

**SIGNAL-IN-SPACE ICD FOR
MESSAGING SERVICE (IRNSS 1A)**

VERSION 1.0

June 2018

SATELLITE NAVIGATION PROGRAMME

**U.R.RAO SATELLITE CENTRE
INDIAN SPACE RESEARCH ORGANIZATION
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Preface

This document provides the Signal and the Data Structure for Messaging service using IRNSS 1A spacecraft. The document addresses the signal modulations, the frequency band, the received power levels, the data structures, their interpretations etc.



Revision Record		
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INTRODUCTION

The Signal-in-space ICD for messaging services provides the information on messaging service offered by ISRO utilizing IRNSS 1A spacecraft. The messaging services are provided to users within Indian region using the IRNSS ground segment and the IRNSS spacecraft. IRNSS 1A spacecraft is placed in an Inclined Geo-Synchronous Orbit with 29° inclination and equatorial crossing at 55° E longitude, and broadcast messages in L5 band frequency.

SCOPE OF THE DOCUMENT

The Signal and the Data Structure for messaging service specifies the interface between the IRNSS 1A spacecraft and the user segment for messaging service. The document provides necessary information for receiver design to decode the messages being transmitted by IRNSS 1A Spacecraft. This document does not address the implementation of applications utilizing the decoded message data.

1. SIGNAL OVERVIEW

1.1 SPACECRAFT CARRIER FREQUENCY

The messaging service signals are broadcast in L5 band frequency. The carrier frequency and the bandwidth of transmission for the messaging service are shown in Table 1.

Table 1: Carrier Frequency and bandwidth

Signal	Carrier Frequency	Bandwidth
L5	1176.45 MHz	24 MHz (1164.45 -1188.45 MHz)

1.2 MODULATION SCHEME

The signal is BPSK(1) modulated on L5 band. The navigation data at data rate of 50 symbols per second (1/2 rate FEC encoded) is modulo 2 added to PRN code chipped at 1.023 Mcps. The CDMA modulated code, modulates the L5 carrier at 1176.45 MHz.

1.3 RECEIVED POWER LEVELS ON GROUND

1.3.1 Nominal Levels

Table 2 indicates the assured power levels of the signals received by a user receiver on ground. The received power on ground is measured at the output of an ideally matched RHCP 0 dBi user receiving antenna when the spacecraft elevation angle is higher than 5°.

Table 2: Nominal received power of signals

Signal	Signal Component	Nominal Received Power (dBW)
L5	BPSK(1)	-159.0

1.4 POLARIZATION CHARACTERISTICS

Signals are Right Hand Circularly Polarized. The antenna axial ratio does not exceed 2.0 dB.

2. USER SEGMENT

The User segment mainly consists of:

- Receiver capable of receiving signal at L5 band frequency.

Figure 1 specifies the radio frequency interface between space and user segments. The Spacecraft provides signals in L5 band.

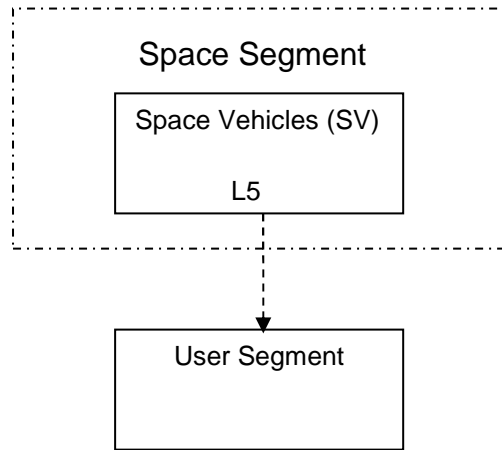


Figure 1:Space Segment Interface with User Segment

3. PRN CODES

The IRNSS spacecrafts utilize Gold codes for the signal. The codes are generated using Linear Feedback Shift Registers.

The code lengths for signal component are listed in Table 3.

Table 3: Code lengths of signals

Code Length (ms)	No. of Chips
1 ms	1023

3.1 PRN CODES

The initial conditions for generation of PRN Codes for IRNSS satellites are as given in Table 4. The length of each code is 1023 chips. The code is chipped at 1.023 Mcps.

3.1.1 Code Generation

For code generation, the two polynomials G1 and G2 are as defined below:

$$G1: X^{10} + X^3 + 1 \text{ and } G2: X^{10} + X^9 + X^8 + X^6 + X^3 + X^2 + 1$$

The G1 and G2 generators are realized by using 10 bits Maximum Length Feedback Shift Registers (MLFSR). The G1 register is initialized with all bits as '1'. The initial state of G2 register is provided in table 4. G1 and G2 are XOR'ed for the generation of the final 1023 chip long PRN sequence. The time period of the PRN sequence is 1 millisecond.

