



1. INTRODUCTION

This document is protocol specification for the Digital Matter G62 LoRaWAN GPS device. Contact info@digitalmatter.com for more information.

1.1. Revision History

Date	Version	Changes
2018-07-06	1.0	Initial Release
2018-04-16	1.1	Changes to example in section 4.1

2. DEVICE BEHAVIOUR

The G62's behaviour can be configured by setting a variety of parameters using a USB programming adapter, or by sending a subset of those parameters during a downlink message. The details of these parameters can be found on the support website.

2.1. Uplink

Uplinks can occur for multiple reasons, depending on what the devices parameters are set to. These include the following:

- Trip start or end
- Periodically during a trip
- Heartbeat (periodically when not in trip)
- Periodic runtime & odometer updates
- Digital input change
- External power change
- Analog input value change

Due to the limitations of the LoRaWAN protocol (and certain regions), uplinks may be queued for several minutes before being sent on the network. If the device cannot send a message for 15 minutes, the uplink will be cancelled (and the data lost). Care should be taken when setting up a device for a specific region.

2.2. Trips

The device uses the term 'trips' to determine when the device is in use (or not). Trips can currently be started from 3 sources:

Ignition digital input – Started when the ignition input sees a voltage greater than 2v.

Run detect – External input voltage going above, or below, pre-set thresholds.

Movement – The internal accelerometer can detect vibrations from movement, and the trip is started when the device moves a certain distance away from its start position.

The current source of trip is sent with the data message. Trip source do not "overwrite" other sources; ie, a source needs to end a trip before a different source can start one.

2.3. Odometer & Runtime

During a trip, runtime and odometer counters are constantly being incremented. These values are stored over the life of the device, and are stored in non-volatile memory (they are not lost when power is removed).

2.4. Inputs

The G62 LoRaWAN has two digital inputs, and one analog input. This can be used to notify the current state of an external device, or alert when certain inputs change. These can be set up in the configuration app.

2.5. Digital Output

The digital output can be controlled through the use of LoRaWAN downlink messages.

2.6. Downlink

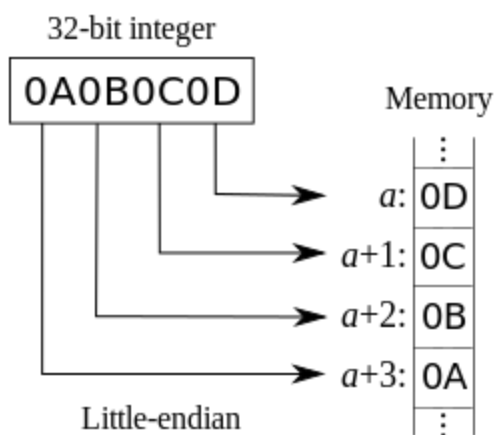
LoRaWAN potentially allows for a downlink with every regular data uplink, but most networks will only allow a few per day. When a parameter update is sent down to the G62, it responds with an application layer acknowledgement uplink as soon as possible. In some regions, this could take several minutes. If the next uplink received is not the expected acknowledgement, the downlink should be resent.

3. NUMBER FORMATS

3.1. Little Endian

Except where noted, all data in the payloads is LITTLE ENDIAN. Be aware of this when converting data fields that consist of more than one byte from the data payload.

<https://en.wikipedia.org/wiki/Endianness#Little>



3.2. Signed (Negative) Numbers

When a field is specified as *signed*, it is represented in 'two's complement' form. Be aware of this when converting signed fields from the data payload. Where unspecified, assume that fields are unsigned.

https://en.wikipedia.org/wiki/Two's_complement

4. UPLINK MESSAGES

LoRaWAN uplink payload limits can be as small as 11 bytes in some regions (for the longest-range transmissions). The packet headers already include the device serial number, and a 'port number' from 1 to 223, which we will use as a message type.

