HD Radio™ Air Interface Design Description - Station Information Service Transport

Rev. E

February 18, 2005

Doc. No. SY_IDD_1020s

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1 Scope

1.1 System Overview

The iBiquity Digital Corporation HD Radio™ system is designed to permit a smooth evolution from current analog amplitude modulation (AM) and frequency modulation (FM) radio to a fully digital in-band on-channel (IBOC) system. This system delivers digital audio and data services to mobile, portable, and fixed receivers from terrestrial transmitters in the existing medium frequency (MF) and very high frequency (VHF) radio bands. Broadcasters may continue to transmit analog AM and FM simultaneously with the new, higher-quality and more robust digital signals, allowing themselves and their listeners to convert from analog to digital radio while maintaining their current frequency allocations.

1.2 Document Overview

This document defines the transport of the Station Information Service (SIS) for subsequent processing by Layer 2. SIS is part of the overall system. This document describes how control and information are passed through the SIS Transport.

2 Referenced Documents

[1] iBiquity Digital Corporation, "HD Radio™ Air Interface Design Description - Layer 1 FM," Doc. No. SY_IDD_1011s, Revision E.

[2] iBiquity Digital Corporation, "HD Radio™ Air Interface Design Description – Layer 1 AM," Doc. No. SY_IDD_1012s, Revision E.

[3] iBiquity Digital Corporation, "HD Radio™ Air Interface Design Description – Layer 2 Channel Multiplex," Doc. No. SY_IDD_1014s, Revision F.

[4] International Telecommunications Union (ITU), "List of ITU-T Recommendation E.164 Assigned Country Codes," ITU Operational Bulletin No. 763 -1.V.2002, 2002.

[5] D. Goldsmith and M. Davis, "UTF-7 A Mail-Safe Transformation Format of Unicode," Internet Engineering Task Force RFC2152, May 1997. Web address: http://www.ietf.org/rfc/rfc2152.txt?number=2152.

3 Abbreviations and Conventions

3.1 Abbreviations and Acronyms

ADV	Advanced
ALFN	Absolute L1 Frame Number
AM	Amplitude Modulation
ASCII	American Standard Code for Information Interchange
CRC	Cyclic Redundancy Check
EBU	European Broadcasting Union
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FM	Frequency Modulation
GPS	Global Positioning System
IBOC	In-Band On-Channel
ID	Identification
ID3	Tag Embedded In MPEG I Layer III Files
ITU	International Telecommunications Union
ITU-T	ITU Telecommunications Standardization Sector
L1	Layer 1
LSB	Least Significant Bit
MF	Medium Frequency
MIME	Multipurpose Internet Mail Extensions
MSB	Most Significant Bit
MSG	Message
PDU	Protocol Data Unit
PIDS	Primary IBOC Data Service Logical Channel
RBDS	Radio Broadcast Data System
SIS	Station Information Service
UTC	Coordinated Universal Time
UTF	Unicode Transformation Format
UTF-7A	7bit UTF
VHF	Very High Frequency

3.2 Presentation Conventions

Unless otherwise noted, the following conventions apply to this document:

- All vectors are indexed starting with 0.
- The element of a vector with the lowest index is considered to be first.
- In drawings and tables, the leftmost bit is considered to occur first in time.
- Bit 0 of a byte or word is considered the most significant bit.
- When presenting the dimensions of a matrix, the number of rows is given first (e.g., an n x m matrix has n rows and m columns).
- In timing diagrams, earliest time is on the left.
- Binary numbers are presented with the most significant bit having the lowest index.
- In representations of binary numbers, the least significant bit is on the right.

4 SIS Protocol PDU Format

The Station Information Service provides broadcast station identification and control information. SIS is transmitted in a series of SIS Protocol Data Units (PDUs) on the Primary IBOC Data Service (PIDS) logical channel. For more information on PIDS see [1] and [2]. SIS PDUs are 80 bits in length as shown in Figure 4-1. The most significant bit of each field is shown on the left. Layer 2 and Layer 1 process MSBs first – i.e. bit 0 is the first bit interleaved by L1. The PDU contents are defined by several control fields within the PDU. The Type bit is normally set to zero. If this bit is a one, the remainder of the PDU contents may be different. This option is reserved for future use.

