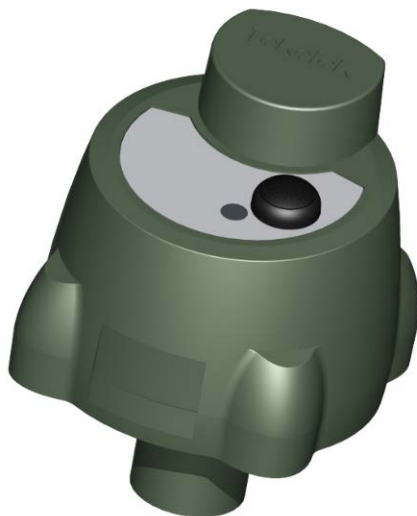




## TEK766 User Configuration Guide



# TEK 766 User Configuration Guide

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## Edit History

	Description	Edited by
V1 01-12-2016	Initial release	SN

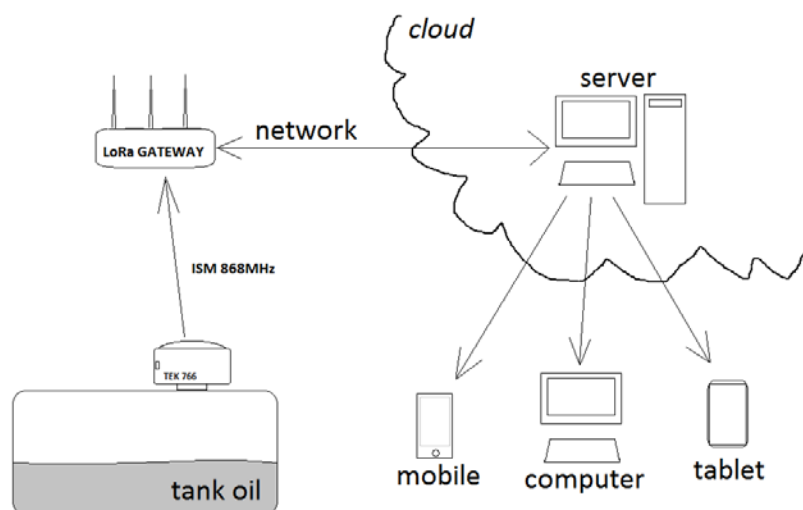
## References and Guidelines

Ref.	Document ID	Description
[1]	CF-5004-01	TEK 766 Configuration_Command_Payload Data Structure Rx.x
[2]	UG-004-02	TEK 766 Installation Instruction Leaflet
[3]	UG-005-02	TEK 766 Waveguide Instruction Leaflet
[4]	DS-5043-01	TEK 766 Datasheet
[5]	–	TEK 766 Operational Specification

# TEK 766 User Configuration Guide

## Introduction

The TEK766 is a battery-powered LoRaWAN enabled ultrasonic sensor, which can be configured to connect to one or more decentralised LoRa gateways according to a pre-determined schedule. Its main purpose will be measuring the quantity of heating Oil in tanks in residential and small commercial properties (this is performed by measuring the ullage (airgap) of the tank). The following document details the structure and meaning of the commands that can be sent to the sensor as well as detailing the decoding of the received packets.



## Operation Modes

Once the device has been successfully activated, it will generally operate in two modes – a manual connection using a brief button press, or according to the internal connection schedule.

## Standard Operation

With default standard operation, the TEK766 will stay in low-power mode for the majority of its lifetime. It will briefly wake up and take an ultrasonic measurement reading of the ullage every 15min and store the result before reverting to low power mode. The operation works on the basis of a '*Scheduler TX period*' and a '*logger Interval*'. The '*Scheduler TX period*' is simply the interval in hours between LoRa radio transmissions of the 'datagrams' (blocks of data).

The '*logging interval*' is the time interval for storing four measurements in a 4 position rotating buffer. Note that the '*logging interval*' must not exceed the duration of the '*Scheduler TX period*' and typically it would be equal to it for no overlapping logging. The buffer is not cleared on transmission of the data.

The default operation for the unit will be that 4 transmissions are sent every 24 hours, one every 6 hours. Every 4<sup>th</sup> transmission will expect an 'ACK' from the server, the other 3 transmissions do not require server acknowledgement. For data redundancy, each transmission will include one

