

## CASIO BAR CODES

Several of the Casiotone keyboard instruments are able to load music from printed bar codes, using a bar code reader consisting of an infra-red LED and a photo diode. The Casio bar codes consist of a series of parallel dark bars printed on a light background. The bars contain pitch information, duration information, and special control codes, as well as a checksum to allow verification that the code has been read correctly.

In what follows, the word 'bar' means a dark bar, or the light space between two dark bars.

The bars are of two different widths, with the wide ones being 2.5 times the width of the narrow ones. It is the ratio of these widths which is important, not their actual dimensions, because the scanning rate of the reader over the bars can vary tremendously.

Each bar, light or dark, represents a bit, either zero or one. An examination of the codes suggests that wide bars represent binary 1, and the narrow bars represent binary 0. (An equally valid, but less logical coding system results if the opposite is assumed)

The printed bar codes are arranged in lines of three kinds, depending on the type of information contained in them, and are named Pitch, Length and Chords. The lines are of variable length, and there are a variable number of lines of code. There is no limit on the length of a line, other than the physical size of the page, as long as the total storage capacity of the instrument is not exceeded. This is worth remembering, because it is possible to generate the bar codes using a computer, and to enter them into the instrument by attaching an infra-red LED to the computer. When the bar code reader is pointed at the LED, the instrument can be 'tricked' into believing that it is reading printed codes. In this case it is possible to enter all the Pitch information as though it was one long line, and the same goes for the Length and Chord data.

The structure of a line of code is as follows:

Guard bars - the pattern 00000010 indicates the start of each line.  
Line number - 4 bits.  
Line type - 4 bits, present only on the first line.  
Variable amount of Pitch, Length or Chord data.  
Trailer pattern - 5 bits.  
Checksum - 4 bits.  
Padding - binary zeroes.

The code used can be best understood if the left-most bit, i.e. the first bit to be scanned, is assumed to be the low order bit. (This is again a case where assuming the opposite will lead to a valid, but less logical code.) Having the low order bit on the left is, of course, the opposite of the normal way of writing numbers, but this causes no problems in generating or decoding the bar codes. For example, if a program is to be written to generate the codes, it is possible to create the 00000010 guard bar pattern by starting with 01000000, and shifting this one place to the right as each bit is required.

A more detailed description of each part of a line follows:

Guard bars.

This fixed pattern is used to indicate the start of a line, and allows the bar code reader to adjust to the initial scanning speed.

Line number.

This 4 bit number starts at 0 on the first line, (as indicated by P01, L01, or C01 on the printed bar codes) and increases by one for each line. After the maximum value of 15 has been reached, it wraps back to 0. (because the low order bit is on the left, the line numbers appear as 0000, 1000, 0100, 1100, ...)

Type indicator.

This 4 bit code is only present on the first Pitch, Length, or Chord line. The codes used are, 1000=Pitch, 0100=Length, and 0010=Chord. (Reversed, these appear as 0001, 0100, and 0010.)

Pitch data.

Consists of 8 bit codes, representing either notes or special control codes. The control codes are:

- 00000000 - Rest.
- 00001101 - Accomp. start.
- 00001110 - Return 1.
- 00010000 - Return 2.

The notes are of the form 01zznnnn where the 01 indicates the fact that it is a note, the zz is the octave number 00, 01, or 10, and the nnnn is the note, 0001=C, 0010=C#, ... 1100=B. i.e. notes from C to B are represented by decimal numbers 1 to 12. As an example, the code printed as 00011010, reversed this becomes 01011000 - the 01 on the left indicates that it is a note, the octave is 01, note is 1000 = decimal 8 which corresponds to G.

Length data.

For each note or rest in the Pitch data, there must be a corresponding value in the Length lines. The Length codes are 8 bit values, which indicate the duration of the corresponding note or rest, in units of 1/48 of a bar. The maximum duration is 255/48 of a bar, ie just over 5 bars, which explains the statement '.. a maximum of five measures of rest can be produced with one press of the Rest Button.' in the Casio instruction book.

Chord data.

8 bit codes, of the form ltttnnnn. l indicates the length, 0=half bar, 1=full bar (not very flexible, this.) ttt is type of chord: 000=no chord, 001=major, 010=minor, 011=7th, 100=minor 7th, 101=major 7th, 110=diminished, 111=augmented. nnnn has the same values given above for Pitch data. For example, the code appearing as 10001001, reversed this is 10010001 - the left-most 1 indicates full bar duration, the next 3 bits, 001=major, low order 4 bits 0001 corresponds to C.

Trailer pattern.

This is a 5 bit pattern, equal to 01111 on all lines except the last one, and equal to 11111 on the last Pitch, Length or Chord line, and is used to mark the end of the variable length portion of the line.

Checksum

The checksum is a 4 bit value, calculated from the contents of the line, and is used to check that the line has been read correctly. The checksum can be calculated as follows. Initialise the checksum to zero at the start of the 1st line, and then break the line up into 4 bit values, each one of which must be subtracted from the checksum. The guard bar pattern is not included in the checksum, but the trailer pattern is. Subtract 15 for the trailer on each line, and an extra 1 if the extra bit is on in the trailer to indicate the last line.

Padding.

The printed code lines may have extra zeroes following the checksum to make all the lines more or less the same length

An example follows, of decoding one line of Pitch information.  
 The line is the first line (P01) of the code supplied by Casio  
 - WHEN THE SAINTS COME MARCHING IN.

| BAR PATTERN | REVERSED CODE | MEANING                | CUMULATIVE CHECKSUM |
|-------------|---------------|------------------------|---------------------|
| 00000010    | 01000000      | Guard pattern          | -                   |
| 0000        | 0000          | Line number 0          | 0000                |
| 0001        | 1000          | Type=Pitch             | 1000                |
| 10110000    | 00001101      | Accomp. start          | 1011                |
| 00000000    | 00000000      | Rest                   | 1011                |
| 10000010    | 01000001      | Note, octave '0' C     | 0110                |
| 10100010    | 01000101      | Note, octave '0' E     | 1101                |
| 01100010    | 01000110      | Note, octave '0' F     | 0011                |
| 00010010    | 01001000      | Note, octave '0' G     | 0111                |
| 00000000    | 00000000      | Rest                   | 0111                |
| 10000010    | 01000001      | Note, octave '0' C     | 0010                |
| 10100010    | 01000101      | Note, octave '0' E     | 1001                |
| 01100010    | 01000110      | Note, octave '0' F     | 1111                |
| 00010010    | 01001000      | Note, octave '0' G     | 0011                |
| 00000000    | 00000000      | Rest                   | 0011                |
| 10000010    | 01000001      | Note, octave '0' C     | 1110                |
| 10100010    | 01000101      | Note, octave '0' E     | 0101                |
| 01100010    | 01000110      | Note, octave '0' F     | 1011                |
| 11110       | 01111         | Trailer, not last line | 1100                |
| 0011        | 1100          | Checksum               |                     |
| 00          | 00            | Padding                |                     |

In case you don't have the bar coded version of the above, it is reproduced below, as well as can be done on this printer.

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