JAVAD GNSS
1731 Technology Drive,
San Jose, CA 95110
Phone: (408)573-8100
Fax: (408)573-9100

LMR400[1] UHF OEM MODULE
Duty Cycle Evaluation[2]

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Author:Vladimir Zhukov, JAVAD GNSS, Inc.
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Revision A

[1] Other names for marketing purposes are AW400Tx, AW400Jv

[2] This report has been prepared confidentially and should not be disclosed to any third party without the written agreement of JAVAD GNSS, Inc

Revisions

Revisions	Date	Author	Comment
A	August 15, 2008	VZ	Initial version

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RF exposure evaluation and Power density are based on duty cycle evaluation. LMR400 DSP based integrated UHF Modem is the single board OEM wireless transceiver intended for SCADA, outdoor telemetry applications and transmission/receiving of differential corrections and additional information by terrestrial radio channels between two GNSS receivers. The LMR400 provides real-time data transmission using spectrum efficient GMSK/BPSK/QPSK/8-PSK/QAM modulations.

Duty cycle depends of the amount of data transmitted by the base station via the given data link. This amount of data should be sufficient to run GNSS rover in DGPS or RTK mode.

1. Code Differential Mode

In code differential, the reference station will transmit either RTCM (Radio Technical Commission for Maritime Services) message type 1 (GPS Differential Corrections) together with RTCM message type 31 (GLONASS Differential Corrections), or RTCM message type 9 (GPS Partial Differential Corrections) together with RTCM message type 34 (GLONASS Partial Differential Corrections). In the second case (i.e., when using partial differential corrections), data for only up to three satellites may be transmitted at one time whereas, in the first case, data for all of the tracked satellites are transmitted simultaneously. This explains why the amount of data in RTCM messages types 9 and 34 is always less or equal to the amount of data in RTCM messages types 1 and 31. Note, however, that this reduction of the amount of transmitted data is achieved at the expense of position accuracy deterioration, which should be born in mind when choosing between the full and partial differential correction messages.

The amount of data required in code differential is described by the following equation:

$$\textbf{[Number of 30-bit words]} = \mathbf{2 + N*2 - [N/3]}, \qquad (1.1)$$

where ***N*** designates the number of satellites.

This equation (1.1) allows us to calculate the amount of data for a single navigation system (either GPS or GLONASS). To get an aggregate estimate of the number of 30-bit words required for GPS+GLONASS, just it is needed calculate separate estimates for GPS and

GLONASS and then sum them up. (Note that the brackets [ ] here designate the operation "division without remainder", e.g., [2/3]=0, [3/3]=1, [4/3]=1).

To go from 30-bit words to 8-bit bytes, the estimated number of bytes, as it follows from the RTCM standard, should be multiplied by 5.

Calculation:

Assuming the reference station has been tracking 10 GPS SVs and 5 GLONASS SVs.

First assume that differential data are transmitted by means of RTCM messages types 1 and 31. Then the number of required 30-bit words is equal to:

$$2 + 10*2 + [10/3] + 2 + 5*2 + [5/3] = 38.$$

Thus the number of bytes 38×5=190 or in bits 190x8=**1520 bps**.

On the other hand, assuming the use of RTCM messages types 9 and 34 (all other things being the same), we will get the following estimate for the number of 30-bit words:

$$2 + 3*2 + [3/3] + 2 + 3*2 + [3/3] = 18.$$

Therefore the number of bytes is 18×5=90 or in bits 90x8=**720 bps**.

2. Real Time Kinematic

Currently JAVAD GNSS receivers support two RTK protocols, specifically:

- RTCM message types 18 and 19;
- RTCM message types 20 and 21;
- CMR

2.1. Protocol Using RTCM Message Types 18 and 19 (or 20 and 21).

The amount of data required in RTK is described by the following equation:

[Number of 30-bit words] = 2*FREQ*(3+2*N), (2.1)

where

N designates the number of satellites,

FREQ = 1 and 2 for single- and dual-frequency receivers, respectively.

This equation allows us to calculate the amount of data for a single navigation system (either GPS or GLONASS). To get an aggregate estimate of the number of 30-bit words required for GPS+GLONASS, just calculate separate estimates for GPS and GLONASS and then sum them up.

It should be born in mind that the reference station will transmit its coordinates too. Reference station coordinates are normally transmitted less frequently than raw measurements. However, these kinds of "rare data" too should be taken into consideration when estimating the peak throughput for the given data link.

Nine 30-bit words are used to transmit the reference station's position, specifically, six words in RTCM message type 3 and three words in RTCM message type 22. To go from 30-bit words to 8-bit bytes, multiply the estimated number of words by 5 (in accordance with the RTCM standard).

Calculation.