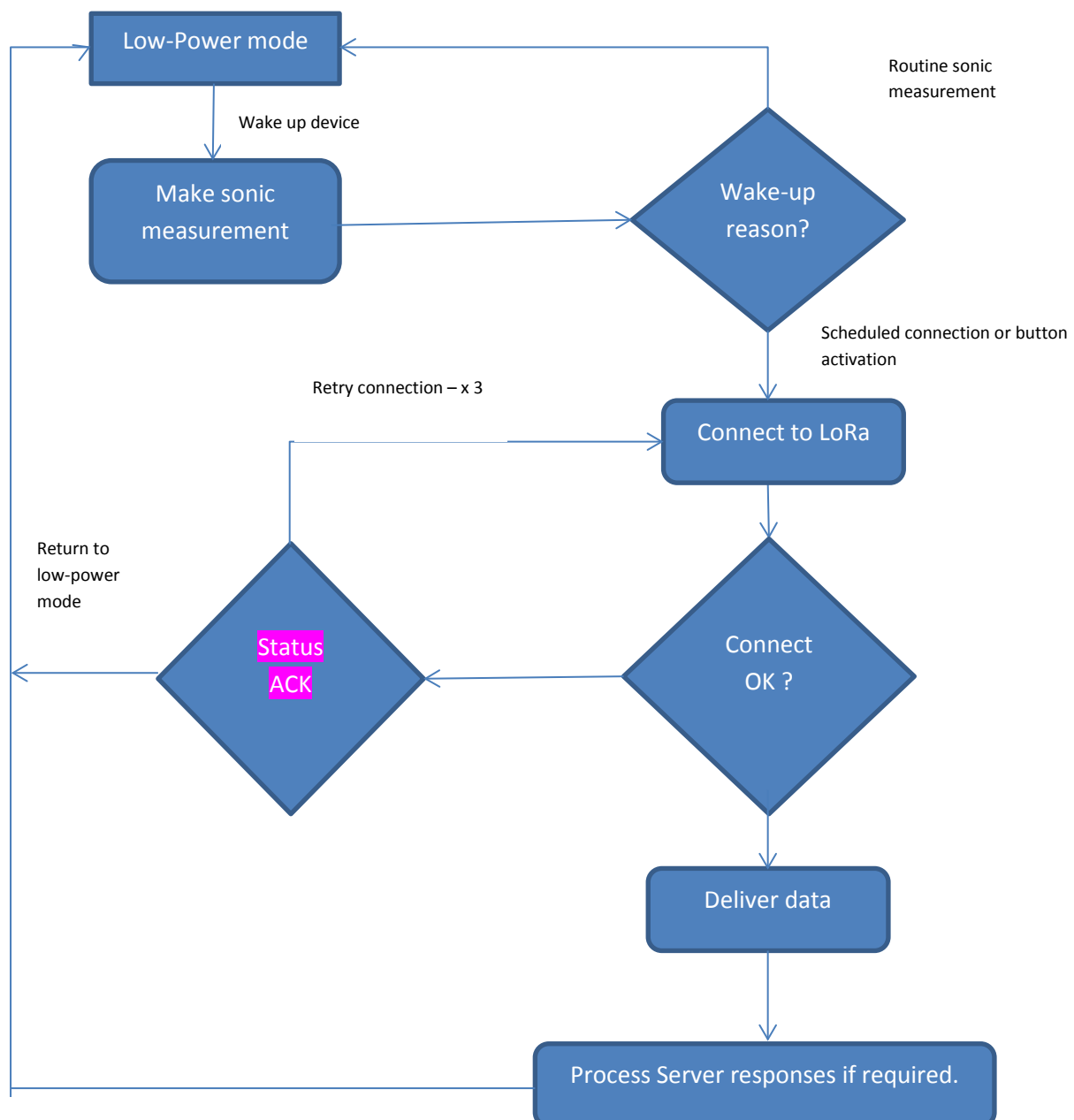
## TEK 766 User Configuration Guide

current ultrasonic reading as part of the payload as well as 3 previous ultrasonic readings. A status datagram is sent once every 7 days

### Manual Operation

The device can be forced to connect to the server at any time by briefly pressing the button for one second on the device. This will wake the device from low power mode, take an ultrasonic measurement, connect to the gateway and transmit a status message which includes a current ultrasonic reading. During the connection, the Green LED will turn on solid, then flash green to indicate that the connection is complete the device will revert back to low-power mode.

### Standard Operation Flowchart



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## Logging Data

The internal buffer will store 4x measurements which contain the following:

- Ullage reported in cm.
- Sonic Result Code
- Sonic RSSI
- Internal PCB Temperature in °C as a signed char.

## Principle of data upload

The device will connect to the Gateway /Application server for one of the following reasons:

- Configuration update -> Soft reset – this occurs in response to a configuration settings update. A hard internal reset would also cause a device communication.
- Manual - the device has had the button pressed for 1 second, to force a connection.
- Manual + Activation – the device has had the button pressed for 1second, to activate the device from dormant mode and subsequently force a connection.
- Scheduled – the device will connect to the server, according to its schedule.
- Regular Status update. Typically once per week per the schedule.
- Reporting of Alarm limit thresholds that have been exceeded (if enabled).

*NOTE – After a device reset, manual activation or after provisioning, a status packet will be uploaded to the server.*

## Application Server Responses

Every time a device makes an outgoing status connection to the gateway, the Application server has the option to respond with configuration settings that may need changing in the device.

Sending responses to the device is very useful for tasks such as when changing the Ultrasonic profile or the connection schedule, though care must be taken as sending the wrong settings could render the device incapable of correct operation.

## Parameter Configuration Setup

The TEK766 will be configured with standard default settings during production.

The following key parameters, as described below, are set with the following default values:

- **Scheduler TX Period** - is the time period between each measurement packet radio transmission to the LoRaWAN network. The *default* transmission rate is once every 6 hours.

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Increasing the frequency of transmissions will reduce operational battery and product life as detailed in the appendix.

