GIS Contactless Card Reader for Eco Rewards

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1. Introduction

The GIS Contactless Card Reader for Eco Rewards in a device for reading ITSO, LASSeO and NFC Tags and recording them for the purpose of generating statistics.

1.1. Hardware

Embedded ARM processor board with 256K Flash and 128K RAM.

LoRaWAN Module using 868MHz unlicensed band.

Tri-colour LED to indicate state of reader as follows:

LED	**Battery**	**LoRa State**	**Card Reading**
Flashing GREEN	Good	On-line	Yes
Flashing AMBER	Poor	On-line	Yes
Flashing RED	Good or Poor	**Off-line**	Yes
Steady RED	Empty	**Off-line**	**No**

Buzzer to indicate card reading state, two quick beeps with green LED on card read ok, one long bleep with red LED for card read failure.

1.2. Software

The software written by GIS reads the card number from the presented ITSO card, LASSeO card or NFC tag and records this along with the current date&time.

Periodlically these records are transmitted to a host system using the LoRa WAN network.

2. Card Processing

2.1. Card Reading Procedure

Card Type	Application	Procedure
DESFire	All	Select Card to obtain UID Reset Card to obtain ATS
	ITSO	Select Application AID A0 02 16 Read file 15 to obtain Shell Save Timestamp+Shell.ISRN to record store
	LASSeO	Select Application AID F4 01 10 Read file 1 to obtain CardHolderNumber Save Timestamp+CardHolderNumber to record store **N.B:** If an ITSO and LASSeO application are encoded on the same card only the ITSO Shell.ISRN will be recorded
	Other	Card ignored
Mifare Ultralite	All	Select Card to obtain UID
	NFC Tag	Read Page 3 to obtain NFC Capability Container Read Pages 4...15 to obtain NDEF record containing TXT CardNumber Save Timestamp+CardNumber to record store
	Other	Card ignored
Mifare+	All	Select Card to obtain UID (may be random) Reset Card to obtain ATS
	ITSO	Select MF A0 00 00 02 16 'I 'T 'S' 'O '- '1 Select DF 01 00 Read EF 1 to obtain Shell Save Timestamp+Shell.ISRN to record store
	Other	Card ignored
Generic Micro	All	Reset Card to obtain ATS
	ITSO	Select Card to obtain UID (may be random) Select MF A0 00 00 02 16 'I 'T 'S' 'O '- '1 Select DF 01 00 Read EF 1 to obtain Shell Save Timestamp+Shell.ISRN to record store
	Other	Card ignored
~~Mobile Phone~~	~~All~~	
	~~NFC Tag Application~~	~~Select Application D2 76 00 00 85 01 01~~ ~~Read CC EF (E101) to obtain NFC Capability Container~~ ~~Read NDEF EF (E104) to obtain NDEF record containing TXT CardNumber~~ ~~Save Timestamp+CardNumber to record store~~
	~~Other~~	~~Phone ignored~~

2.2. Record Store

The reader contains a Flash chip (2Mbyte) which is used to store the details of cards read before they are transmitted to the host.

The following record will be stored for each card read:

Field	**Size (bytes)**	**Usage**
Timestamp	4	Date/time of capture in seconds since 2001/01/01 00:00
Type	1	One of ITSO, LASSEO, NFC
Serial	9	ITSO Card: 9 bytes, 18 BCD digits LASSeO Card: 8 bytes, 16 BCD digits NFC Tag: 5 bytes, 10 BCD digits
Spare	2	
Total	**16**	

The reader uses two pointers into the record flash memory to manage a cyclic buffer of records. The Flash can store 130816 records before becoming full.

3. Host Communication

3.1. Cards Message

The reader will send the card records over a LoRa network link to a LoRaWAN server. The LoRa payload will consist of the following fields:

Field	**Size (bytes)**	**Usage**	
DevID	4	Device identifier (8 BCD digits)	
TSN	4	Transaction Sequence (8 BCD digits)	
Type	1	0x63 = ITSO Card 0x4C = LASSeO Card 0x54 = NFC Tag	Repeated up to 4 time
Serial	8	ITSO Card Number (less first byte 0x63), 16 BCD digits	
	8	LASSeO Card Number, 16 BCD digits	
	5	NFC Tag Number	
Timestamp	3	Date/time of capture in minutes since 2019/01/01 00:00	
Total	**44 to 50**		

Worst case, 3 ITSO records, 44 bytes:

```
ID ID ID ID TS TS TS TS 63 XX XX XX XX XX XX XX
XX TT TT TT 63 XX XX XX XX XX XX XX XX TT TT TT
63 XX XX XX XX XX XX XX XX TT TT TT
```

