

Chapter 4

Envelope Data

The synthesizer has three main sections, which are Pitch (DCO), Wave (DCW), and Amplitude (DCA). Each of these sections has an envelope that can be customized. Any given envelope has eight steps, and each step has both a rate and a level. This chapter is concerned with the details of the envelope rate and level data.

4.1 Introduction

The Casio CZ-1 Sysex Document has information about the envelope data, but it doesn't do a very good job of explaining it. It also contains some notable errors. This chapter is essentially a rewrite of Casio's sysex document, but with an effort to improve and clarify every part of it.

4.2 Human Values, Machine Values

Every envelope data, as well as many other parts of the Casio sysex data, have both a **human** and a **machine** value.

Human value The human value is easy to understand; it is what's displayed on the LCD, and other places where a "friendly" value is desired.

Machine value The machine value is presumably what the machine uses internally to do the job of processing audio.

When Casio made the CZ line, they were planning to sell it to Western audiences, not to robots. That's why there is a human value that uses decimal numbers, rather than displaying the hex number directly.

When Casio made the CZ line, the display was a compact LCD that did not have space for many characters. That is why the human numbers for envelope data range from 0 to 99. Anything more would have required a third digit on the LCD, and would not have fit.

4.3 Old Myths Die Hard

Now for the interesting part! Using the two pieces of logic above, many in the Casio community assume that envelope data goes **beyond** 99, and that your patches sound amazing when you take them above 99.

It's a seductive idea. It sounds like it must be true. Unfortunately it is not really true. There are a handful of values above 99, but most envelopes stop squarely at 99.

To understand why this is, you have to understand two things.

1. First, the machine value for envelope data is only 7 bits long, so the maximum machine value is **0x7F** or 127. Bit-wise, there can be no greater machine value than **0x7F**
2. Second, the machine values are **mapped** to corresponding human values, and four out of six envelopes, 99 is mapped to 0x7F.

Yes, that means that for four out of six envelopes, the human value 99 is mapped to the bit-wise highest possible machine value, **0x7F** . Take this opportunity to review the tables that map human values to machine values, and you will see that most envelopes cannot go beyond 99.

4.4 Converting Between Human And Machine Values

This section deals with how to convert from human values to machine values and back.

The equations I show on the following pages are in some cases different than Casio's original equations. These are not just guesses; I actually spent time working them out and testing them. They have all been tested to make sure they perform consistently together. And the results have all been compared against Casio's original tables.

4.5 Notes

Envelope data are alike in many ways. The following notes should be considered to apply to all types of envelope data.

4.5.1 Table Notes

The following notes apply to all tables in this document.

In the tables, sysex values are show in base 16 format, since this is how you are most likely to encounter them. All base 16 numbers are prefixed with **0x** to show that they are base 16 numbers.

The tables shown here were created using the equations shown on the same page. So if you want to verify the equations, you can compare the new tables with Casio's tables.

4.5.2 Equation Notes

The following notes apply to all equations in this document.

- α = human value, what is displayed on the LCD
- β = machine value, what the machine uses internally
- All equations are shown in **base 10 only** to prevent confusion.
- For all equations, use only **integer math**, no decimals and no fractions. For example, wrong though it may seem, $9 / 5 = 1$. That is the nature of the computer code used in the CZ. That is also why you must sometimes add 1 when doing division, instead of simply reversing the equation.

4.6 Pitch Envelope—Rate

human	sysex	human	sysex	human	sysex	human	sysex
0	0x00	25	0x20	50	0x40	75	0x60
1	0x01	26	0x21	51	0x41	76	0x61
2	0x02	27	0x22	52	0x42	77	0x62
3	0x03	28	0x23	53	0x43	78	0x64
4	0x05	29	0x25	54	0x45	79	0x65
5	0x06	30	0x26	55	0x46	80	0x66
6	0x07	31	0x27	56	0x47	81	0x67
7	0x08	32	0x29	57	0x49	82	0x69
8	0x0A	33	0x2A	58	0x4A	83	0x6A
9	0x0B	34	0x2B	59	0x4B	84	0x6B
10	0x0C	35	0x2C	60	0x4C	85	0x6D
11	0x0E	36	0x2E	61	0x4E	86	0x6E
12	0x0F	37	0x2F	62	0x4F	87	0x6F
13	0x10	38	0x30	63	0x50	88	0x70
14	0x11	39	0x32	64	0x52	89	0x72
15	0x13	40	0x33	65	0x53	90	0x73
16	0x14	41	0x34	66	0x54	91	0x74
17	0x15	42	0x35	67	0x55	92	0x76
18	0x17	43	0x37	68	0x57	93	0x77
19	0x18	44	0x38	69	0x58	94	0x78
20	0x19	45	0x39	70	0x59	95	0x79
21	0x1A	46	0x3B	71	0x5B	96	0x7B
22	0x1C	47	0x3C	72	0x5C	97	0x7C
23	0x1D	48	0x3D	73	0x5D	98	0x7D
24	0x1E	49	0x3E	74	0x5E	99	0x7F