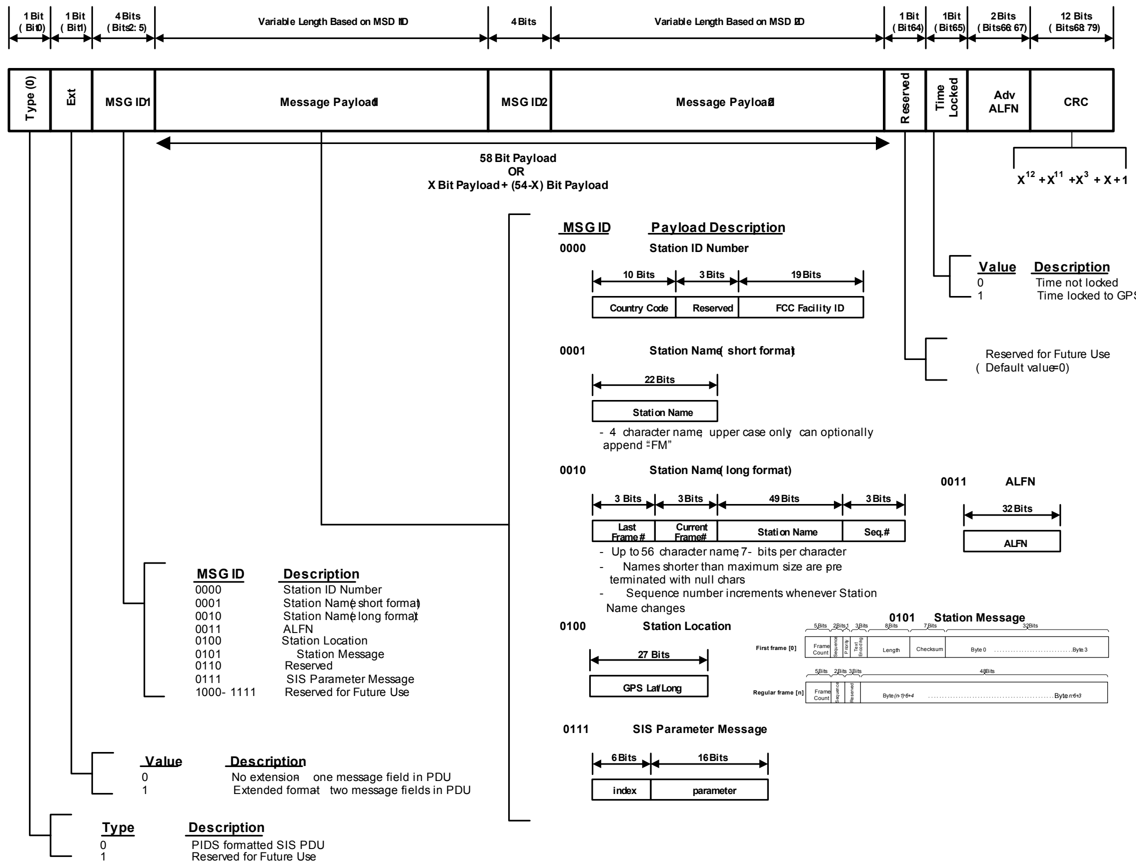

Figure 4-1 SIS PDU Format – Type = 0

Type 0 PDUs may contain two independent variable-length short message fields or a single longer message, depending on the state of the Ext bit. If Ext = 0, the message 1 field is up to 58 bits in length and the message contents are determined by the state of the first message ID field, MSG ID 1. Any unused bits at the end of the message payload 1 field are zeroed. If Ext = 1, then the first message has a length and contents defined by MSG ID 1, and message 2 is active, with length and contents defined by MSG ID 2. In this case, the combined lengths of the two messages must be no greater than 54 bits. Any unused bits at the end of message payload 2 are zeroed.

The definitions of the MSG ID 1 and MSG ID 2 fields are identical. Refer to Table 4-1 for details of the MSG ID field. Any message may be placed in either message 1 or message 2 provided that the total 56-bit available payload length is not violated when combined with a second message. Longer messages must use the single message option (Ext = 0).

Table 4-1 MSG ID Definitions

MSG ID	Payload	Description	Comments
0000	32	Station ID Number	Used for Networking Applications. Consists of Country Code and FCC facility ID.
0001	22	Station Name (short format)	Identifies the 4-alpha-character station call sign plus an optional extension.
0010	58	Station Name (long format)	Identifies the station call sign or other identifying information in the long format. May consist of up to 56 alphanumeric characters.
0011	32	ALFN	Identifies the current Absolute Layer 1 frame number.
0100	27	Station Location	Provides the 3-dimensional geographic station location. Used for receiver position determination.
0101	58	Station Message	Allows a station to send an arbitrary text message
0110	27	Reserved	Reserved
0111	22	SIS Parameter Message	Carries the Leap Second/Time Offset and Local Time data parameters
1000	—	Reserved	Reserved
1001-1111	—	Reserved	Reserved for future use.

The subsections below describe each message type.

4.1 Station ID Number (MSG ID = 0000)

The Station ID Number is uniquely assigned to each broadcasting facility. It consists of the following as shown in Table 4-2. Figure 4-2 shows the message structure for the Station ID.

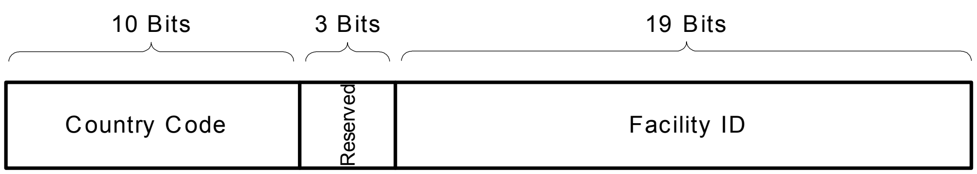

Figure 4-2 Station ID Message Structure

Table 4-2 Station ID Number Format

Field	# of bits	Description
Country Code	10	Binary representation of ITU Country Code (ITU E.164) (refer to [4] for a list of the codes); U.S. Code 001; Valid range = 0 – 999.
Reserved	3	Reserved bits default to ‘0’.
FCC Facility ID (USA only)	19	Binary representation of unique facility ID assigned by the FCC; FCC controlled for U.S. territory - (http://www.fcc.gov/searchtools.html)

4.2 Station Name

The station name has both a short and a long format. The short format may be used with the two-message PDU structure so that it may be multiplexed with other messages and thus can be repeated frequently. The long format requires the single message structure and may be extended across multiple PDUs. This format can be used to identify stations by a moderately long text string.