- **Status TX Period** - is the time period between each status packet radio transmission. The *default* transmission rate is once every 7 days. The status period should be a minimum of twice the Scheduler TX period.
- **Logger Interval** - This logger has a 4 position rolling buffer and has 3 redundant readings in order to ensure data integrity. So for a TX Period of 1h - the Ultrasonic readings in the 4 position buffer will include the currently hourly reading plus the 3 previous hourly readings. The logging Interval is normally set to be equal to the scheduler TX Period – *default* is 360 minutes. It can be set to other values but should be an integer divider of the Scheduler TX Period (see the custom profile for 1 week).
- **TX Randomisation Period** – is a time interval. The range allowed is from 1 sec to 1/4 of the scheduler TX period, during which the TX transmission can randomly occur. Its function is to avoid multiple units in a population transmitting at the same time. The *default* randomisation period is 60 minutes.
- **Ultrasonic Ping Rate** – this describes how often an ultrasonic level measurement is performed. The *default* ping rate is once every 15 minutes. A faster ping rate (e.g 1 min) might be used to detect an alarm condition.
- **Ultrasonic characteristics profile** – this sets the characteristics of the advanced ultrasonic routine. There is a *default* Standard ultrasonic profile or a Waveguide profile designed to be used with waveguide pipe for cases where the standard TEK 766 sensor would have measurement difficulties. See document UG-005-xx for further details.
- **Alarm Static Threshold Limits** – there are static alarm limits allowed. This allows the user to set three static limits in ‘cm’ which if any are tripped will cause an alarm RF packet to be sent to the LoRaWAN network. The *default* setup has the Alarm function disabled.
- **Ultrasonic SRC/SRSSI Filter Threshold Limits** - There is a measurement validity metric associated with each ultrasonic measurement. It consists of two parts – amplitude of the returning echo converted into a quality factor SRSSI (1 to 10) and SRC (sonic result code) which determines how valid a reading is likely to be (1 to 10). A *default* value of SRC = 9 and SRSSI = 4 is used. These limits must be exceeded before a valid alarm is generated. Refer to the appendix for more details.
- **Configuration Flags** – this is used to setup how often a TX scheduled transmission is acknowledged by the LoRaWAN network. The *default* setup is one acknowledgment for every 4<sup>th</sup> transmission.

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The configurable parameters listing default and minimum and maximum values are listed:

PARAMETER:	MINIMUM	MAXIMUM	DEFAULT	UNITS
Scheduler TX Period	1	720	6	Hours
Status TX Period	1	30	7	Days
Logger Interval	2	1440	360	Minutes
TX Randomisation Period	1	240	60	Minutes
Ultrasonic Ping Rate	1	240	15	Minutes
Alarm Static Threshold Limits	22	400	0	cm
Sonic SRC/SRSSI Filter limits	1:1	10:10	9:4	-

### Excel Spreadsheet:

The accompanying document to this TEK 766 User manual is an excel spreadsheet which performs the formatting and calculations required to process user data entry into command parameters that the sensor can understand. It also decodes both sensor and Application Gateway Server responses (assumes decrypted data).

The document is “CF-5004-01 TEK 766 Configuration\_Command\_Payload Data Structure Rx.x”.

It is organised into six tabs:

Tab 1	Shows Flowcharts which give an overview of the Sensor operation.
Tab 2	Shows the ‘Datagrams’ that the sensor sends to the Application Gateway Server.
Tab 2A	Shows the ‘Datagrams’ that the sensor receives from the Application Gateway Server.
Tab 3	Shows the configuration memory addresses that control the sensor.
Tab 4	Shows how to configure a sensor schedule to communicate with the server.
Tab 5	Shows how to configure the sensor to generate threshold alarms for static limits.
Tab 6	Shows other miscellaneous other parameters.



# TEK 766 User Configuration Guide

## 1. Message Types

The sensor (TEK 766) transmits or receives several packet types aside from the standard measurement packet and periodic status packet. These are listed in the table below from the “CF-5004-01 TEK 766 Configuration\_Command\_Payload Data Structure Rx.x” document.

Datagram Frame Type	Comment	Payload Msg Type
Measurement	Data Measurement Upload - periodic on variable schedule	10h
Status	Data Status Upload - periodic on variable schedule	30h
Sensor response Ack/Nack	A Soft "ack" or "nack" for write request, or "nack" for a read/write request failure	40h
Parameter Read Request	Application Server Requests Parameters Settings	41h
Parameter Write Request	Update of Parameters on Sensor(TEK 766 /790)	42h
Parameter Read Response	Sensor sends Parameter Settings	43h
Alarm Notification	Sensor sends Alarm Notification.	45h
Diagnostic Read Request	Server requests the device sends diagnostic data to the server	46h
Diagnostic Read Response	device sends diagnostic data (mostly ultrasonic) to the server	47h

The key ‘Datagrams’ (packet data types) are as follows and are detailed in <tab 2 & 2A Datagrams>:

- 1) **MEASUREMENT DATAGRAM** – this is the standard datagram that the sensor sends as scheduled (default every 6 hours) to the application gateway server. It includes the latest ultrasonic measurement plus the 3 previously sent readings. For example the most recent reading below is made just prior to the current scheduled transmission whereas the other three readings are made 6, 12, & 18 hours previously on the default 6 hour schedule.

TEK766 Sonic measurement frame		Confirmed?			Paste RF Packet below:
Data Upload (from Mote to server)		Varies	Sensor -> Gateway	Quick Parse	10000600005505aa005505aa005505aa005505aa
Payload Message (Type)	10h			10	Measurement
Prod ID (TEK 766/TEK790)				00	
Alarms Byte			00000110	06	Lim1: 0, Lim2: 1, Lim3: 1
Reserved				00	
Ullage Byte (MSB) - Most Recent Reading				00	
Ullage Byte (LSB)				55	Ullage: 85cm
Temperature		-5	0	05	PCB: 5°C
SRC / SRSSI ( 1 nibble each)				aa	SRC: 10 SRSSI: 10
Ullage Byte (MSB)				00	
Ullage Byte (LSB)				55	Ullage: 85cm
Temperature		-5	0	05	PCB: 5°C
SRC / SRSSI ( 1 nibble each)				aa	SRC: 10 SRSSI: 10
Ullage Byte (MSB)				00	
Ullage Byte (LSB)				55	Ullage: 85cm
Temperature		-5	0	05	PCB: 5°C
SRC / SRSSI ( 1 nibble each)				aa	SRC: 10 SRSSI: 10
Ullage Byte (MSB) - Latest Reading				00	
Ullage Byte (LSB)				55	Ullage: 85cm
Temperature		-5	0	05	PCB: 5°C
SRC / SRSSI ( 1 nibble each)				aa	SRC: 10 SRSSI: 10

The individual readings comprise of Ullage (LSB & MSB bytes). This represents the distance between the ultrasonic transducer and the surface of the oil. From this a calculation of the tank % full can be calculated. The temperature within the tank is also provided (one byte) and a one byte metric of the quality of the ultrasonic measurement called SRC/ SRSSI is also provided.

