University of Massachusetts Lowell
CENTER FOR ATMOSPHERIC RESEARCH
600 Suffolk Street
Lowell, Massachusetts 01854

Decoding of Status Information in MMM Digisonde Ionograms

Ivan A. Galkin

TECHNICAL MEMORANDUM

V1.0

September 2001

Introduction

This document details the procedure of converting the echo status information stored in MMM ionograms (polarization, direction, Doppler shift) to the appropriate physical units. The MMM format description can be found elsewhere [1-2], including the descriptions of the Digisonde control parameters (and corresponding preface characters) that are used in this text.

The MMM format was historically designed for Digisonde 256 and later replicated in the later generation of the ionosonde, Digisonde Portable Sounder (DPS). Out of the variety of MMM format options existing in Digisonde 256, only two were implemented in DPS, known as “MMM” for Doppler ionograms and “BEM” for multi-beam (directional) ionograms. This document describes the conversion procedure for only so-called “P1=1” ionograms made by Digisonde 256, where each ionogram bin holds one byte of echo data, [**AAAACCCC]** (4 bit AMPLITUDE in the upper nibble and 4 bit CHANNEL NUMBER in the lower nibble) for 128 heights mode, or [**AAAAAHHH]** (5 bit AMPLITUDE in the upper bits and 3 bit CHANNEL NUMBER in the lower bits) for 256 heights mode. All MMM ionograms made by DPS are P1=1, [**AAAACCCC]** ionograms with 128 heights only and two combinations of antenna sequencing options, Z and T (Z=D, T=1 for “MMM” Doppler ionograms, and Z=D, T=3 for “BEM” multi-beam ionograms). Other settings of the recording control parameter P1 appear to be used very rarely, and for this reason they are not supported by the visualization software (ADEP, Viewer, SAO Explorer), with one notable exception of “P1=B” (precision group height Digisonde 256 ionograms), and not discussed here.

Decoding of Channel Number [CCCC]

The values of Polarization, Doppler shift and Echo Direction (Zenith and Azimuth) are derived from the Channel Number value **[CCCC]** using a number of conversions as indicated in Figure 1.

Decoding starts with translation of the 4 bit Channel Number **[CCCC]** to 4 bit Status **[SSSS]** using the "C-to-S" Table shown in Table 1.

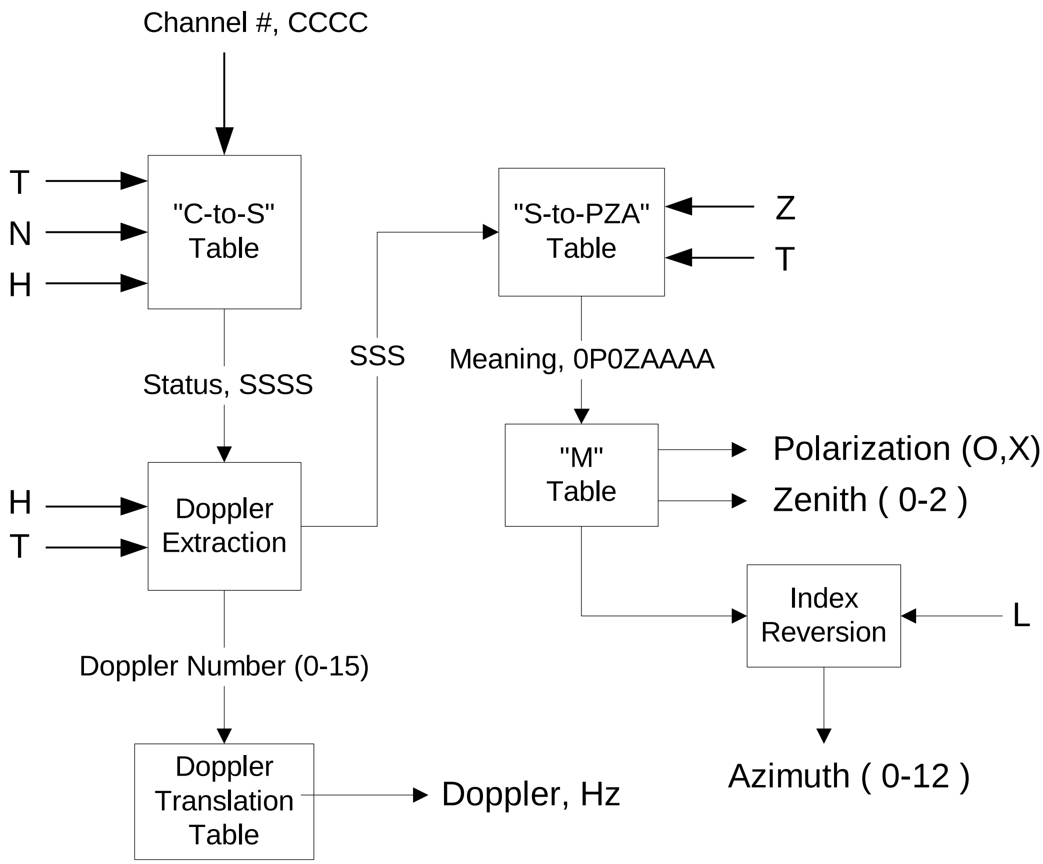

Figure 1. Decoding of Channel Number CCCC.