Table 4: Code Phase assignment for signals

Satellite ID	Initial Condition for G2 Register	First 10 Chips in Octal2
IRNSS-1A	1110100111	0130
IRNSS-1B	0000100110	1731
IRNSS-1C	1000110100	0713
IRNSS-1D	0101110010	1215
IRNSS-1E	1110110000	0117
IRNSS-1F	0001101011	1624
IRNSS-1G	0000010100	1753

Currently the messaging service is broadcasted from IRNSS 1A.

The Figure below shows the generation of code.

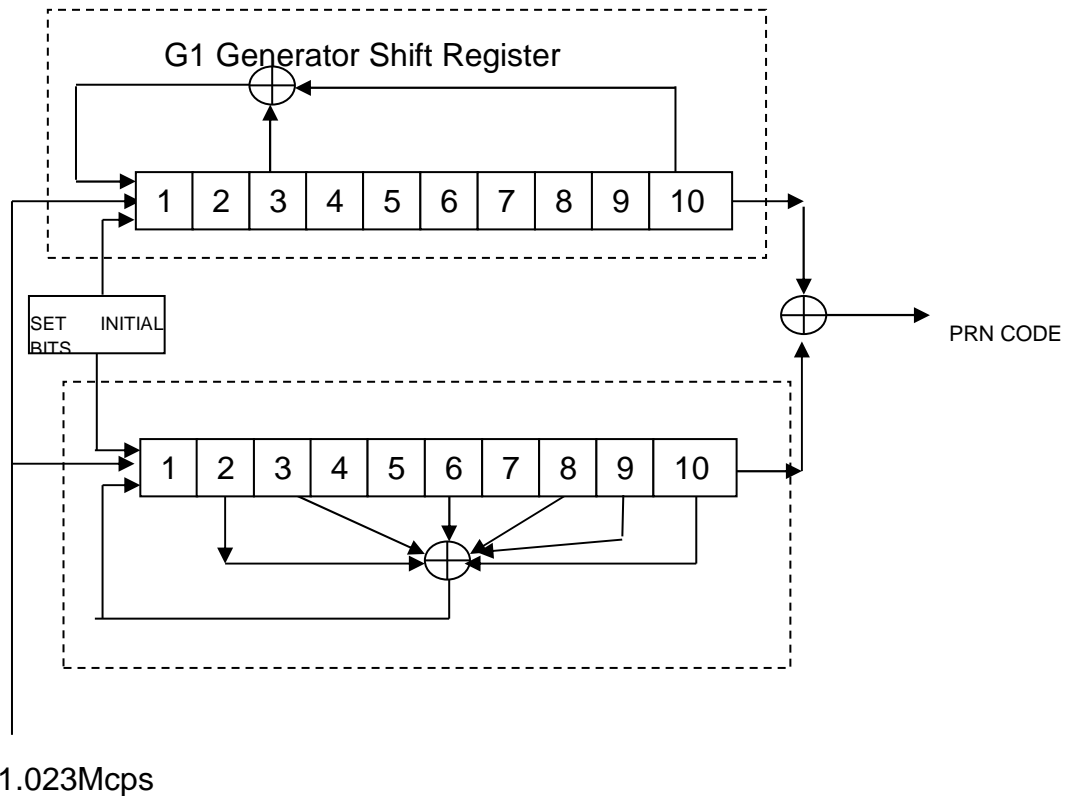


Figure 2: PRN Code Generator

4. DATA STRUCTURE

The Signal-In-Space transmits messages in L5 band. Data is transmitted in sub-frames of 600 symbols transmitted at 50 symbols per second. Sub-frame has 16 bit Sync word followed by 584 bits of interleaved data. The sub-frame format is shown in Figure 3.

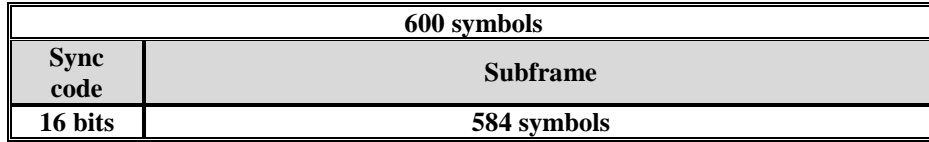


Figure 3 : Subframe Structure

The 584 symbols of interleaved data are obtained from FEC encoding 292 sub-frame bits.