Table 4.1: Pitch Envelope, Rates

4.6.1 Pitch Envelope, Rate Equations

α = human value, what is displayed on the LCD

β = machine value, what the machine uses internally

Convert human rate to sysex rate

$$\beta = (\alpha * 127) / 99$$

Convert sysex rate to human rate

if $\beta = 0$, then $\alpha = 0$

if $\beta = 127$, then $\alpha = 99$

otherwise, $\alpha = [(\beta * 99) / 127] + 1$

4.7 Pitch Envelope—Level

human	sysex	human	sysex	human	sysex	human	sysex	human	sysex
0	0x00	25	0x19	50	0x32	75	0x4F	100	0x68
1	0x01	26	0x1A	51	0x33	76	0x50	101	0x69
2	0x02	27	0x1B	52	0x34	77	0x51	102	0x6A
3	0x03	28	0x1C	53	0x35	78	0x52	103	0x6B
4	0x04	29	0x1D	54	0x36	79	0x53	104	0x6C
5	0x05	30	0x1E	55	0x37	80	0x54	105	0x6D
6	0x06	31	0x1F	56	0x38	81	0x55	106	0x6E
7	0x07	32	0x20	57	0x39	82	0x56	107	0x6F
8	0x08	33	0x21	58	0x3A	83	0x57	108	0x70
9	0x09	34	0x22	59	0x3B	84	0x58	109	0x71
10	0x0A	35	0x23	60	0x3C	85	0x59	110	0x72
11	0x0B	36	0x24	61	0x3D	86	0x5A	111	0x73
12	0x0C	37	0x25	62	0x3E	87	0x5B	112	0x74
13	0x0D	38	0x26	63	0x3F	88	0x5C	113	0x75
14	0x0E	39	0x27	64	0x44	89	0x5D	114	0x76
15	0x0F	40	0x28	65	0x45	90	0x5E	115	0x77
16	0x10	41	0x29	66	0x46	91	0x5F	116	0x78
17	0x11	42	0x2A	67	0x47	92	0x60	117	0x79
18	0x12	43	0x2B	68	0x48	93	0x61	118	0x7A
19	0x13	44	0x2C	69	0x49	94	0x62	119	0x7B
20	0x14	45	0x2D	70	0x4A	95	0x63	120	0x7C
21	0x15	46	0x2E	71	0x4B	96	0x64	121	0x7D
22	0x16	47	0x2F	72	0x4C	97	0x65	122	0x7E
23	0x17	48	0x30	73	0x4D	98	0x66	123	0x7F
24	0x18	49	0x31	74	0x4E	99	0x67		