# OF DOPPLERS	2		4		8		16
# OF HEIGHTS*	128	256	128	256	128	256	128
ANT OPTION (T)	3,7,11,15	2,6,10,14	2,6,10,14	1,5,9,13	1,5,9,13	0,4,8,12	0,4,8,12
CHANNEL	STATUS		STATUS		STATUS		STATUS
0	8		8		8		8
1	9		9		9		9
2	10		10		10		10
3	11		11		11		11
4	12		12		12		12
5	13		13		13		13
6	14		14		14		14
7	15		15		15		15
8	0		4		6		7
9	1		5		7		6
10	2		6		4		5
11	3		7		5		4
12	4		0		2		3
13	5		1		3		2
14	6		2		0		1
15	7		3		1		0

*H < 8: 128 heights; H $\geq$ 8: 256 heights

Table 1. Conversion of Channel Number [CCCC] to Status [SSSS].

The contents of 4 bits of Status **[SSSS]** varies significantly, depending on the program settings. The upper bits of the Status are usually taken by the Doppler Index **[DDDD]**, and the next step is determining how many bits are actually taken by the Doppler Index. Table 2 shows the number of Doppler lines stored in the MMM data, depending on the number of heights, H, and the antenna sequencing options, Z and T.

T	Ionogram Antenna Config.	Doppler Frequencies in Ionogram or Fixed Frequency Modes			
		128 Range Bins (H < 6) X = 0, 4, 5, 6, 7	H < 8; X = 1, 2, 3 or H ≥ 8; X = 0, 4, 5, 6, 7	H ≥ 8; X = 1, 2, 3 or H < 8; X = 8 to F	H ≥ 8 and X = 8 to F
0, 8	1	±1/2T ±3/2T ±5/2T ±7/2T ±9/2T ±11/2T ±13/2T ±15/2T	±1/2T ±3/2T ±5/2T ±7/2T	±1/2T ±3/2T	±1/2T
1, 9	2	±1/2T ±3/2T ±5/2T ±7/2T	±1/2T ±3/2T	±1/2T	
2, A	4	±1/2T ±3/2T	±1/2T		
3, B	8	±1/2T			
4, C	1	±1/T ±3/T ±5/T ±7/T ±9/T ±11/T ±13/T ±15/T	±1/T ±3/T ±5/T ±7/T	±1/T ±3/T	±1/T
5, D	2	±1/T ±3/T ±5/T ±7/T	±1/T ±3/T	±1/T	
6, E	4	±1/T ±3/T	±1/T		
7, F	8	±1/T			

Remarks: Doppler Frequencies in (Hz) for Integration Time T in (sec)

Table 2. Number of Doppler lines and Doppler spacing.

Table 2 also indicates the Doppler spacing expressed in 1/*T* units, where *T* is the Integration time in seconds. As seen in the Table 2, the Doppler spacing is doubled for antenna sequencing option T = 4,5,6,7,C,D,E, and F.

Equation (1) provides the calculations of the integration time *T* for Digisonde 256:

$$T = \frac{B \cdot L \cdot S}{R} \quad (1)$$

where

B = number of Digisonde 256 beams

L = number of looks (pulses per frequency), 2^N

S = 2 for “intrapulse” and “2 samples” modes (see Table 3), or 1 otherwise.

R = pulse repetition rate, pps

The Digisonde 256 *beam* is characterized by its *direction* and *polarization*. There are 16 channels in Digisonde 256 taken by data for available beams and Doppler lines, so the number of beams, *B*, can be obtained as

$$B = \begin{cases} 16/D, & D > 0 \\ 16, & D = 0 \end{cases} \tag{2}$$

where D is total number of Doppler lines from Table 2.

W	Pulse Width [μsec]	Sample Weight
0	66	Full
1	133	
2	2 × 66 (intrapulse)	
3	133 (2 samples)	
4	66	Hanning
5	133	
6	2 × 66 (intrapulse)	
7	133 (2 samples)	

Table 3. “Intrapulse” and “2 samples” modes requiring double integration time.

