lower 7 bits of S0.
The log samples are synchronised to the real-time clock i.e. samples will be taken on the hour and multiples of 15 minutes after that. The log has 28 positions. Therefore, the logger will cover a minimum period of 28 x 15 minutes = 7 hours or a maximum of 31 x 28 hours = 868 hours. Each time a new sample is taken the oldest sample "drops off" the end of the log.

3.3 GSM listen time – S1

Once the unit has delivered its payload it can be configured to stay on the cellular network in listen mode to pick up any SMS that the user may wish to send to it. The duration that the unit will stay in listen mode after a scheduled upload is defined by the S1 setting. The listen time is set in increments of 5 minutes up to a maximum of 155 minutes. When the unit receives an SMS or TSP command the timer is reset, with the exception of an R1=80 command (see Section 3.17) which will cause the GSM module to shut down and enter sleep mode.
The duration that a unit remains connected to the GSM network is critical for battery life which must be balanced with allowing sufficient time for SMS commands to be received.
Unit will emit a beep once every 4 seconds when not sending or receiving data.
When the unit receives data, it will emit a high beep followed directly by a low beep.
When the unit has sent data, it will emit a low beep followed directly by a high beep.

3.4 Schedule configurator – S2

The system will upload the data from the logging buffer at regular intervals defined by settings in the S2 register (only values since the last scheduled upload will be transmitted). (See Section 3.16.3)
The unit can be configured to send data once per day on particular days of the week or can be configured to send more regularly i.e. every 2 hours or 4 hours, between specific times. These settings can also be over written to have unit send data fortnightly or monthly.

3.5 SMS Fallback

The unit can communicate over GPRS or via SMS. The default communication is over GPRS with the unit falling back to SMS in the event of the GPRS communications being unsuccessful.
For SMS fallback to work, the Sim Card and Network must SMS. S9 must be populated with the MSISDN (phone number) of an SMS listening service. The data delivered by SMS is uses the same format as for GPRS.

3.6 CRC checking – S3

CRC is a Cyclic Redundancy Check added to the end of any message sent to the unit and is used for basic message integrity. This feature can be enabled/disabled via bit 4 of S3.

3.7 Bund Switch – S3

A bund switch is a simple input switch that is normally closed. When enabled, if the switch opens, this alarm is triggered and a message type 8 is sent to the server. The bund switch alarm is enabled using bit 3 of S3.
Note that the sensor will only connect once unless there is a change in the switch status. See example below.

Device set to make a measurement every 15 minutes			
S3, bit 3 set to 1 so that the alarm on change is enabled.			
Time	Switch input	Measurement	Action
12:00	0	Yes	None
12:05	1	No	None
12:10	0	No	None
12:15	0	Yes	None
12:20	0	No	None
12:25	1	No	None
12:30	1	Yes	Connect and send alarm
12:35	1	No	None
12:40	1	No	None
12:45	1	Yes	None
12:50	0	No	None
12:55	1	No	None
13:00	1	Yes	None
13:05	1	No	None
13:10	0	No	None
13:15	0	Yes	Connect and send alarm
13:20	0	No	None

3.8 Alarms – S4, S5, S6, S7, S8 & S27

Static Alarm: Static alarms are based on the sampled values. There are three separate static alarms configured by S4, S5 and S6. These can be configured to alarm when the measured value is higher or lower than the defined threshold and a hysteresis value can also be defined. Note that the unit adds 3cm to the hysteresis value entered to compensate for any jitter in the ultrasonic measurement. Only values that meet the sonic quality criteria set in S27 will cause the alarm to trigger. When a static alarm is activated, an immediate message type 8 is sent to the server – see section on message types for further information.

Dynamic Alarm: Dynamic alarms are based on entries in the sample buffer. There are up to 2 dynamic alarms configured with S7 and S8. A least squares method is used to calculate the slope of the measurements in the sample buffer. Only valid readings are used based on the filter set by S27. A minimum of 6 valid readings in the sample buffer are required before a dynamic alarm is triggered. When a dynamic alarm is triggered an immediate message type 8 is sent to the server – see section on message types for further information.