4.1. Uplink Port 1: Full Data Message

Length = 17 bytes. If the selected region and parameters don't support sending 17 bytes all at once, this message will be split into 2 separate messages (see Data Message Part 1 & 2).

Offset	Description
0.0-0.1	Trip type: 0 = no trip, 1 = ignition, 2 = GPS or accelerometer movement, 3 = run detect
0.2	External power good flag
0.3	GPS position is current (could get GPS fix)
0.4 (INT28)	28 bit latitude, signed , Degrees x 10 ⁷ / 16
4.0	Ignition state
4.1	Digital input 1 state
4.2	Digital input 2 state
4.3	Digital out state
4.4 (INT28)	28 bit longitude, signed , Degrees x 10 ⁷ / 16
8 (BYTE)	Heading, LSb = 2°
9 (BYTE)	Speed, LSb = 1 km/h
10 (BYTE)	Battery voltage (20 mV)
11 (UINT16)	External voltage (mV)
13 (UINT16)	Analog input voltage (mV)
15 (INT8)	Internal temperature (degC)
16 (BYTE)	GPS position accuracy (metres)

Example: AA26F5EC16A108450A12CAC9330000171C

- A
 - 1010 in binary
 - 10 – Movement trip
 - 0 – No external power
 - 1 – Gps fix is current
- A026F5EC little endian (lowest nibble set to 0)
 - ECF526A0 in hex
 - -319478112 in decimal (signed)
 - -31.9478112° - Latitude
- 6

- 0110 in binary
- 0 – Ignition input low
- 1 – Digital input 1 high
- 1 – Digital input 2 high
- 0 – Digital output off
- 10A10845 little endian (lowest nibble set to 0)
 - 4508A110 in hex
 - 1158193424 in decimal (signed)
 - 115.8193424° - Longitude
- 0A
 - 10 x 2 = 20° - Heading
- 12
 - 18 km/h – Speed
- CA
 - 202 x 20 mV = 4040 mV (4.04 V) – Battery voltage
- C933 little endian
 - 33C9 hex
 - 13257 decimal (unsigned)
 - 13.257 V – External voltage
- 0000 little endian
 - 0000 hex
 - 0 decimal (unsigned)
 - 0 V – Analog input
- 17 (signed)
 - 23°C – Internal temperature
- 1C
 - 28 m – GPS position accuracy

4.2. Uplink Port 2: Data Message Part 1

Length = 11 bytes.

Offset	Description
0.0-0.1	Trip type: 0 = no trip, 1 = ignition, 2 = GPS or accelerometer movement, 3 = run detect
0.2	External power good flag
0.3	GPS position is current (could get GPS fix)
0.4 (INT28)	28 bit latitude, signed , Degrees x 10 ⁷ / 16
4.0	Ignition state
4.1	Digital input 1 state
4.2	Digital input 2 state
4.3	Digital out state
4.4 (INT28)	28 bit longitude, signed , Degrees x 10 ⁷ / 16
8 (BYTE)	Heading, LSb = 2°

9 (BYTE)	Speed, LSb = 1 km/h
10 (BYTE)	Battery voltage (20mV)

4.3. Uplink Port 3: Data Message Part 2

Length = 6 bytes.

Offset	Description
0 (UINT16)	External voltage (mV)
2 (UINT16)	Analog input voltage (mV)
4 (INT8)	Internal temperature (degC)
5 (BYTE)	GPS position accuracy (metres)

4.4. Uplink Port 4: Odometer & Run Hours Message

Length = 8 bytes.

Offset	Description
0 (UINT32)	Total device runtime (seconds)
4 (UINT32)	Odometer (10 metres)

4.5. Uplink Port 5: Downlink Ack

Offset	Description
0.0 - 0.6	Sequence number (identifies downlink to server)
0.7	0: Downlink rejected, 1: Downlink accepted
1	Firmware major version
2	Firmware minor version

5. DOWNLINK MESSAGES

LoRaWAN downlink payloads can be as small as 11 bytes in some regions (for the longest-range transmissions). The packet headers already include a 'port number' from 1 to 223, which we will use as a message type. The G62 sends an explicit acknowledgement uplink (port 5) on reception of a downlink. It sends the acknowledgement only once, as soon as possible (limited by network, and after any already pending messages). The uplink includes a sequence number to help identify the specific downlink being acknowledged, despite any queuing / buffering in the network. 'Confirmed' and 'unconfirmed' downlinks are handled in the same way.