A Datagram packet to be decoded is placed in cell G22 as shown above and the decoded values are also shown.

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- 2) **STATUS DATAGRAM:** - this is a packet sent by the sensor once every 7 days (default schedule). It also is generated by pressing the sensor pushbutton and is used for device installation. It shows key information such as battery information, schedule information and an ultrasonic measurement.

TEK766 Status Packet					Paste RF Packet below:
Status Frame (from Mote to server)		YES	Sensor -> Gateway	Quick Parse	30010001010035002f00390004170034103a
Payload Message (Type)	30h			30	Status
Prod ID (TEK 766/TEK790)				01	
Reserved				00	
Hardware ID				01	
Software ID H				01	
Software ID L				00	SWID: 256
Status Byte		00110101		35	Contact: 1 Reset: 5 Active: 1
Reserved				00	
Unit RSSI				2f	RSSI: -47 dBm
Reserved				00	
Battery % remaining				39	57%
Measurement Steps (MSB)				00	
Measurement Steps (LSB)				04	Logging: 4 mins
Scheduled TX Period				17	23 Hours
Ullage Byte 1 (MSB)				00	
Ullage Byte 2 (LSB)				34	Ullage: 52cm
Temperature		-16		10	PCB: 16°C
SRC / SRSSI ( 1 nibble each)				3a	SRC: 3 SRSSI: 10

A Datagram packet to be decoded is placed in cell G46 as shown above and the decoded values are also shown. Note: the scheduled TX period is limited to a single byte and so is limited to representing a maximum of 255 hours.

- 3) **ALARM DATAGRAM:** - If a valid ultrasonic reading exceeds an alarm threshold then an alarm packet is sent. It will indicate which of the three static limits was exceeded and also two ultrasonic readings – the first is the one that exceeded the reading and the second is the previous logged reading before that.

TEK766 Alarm Notification					Paste RF Packet below:
Alarm Notification (from Mote to Server)		YES	Sensor -> Gateway	Quick Parse	45000100004b18aa00000000
Payload Message (Type)	45h			45	Alarm!!
Prod ID (TEK 766/TEK790)				00	ProdID: 00
Alarms Byte		00000001		01	Lim1: 1, Lim2: 0, Lim3: 0
Reserved				00	
Ullage Byte (MSB)				00	
Ullage Byte (LSB)				4b	Ullage: 75cm
Temperature				18	PCB: 24°C
SRC / SRSSI ( 1 nibble each)				aa	SRC: 10 SRSSI: 10
Ullage Byte (MSB)				00	
Ullage Byte (LSB)				00	Ullage: 0cm
Temperature				00	PCB: 0°C
SRC / SRSSI ( 1 nibble each)				00	SRC: 0 SRSSI: 0

A Datagram packet to be decoded is placed in cell G68 as shown above and the decoded values are also shown.

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- 4) **PARAMETER READ RESPONSE DATAGRAM** – This is the datagram that the sensor sends in response to the Application Gateway server requesting information on a current setting.

					Paste RF Packet below:	
Parameter Read Response		YES	Sensor -> Gateway	QuickParse	43010002400150D0	
Payload Message (Type)	43h			43		
Prod ID (TEK 766/TEK790)				01		
Reserved				00		
Data Length n				02		
Parameter Category				40		
Parameter ID				01		
Param Data (n bytes)				50		
Data Length n				D0		
Parameter Category						
Parameter ID						
Param Data (n bytes)						
Data Length n						
Parameter Category						
Parameter ID						
Param Data (n bytes)						
Data Length n						
Parameter Category						
Parameter ID						
Param Data (n bytes)						

A response frame to read parameters response largely resembles a write parameters request. I.e. the payload contains a setting length field (as different parameters are of different length) as well as the Category, ID and corresponding parameter value.

Sample response to Parameter read request:  
43010002400150D0

This response contains the parameter 0x4001 = D050

Please note the byte order of multi-byte parameter responses are LSB first. I.e. a value of 20 in a 4-byte parameter is represented as 0x14000000

Static Limit 1					
1	533				
1					
4	cms/5				
80	cms/%				
D050					
		Tekelek Parameter: 0x4001		Value (Hex)	D050

In the above example, the Alarm static limit 1 parameter is read back. It corresponds to the previous setting that was written to the parameter [ 0xD050 ].

Write - Static Alarm 1      42000002400150D0

Notes: All 'parameter read responses' are 'confirmed' packets that is, the sensor will make three attempts to send the data. If unsuccessful, the Application server will have to make another attempt by sending a new 'parameter read request'. For sensors in areas with weak signal strength – it is recommended to send shorter parameter requests.

- 5) **PARAMETER READ REQUEST:** - For the example in (4) above, the Application server has to send a 'parameter read request' to request this data.

Parameter Read Request		NO	Gateway -> Sensor	Parameter read request
Payload Message (Type)	41h		41	
Prod ID (TEK 766/TEK790)			00	
Reserved			00	
Parameter Category			40	
Parameter ID			01	
Parameter Category				
Parameter ID				
Parameter Category				
Parameter ID				
Parameter Category				
Parameter ID				
Parameter Category				
Parameter ID				
Parameter Category				
Parameter ID				

This can contain several parameter requests concatenated together, though care must be taken not to request settings which combined size would exceed 45 bytes.