Note that it is recommended that a minimum of 5cm change is looked for over the full log which sets limitations on possible settings.

3.9 Standard communications – S9, S10, S12, S13, S14 & S15

When communicating over GPRS, the unit connects to the Cellular network with settings defined in S12, S13 and S14 (GPRS APN, username and password). The data will be sent to the IP address and port number stored in S15 and S16 respectively. The server at this IP address can then pick up communications coming on this port and parse as per detailed in Section 3.16.7.
In SMS mode, the unit can send an SMS to the number which are stored in S9. The default telephone numbers are for a Clickatell service which interprets the machine-readable SMS and transmits the data to the Tekelek production server

3.10 System password – S11

Any commands sent to the unit need to start with the password set in S11. The default password is TEK811.

3.11 Ultrasonic measurements – S17

The product reads values from the ultrasonic sensor. The recommended setting for S17 is 0049351928 in standard mode or 0014FF3C3C in waveguide mode. Changes should not be made to these settings without help from technical support as incorrect values will compromise the validity of any measurements taken. When the ultrasonic sensor takes a reading, it applies a score to the quality of the reflected signal received (See Section 3.16.7). All values are logged together with the SRC and SRSSI. S27 defines the limits for a valid measurement for use in triggering alarms to help avoid alarms being triggered incorrectly. The recommended setting for S27 is 49 and again should not be changed without input from technical support.

3.12 Retry configurator – S23

In the event of the unit not being able to deliver its payload successfully it can make a number of subsequent attempts to deliver the data. The total number of attempts that the unit will make can be configured using S23. Note that in the event of SMS being enabled (see section on SMS Fallback), the last try attempt will be via SMS.

3.13 Schedule delay – S24

The S2 register can define the upload schedule in increments of 15 minutes. If a number of units are installed together this can lead to excessive network traffic at these times. A different schedule delay can be configured for each unit to overcome such a problem. S24 is used to configure the delay in minutes from the schedule upload time configured by S2.

3.14 Manual wakeup

Holding a magnet to the hot spot will cause the unit to take 10 ultrasonic samples in quick succession, filling the sampling buffer, and will transmit this data in a message type 8 to the server. Therefore, the contents of the sampling buffer are effectively cleared when the unit is activated with a magnet.

3.15 SRC & SRSSI

There are two parameters used with products capable of advanced sonics' SRC and SRSSI. Both parameters give a measure of validity to the measurement. See separate document "*9-6034-XX Advanced Sonics SRC Parameters"* for more information.

3.16 Configuration Commands

3.16.1 S0: Logger Configuration

Logger Speed:

- Range of 0 - 31.75 Hours
- Multiples of 0.25 hours
- 0 = Locked to Sampling Rate

Configuration	Command	Formula	Description
Logger Speed	0.00	A	Desired logger Speed, hours, in 0.25-hour increments. Max 31 hours
Sampling Period	1	B	Desired sampling period: 0 if once per min, 1 if once every 15 mins
RESULT:	**S0=80**		***Data sample once every 15 mins, Logged ever 15 mins***

Formula:
S0=(128 x B) + (A x 4)

Example:

- S0=(128 x 1) + (0.00 x 4)
- S0=128 + 0
- S0=128
- S0=0x80

3.16.2 S1: GSM Listen Configuration

- Max of 155 minutes
- Multiples of 5 minutes

Configuration	Command	Formula	Description
GSM Listen Period	5	A	Desired GSM listen Period
RESULT:	**S1=01**		***GSM listen period 5 minutes***

Formula:
S1=(A/5)

Example:

- S1= (5/5)
- S1=1
- S1=0x01

3.16.3 S2: Schedule Configuration

This parameter defines how the ECU is configured to regularly send logged measurement data in Data Message Type 4 to the server.