5.1. Downlink Port 1: Set Trip Parameters

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reserved, set to zero
1.0	Enable movement trips, default true
1.1	Enable ignition trips, default true
1.2	Enable run detect trips, default false
1.3	Transmit runtime/odometer at trip end, default false
1.4-1.7	Reserved, set to zero
2 (BYTE)	In trip upload period, 1-127: 1-127 seconds, 129-255: 1-127 minutes, 0 or 128 disables, default 10 mins (138)
3 (BYTE)	Heartbeat period, 10 minutes, 0 disables, default 2 hrs (12)
4 (BYTE)	Odometer/Runtime upload period, 1 hour, 0 disables, default 1 day (24)
5 (BYTE)	Movement trip speed threshold, 1 km/h, default 10 kmh
6 (BYTE)	Accelerometer wakeup threshold, 63 mG, 1-8 (63 – 504 mG) default 63 mG (1)
7 (BYTE)	Accelerometer wakeup time, 80 ms, 0-12 (0 – 960 ms), default 0 ms (0)

5.2. Downlink Port 2: Set GPS Parameters

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Require 3D GPS fixes, default true
1 (BYTE)	Required PDOP for valid GPS, 25-100: 2.5 to 10.0, default 10.0 (100)
2 (BYTE)	Required position accuracy for valid GPS, 5-100: 5-100 m, default 75 m
3 (BYTE)	Required speed accuracy for valid GPS, 0.1 km/h, 2.9-19.8 km/h, default 10 km/h (100)
4 (BYTE)	Discard first N GPS points to allow solution to settle, 0-32: 0-32 positions, default 3
5 (BYTE)	Static hold threshold, 0.1 km/h, 0-9.0 km/h, default 5 km/h (50)

5.3. Downlink Port 3: Set Digital Input Parameters

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reserved, set to zero
1.0	External voltage: Transmit on low to high, default true
1.1	External voltage: Transmit on high to low, default true

1.2	Ignition Input: transmit on low to high, default false (If using ignition-based trips then leave this false)
1.3	Ignition Input: transmit on low to high, default false (If using ignition-based trips then leave this false)
1.4	Digital input 1: Transmit on low to high, default false
1.5	Digital input 1: Transmit on high to low, default false
1.6	Digital input 2: Transmit on low to high, default false
1.7	Digital input 2: Transmit on high to low, default false
2 (BYTE)	Ignition input debounce period, 10 ms, 0 – 2.55s, default 1s (100)
3 (BYTE)	Digital input 1 debounce period, 10 ms, 0 – 2.55s, default 1s (100)
4 (BYTE)	Digital input 2 debounce period, 10 ms, 0 – 2.55s, default 1s (100)

5.4. Downlink Port 4: Set Analog Input Parameters

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Upload on alarm reset, default true
1 (UINT16)	Analog input alarm high threshold, 1 mV, 0 – 30 V, 0 to disable, default 0
3 (UINT16)	Analog input alarm low threshold, 1 mV, 0 – 30V, 0 to disable, default 0
5 (BYTE)	Hysteresis, 10 mV, 10 – 2550 mV, default 100 (10)

5.5. Downlink Port 5: Set Run Detect Parameters

Note: Both thresholds must be valid if run detect is being used.