Best case, 2 NFC plus 2 ITSO records, 50 bytes:

```
ID ID ID ID TS TS TS TS 4E XX XX XX XX XX TT TT
TT 4E XX XX XX XX XX TT TT TT 63 XX XX XX XX XX
XX XX XX TT TT TT 63 XX XX XX XX XX XX XX XX TT
TT TT
```

For example:

```
05 11 18 70 00 00 00 12 4C 63 38 00 00 85 35 15 '...p....Lc8...5.'
01 07 BF 80 54 22 22 23 00 13 07 BF 80 54 22 22 '....T""#.....T""'
23 00 12 07 BF 81                               '#.....         '
```

3.2. Status Message

Periodically the reader will send a status message containing the following information:

Field	**Size (bytes)**	**Usage**
DevID	4	Device identifier (8 BCD digits)
TSN	4	Transaction Sequence (8 BCD digits)
Date	4	YYYYMMDD, 8 BCD digits
Time	2	HHMM, 4 BCD digits
Uptime	4	Minutes, 8 BCD digits
Battery	2	XXXX mV (solar power) 3800 (mains power), 4 BCD digits
USB	2	YYYY mV (solar power), 0000 (mains power), 4 BCD digits
Storage	4	Number of messages pending, 8 BCD digits
Total	**26**	

For example:

```
05 11 18 70 00 00 00 12 20 19 12 19 14 31 00 00 '...p.... ....1..'
01 25 40 80 48 88 00 00 00 00                   '.%@.H.........'
```

3.3. Status Response

In response to the status message the host may send the following information:

Field	**Size (bytes)**	**Usage**
Header	5	String ‘SETDT’
Date	4	YYYYMMDD (8 BCD digits)
Time	2	HHMM (4 BCD digits)
Total	**11**	

The reader may be requested to re-start by sending a response message containing the value ‘RESTART’ followed by the device identifier as a string, e.g. ‘RESTART0511870’.

4. Configuration

4.1. LoRa Configuration

A configuration file (LORA.INI) will be read by the reader on start-up to configure it's LoRa stack.

The following configuration items are required:

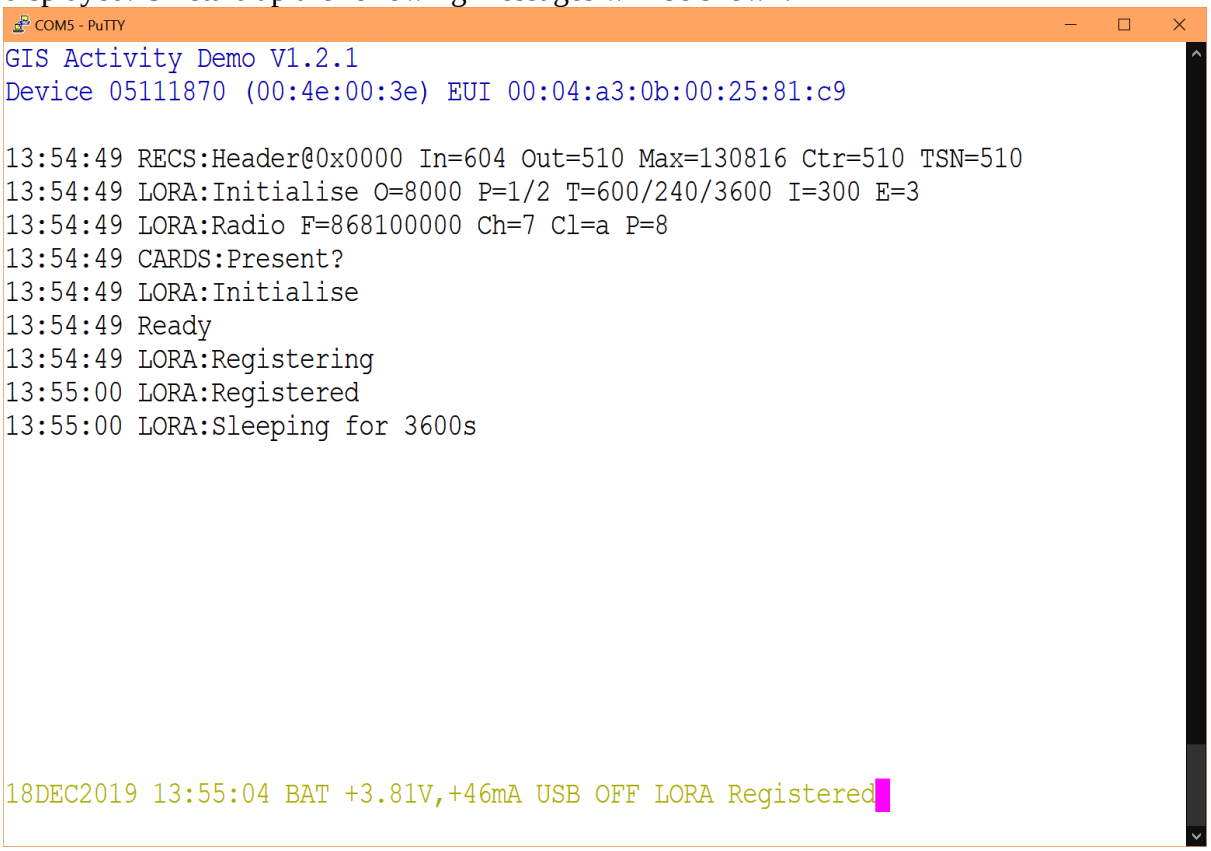
Item	Format	Usage
Version	V.L.I	Firmware version
Options	Bit mask	To use ADR set option A To use OTAA link establishment set option O, otherwise ABP will be used To send data un-confirmed set option U
DataPort	Decimal	Port to which card record messages will be sent
StatusPort	Decimal	Port to which status messages will be sent&received
Frequency	Decimal	LoRa frequency to be used, minimum 863000000Hz, maximum 870000000Hz
ChannelID	Decimal	LoRa channel to be used, 3 thru 15
Class	'a' or 'c'	LoRa class to be used
Power	Decimal	LoRa power level to be used, minimum -3, maximum +14
AppEUI	Binary [8]	Application EUI expected by LoRaWAN gateway when using OTAA link establishment
Key1	Binary [16]	When using OTAA this is the Application Key expected by the LoRaWan gateway, otherwise the ABP Network Session Key expected by the LoRaWan gateway
Key2	Binary [16]	When using ABP this is the Application Session Key expected by the LoRaWan gateway