- If the End Time entered is before the Start time, no scheduled data will be transmitted

Configuration	Command							Formula	Description
	Sunday	Saturday	Friday	Thursday	Wednesday	Tuesday	Monday		
Day to upload	1	1	1	1	1	1	1	A	Enter '1' to select day(s) of week for data delivery
	8							B	Enter Time to Dial, Hours
	0							C	Enter Time to Dial, Minutes (Will be rounded to 15 min intervals)
Upload Frequency	0							D	Upload once in 24 hours
	1								Upload Every 2 hours (Recommended for test only)
	2								Upload Every Hour (Recommended for test only)
	3								Upload Every 4 hours (Recommended for test only)
End Time (if more than once per day)								F	Enter End time (Hours) (> Start Time) (Ignored if once per day)
Weekly Override: > once per week	0							G	Override weekly schedule: Enter '1' if fortnightly or once per month delivery required.
	0							H	Enter '1' for once per month, on the 21st, ***or***, enter '0' for Fortnightly on the 1st & 14th each month
RESULT:	**S2=7F2056**								***Daily @ 08:00***

Formula:

A=(Sunday,Saturday,Friday,Thursday,Wednesday,Tuesday,Monday)

1. **XX**= (G,**A**)
2. **YY**= (H x 128) + (B x 4) + (C/15)
3. **ZZ**= (D x 32) + F
4. S2=**XXYYZZ**

Example:

1. XX=(0b01111111)
   XX=0x7F

2. YY=(0 x 128) + (8 x 4) + (0/15)
   YY=(0 + 32 + 0)
   YY=32
   YY=0x20

3. ZZ=(1 x 64) + (0 x 32) + 22
   ZZ=64 + 0 + 22
   ZZ=86
   ZZ=0x56

4. S2=7F2056

3.16.4 S3: Control Configuration

Configuration	Command	Formula	Description
Network Communication mode	00	A	Select 00=LTE CatM1, 01=LTE NB-IOT, 10=GSM
Reserved	0	B	
Bund Switch	0	C	1=Enable
CRC Check	0	D	CRC checking of incoming data. 1=Enable *Note! If set, will disable phone commands!*
Reserved	0	B	
Reserved	1	F	
Verbose TSP	0	G	1=Enable additional TSP info (Engineering debug)
RESULT:	**S3=44**		

Formula:
S3=G,F,E,D,C,B,A

Example:
- S3=0b01000100
- S3=0x44

3.16.5 S4, S5, S6: Static Limit Configuration

Configuration	Command	Command	Command	Formula	Description
Limit Polarity	1	0	0	A	1= alarm when measured ullage value is higher than the threshold, 0 = alarm when measured ullage value is lower than the threshold
Alarm Enabled	1	0	0	B	1 = Enabled, 0 = Disable. N.B. Alarm Status flags in Message headers will be set, irrespectively.
Hysteresis	10	0	0	C	Reset level is 3 greater than value entered here
Threshold	150	0	0	D	The setting threshold for level alarm.
RESULT:	**S4=E896**	**S5=0000**	**S6=0000**		**S4 Example: Alarm set if measured units are >150, reset level = 137**

Formula:
$S4= D + C \times (2^{10}) + B \times (2^{14}) + A \times (2^{15})$

Example:
- $S4=150 + 10 \times (2^{10}) + 1 \times (2^{14}) + 1 \times (2^{15})$
- S4=150 + 10240 + 16384 + 32768
- S4=59542
- S4=0xE896

3.16.6 S7, S8: Dynamic Limit Configuration

- Range of 0 - 6.3, in increments of 0.1 units.
- Fixed Hysteresis of 0.1 units/min(15mins) will clear alarm flag

Configuration	Command	Command	Formula	Description
Polarity	1	0	A	1= Alarm if Rising Units (Tank Not Emptying) 0= Alarm if Falling Units (Tank Not Filling)
Alarm Enabled	1	0	B	1=Enabled, 0 = Disable (Alarm Status flags will be set, irrespectively)
Rate	4.0	0.0	C	CMs per minute or CMs per 15 minutes, depending on S0 Range 0-6.3, in increments of 0.1 units Alarm if change = C/15 {Round to 2 decimal places}
RESULT:	**S7=E8**	**S8=00**		**S7 Example: Alarm if change >0.27 cms/min**