4.2.1 Station Name Short Format (MSG ID = 0001)

Four-character station names may be broadcast with the short format. The field is 22 bits in length with the first bit on the left. Each character is five bits in length (MSB first, or leftmost), followed by a 2-bit extension. Refer to Table 4-3 for details of the format and Table 4-4 for the bit values for each character. Only upper case characters are defined, plus a limited number of special characters, as shown. The space character may be used, for example, to terminate a three-character call sign.
The first 5 bits are assumed to contain the leftmost character. For example, a station name of "ABCD" would be encoded in binary as 00000 00001 00010 00011 00. The 2-bit extension may be used to append an extension to the right of the other four characters.

Table 4-3 Station Name Short Format Bit Assignments

Field Bit Positions	Description
0:4	Leftmost Character
5:9	Second Leftmost Character
10:14	Third Leftmost Character
15:19	Rightmost Character
20:21	Extension: 00 = no extension 01 = Append "-FM" 10 = Reserved for future use 11 = Reserved for future use

Table 4-4 Station Name Character Definitions for Short Format

Value (MSB:LSB)	Character
00000	A
00001	B
00010	C
. . .	. . .
11000	Y
11001	Z
11010	Space character
11011	?
11100	-
11101	*

11110	$
11111	Reserved

4.2.2 Station Name Long Format (MSG ID = 0010)

The long format permits the station name to consist of textual strings. Each message contains seven characters encoded in the 7-bit Unicode (UTF-7) format (see [5]). Letters, numbers, and most punctuation follow the same character mapping as US-ASCII. As described in [5], additional characters may be defined through the use of shift sequences.

A character string may be extended over up to eight PDUs. The first three bits of the field specify the frame number of the last frame (or equivalently, the total number of SIS PDUs containing the message minus one) and the next three bits specify the frame number of the current PDU. PDU number zero is considered the leftmost of the string. The seven most significant station name bits within a PDU define the leftmost character for that PDU. For the last SIS PDU of the string, unused message bits are filled in with NULL characters. Refer to Figure 4-1 for details.

The three LSBs of the station name field define the sequence number. This number is incremented modulo eight each time the character string is changed. The sequence number will only change within the PDU containing frame 0 of the message. All frames of the same message content will always have the same sequence number.

4.3 Absolute Layer 1 Frame Number (MSG ID = 0011)

This field contains the 32-bit ALFN. ALFN increments every L1 frame period coincident with the start of L1 block 0. In all AM and FM service modes, the ALFN that is sent corresponds to the actual frame number at the time it is broadcast over the air. Refer to reference [1] or [2], Section 6 for details. If bit 65 of a PDU (regardless of MSG ID 1 or MSG ID 2) is set to one, the ALFN is locked to GPS time. In such cases, ALFN can be used to provide a precise time of day in the receiver. If bit 65 is cleared, ALFN is not GPS-locked. In this case, ALFN may only be used to indicate a rough time of day.

The contents of this ‘standard ALFN’ field are the same as that sent in the ‘Advanced Processing (Adv)’ ALFN field (bits 66:67), but provides an optional method to supply ALFN in parallel rather than in a serial fashion. See Subsection 5.3 for more details on the Adv ALFN.

The ‘standard ALFN’ is optional and is not transmitted on a guaranteed schedule. The broadcaster can choose to send or schedule it or to not send it at all. On the other hand although the Adv ALFN is always transmitted, it takes a longer time to acquire due to its low bit rate and time diversity. Thus broadcast stations that may choose to send audio or data applications that require a fast (but not very robust) ALFN acquisition can send it in the ‘standard ALFN’.

4.4 Station Location (MSG ID 0100)

This field indicates the absolute three-dimensional location of the feedpoint of the broadcast antenna. Such location information may be used by the receiver for position determination. The format is shown in Figure 4-3. Position information is split into two messages – a high and a low portion. Altitude is in units of meters·16 (i.e. the LSB is equal to 16 meters). Latitude and longitude are both in the same fractional formats. The LSB is equal to 1/8192 degrees. The MSB is the sign bit, which indicates the hemisphere. Positive longitude values represent positions north of the equator. Positive longitudes are in the eastern hemisphere. Longitude ranges are from -180 to +180, while permissible latitude values are between -90 and +90. Anything outside of these ranges is invalid. Refer to Subsection 5.1 for example.

WGS 84 (used by GPS) is used as the reference datum for location information.

