QB50 SE01 AX.25 Beacon Decoder

1. Beacon Description

qbee's transmitter uses the following RF parameters:

Modulation	GFSK
Modulation index	0.6667
Packet format	AX-25*, CSP
Encoding	NRZI with stuffing / G3RUH scrambled for AX.25, RS(223,255) for CSP
Carrier-Frequency	435.800 MHz
Nominal data rate	9600 baud
AX-25 Source Address Field	From: ON01SE
	To: ON01SE
Interval	10 s (LEOP), 30 s (during routine Operations [to be commanded])
Decoder	https://github.com/opencosmos/qb01-beacon-decoder

**NOTE on AX.25: The qb01 beacon callsign fields are not bit-shifted, so unfortunately an AX.25-compliant TNC will have trouble decoding them. Instead, simply discard the AX.25 framing (first 16 bytes + last 2 bytes). The next level is Reed-Solomon FEC so the AX.25 CRC16 is not essential.*

If your TNC insists on deframing the AX.25 itself, it will probably read the CSP header and the time field as a "via" callsign, so alter the decoder appropriately to handle the lack of the "time" field.

Byte and Bit order notes

Byte order: Least Significant Byte (LSB) first on multi-byte numbers

Bit order: Least Significant Bit first

2. Beacon Structure

<table>
<tr><td colspan="7">Encoded NRZI</td></tr>
<tr><td colspan="7">Scrambled G3RUH</td></tr>
<tr><td></td><td></td><td colspan="4">CCSDS RS(223,255)</td><td></td></tr>
<tr><td>Preamble: 50x 0x7e</td><td>AX.25 header</td><td></td><td></td><td></td><td></td><td>AX.25 CRC16</td></tr>
<tr><td>50 bytes</td><td>16 bytes</td><td></td><td></td><td></td><td></td><td>2 bytes</td></tr>
<tr><td></td><td></td><td>CSP Header</td><td>SAT ID</td><td>Beacon data</td><td>RS parity</td><td></td></tr>
<tr><td></td><td></td><td>4 bytes</td><td>4 bytes</td><td>28 bytes</td><td>32 bytes</td><td></td></tr>
</table>

Decoding procedure:

(fm_demodulate → demodulate_gfsk → clock_recovery →) decode_g3ruh → decode_stuffed_nrzi → detect_preamble → extract_packets → deframe_ax25 → decode_rs → deframe_csp

Beacon data structure

Name	Offset [bytes]	Size [byte]	Comments	Content item	Size [bits]	Type	Comment
WOD	0	12	format reference in: QB50 Whole Orbit Data - Iss4.pdf https://qb50.eu/index.php/tech-docs/category/15-whole-orbital-data	LSB: time	32	uint32_t	[s] after 2000-01-01T00:00:00Z
				Mode	8	uint8_t	
				Battery voltage	8	uint8_t	
				Battery current	8	uint8_t	
				3.3V bus current	8	uint8_t	
				5V bus current	8	uint8_t	
				Comms temperature	8	uint8_t	not valid
				EPS temperature	8	uint8_t	
				Battery temperature	8	uint8_t	
Power info	12	1	LSB	ADCS	1	bit	1 = power is ON 0 = power is OFF
				FIPEX	1	bit	
				GPS	1	bit	
				OCOBC	1	bit	
				not used	4		
Services enabled	13	1	LSB	ADCS	1	bit	1 = service enabled 0 = service disabled
				FIPEX	1	bit	
				OCOBC	1	bit	
				not used	5		
Services running	14	1	LSB	ADCS	1	bit	1 = service running 0 = service running
				FIPEX	1	bit	
				OCOBC	1	bit	
				not used	5		
Reserved	15	≥13				char	
TOTAL Size		***≥28 bytes***					

3. Data platform and support

Beacon information received by the radio amateur community can be uploaded to the QB50 dedicated webpage: https://upload.qb50.eu/upload/ following the specifications defined in https://upload.qb50.eu/upload-help/

The LTU-Open Cosmos team will welcome support from the radio amateur community. Information regarding the received beacon and metadata (SNR, Doppler shift sensed, UTC timetaged Az/El points, etc) can be sent to qb01@open-cosmos.com.

A decoder for qb01 beacon packet can be found in Open Cosmos' github: https://github.com/opencosmos/qb01-beacon-decoder. Received data can also be uploaded there by sending a Pull Request after having forked and updated the repository.

More information can be found at www.open-cosmos.com/SE01.

4. Orbit & TLE

Released from the International Space Station on Wed 17/05/2017 at 01:45h UTC.

The preliminary assigned designation to *qbee* is `1998-067LM`.

```
TLE fetched on 24th May 2017

0 OBJECT E
1 42704U 98067LM  17143.48763919 +.00011231 +00000-0 +17188-3 0  9996
2 42704 051.6427 161.3863 0001922 145.4714 335.0503 15.54886122001015
```