Formula:

S7= A x (2^7) + B x (2^6) + C x 10

Example:

- S7=1 x (2^7) + 1 x (2^6) + 4.0 x 10
- S7=128 x 64 + 40
- S7=232
- S7=0xE8

3.16.7 S9 – S18: SMS, APN, URL and Tank Details Configuration

- The following Parameters S9 to S16 are Ascii, with max length of 20 characters (A20)
- If using a waveguide, the recommended value of S17 is 0014FF3C3C

S-	Description	Default
S9:	Server SMS Phone Number (A20)	
S10:	Reserved	
S11:	Unit Password (A6)	TEK811
S12:	GPRS APN (A40)	
S13:	GPRS APN User Name (A20)	
S14:	GPRS APN Password (A20)	
S15:	Destination Server IP address or URL (A40)	
S16:	Destination Server Port Number (A5)	
S17:	Ultrasonic Measurement (A5)	0049351928
S18:	Tank Height (A4)	300

3.16.8 S21 MCC_MNC Mobile Country Code / Operator Code

For NB-IOT operation, entering this setting is essential.
The setting parameter is the mobile operator's short code, and should be set according to the sim card in use.
Eg, for Vodafone Ireland, the network operator short code is 27201
Leave blank if GSM.

3.16.9 S22 LTE Band

NB-IOT operation, entering this setting is essential.
For Cat M1 operation, the setting is recommended (it reduces network search time, hence reduces power consumption)
For GSM operation, it has no function.
LTE Band lookup table.

Band	**S22 Code**
B1	1
B2	2
B3	4
B4	8
B5	10
B8	80
B12	800
B13	1000
B18	20000
B19	40000
B20	80000
B26	2000000
B28	8000000
B39	4000000000

3.16.10 S23: Message Deliver Configuration

- Try Tickets max of 8
- Try Period max of 320 seconds

Configuration	Command	Formula	Description
Try Tickets	4	A	Number of delivery attempts
Try Period	30	B	Time between tries (seconds)
RESULT:	**S23=13**		

Formula:

1. X=A-1
2. Y=(B/10) -1 *{Note: Result of B/10 to be rounded down}*
3. S23= X + (Y x 8)

Example:

1. X=4-1
   X=3

2. Y=(30/10) -1
   Y=3-1
   Y=2

3. S23=3 + (2 x 8)
   S23=19
   S23=0x13

3.16.11 S24: Schedule Delay

- Max delay of 14 minutes
- Default = No delay (0 minutes)

Configuration	Command	Formula	Description
Delay	5	A	Data Drop Delay from Scheduled
RESULT:	**S24=05**		

Formula:

S24=A

Example:

- S24=5
- S24=0x05

3.16.12 S26: Control2 Configuration

- 1 = Enabled, 0 = Disabled

Configuration	Command	Formula	Description
Reserved	0	A	
Reserved	0	B	
Reserved	0	C	
Reserved	0	D	
Reserved	0	E	
Reserved	0	F	
Reserved	0	G	
Reserved	0	H	
RESULT:	**S26=40**		

Formula:
S26=H,G,F,E,D,C,B,A

Example:
- S26=0b01000000
- S26=0x40

3.16.13 S27: Sonic Quality Filter

- SRC = 9 (recommended normally), SRC = 10 (is recommended for Wave Guide applications)

Configuration	Command	Formula	Description
RSSI	4	A	RSSI Filter
SCR	9	B	SCR Filter
RESULT:	**S27=49**		

Formula:
S27=A,B

Example:
S27=0x49

3.17 Request commands

Commands can be sent via SMS or via GPRS (converted to hex)

Request commands are available as follows:

<password>,R2= yy/mm/dd:hh/mm/ss	set RTC
<password>,R3=ACTIVE	sets units to active state
<password>,R4=DEACT	de-activates scheduled uploads
<password>,R6=03	close TCP connection
<password>,R1=80	shutdown modem and sleep

S parameters can be programmed using the following format:
*password,*Sx = yyyy
where x is the number of the S parameter that is to be set and yyyy is the value to which it will be set. Note that commands can be concatenated (separated by commas).