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reserved, set to zero
1 (BYTE)	Run detect start time, seconds, default 5
2 (BYTE)	Run detect end time, seconds, default 20
3 (UINT16)	Run detect high threshold, 1 mV, 0 – 36 V, default 10 V
5 (UINT16)	Run detect low threshold, 1 mV, 0 – 36 V, default 5 V

5.6. Downlink Port 6: Set LoRaWAN Channels

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)

0.7	Reserved, set to zero
1.0 - 1.3	Minimum data rate to use when ADR is disabled, default is 0 (DR0)
1.4 - 1.7	Maximum data rate to use when ADR is disabled, default is 2 (DR2)
2 - 10	Uplink channel mask, set bits are enabled channels, LSb of the 1 st byte is channel 0, MSb of the 9 th byte is channel 71, set all zeros (default) for the region-specific defaults

The G62 will spread its transmissions out over the allowed data rates in such a way as to equalize the time spent on-air at each data rate. For the default setting of DR0-DR2, this gives a 16 / 30 / 54% split between the three data rates, and maximizes the gateway's capacity. However, the relative range of the three data rates are 100, 75, and 50% respectively. When ADR is enabled, the network server controls the data rate instead.

The uplink channel mask should be left 0 (default) in regions where the network join channels are fixed: EU863-870, IN865-867, AS923, and KR920-923. In these regions, the gateway will tell the G62 which channels to use, during the join procedure.

In regions where the join channels are not specified (US902-928, AU915-928), you should set the channel mask to avoid continued transmission on unused channels. In these regions the gateway will usually not tell the G62 which channels to use, resulting in significant packet loss if the mask hasn't been programmed.

5.7. Downlink Port 7: Set LoRaWAN Application

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Set AppEUI, 0: Use default AppEUI, 1: Use supplied AppEUI, default 0
1 - 8	AppEUI, big endian , ie. default AppEUI 70-B3-D5-70-50-00-00-05 is encoded with first byte as 0x70 and the second byte 0xB3, where 70-B3-D5-70-5 is the manufacturer identifying portion of the AppEUI

The acknowledgement will be transmitted **once** on the existing AppEUI, and then the G62 will switch to the new AppEUI. It continues to use the already provisioned AppKey, which cannot be programmed over the air.

5.8. Downlink Port 8: Set Advanced LoRaWAN Options

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Reserved, set to zero
1 (BYTE)	Days between network joins, 0 disables, default 14
2.0 - 2.1	ADR support, 0: Never, 1: When out-of-trip, 2: Always, default never
2.2 - 2.7	Reserved, set to zero

By default, the G62 rejoins the network once a fortnight, in case the network server has somehow forgotten the session keys. This period can be extended to up to 255 days, or disabled entirely. However, if a device is accidentally deleted on the network server, or the

network server suffers a database failure and loses the session keys, the server will be unable to decrypt any device data until it has rejoined. Rejoining fortnightly generates several extra transmissions, but lowers the time spent out of service in the event of an accident.

By default, the G62 does not request Adaptive Data Rate (ADR) when sending uplinks, choosing instead to control its data rate according to the configured range. However, you may wish to enable ADR when the tracked asset is mostly stationary, to optimize power usage and network capacity. You can also force ADR on at all times, in order to control it using a policy on the network server.

If the G62 is configured to enable ADR when out-of-trip, it will switch to its lowest configured data rate, and highest transmit power, whenever a trip ends. Thereafter, the network server will configure it to a lower power mode if appropriate.

Please remember that the ADR adaptation rate in LoRaWAN 1.0 is extremely slow. If the device loses connectivity, it takes 96 lost transmissions before it will attempt to increase its transmit range. This adaptation rate will be adjustable in a future LoRaWAN release.

5.9. Downlink Port 9: Set Digital Output

Offset	Description
0.0 - 0.6	Downlink sequence number (reported in acknowledgement)
0.7	Digital output state to be written (true = on)

Note: The state of the digital output is stored in non-volatile memory, so is not lost on power loss.

6. CONTACT INFORMATION

For the latest version of this document plus other product information please visit our website at www.digitalmatter.com/support, or contact DM at info@digitalmatter.com.