Sample parameter read request payload:  
4100004001

This requests parameter 0x4001

The Datagram above shows this request.

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The excel spreadsheet <tab 3. Parameters> shows the standard control parameters.

Parameter list								
Tekelek Settings 0x40	0x00	R/W	R/W	Sonic Control	u32	4	1228216616	Characteristic of the Advanced Sonics routine
	0x01	R/W	R/W	Static Limit1	u16	2	0	Characteristics of the Limit Alarm (Low/High, Threshold etc)
	0x02	R/W	R/W	Static Limit2	u16	2	0	Characteristics of the Limit Alarm (Low/High, Threshold etc)
	0x03	R/W	R/W	Static Limit3	u16	2	0	Characteristics of the Limit Alarm (Low/High, Threshold etc)
	0x04	R/W	R/W	SRC/RSSI Filter	u8	1	0	Filters whether a measurement can trigger alarm
	0x05	R/W	R/W	PingRate	u8	1	15	How often (in minutes) ultrasonic ping/LPG sample occurs
	0x06	R/W	R/W	RF_RSSI Threshold	s8	1	-120	RF RSSI Threshold to generate LED flash response.
	0x07	R/W	R/W	ControlByte	u8	1	0	Bitwise flags such as bund enable, measurement frame confirmations.

- 6) **PARAMETER WRITE REQUEST:** – A ‘parameter write request’ is issued by the Application server to request the sensor to change one of its internal parameters. In the example below the scheduler parameter that sets the status TX period is changed to 7 days.

Scheduler	0x05	R/W	R/W	Status frame period	u32	4	604800	s	Time between two status frame transmissio	2.0	1440.0	Hours
-----------	------	-----	-----	---------------------	-----	---	--------	---	---	-----	--------	-------

Parameter Write Request ("S" Parameters)		NO	Gateway -> Sensor	
Payload Message (Type)	42h	42		
Prod ID (TEK 766/TEK790)		00		
Reserved		00		
Data Length n		04		
Parameter Category		05		Parameter write request
Parameter ID		05		
Param Data (n bytes)		04		The data representing the S parameters may be of variable length
Data Length n				
Parameter Category				This is because multiple parameters can be sent simultaneously, and each parameter is of variable length (as indicated by the Data Length field)
Parameter ID				
Param Data (n bytes)				Sample payload: 42000004050580510100
Data Length n				This writes parameter param 0x0505 = 80510100 [ this represents 7 days ]
Parameter Category				
Parameter ID				Please note the byte order of multi-byte parameter responses are LSB first. i.e. a value of 20 in a 4-byte parameter is represented as 0x14000000.
Param Data (n bytes)				

- 7) **Parameter ACK Response:** - the sensor responds to any application server request with an acknowledgement.

The ‘ACK’ response is of one of three types.

- 4000 = OK - Sensor accepts the request and will action it.
- 4001 = Request Failed – possible because the value requested is out of range.
- 4002 = Request command not recognized.

Parameter ACK Response		YES	Sensor -> Gateway	
Response ACK	40h			
Response code				Response code can be used to provide additional information about how the downlink frame was interpreted in the device. i.e. if writing a setting which was out of range or read-only, it would provide highlight that sending the data failed. 4000 = OK, 4001 = Request Failed, 4002 = Request not recognized.

For the example in (6) above – the sensor will respond with ‘4000’ and then will perform a soft reset to save the value and send a status datagram to the application server.

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## 2. Scheduler

The sensor connection scheduler will use the internal microcontroller's inbuilt hardware and run autonomously in normal operation with the configured schedule. To configure a sensor schedule, open <tab 4. Scheduler> of "CF-5004-01 TEK 766..." excel document. The default schedule values are listed as per below in yellow. Enter the custom values as required, by copying the default schedule or another of the custom profiles as provided and pasting starting at cell G14.

	Default Schedule	Custom profile	
	Transmits every 6 hours, logs every 6 hours (3 reading TX overlap)	Enter custom schedule below: ↓	
Parameter Description:			
TX Period (0500)	6	1	hours
TX Randomization level (0502)	60	5	mins
Logging interval (0503)	360	60	mins
Status message TX period (0505)	7	1	days
Periodic task	24	24	hours
UltraSonic "Ping rate"(4005)	15	15	mins

Cell E40 will generate the required command (as shown below) to be sent over the LoRaWAN network to the sensor.

RF Downlink Command (Custom)	→	420000040500100E00000405022C010000040503100E000004050580510100040507805101000140050F
------------------------------	---	--

It is recommended to copy the required cell (right click , copy and paste 'value' only) to cell E42 as shown to prevent over-writing of calculation cells.

→	420000040500C40E0000040502010000000405033C0F0000040505120E00000405078051010001400501
---	--

It is possible, because of the flexibility of the scheduler, to input values that may cause unexpected behaviour - e.g. if the Logging Interval or TX Randomisation period is longer than the recommended values. For this reason, it is preferred to use one of the tested preferred schedules as listed below. Note: It is only possible to change a sensor configuration when the sensor wakes up to perform a measurement and transmits to the LoRaWAN network or manually by pressing the sensor button.