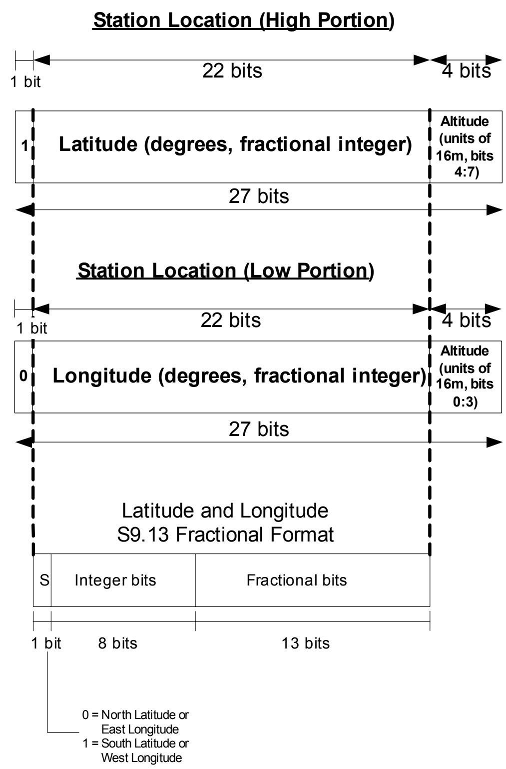

Figure 4-3 Station Location Field Format

4.5 Station Message (MSG ID 0101)

This field allows the station to send any arbitrary text message. Such text messages can be a logo, a telephone call-in number or other text messages. The Station Message has a payload of 58 bits. This message can span over multiple L1 frames. Figure 4-4 shows the message structure for the Station Message.

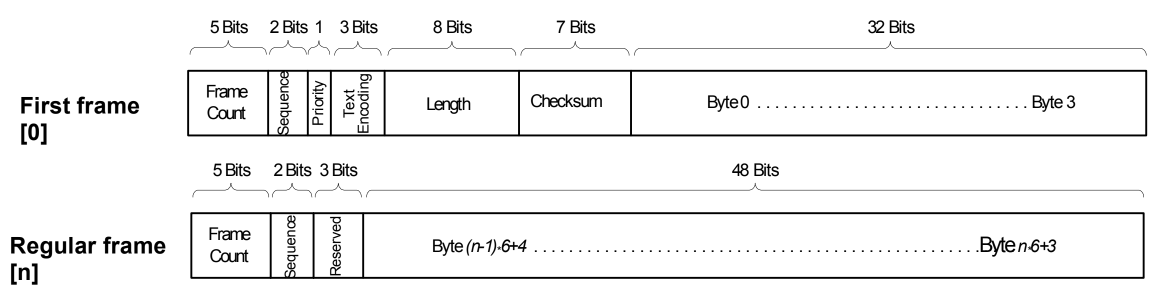

Figure 4-4 Station Message – structure

Every frame indicates the frame number or frame count [0…31]. It also indicates the message sequence [0, 3]. The message sequence numbers give an indication when continuation messages are lost. The first frame also indicates the message priority [0, 1] and the message length [0…123]. The priority indicator indicates that the message has an elevated importance. When multiple messages are deployed, a message with the priority indicator set will advance to the top of the queue. Any change in the message content or the priority is considered a new message and the sequence number is incremented. A 7-bit checksum is included in the first frame to increase receive reliability.

The first frame alone carries 4 or 2 characters based on 8-bit and 16-bit encoding respectively. The following frames can carry up to 6 or 3 characters based on 8-bit and 16-bit encoding respectively.

The Station Message can be used to send a string of up to 124 characters per message spanning up to 21 frames for 8-bit encoding such as ISO-646 and ISO-8859-1. It can also be used to send up to 95 characters per message spanning up to 32 frames for 16-bit encoding such as Unicode/ISO-10646-1. This is expandable to other formats in future, although it must maintain the limit of 124 characters spanning over 32 frames.

The character format is defined in the message. This enables multi-lingual support and allows support of current and future standards. All the current standards preserve the UTF-7 coding format. When the station message is restricted to using the UTF-7 format, the text encoding code is default to '0'. The text encoding supported by the Station Message field bridges ID3 standard definitions and RBDS definitions. The ID3 standard supports ISO-8859-1 and UNICODE (ISO-10646-1). However, RBDS supports ISO-646 repertoire table E.1-E.3 as defined by the EBU and Repertoire E.1 covers ISO-8859-1. The text encoding definitions supported by Station Message are indicated in Table 4-5.

Table 4-5 Station Message - Text Encoding Definitions

Value	Service Type
000 (default)	ISO-646 repertoire E.1
001	ISO-646 repertoire E.2
010	ISO-646 repertoire E.3
011	Reserved
100	Unicode / ISO-10646-1
101-111	Reserved

4.6 SIS Parameter Message (MSG ID 0111)

This field is used to carry arbitrary parameters, the first of which is the leap second correction factor. It can be used to carry additional parameters in the future. The SIS Parameter message has a payload of 22-bits which consists of a 6-bit index and a 16-bit parameter. The parameters are defined in Table 4-6. Refer to Subsection 5.4 for details on the application of the Leap Second and the Local Time parameters shown below. The subsections below define the Field bit positions for the Local Time parameter.