Note: The command R3=ACTIVE should be issued to the sensor upon first activation.

3.18 SMS text back

Details of SMS text back queries are in the commands and config file. When a text back query is received the reply is sent to the number from which the query came.

Command	Meaning	Response Example	Note
Ullage=?	TextBack to me the Tank Fuel level reading	Ullage=63, (Older Readings= 63,0,0,0,0,0,0,cms).	Ullage is the term used for the air space between the liquid level and the top of the tank. The readings are from the sampling buffer.
TEK811, Info=?	(Password Protected) Status Information: IMEI, HW Version, SW Version, Battery, RSSI, Network Operator, RTC, Active/Deact.	IMEI=866425030678884 HW=33 FW=1.3 Bat=46 CSQ=28 Server="EDGE","27202","GSM 900",106 RTC 21/11/18 10:10:14 D	Server gives information regarding the network in use. RTC is the Real time clock in the unit.
TEK811, Set=?,n	(Password Protected) Dump of S parameters, starting at n. (If 'n' omitted, will start at S0)	S0=01,S1=01,S2=7F0056,S3=86,S4=C050,S5=4064,S6=0000,S7=FC,S8=7C,S9=,S10=,S11=TEK811,S12=internet,S13=,S14=,S15=88.87.179.118,S16=9000,S17=0049351928,S18=300	The starting number n can be varied. In the example of using start number=0, not all of the S-parameters may fit into 160 characters. Therefore, more than 1 dump may be needed. In the example shown, the 1st 15 S=params occupies 152 chars. Another Texback command Set=?,16 would be needed to follow.

4. Technical Specification

4.1 Reed switch interface

A reed switch provides a user interface input for the Ultrasonic sensor. The reed switch is triggered by a user held magnet.

4.2 LED output

The Ultrasonic sensor status feedback will be provided via a bicolour LED. Detailed further in document.

4.3 Buzzer

The Ultrasonic sensor status feedback will also be provided via a buzzer. Detailed further in document.

4.4 TSP Interface

Test interface (transponder) can be used for test and parameter programming purposes. The transponder does not form part of the product.

4.5 GSM Connectivity

GSM Communications is provided by an on-board GSM Module. The Ultrasonic sensor communicates using standard GSM protocols / services available from a common-carrier.

5. On-site Maintenance Checks

5.1 Mounting

During on-site maintenance, the operator must ensure that the Ultrasonic sensor is still securely tightened.

5.2 Environment

During on-site maintenance, the operator must check that external environment does not degrade the performance of the sensor, such as clay, dust, water, etc.

6. Trouble Shooting

6.1 LED Flash Code

LED Pattern	Function
Green / Red / Off	**LED test:** When a magnet is held against the hot spot the LED will briefly indicate Green followed briefly by Red and then off.
Red LED - On continuous	**Awake:** Modem powered up, Attempting to register on network
Red LED - Flashing	**Registered on Network OK**, attempting to contact server.
Green LED - On continuous	**GSM Awake:** Data packet was transmitted successfully AND a response was received from server to Activate the unit

6.2 Beep Pattern

Beep Pattern	Definition
Low beep once per second	Network Registration
High beep once per second	GPRS Registration
Low beep once every 4 seconds	Network Registered / TCP Listen
Low beep once every 1 seconds	Re-establish Network
High / Low combination beep	Incoming Data
Low / High combination beep	Outgoing Data
Low double-beep every 4 seconds	Network Listen (Data Received & Unit Active)
High double-beep every 4 seconds	TCP Listen (Data Received & Unit Active)

For further details please see additional documents:

- *DS-5049-XX TEK 811 Datasheet*
- *9-5956-XX TEK 811 Ultrasonic 4G NB-IoT_CAT-M1 Installation Guide A4*
- *9-6034-XX Advanced Sonics SRC Parameters*
- *9-6035-XX Advanced Sonics SRC Parameters - French*
- *MI-5247-XX TEK 811 Battery Replacement*
- *MI-5250-XX TEK 811 SIM Card Replacement*