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Custom profile - TX Period 1h		Custom profile - TX Period 3h		Custom profile - TX Period 12h		Custom profile - TX Period 24h		Custom profile - TX Period 1 week	
Enter custom schedule starting in Cell G14.		Enter custom schedule starting in Cell G14.		Enter custom schedule starting in Cell G14.		Enter custom schedule starting in Cell G14.		Enter custom schedule starting in Cell G14.	
1	hours	3	hours	12	hours	24	hours	168	hours
5	mins	15	mins	30	mins	60	mins	240	mins
60	mins	180	mins	720	mins	1440	mins	1440	mins
1	days	7	days	7	days	7	days	14	days
15	mins	15	mins	15	mins	15	mins	15	mins

The scheduler memory addresses and minimum to maximum limits are shown below from tab <3. Parameter>

							Time		Min	Max	Units	
Scheduler 0x05	0x00	R/W	R/W	TX Period	u32	4	86400	s	Duration of all transmission windows. (Usually 24hours)	1.0	720.0	Hours
	0x02	R/W	R/W	TX randomisation period	u32	4	3600	s	Duration of one transmission window - randomisation.	1.0	14400.0	Secs
	0x03	R/W	R/W	Logger Interval Period	u32	4	21600	s	Time between two index measurements	2.0	1440.0	Mins
	0x05	R/W	R/W	Status frame period	u32	4	604800	s	Time between two status frame transmissions	2.0	1440.0	Hours
	0x07	R/W	R/W	Periodic task period	u32	4	86400	s	Time between two executions of the periodic task (parameter flush memory save)	1.0	1.0	

Caution is advised if minimum and maximum values are chosen that are outside of the provided custom profile values. The ratios between the 'Scheduled TX period' and the other key parameters should be observed as per the table below.

Scheduled TX Period	1
Status TX Period	>=2
Logger Interval	<= 1
TX Randomisation Period	<= 1/4

- Logger Interval should divide evenly into the schedule TX Period value

Some customers may use a summer schedule to economise on battery usage. In this case where the scheduler TX Period is extended for example to the custom profile period of 1 week. In this case it is recommended to set a Logger Interval period of 1440 minutes (24 hours) so that the 4 days in that week are measured.

Using a Schedule TX Period less than the default value of 6 hours will reduce battery lifetime.

## TEK 766 User Configuration Guide

### 3. Alarm

Each sensor has three static limit alarms that are programmed in centimetres as shown below from <tab 5. Alarm>. An alarm is generated when a valid ultrasonic measurement is made that exceeds the static alarm threshold limits. There is also a polarity flag which can set the direction of the alarm threshold so that an alarm is generated if the ullage is less or greater than these values. A hysteresis level limit of between [0...15cm] is allowed. Note: the minimum threshold level alarm is set to 22cm for operational reasons.

		Static Limit 1	Static Limit 2	Static Limit 3
<b>Limit Polarity Flag:</b>	Set if reading Higher than Threshold, 0= Lower. (See note to the right).	1	0	0
<b>Enable alarm:</b>	1=Enabled, 0 = Disable (Alarm Status flags will be set, irrespective)	1	0	0
<b>Hysteresis: cm</b>	The "tolerance" to be exceeded before clearing alarm (15 max)	5	2	2
<b>Threshold : cm</b>	The threshold for level alarm	100	110	120
	lim n (hex) =	D464	086E	0878

NOTE - Regarding direction of alarm threshold

If Polarity is 1, Alarm Status flag Set when (Ullage ) > Threshold,

Cleared when (Ullage+Hysteresis+2) < Threshold,

If Polarity is 0, Alarm Status flag Set when (Ullage ) < Threshold,

Clear when (Ullage ) > Threshold+Hysteresis+2.

Flags are Set/Cleared irrespective of Enable.

If Alarm enabled, RTU will upload to server irrespective of programmed schedule.

Note: There is a static constant hysteresis of 2cm.

The static limits is entered as shown above as required and the excel spreadsheet will generate the data required to be written to the parameter addresses as shown below.

	Value (Hex)
Tekelek Parameter: 0x4001	D464
Tekelek Parameter: 0x4002	086E
Tekelek Parameter: 0x4003	0878


Cell D35 of the spreadsheet will perform the calculations required to generate the required command packet that should be sent from the LoRaWAN network to the sensor.

Write RF Downlink Command (all alarms):	42000002400164D40240026E080240037808
---	--------------------------------------

It is possible to modify single alarm limits and cells D38 – D41 show this option.

Write - Static Alarm 1	42000002400164D4
Write - Static Alarm 2	4200000240026E08
Write - Static Alarm 3	4200000240037808

It is recommended to copy the required cell (right click, copy and paste 'value' only) to cell D42 as shown to prevent over-writing of calculation cells.


	Copy & paste to the adjacent cell from above and then copy string to end server.	42000002400164FC02400264140240035A3C
---	--	--------------------------------------

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A valid ultrasonic measurement is used to test against the static alarm limits. This requires that the ultrasonic reading must exceed the SRC & SRSSI filter limits to be considered a valid reading. These limits (nibbles) are accessible in the <tab 6. Miscellaneous Parameters> on cells E31 & I31. The default values are {9: 4}; it is not recommended to change these without guidance from application support.

	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
	SRC Filter: 0 - A (Hex)				SRSSI Filter : 0 - A (Hex)			
Enter Values ->	9				4			
Tekelek Parameter: 0x4004	Value (Hex)							
	94							

Copy Cell D34 into Cell D35 (right click, copy and paste value).


	RF Write Downlink Command:	42000001400494
		42000001400492

Once an alarm is generated, it is sent from the sensor and it requires a server response over the LoRaWAN network. The sensor will make three attempts to send an alarm packet if an acknowledgment is not received and no further attempts will be made. A new alarm will only be generated once the existing alarm condition has been cleared (see note above).

The device alarms are default off unless enabled.

## 4. Miscellaneous Parameters

- 1) Configuration bytes in <tab 6. Miscellaneous Parameters> allow for setting of confirmation datagrams.