Table 4-6 SIS Parameter Message Format

Index	Parameter	Initial Value
0	Leap Second Offset Most significant byte: Pending Offset (8-bit signed) Least significant byte: Current Offset (8-bit signed)	0x0D0D
1	GPS Time of pending leap second adjustment (16 LSBs)	0
2	GPS Time of pending leap second adjustment (16 MSBs)	0
3	Local Time data (refer to Subsection 4.6.1)	(Local data)
4-63	Reserved for future use.	—

4.6.1 Local Time Parameter – Field Bit Positions

The bits positions of the various Local Time parameters are summarized in Table 4-7.

Table 4-7 Local Time data

Bits	Parameter	Units	Format
0:10	Local time zone UTC offset	Minutes	Signed Integer
11:13	DST Schedule	N/A	N/A
14	DST local deployment indicator	N/A	1 = yes
15	DST regional deployment indicator	N/A	1 = yes

4.6.1.1 Local time zone UTC offset

This constitutes the higher order part of the word and provides static data on the local time zone (offset from UTC when DST not in effect, in minutes).

These data for the U.S. standard time zones are shown in Table 4-8.

Table 4-8 Local time zone UTC offset

Time Zone	Bits (0:10)	Reference
Atlantic	11100010000	(UTC –4 hours)
Eastern	11011010100	(UTC –5 hours)
Central	11010011000	(UTC –6 hours)
Mountain	11001011100	(UTC –7 hours)
Pacific	11000100000	(UTC –8 hours)
Alaska	10111100100	(UTC –9 hours)
Hawaii-Aleutian	10110101000	(UTC –10 hours)
Samoa	10101101100	(UTC –11 hours)
Chamorro	01001011000	(UTC +10 hours)
In addition, for Canada:		
Newfoundland	11100101110	(UTC –3 1/2 hours)

4.6.1.2 DST Schedule

These bits provide static data on the schedule of Daylight Saving Time (DST) used regionally (e.g., nationally), regardless of whether or not DST is practiced locally.

Table 4-9 shows the values of the bits 11:13 based on the Daylight Saving Time Schedule.

Table 4-9 DST Schedule

Bits 11:13	Daylight Saving Time Schedule
000	Daylight Saving Time not practiced in this nation (e.g., Japan, Central America), or practiced on an irregular schedule (e.g., Israel, Palestine)
001	U.S./Canada: 2 AM on first Sunday of April until 2 AM on last Sunday of October
010	European Union (EU): 01:00 UTC on last Sunday of March until 01:00 UTC on last Sunday of October.
011 - 111	Reserved

Other global practices for DST may be added to this table as HD Radios' are introduced into those nations. An overflow of this table may be continued in another, future SIS Parameter Message type.

In the United States and Canada, broadcasters must use a field value of 001 year-round, regardless of whether or not their local community practices Daylight Saving Time.

4.6.1.3 DST local deployment indicator

This bit provides static data on whether or not DST is practiced locally, 1 if it is, and 0 if it is not.

In the United States, bit 14 is set to 1 year-round, except in Hawaii, American Samoa, Guam, Puerto Rico, the Virgin Islands, and major portions of Indiana and Arizona. In Canada, bit 14 is set to 1 year-round, except in most of Saskatchewan and portions of other Provinces, including British Columbia and Quebec.

In May 2001, the California state legislature sent a Senate Joint Resolution (SJRX2 1) to the White House and Congress asking that California be allowed to extend Daylight Saving Time year round. The Federal government has not yet acted on this request. Concurrence would require the use of UTC local offset 11001011100 (UTC –7 hours), DST Schedule 001, and DST Practice (Bit 14) 0, year-round, in order to make California broadcasters most compatible with those of neighboring communities (e.g., Yuma, AZ).

4.6.1.4 DST regional deployment indicator

This bit provides seasonal data as to whether or not DST is in effect regionally (e.g., nationally), 1 if it is, and 0 if it is not.

Simple receivers can use this bit exclusively (ignoring Bits 11:13) to determine when to set the display clock one hour forward. Receivers should honor this bit only if Bit 14 or user setup indicates that DST is practiced locally. However, since this datum is not guaranteed in real time (either by all broadcasters, or in a timely manner by broadcasters that do provide it), more upscale receiver designs may instead prefer to internally compute the period of DST using the static data provided in bits 11:13. This will provide a better consumer experience. However, all receivers should honor this bit in preference to any predetermined schedule indicated by Bits 11:13. National rules for DST change occasionally, and the receiver firmware may not be up-to-date—or appropriate for the nation in which the receiver is being used.

In the United States and Canada, this bit should be set to 1 when the nation as a whole is practicing Daylight Saving Time (i.e., in the summer), regardless of whether or not it is being practiced locally.

4.7 CRC Field

Each PDU is terminated with a 12-bit CRC whose polynomial is shown in Figure 4-1. The CRC is computed based on all 68 bits of the other fields in the PDU, including unused message payload bits, which are always set to zero.