Table 4.2: Pitch Envelope, Levels

4.7.1 Pitch Envelope, Level Equations

α = human value, what is displayed on the LCD

β = machine value, what the machine uses internally

Convert human level to sysex level

if $\alpha > 63$, then $\beta = \alpha + 4$

otherwise, $\alpha = \beta$

Convert sysex level to human level

if $\beta > 63$, then $\alpha = \beta - 4$

otherwise, $\beta = \alpha$

4.8 Wave Envelope—Rate

human	sysex	human	sysex	human	sysex	human	sysex
0	0x08	25	0x26	50	0x44	75	0x62
1	0x09	26	0x27	51	0x45	76	0x63
2	0x0A	27	0x28	52	0x46	77	0x64
3	0x0B	28	0x29	53	0x47	78	0x65
4	0x0C	29	0x2A	54	0x48	79	0x66
5	0x0E	30	0x2C	55	0x4A	80	0x68
6	0x0F	31	0x2D	56	0x4B	81	0x69
7	0x10	32	0x2E	57	0x4C	82	0x6A
8	0x11	33	0x2F	58	0x4D	83	0x6B
9	0x12	34	0x30	59	0x4E	84	0x6C
10	0x14	35	0x32	60	0x50	85	0x6E
11	0x15	36	0x33	61	0x51	86	0x6F
12	0x16	37	0x34	62	0x52	87	0x70
13	0x17	38	0x35	63	0x53	88	0x71
14	0x18	39	0x36	64	0x54	89	0x72
15	0x1A	40	0x38	65	0x56	90	0x74
16	0x1B	41	0x39	66	0x57	91	0x75
17	0x1C	42	0x3A	67	0x58	92	0x76
18	0x1D	43	0x3B	68	0x59	93	0x77
19	0x1E	44	0x3C	69	0x5A	94	0x78
20	0x20	45	0x3E	70	0x5C	95	0x7A
21	0x21	46	0x3F	71	0x5D	96	0x7B
22	0x22	47	0x40	72	0x5E	97	0x7C
23	0x23	48	0x41	73	0x5F	98	0x7D
24	0x24	49	0x42	74	0x60	99	0x7F

Table 4.3: Wave Envelope, Rates

4.8.1 Wave Envelope, Rate Equations

α = human value, what is displayed on the LCD

β = machine value, what the machine uses internally

Convert human rate to sysex rate

$$\beta = [(\alpha * 119) / 99] + 8$$

Convert sysex rate to human rate

if $\beta = 8$, then $\alpha = 0$

if $\beta = 127$, then $\alpha = 99$

otherwise, $\alpha = \{ [(\beta - 8) * 99] / 119 \} + 1$

4.9 Wave Envelope—Level

human	sysex	human	sysex	human	sysex	human	sysex
0	0x00	25	0x20	50	0x40	75	0x60
1	0x01	26	0x21	51	0x41	76	0x61
2	0x02	27	0x22	52	0x42	77	0x62
3	0x03	28	0x23	53	0x43	78	0x64
4	0x05	29	0x25	54	0x45	79	0x65
5	0x06	30	0x26	55	0x46	80	0x66
6	0x07	31	0x27	56	0x47	81	0x67
7	0x08	32	0x29	57	0x49	82	0x69
8	0x0A	33	0x2A	58	0x4A	83	0x6A
9	0x0B	34	0x2B	59	0x4B	84	0x6B
10	0x0C	35	0x2C	60	0x4C	85	0x6D
11	0x0E	36	0x2E	61	0x4E	86	0x6E
12	0x0F	37	0x2F	62	0x4F	87	0x6F
13	0x10	38	0x30	63	0x50	88	0x70
14	0x11	39	0x32	64	0x52	89	0x72
15	0x13	40	0x33	65	0x53	90	0x73
16	0x14	41	0x34	66	0x54	91	0x74
17	0x15	42	0x35	67	0x55	92	0x76
18	0x17	43	0x37	68	0x57	93	0x77
19	0x18	44	0x38	69	0x58	94	0x78
20	0x19	45	0x39	70	0x59	95	0x79
21	0x1A	46	0x3B	71	0x5B	96	0x7B
22	0x1C	47	0x3C	72	0x5C	97	0x7C
23	0x1D	48	0x3D	73	0x5D	98	0x7D
24	0x1E	49	0x3E	74	0x5E	99	0x7F