3) Config Flags	1 byte								
This parameter is used to enable/disable an external Bund float switch (not currently implemented) and choose how frequently the unit sends a "confirmed" measurement frame.		Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
		TBD	TBD	TBD	TBD	TBD	Measurement Frame Confirmations		BundEnable
Enter Values ->		0	0	0	0	0	1		0
Value (Hex)									
Example:	Tekelek Parameter: 0x4007	02							
	RF Write Downlink Command:	42000001400702							



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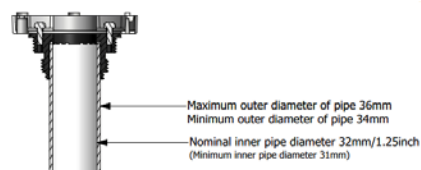
Bit 1 & 2 of the *Configuration flags* set the 'Measurement Frame Confirmation' – this is how frequently measurement datagrams are 'confirmed' or acknowledged by the LoRaWAN network server. There is a network cost of sending acknowledgment packets to sensors hence there are four options allowed:

0 = No confirmed transmissions - ACK is OFF.
1= Confirm every transmission (usually for long TX transmission periods (summer schedule)).
2 = Confirm every 4th transmission.
3 = Confirm every 8th transmission.

The parameter 0x4007 as shown above allows the user to write the appropriate value.

- 2) **SONIC CONTROL:** - The ultrasonic measurement routines allows for different configurations depending on the physical setup of the tank. The default value allows for sensors to operate in non-waveguide mode.

A waveguide option is used where there are obstructions in tanks that would cause problems with the ultrasonic signal propagating in the tank. It involves the use of a



Waveguide pipe as shown in the above graphic. Refer to document UG-005-01 for further details. The waveguide profile is [14FF3C3C], the standard profile is as below.

4) <b>Sonic Control</b>	4 Bytes	
The Sonic Control parameter is only applicable to the TEK766 ultrasonic variant. It represents the optimal ultrasonic configuration for most site installations.		
Example:	Tekelek Parameter: 0x4000	Value (Hex) 49351928
RF Write Downlink Command:	42000004400028193549	

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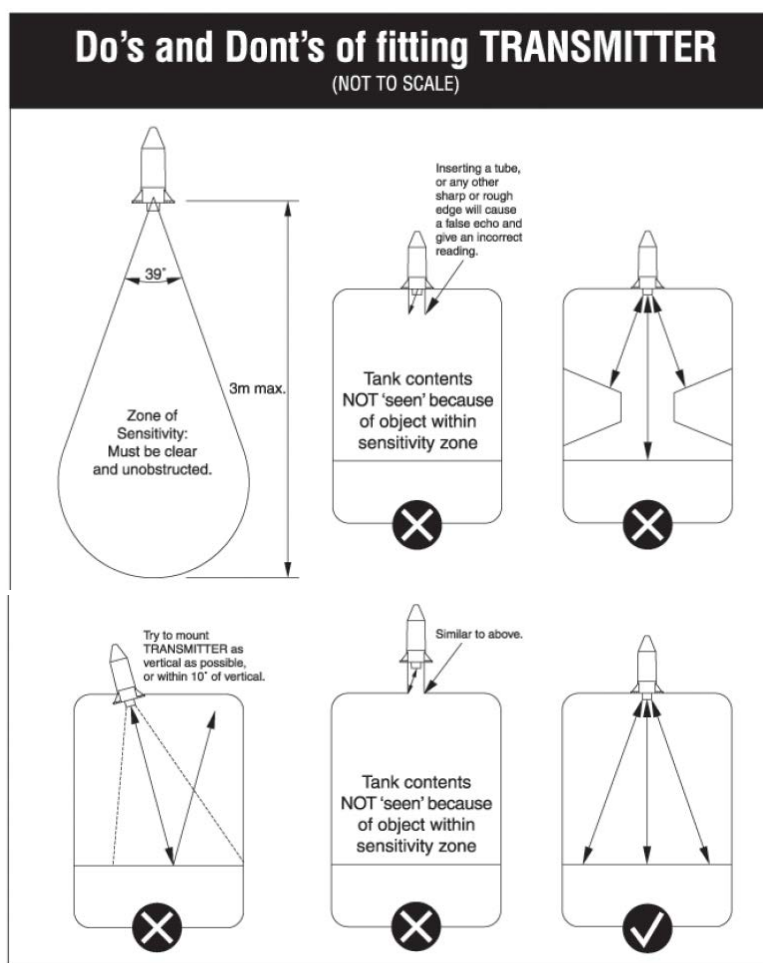
## Appendix

### 1. Ultrasonic Operation – SRC & SRSSI.

The TEK766 uses ultrasonic echoes to calculate the distance from the unit and the surface of the liquid.

There are many factors which affect the accuracy and reliability of the ultrasonic readings:

- Alignment – Ensure the sensor is not tilted to the side, so the ultrasonic pulse travels perpendicular to the liquid.
- Tightness – Screwing the unit too tightly onto the tank can cause the transducer vibrations to be absorbed into the wall of the tank, instead of being pushed downwards towards the liquid.
- Temperature – Extreme cold (i.e.  $-10^{\circ}\text{C}$  or lower) reduces the ability of the transducer to make close range measurements.
- Installation location – The sensor cannot have any obstructions in its ultrasonic path to the surface of the liquid. So ensure sensor is mounted away from the sides of the tank, and away from any internal strengthening struts.



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In addition to the Ullage (represented in CM), there are two additional parameters which can be used to identify the quality and reliability of an ultrasonic reading.