5 Applications and Examples

5.1 Station Location Example

As an example of how the position information is constructed, consider a location at N 39˚ 11’ 46.32”, W 76˚ 49’ 6.59’, and an altitude of 90.7 meters. The first step is to convert latitude and longitude to decimal degrees:

$$\text{Latitude} = 39 + \frac{11}{60} + \frac{46.32}{3600} = 39.1962 \text{ deg}$$

$$\text{Longitude} = 76 + \frac{49}{60} + \frac{6.59}{3600} = 76.8185 \text{ deg}$$

The next step is to convert all three parameters to the proper fractional format:

Latitude: 39.1962˚ · 8192 = 321095 rounded to the nearest integer, = 0x04E647

Longitude: 76.8185˚ · 8192 = 629297 rounded to the nearest integer, = 0x099A31, however, it is necessary to take the two’s complement of this number to get West longitude = 0x3665CF

Altitude = ROUND (90.7/16) = 6 = 0x06

Finally, the parameters are packed into the appropriate message format:

High portion = 0x44E6470

Low portion = 0x3665CF6

It must be noted that frequency translator stations must exercise care in the use of the station ID number, station name, and station location. It the translator station acts as a repeater, then it will convey the station information of the primary station, not the translator station. It may be necessary for the translator station to produce its own station information to ensure proper operation of the system.

5.2 Example Scheduling of SIS PDUs on the PIDS Logical Channel

Table 5-1 shows an example of how SIS PDUs may be distributed across a single L1 frame. In FM there are 16 PIDS blocks per frame, while in AM there are only 8. In the example, the short format station name is sent in every PIDS block in the message 1 payload, while various types are sent in the second message payload. The leap second offset and the GPS time of a pending leap second adjustment parameters are not shown in this example, but the suggested message rates are ~1/minute. Also, the scheduling of the Station message and Long Format Station Name is different since it can span multiple L1 frames.

Table 5-1 Example Scheduling of SIS PDU Messages

L1 Block #	MSG ID 1	Description	MSG ID 2	Description
0	0001	Station Name	0011	ALFN
1	0001	Station Name	0000	Station ID Number
2	0001	Station Name	0000	Station ID Number
3	0001	Station Name	0100	Location (High)
4	0001	Station Name	0000	Station ID Number
5	0001	Station Name	0000	Station ID Number
6	0001	Station Name	0100	Location (Low)
7	0001	Station Name	0000	Station ID Number
8	0001	Station Name	0000	Station ID Number

L1 Block #	MSG ID 1	Description	MSG ID 2	Description
9	0001	Station Name	0000	Station ID Number
10	0001	Station Name	0000	Station ID Number
11	0001	Station Name	0100	Location (High)
12	0001	Station Name	0000	Station ID Number
13	0001	Station Name	0000	Station ID Number
14	0001	Station Name	0100	Location (Low)
15	0001	Station Name	0000	Station ID Number

5.3 ADV Absolute L1 Frame Number Processing

The SIS Transport allocates two bits to broadcast the absolute L1 frame number in a serial fashion. The format is different for AM and FM as outlined in the following two subsections. In both cases, the value of ALFN to be transmitted over the PIDS channel is updated coincident with L1 block 0 of each L1 frame.

The standard ALFN is optional while the ADV ALFN is always transmitted. The ADV ALFN uses less channel capacity than the standard ALFN. For applications where the ALFN is required in a parallel format the standard ALFN can be used. 'Advanced processing' is a term to indicate that there is more than just regular send and detect. What it has is enormous robustness to time diversity. The way it is spread over time allows maintaining higher reliability with extremely low bit rate. This is as opposed to the cases when once in a while you send the entire ALFN in one message.

5.3.1 FM System Processing

The 16 LSBs, labeled d16 through d31in Figure 5-1, are transmitted as 2-bit pairs mapped into the Adv ALFN field of each PIDS block starting with block 0. ALFN bits d30:31 are broadcast at block 0 of each frame, ALFN bits d28:29 are broadcast at block 1 of each frame and ALFN bits d16:17 are broadcast at block 7 of each frame.

ALFN bits d0:15 are further subdivided into pairs and mapped to the Adv ALFN field in blocks 8 through 15 as shown.