For example:

```
[GISLORA]
Version=1.1.1
Options=O
[RADIO]
Frequency=868100000
ChannelID=7
Class=a
Power=8
[APPLICATION]
DataPort=1
StatusPort=2
AppEUI=70B3D57ED0025CDF
Key1=E3FCB36FF9A78F1833289562A34C317C
Key2=
```

5. Diagnostic Console

The readers serial port can be connected to PC using a USB←→Serial converter. Running a terminal emulator (e.g. Putty@115200,8,N,1) allows diagnostics to be displayed. On start-up the following messages will be shown:



Information is displayed with a time prefix and a module prefix. The top line shows the software revision. The next line shows the device identifier (in decimal and hex) and the device EUI. The final line shows the date and time; the battery voltage; the voltage of the USB input; and the state of the LoRa connection.

Diagnostics are available from the following modules.

5.1. Record Store

The `RECS` prefix identifies messages relating to the messages store, for example:

```
RECS:Header@0x0000 In=10 Out=10 Max=130816 Ctr=10 TSN=10
```

This shows the current `In` and `Out` pointers into the record store, and the `Max` number of records which can be stored before the reader stops reading cards. The `Ctr` is the total number of records the reader has processed; and the `TSN` is the current transaction sequence number.

5.2. Card Reader

The `CARDS` prefix identifies message occurring during card processing.
The message `CARD: Present?` indicates the card reader has been initialised and is waiting a card to be presented.

When a card is presented one of the following messages will be displayed depending on the card type:

Card Type	Message
ITSO	`CARDS:ITSO 633597 0109 1028 6281`
LASSeO	`CARDS:LASSeO 633800 0085 3515 01`
NFC	`CARDS:NFCTag 2222230012`

5.3. LoRa

The `LORA` prefix identifies message occurring during data transmission.

The initial start-up sequence will typically be:

```
14:04:14 LORA:Initialise
14:04:14 LORA:Awaiting Registration
14:04:17 LORA:Registered
14:04:22 LORA:Sleeping for 3600s
```

An attempt to send records will show the following sequence of events:

```
13:58:33 LORA:Publishing 44 bytes on Port 1
05 11 18 70 00 00 05 10 54 22 22 23 00 12 19 E1 '...p....T""#....'
24 54 22 22 23 00 13 19 E1 34 54 22 22 23 00 12 '$T""#....4T""#..'
19 E1 47 54 22 22 23 00 13 19 E1 5E             '..GT""#....^    '
13:58:33 LORA:Awoken
13:58:33 LORA:Transmitting 44 bytes on Port 1
13:59:22 LORA:Received 0 bytes on Port 0
13:59:24 RECS:Header@0x0000 In=604 Out=514 Ctr=514 TSN=514
13:59:24 LORA:Sleeping for 3600s
```

5.4. Commands

The following commands may be executed by pressing the corresponding key on the terminal:

Key	Action	Description
c	Fake card	Generate a fake UID and store it
1…9	Counter	Repeat following fake card command n times
d	Date	Enter Year, Month and day to set RTC
t	Time	Enter Hour and Minute to set RTC
l	Transmit	Initiate LoRa transmission if not already in progress
r	Restart	Restart LoRa connection if not already registered
SPACE	Refresh	Refresh terminal output