4.1 BIT AND BYTE ORDERING CRITERIA

The following bit and byte ordering criteria will be used while formatting the data:

- The most significant bit/byte is numbered as bit/byte 1
- The most significant bit/byte is transmitted first

4.2 FEC ENCODING

The sub-frame of 292 bits is rate 1/2 convolution encoded and clocked at 50 symbols per second. Figure 4 depicts the convolution coding scheme

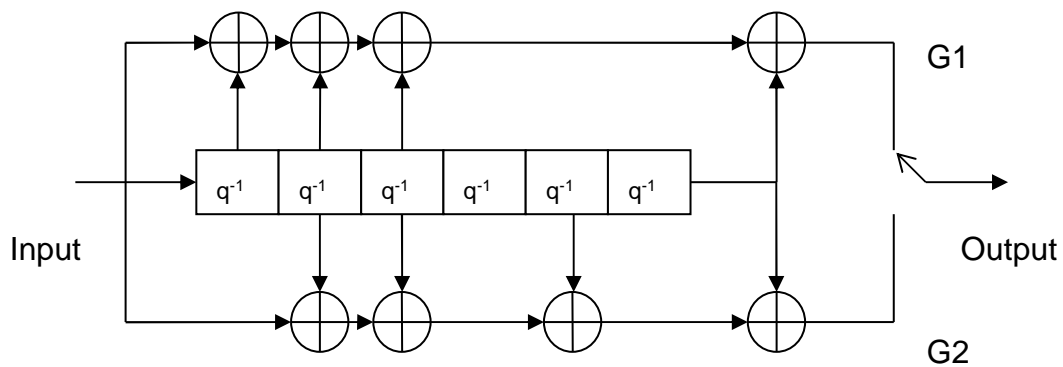


Figure 4: FEC Encoding

The convolution encoding for the data is performed as per the parameters given in Table 5.

Table 5: FEC encoding parameters

Parameter	Value
Coding Rate	1/2
Coding Scheme	Convolution
Constraint Length	7
Generator Polynomial	G1 = (171) _o G2 = (133) _o
Encoding Sequence	G1 then G2

Each sub-frame of 292 bits, after encoding, results in 584 symbols.

4.3 INTERLEAVING

The 584 symbols of FEC encoded data is interleaved using a block interleaver with *n* columns and *k* rows. Data is written in columns and then, read in rows. Table 6 indicates the interleaving mechanism.

Table 6: Interleaving parameters

Parameter	Arrangement
Block Interleaver size	584
Block Interleaver Dimensions (<i>n</i> columns x <i>k</i> rows)	73 x 8

4.4 SYNC WORD

The Synchronization pattern for each of the sub-frame is 16 bit word. The Synchronization word is not encoded. The synchronization pattern allows the receiver to achieve synchronization to the sub-frame. The Sync pattern is EB90 Hex.

4.5 TAIL BITS

The tail bit field consists of 6 zero value bits enabling completion of the FEC decoding of each sub-frame in the user receiver.

4.6 CYCLIC REDUNDANCY CHECK (CRC)

The data signal contains parity coding according to the following conventions. CRC – 24Q polynomial shall be used for each Sub frame, applied on the first 262 bits of the sub-frame. Twenty-four bits of CRC parity will provide protection against burst as well as random errors with a probability of undetected error $\leq 2^{-24} = 5.96 \times 10^{-8}$ for all channel bit error probabilities ≤ 0.5

The generator polynomial is given as

$$g(X) = \sum_{i=0}^{24} g_i X^i$$

$g_i = 1$ for i equal to 0, 1, 3, 4, 5, 6, 7, 10, 11, 14, 17, 18, 23, 24
 $= 0$ otherwise

4.7 Sub Frame Structure

Each Sub-frame is 292 bits long (without FEC encoding and Sync Word). The start of each sub-frame is with TLM word of 8 bits. Each sub-frame ends with 24 bit CRC followed by 6 tail bits. The sub frame structure for satellite ID 1 is as given below:

1	9	26	27	28	29	30	31	37	257	263	287
TLM	TOWC	RESERVED				MESSAGING ENABLE	MESSAGE ID	DATA	RESERVED	CRC	Tail
8 BITS	17 BITS	4 BITS				1 BIT	6 BITS	220 BITS	6 BITS	24 BITS	6 BITS

Figure 5: Structure of Sub-frame

4.7.1 TLM

The 8 bits of TLM word are reserved for future.

4.7.2 Time of Week Count (TOWC)

The time of week counter (TOWC) indicates the number of 12 second counts at which the next subframe will begin. It is represented in 17 bits. The Time of Week Count (TOWC) value ranges from 1 to 50400 to cover one entire week. The Time Of Week (TOW) in seconds is obtained by multiplying TOWC with 12. The TOWC will have a value of 1 at week change over (Changeover from Saturday to Sunday). To derive current time the receiver shall subtract 12 from TOW. As the TOWC is always initialized at the beginning of week, the continuous time keeping if required, to be done at the user receiver end. Refer Annexure 1 for addition information on computation of IST/UTC from TOWC

If the user receiver needs absolute time, it is expected that the users to feed the absolute time at start up giving details on week number or year, month and day as part of user data.