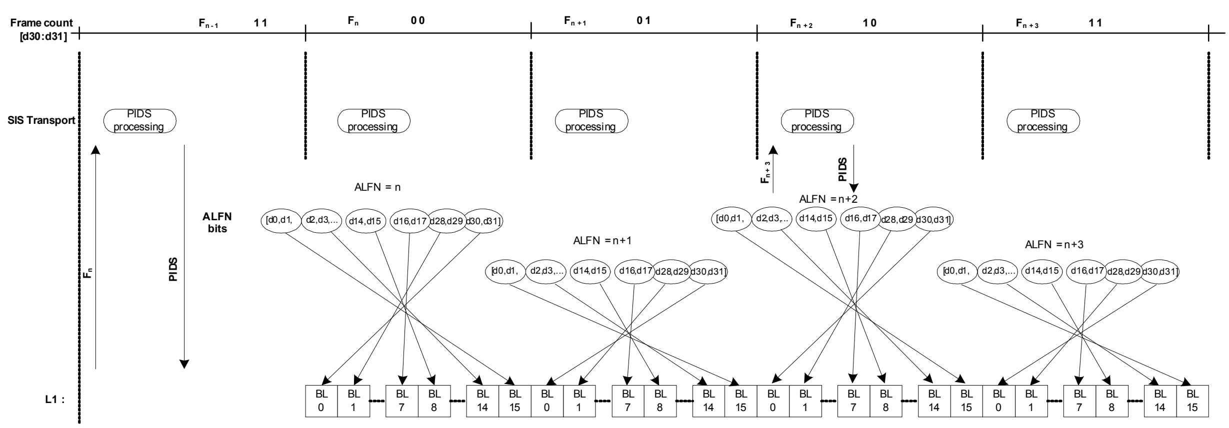

Figure 5-1 Broadcasting ALFN over HD Radio FM System

5.3.2 AM System Processing

The 32 bits are subdivided into 16 bits numbered d16 through d31 (16 LSBs) and 16 bits indexed d0 through d15 (16 MSBs), as shown in Figure 5-2. ALFN bits d16:31 are subdivided into pairs and mapped to the two-bit Adv ALFN field of each PIDS block starting with block 0. ALFN bits d30:31 are broadcast at block 0 of each frame, ALFN bits d28:29 are broadcast at block 1 of each frame and ALFN bits d16:17 are broadcast at block 7 of the frame. This process takes place when ALFN d30:31 is not equal to 00.

ALFN bits d0:15 are subdivided into pairs and mapped to the Adv ALFN field in blocks 0 through 7 as shown. This occurs once every four frames and is indicated when ALFN d30:31 is equal to 00.

The 16 LSBs of the ALFN are broadcast in three out of every four PIDS blocks; the 16 MSBs are broadcast once every four PIDS blocks.

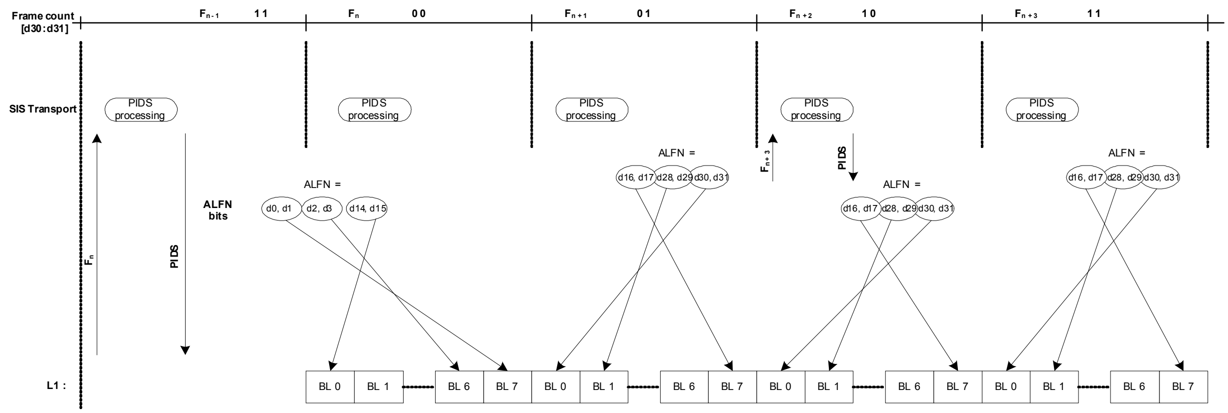

Figure 5-2 Broadcasting ALFN over HD Radio AM System

5.3.3 Handling of Absolute L1 Frame Number in Layer 1

L1 does not handle ALFN directly, in regards to broadcasting the frame number. The frame number is conveyed over the PIDS logical channel in Layer 1 as part of an SIS message.

In all AM and FM service modes, the relevant portion of the ALFN being sent applies to the actual frame number at the time it is broadcast. Thus Layer 1 must ensure proper synchronization of the ALFN being sent relative to absolute GPS time.

5.4 Clock Support

The SIS Transport allows for data to be broadcast making display clocks associated with receivers easier for consumers to use. The provision of these data by a broadcaster is optional if the ALFN is locked to GPS time (Bit 65 of the SIS PDU set to one), and forbidden if it is not (Bit 65 of the SIS PDU set to zero). If present at all, these data may be sent approximately once per minute, or otherwise at the convenience of the broadcaster. Receivers may utilize these data as best suits their design goals.

5.4.1 Handling Leap Seconds

The time standard for clocks around the world is UTC- Coordinated Universal Time. To keep UTC synchronized to astronomical time (defined by the earth's rotation) it is occasionally adjusted by a second. The adjustments average about once a year (so far) and occur as leap seconds, meaning all UTC clocks observe a 61 second minute at midnight when the adjustment occurs. The standard practice is to make adjustments at midnight UTC either December 31 or June 30.

As explained in Subsection 4.3, bit 65 of a PDU must be set to one for the ALFN to be locked to GPS time and the time of day calculation to be accurate.

HD Radio transmissions may be synchronized to GPS time, which does not have any leap second adjustments. This means that GPS runs ahead of UTC and the receiver derives UTC time as follows:

$$\text{Time(UTC)} = \text{Time(GPS)} - \text{Leap Seconds}$$

$$\text{Time(UTC)} = (65536 / 44100) \cdot \text{ALFN} - \text{Leap Seconds}$$

Since 1980, 13 leap seconds have been added to UTC, so GPS is now running 13 seconds ahead of UTC. No leap seconds are planned for 2004, so the Leap Seconds value of 13 is correct through the end of the year. In order to properly derive UTC time from the ALFN beyond 2004, receivers need to be made aware of changes in leap seconds. To accomplish this, an SIS message is used to send arbitrary parameters, the first of which would be the leap second correction factor.