Table 4.4: Wave Envelope, Levels

4.9.1 Wave Envelope, Level Equations

α = human value, what is displayed on the LCD

β = machine value, what the machine uses internally

Convert human level to sysex level

$$\beta = (\alpha * 127) / 99$$

Convert sysex level to human level

if $\beta = 0$, then $\alpha = 0$

if $\beta = 127$, then $\alpha = 99$

otherwise, $\alpha = [(\beta * 99) / 127] + 1$

4.10 Amp Envelope—Rate

human	sysex	human	sysex	human	sysex	human	sysex	human	sysex
0	0x00	25	0x1E	50	0x3C	75	0x5A	100	0x78
1	0x01	26	0x1F	51	0x3D	76	0x5B	101	0x79
2	0x02	27	0x20	52	0x3E	77	0x5C	102	0x7A
3	0x03	28	0x21	53	0x3F	78	0x5D	103	0x7B
4	0x04	29	0x22	54	0x40	79	0x5E	104	0x7D
5	0x06	30	0x24	55	0x42	80	0x60	105	0x7E
6	0x07	31	0x25	56	0x43	81	0x61	106	0x7F
7	0x08	32	0x26	57	0x44	82	0x62		
8	0x09	33	0x27	58	0x45	83	0x63		
9	0x0A	34	0x28	59	0x46	84	0x64		
10	0x0C	35	0x2A	60	0x48	85	0x66		
11	0x0D	36	0x2B	61	0x49	86	0x67		
12	0x0E	37	0x2C	62	0x4A	87	0x68		
13	0x0F	38	0x2D	63	0x4B	88	0x69		
14	0x10	39	0x2E	64	0x4C	89	0x6A		
15	0x12	40	0x30	65	0x4E	90	0x6C		
16	0x13	41	0x31	66	0x4F	91	0x6D		
17	0x14	42	0x32	67	0x50	92	0x6E		
18	0x15	43	0x33	68	0x51	93	0x6F		
19	0x16	44	0x34	69	0x52	94	0x70		
20	0x18	45	0x36	70	0x54	95	0x72		
21	0x19	46	0x37	71	0x55	96	0x73		
22	0x1A	47	0x38	72	0x56	97	0x74		
23	0x1B	48	0x39	73	0x57	98	0x75		
24	0x1C	49	0x3A	74	0x58	99	0x77		

Table 4.5: Amp Envelope, Rates

4.10.1 Amp Envelope, Rate Equations

α = human value, what is displayed on the LCD

β = machine value, what the machine uses internally

Convert human rate to sysex rate

$$\beta = (\alpha * 119) / 99$$

Convert sysex rate to human rate

if $\beta = 0$, then $\alpha = 0$

if $\beta = 119$, then $\alpha = 99$

otherwise, $\alpha = [(\beta * 99) / 119] + 1$

4.11 Amp Envelope—Level

human	sysex	human	sysex	human	sysex	human	sysex
0	0x00	25	0x35	50	0x4E	75	0x67
1	0x1D	26	0x36	51	0x4F	76	0x68
2	0x1E	27	0x37	52	0x50	77	0x69
3	0x1F	28	0x38	53	0x51	78	0x6A
4	0x20	29	0x39	54	0x52	79	0x6B
5	0x21	30	0x3A	55	0x53	80	0x6C
6	0x22	31	0x3B	56	0x54	81	0x6D
7	0x23	32	0x3C	57	0x55	82	0x6E
8	0x24	33	0x3D	58	0x56	83	0x6F
9	0x25	34	0x3E	59	0x57	84	0x70
10	0x26	35	0x3F	60	0x58	85	0x71
11	0x27	36	0x40	61	0x59	86	0x72
12	0x28	37	0x41	62	0x5A	87	0x73
13	0x29	38	0x42	63	0x5B	88	0x74
14	0x2A	39	0x43	64	0x5C	89	0x75
15	0x2B	40	0x44	65	0x5D	90	0x76
16	0x2C	41	0x45	66	0x5E	91	0x77
17	0x2D	42	0x46	67	0x5F	92	0x78
18	0x2E	43	0x47	68	0x60	93	0x79
19	0x2F	44	0x48	69	0x61	94	0x7A
20	0x30	45	0x49	70	0x62	95	0x7B
21	0x31	46	0x4A	71	0x63	96	0x7C
22	0x32	47	0x4B	72	0x64	97	0x7D
23	0x33	48	0x4C	73	0x65	98	0x7E
24	0x34	49	0x4D	74	0x66	99	0x7F

Table 4.6: Amp Envelope, Levels

4.11.1 Amp Envelope, Level Equations

α = human value, what is displayed on the LCD

β = machine value, what the machine uses internally

Convert human level to sysex level

if $\alpha = 0$, then $\beta = 0$
otherwise, $\beta = \alpha + 28$

Convert sysex level to human level

if $\beta = 0$, then $\alpha = 0$
otherwise, $\alpha = \beta - 28$