4.7.3 Reserved

The bits 26 to 29 & 257 to 262 are reserved.

4.7.4 Messaging Enable Flag

This flag bit at bit no. 30 will indicate messaging service is active (If value is '1'). The receiver needs to check the status of this bit to proceed for using the decoded data for messaging application.

4.7.5 Message ID

Each message in the frame has a 6-bit identifier that uniquely identifies the Message ID in the frame. Each messaging service broadcaster will be allocated a unique Message ID. The allocated message ID is to be used for decoding the relevant messages.

5. SUBFRAME FEATURES

5.1 Idle Pattern

When there is no valid data available on board for a given message ID, Idle Pattern containing alternating zeroes and ones is transmitted in the data part of the navigation sub-frames of IRNSS. Idle pattern shall begin from bit 37, the first bit being a zero. When idle pattern is transmitted the CRC will be corrupted for the corresponding sub-frame.

5.2 Null Message

A message with message ID 0 is defined as Null message and shall be ignored by user.

6. MESSAGES

A message segment in a sub-frame is of length 220 bits. A message ID may contain multiple segments of messages (each 220 bits long). The decoding scheme for a given message ID shall be provided by the respective message broadcaster. 64 different message IDs are available in the messaging service.

7. MESSAGING USER RECEIVER

The user receiver needs to acquire, track, and demodulate signals as per the ICD. The receiver shall provide the 220 bit message along with TOWC, Message ID as output to the user. The Message ID shall be used to decode the message by the receiver. The receiver shall have the provision to accept Message ID as inputs in order to identify and provide only the corresponding message for a given user.

8. MESSAGING & NAVIGATION RECEIVER

This ICD shall be followed by the receivers for the messaging service. Receivers developed for messaging service can implement Navigation capabilities by following "IRNSS SIGNAL-IN-SPACE ICD FOR SPS VERSION 1.1" available at www.isro.gov.in.

ANNEXURE 1- Computation of Indian Standard Time (IST) using TOWC

The receiver shall compute time from TOWC value broadcast in the sub-frame. The time of week counter (TOWC) indicates the number of 12 second counts at which the next sub-frame will begin. The Time of Week Count (TOWC) value ranges from 1 to 50400 to cover entire week. Steps to compute time:

1. Read TOWC value from sub-frame data.
2. Multiply TOWC with 12 to obtain the Time Of Week (TOW) value in seconds.
(The TOWC will have a value of 1 at 00:00:00 hrs, UTC on Sunday)
3. Subtract 12 seconds to compute the time of broadcast of the current sub-frame.
4. Compute the day, hours, minutes and seconds that has elapsed from Sunday, using the TOW value in seconds. This shall provide the time in UTC.
5. Add 5hrs 30 mins to the time computed in Step 4 to obtain the time in IST.
6. The user shall feed the year, month and date information as part of user data. As the TOWC is always initialized at the beginning of week, the continuous time keeping is required to be done at the user receiver end.

Example

TOWC value	= 24843
Time of week in Seconds	= 24843 x 12 seconds = 298116 seconds
Time of week at the start of current sub-frame	= 298116-12 seconds = 298104 seconds

Hence, No. of seconds elapsed since 00:00:00 hrs (UTC) on Sunday are 298104 seconds

No. of days elapsed from start of Sunday	= 298104 / 86400 = 3.4502778 days (Wednesday)
--	---

Time of day

Hours	= 0.4502778 x 24 = 10.806667 hours
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Minutes	= 0.806667 x 60 = 48.4 minutes
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Seconds	= 0.4 x 60 = 24 seconds
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Time in IST	= 10:48:24 + 05:30 hrs = 16:18:24 hrs
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Day & Time in IST : Wednesday, 16:18:24 hrs

ACRONYMS

BPSK	Binary Phase Shift Keying
CDMA	Code Division Multiple Access
CRC	Cyclic Redundancy Check
dB	Decibel
FEC	Forward Error Correction
ICD	Interface Control Document
IRNSS	Indian Regional Navigation Satellite System
ISRO	Indian Space Research Organization
MCPS	Mega Chips Per Seconds
MLFSR	Maximum Length Feedback Shift Register
NavIC	Navigation Using Indian Constellation
PRN	Pseudo Random Noise
RHCP	Right Hand Circularly Polarization
SIS	Signa-in-Space
SPS	Standard Positioning Service
SV	Space Vehicle
TLM	Telemetry
TOW	Time of Week
TOWC	Time of Week Count