Equation (3) provides the calculations of the integration time T for DPS systems:

$$T = \frac{P \cdot C \cdot L \cdot A \cdot M}{R} \tag{3}$$

where

P = number of polarizations (usually 2, but 1 in the O-only mode)

C = number of codes (2 for complementary codes, otherwise 1)

L = number of looks (pulses per frequency), 2^N

A = number of sequentially scanned antennas (4 for DPS-1 multi-beam ionograms)

M = number of fine frequency steps in the frequency multiplexing mode

R = pulse repetition rate

The "S-to-PZA" Table converts 3 lower bits of the Status **[SSS]** to 8 bit Meaning **[0P0ZAAAA]**, depending on the setting of antenna sequencing options, Z and T. There are total of six "S-to-DM" Tables, and for each station location only one is selected, depending on the sounder model (Digisonde 256 or DPS) and antenna configuration (“Standard”, “Rotated”, or “Mirror”), as described in the Table 4. The ASCII files with the M-to-PZA tables are part of standard distribution of Digisonde analysis software tools (ADEP, Viewer, SAO Explorer). They are omitted from this document because of their size.

	Receiving Antenna Pattern		
	Standard	Rotated	Mirror
Digisonde 256	STANDARD.ZTS	ROTATED.ZTS	MIRROR.ZTS
DPS	STANDARD.ZTP	ROTATED.ZTP	MIRROR.ZTP

Table 4. “S-to-PZA” Tables for conversion of Status to Meaning.

The 8 bit Meaning value **[0P0ZAAAA]** stores Azimuth Angle Index in its lower nibble, taking values 0 to 12, where 0 corresponds to the vertical echo, and 12 directions are enumerated using counter-clockwise 30^{o} scheme shown in Figure 2.

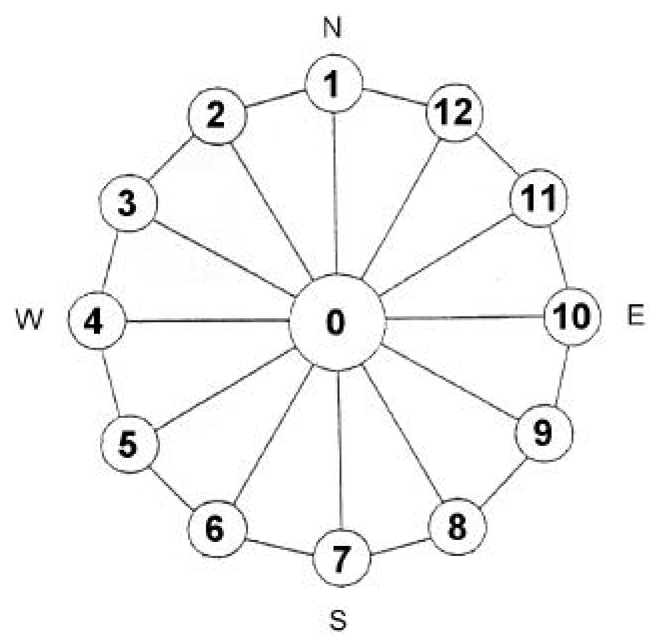

Figure 2. Azimuth Angle Index enumeration (0-12)

Table 5 provides the Azimuth Angle in physical units and other useful codes corresponding to the Azimuth Angle Index.

Azimuth Angle Index	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Azimuth, ^{o}	-	0	30	60	90	120	150	180	210	240	270	300	330
Azimuth, geomap	-	N	NNW	WNW	W	WSW	SSW	S	SSE	ESE	E	ENE	NNE
D256 codes, large zenith	V	N	O	P	W	X	Y	S	T	U	E	F	G
D256 codes, small zenith	0	1	2	3	4	5	6	7	8	9	A	B	C

Table 5. Azimuth in various representations.

For the antenna configurations with the clock-wise increments of the azimuth, the Azimuth Angle Index is inverted before stored in the Meaning byte, as indicated in Figure 3.

In the Meaning byte, **[0P0ZAAAA]**, there are two more bits to indicate Polarization P (0=ordinary, 1=extraordinary) and Zenith angle (0=small, 1=large). Typicall arrangement for vertical sounding with Digisonde 256 is 7.5^o (small zenith) and 15^o (large zenith). DPS system has one, adjustable zenith angle specified in ARMENU.DPS system configuration file (typically 30^o).

Decoding of Channel Number [HHH]

Three bits of $\mathbf{H_2\ H_1\ H_0}$ should be converted to the 4-bit channel number $\mathbf{C_3C_2C_1C_0}$:

$C_3 = H_2$

$C_2 = 0$

$C_1 = H_1$ (if $H_2 = 0$) or [not H_1] (if $H_2 = 1$)

$C_0 = H_0$

and then channel number CCCC can be converted to the echo status using procedure shown in Figure 1.

References

1. Bibl, K., B.W. Reinisch, D.F. Kitrosser, *Digisonde 256, General desciption of the compact digital ionospheric sounder*, UMLCAR, 1981.

2. Galkin, I.A., R. R. Gamache, J. L. Scali and J. Tang, *MMM, ARTIST and Raw Data Formats*, UMLCAR Technical Memo 0503/IG, 1995.