Assuming the reference station has been tracking 10 GPS SVs and 5 GLONASS SVs. Let's also assume that dual-frequency data are transmitted. Then the number of required 30-bit words is equal to:

$$2*2*(3 + 10*2) + 2*2*(3 + 5*2) = 144.$$

Thus the number of bytes 144×5=720. The data amount corresponding to the "peak throughput" is equal to 144+9 = 153 30-bit words or 153*5= 765 bytes or in bits 765x8= **6120 bps**.

2.2. CMR and CMR Plus protocols

The amount of data required in RTK is described by the following equation:

[Number of bytes] = 6 + N * (8 + (FREQ-1) * 7), (2.2)

where

N designates the number of satellites,

FREQ = 1 and 2 for single- and dual-frequency receivers, respectively.

This equation allows us to calculate the amount of data for a single navigation system (either GPS or GLONASS). To get an aggregate estimate of the number of 8-bit bytes required for GPS+GLONASS, just calculate separate estimates for GPS and GLONASS and then sum them up.

It should be born in mind that the reference station will transmit its coordinates and description too. Reference station coordinates and description are normally transmitted far less frequently than raw measurements. However, these kinds of data too should be taken into consideration when estimating the peak throughput for the data link. When the CMR protocol is used, 31 bytes are required to transmit the reference station's position (recall that this is the size of CMR message type 1) and 81 bytes (maximum) are required to transmit the reference station's description (CMR message type 2).

To further the progress of reducing the peak throughput, Trimble Navigation Limited has developed a new technique which allows the receiver to transmit the reference station information by small frames (Scrolling Station Information), in preference to sending all of the information at a time. Each frame is 16 bytes in size (7-byte message body plus 9 auxiliary bytes), and is transmitted along with CMR Message Types 0 and TPS proprietary GLONASS message.

Below are calculated the performance of the CMR and CMR Plus formats.

Assuming the reference station has been tracking 10 GPS SVs and 5 GLONASS SVs. Let us also assume that dual-frequency CMR data are transmitted by the reference station.

CMR	**CMR Plus**
The minimum amount of data required in RTK: 6+10*(8+7) + 6+5*(8+7) = 237 bytes. The amount of data corresponding to the data channel's *peak throughput*: 237+31+81= 349 bytes or in bits 349x8=**2792 bps**	The minimum amount of data required in RTK: 6+10*(8+7) + 6+5*(8+7) = 237 bytes. The amount of data corresponding to the data channel's *peak throughput*: 237+16=253 bytes or in bits 253x8=**2024bps**.

3. Summary table

Mode	Transmitted amount of data, bps
RTCM messages types 1 and 31	1520
RTCM messages types 9 and 34	720
RTCM messages types 18 and 19 (20 and 21)	6120
CMR	2792
CMR Plus	2024

The max amount of data to be transmitted is by using RTCM messages types 18 and 19 or (20,21). $\mathbf{L_{MAXRTCM}}$ **= 6120 bps.**

$\mathbf{L_{MAXCMR}}$ **= 2792 bps**

4. Duty Cycle Calculation

The calculation will be done for typical scenario.

The service protocol information is 5 % of transmitted amount of data. It means:

$L_{TRANSMRTCM} = L_{MAXRTCM} + 0.05x\ L_{MAXRTCM}$ = 6120 + 0.05x6120 = 6120+306 = **6426 bps**.

By using Forward Error corrections (FEC):

$L_{TRANSMRTCM\ (FEC)} = 1.5xL_{MAXRTCM} + 0.05x\ L_{MAXRTCM} =$

= 1.5x6120 + 0.05x 6120 = 9180 + 306 = **9486 bps**.

$L_{TRANSMCMR} = L_{MAXCMR} + 0.05x\ L_{MAXCMR}$ = 2792 + 0.05x2792 = 2792+140 = **2932 bps**.

By using Forward Error corrections (FEC):

$L_{TRANSMCMR\ (FEC)} = 1.5xL_{MAXCMR} + 0.05x\ L_{MAXCMR} =$

= 1.5x2792 + 0.05x 2792 = 4188 + 140 = **4328 bps**.

RTCM:

Transmitting period without FEC = 6426/19200 = 0.33 sec

Transmitting period with FEC = 9486/19200 = 0.49 sec

Ton **-** the possible longest time when transmitter is ON during 30 min in normal operation

Toff - the possible shortest time when transmitter is OFF during 30 min in normal operation

DC - Duty Cycle

Ton_{RTCM} = 0.49 sec

$Toff_{RTCM}$ = 0.51 sec

DC_{RTCM} = (Ton)/(Ton+Toff) = 0.49/(0.49+0.51)=0.49 (49%)

CMR:

Transmitting period without FEC = 2932/19200 = 0.15 sec

Transmitting period with FEC = 4328/19200 = 0.23 sec

Ton_{CMR} = 0.23 sec

$Toff_{CMR}$ = 0.77 sec

DC_{CMR} = (Ton)/(Ton+Toff) = 0.23/(0.23+0.77)=0.23 (23%)

Conclusion: In the typical real life scenarios Duty Cycle of LMR400 OEM UHF radio does not exceed 50 %.