The parameters that are needed to continuously account for leap seconds in the calculation of UTC from the ALFN are:

- the current time offset (GPS time – UTC time),
- the GPS time of a pending leap second adjustment,
- the new time offset after the adjustment.

These parameters are sent over the SIS and saved in persistent storage by the receiver so that accurate UTC time can be computed when necessary.

5.4.2 Handling Local Time

Local time differs from UTC owing to both the local time zone and the local practice with respect to observing some form of Daylight Saving Time (DST). SIS Parameter Message Type 3 provides digital data on these local customs, so that a receiver's digital display clock can automatically match the local time as spoken in main program audio.

These data describe the local custom at the location of the broadcaster, which may or may not be the same as the local custom at the place of the receiver. Near time-zone boundaries, consumers can receive a multiplicity of stations providing different data. Therefore, these data are provided only as *hints*, the interpretation and utilization of which should be made discretionary, subject to customer control. Receivers may use these data as initial guesses (e.g., at initial installation) as to what a persistent configuration should be, with the expectation that consumers may manually adjust the initial guess. (Most of the time, no manual adjustment would be necessary.) Mobile receivers may have a design option to update their clocks with different, localized data as they travel across the country. Or receivers may ignore these data entirely.

AM broadcasters may refrain from transmitting, and AM receivers may refrain from interpreting, these data during evening and nighttime hours.

5.4.2.1 Examples

A number of examples drawn from in and near the State of Indiana can help illustrate what data broadcasters should provide, and how consumer receivers should interpret it.

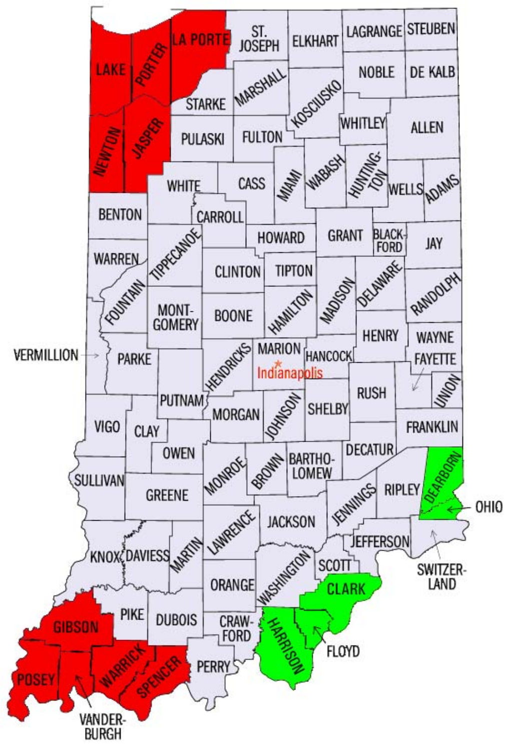

Figure 5-3 Local Time in Indiana

Indiana lies within the Eastern time zone, except for five counties in the northwest (near Chicago, IL) and five counties in the southwest (including Evansville, IN) that are in the Central time zone. These ten counties observe Daylight Saving Time, while the rest of the state officially does not. They are indicated in Figure 5-3 in dark gray (or red). However, two counties near Cincinnati, OH, and three counties near Louisville, KY, unofficially observe Daylight Saving Time, along with their big-city neighbors. They are indicated in Figure 5-3 in medium gray (or green).

Example 1, Indianapolis, IN

Local Time Parameter = 11011010100 001 0 S (S=0 in Winter, 1 in Summer)

Like consumers in most of the country, few listeners to Indianapolis broadcasters (in the center of the state) would need to manually override these automatic settings. Because Bit 14 is 0 (and not manually overridden), receivers would not show Daylight Saving Time even when Bit 15 is 1 (in the summer).

Example 2, South Bend, IN, and Elkhart, IN

Local Time Parameter = 11011010100 001 0 S (S=0 in Winter, 1 in Summer)

These cities, near the northern border of Indiana, follow the same local custom as Indianapolis. However, their market areas extend into southern Michigan (e.g., Cass County), which does observe Daylight Saving Time. Therefore, customers in Michigan should manually setup their receivers to observe DST, regardless of any automatic data (on Bit 14) they might receive. Bits 11:13 and 15 are available for these receivers to use from their local Indiana broadcasters. Similarly, some customers in Indiana may wish to manually setup their receivers to not observe DST, regardless of any automatic data they might receive (e.g., from Michigan).

Example 3, Cincinnati, OH and Louisville, KY

Local Time Parameter = 11011010100 001 1 S (S=0 in Winter, 1 in Summer)

For most of the listening area of these major cities, the automatic data would be correct. However, listeners in Indiana might want to manually setup their receivers to ensure that their local DST custom is followed consistently, no matter what stations they receive.

Example 4, Evansville, IN, Chicago, IL, and Northwest IN (e.g., Hammond, IN)

Local Time Parameter = 11010011000 001 1 S (S=0 in Winter, 1 in Summer)

For most of these listening areas, the automatic data would be correct. However, listeners in surrounding areas might want to manually setup their receivers to ensure that their local Time Zone and DST customs are followed consistently, no matter what stations they receive.