- 1) Sonic RSSI: The SRSSI value indicates the amplitude of the ultrasonic echo received by the transducer. This amplitude is converted into a quality factor ranging from 1-10 (10 being the strongest echo).
- 2) Sonic Result Code: The SRC represents the result code of the ultrasonic algorithm, which can be used to deduce whether a reading is likely to be valid or not. And SRC of 9 or 10 are optimal.

Sonic Result Code	Range Near < 80cm Far >= 80cm	Description
10	Near & Far	Good quality ultrasonic echo.
9	Near	Detected echo indicates operation in 'blind zone'. i.e. <= 24cms.
8	Near & Far	Best Echo is not the 1 <sup>st</sup> one detected.
7	Near	The first echo was < 25cm but the subsequent echo was stronger so that one was chosen instead.
6	Far	Ullage > 50cm & < 80cm. In this range, Near field algorithm should have reported.
5	Near	Multiple echoes, <= 24 cms.
4	Far	Best Echo > 300cm limit. 1 <sup>st</sup> echo seen is reported.
3	Near	Best Echo > 24cm but a high level of noise
2	Far	Best Echo < 50cms. In this range, Near field algorithm should have reported.
1	Near	1 <sup>st</sup> echo is strongest, but High levels of energy bunched up in the very near field <= 24cms.
0	Near & Far	No echo detected

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## 2. TEK 766 Configuration Application.

A TEK 766 Packet Parser software tool exists that replicates a subset of the excel spreadsheet functionality. It decodes and calculate configuration packets to be sent or received from the sensor. It does not have the full functionality of the excel spreadsheet.

The screenshot shows the 'STATUS PACKET' tab of the 'TEK 766 LoRa Packet Parser V1.0' application. The interface includes a 'Convert' button, a text input field for 'Enter Data Packet for Decoding', and a 'Decode' section with input fields for 'Ullage (cm)', 'DegC', 'SRC:SRSSI', 'TX Period', 'Measure Steps (min)', 'Battery %', 'RSSI', 'Status', 'HW ID', and 'SW ID'. There is also a checkbox for 'Static Alarm 1' and a 'QUIT' button. On the right, a table titled 'TEK766 Status Packet' lists 18 items with corresponding values and progress indicators.

TEK766 Status Packet	
Status Frame (from Mote to server)	
1 Payload Message (Type)	30h
2 Prod ID (TEK 766/TEK790)	
3 Reserved	
4 Hardware ID	
5 Software ID H	
6 Software ID L	
7 Status Byte	
8 Reserved	
9 Unit RSSI	
10 Reserved	
11 Battery % remaining	
12 Measurement Steps (MSB)	
13 Measurement Steps (LSB)	
14 TX Period	
15 Ullage Byte 1	
16 Ullage Byte 2	
17 Temperature	
18 SRC / SRSSI ( 1 nibble each)	

The screenshot shows the 'SCHEDULER' tab of the 'TEK 766 LoRa Packet Parser V1.0' application. It features a 'Scheduler' section with four dropdown menus for 'TX Period (Hours)', 'Ping Rate (Minutes)', 'Logging Rate (Minutes)', and 'Status TX Period (Days)', along with a 'Default' button. Below this is a 'DataGram Packet for Network Server' section with a 'Convert' button, a 'Clear' button, and a text input field.

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TEK 766 LoRa Packet Parser V1.0

STATUS PACKET | MEASURE PACKET | **ALARMS** | SCHEDULER | PARAM READ

**Single Alarm**

1 Select Static Alarm

☐ Enable Alarm

☐ Higher than Threshold

Hysteresis (cm)

Alarm Threshold Limit (cm)

**Multiple Alarm**

☐ Static Alarm 2

☐ Enable Alarm

☐ Higher than Threshold

Hysteresis (cm)

Alarm Threshold Limit (cm)

**Multiple Alarm**

☐ Static Alarm 3

☐ Enable Alarm

☐ Higher than Threshold

Hysteresis (cm)

Alarm Threshold Limit (cm)

Calc

-> Packet for network server

### 3. TEK 766 Battery Life Estimator.

Schedule TX Period      Spreading Factor      Battery Life estimate      Ping Rate

6 hours	SF7	14 years *	15 mins
6 hours	SF12	9 years	15 mins
1 hour	SF12	4 years	15 mins
1 hour	SF7	9 years	15 mins
12 hours	SF12	11 years	15 mins
12 hours	SF7	14 years	15 mins
6 hours	SF7	10 years	1 min
6 hours	SF12	6 years	1 min

**Note \*** : Based on activation within 6 months of the manufacturing date of the product, and device configuration for one LoRaWAN connection every six hours and one ultrasonic measurement every 15 minutes from an excellent LoRaWAN coverage (SF7), and a normal distribution over the operating temperature range centered at +25°C (77°F). SF7 time on air is estimated at 65ms. SF12 is estimated at 1800ms. Note: This is an approximation only.

### 4. TEK 766 Button Press.

The button and LED can appear unresponsive occasionally if the sensor is active for example performing a join request to the LoRaWAN network. This is a consequence of internal activity and the user is advised to wait for a few minutes before retrying. Note: There is a regulatory limit to the number of button presses allowed per hour. After ten button presses, the sensor will not respond to further button presses until an hour has elapsed.

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### 5. MAC Duty Cycle Command

- 1) LoRaWAN MAC Duty Cycle commands allow for extension of a sensors transmission duty cycle independently from the sensors inbuilt scheduler. However the sensors internal firmware requires that the ratio of the set scheduler transmission period to that of the transmission period (as set by the MAC Duty Cycle control command) be  $\leq 6$ .