

# Cover Page

## Navigational Aids Audio Characteristics

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## 1 ACRONYMS

|        |  |
|--------|--|
| ADF    | Automatic Direction Finder                         |
| DME    | Distance Measuring Equipment                       |
| FAA    | Federal Aviation Administration                    |
| ICAO   | International Civil Aviation Organization          |
| NDB    | Non-Directional Beacon                             |
| TACAN  | Tactical Air Navigation                            |
| VHF    | Very High Frequency                                |
| VOR    | VHF Omni-directional Range                         |
| VORTAC | VHF Omni-directional Range/Tactical Air Navigation |

## 2 Navigational Aids Audio Characteristics

The following information describes the characteristics of the received audio signal of the following navigational aids. Each item is associated with a transmitter, whose characteristics are governed by several agencies. This data was compiled from the FAA and ICAO documents. Some data was obtained by examining the specifications of actual navigational aid equipment manufacturers. This information is intended for the generation of audio from simulated radio receivers. There are conflicts between the ICAO and existing FAA standards and these are noted. This document also represents the ICAO recommendations as of this printing, which differs from previous specifications. Note that the information contained herein is intended for use in the simulation of audio for flight simulators only.

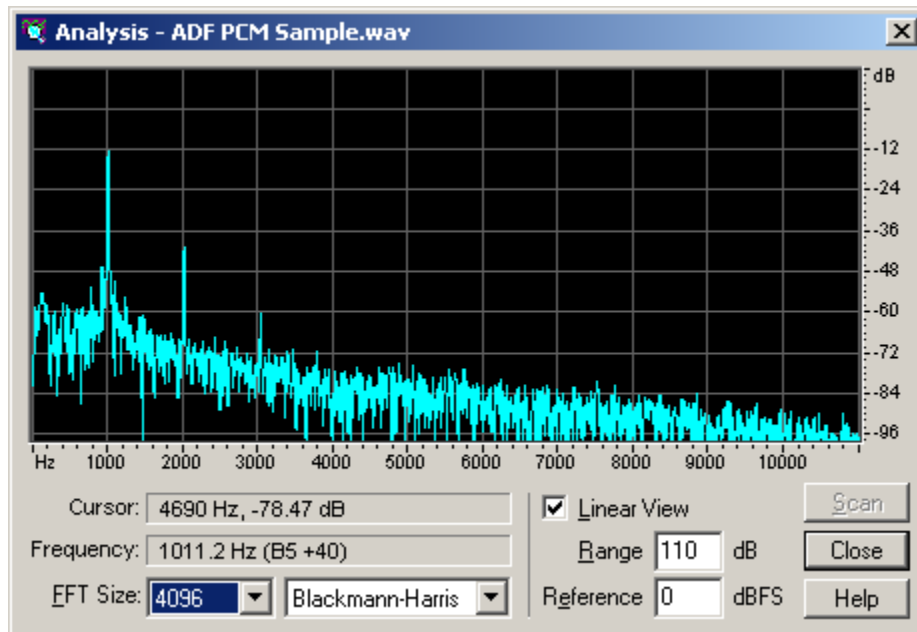
### 2.1 INTERNATIONAL MORSE CODE TIMING

Internal Morse code timing of seven words per minute is defined herein as .110 dot times. That is, the time that the dot is on (Measured). Dashes are three dots in duration. Spaces between intra-character dots and dashes are one dot. Character spaces are one dash. All NAVAIDS herein using international Morse code are seven words per minute keying rate.

## 2.2 TONE WAVEFORM

The references do not specify the waveform characteristics of the identification tone however, frequency domain analysis shows significant harmonics above the fundamental with actual recordings of navigational stations. Remember that the actual aircraft receiver may generate DME identification tones internally and therefore the waveform spectrum may be specific to the receiver. The tone shown below is a spectrum during the identifier portion of an actual VOR station.

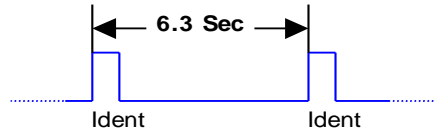
Figure 1, Tone Spectral Characteristics



## 2.3 NDB (ADF)

The ICAO specification states the following for NDB stations. *"An International Morse Code identification tone at least once every thirty seconds at seven words per minute at 1020Hz +/- 50Hz or 400Hz +/- 25Hz. All NDB stations are continuous carrier except those not associated with holding, approach or landings aids, and having a radius of rated coverage of less than 92.7km (50nm)."* Note that the specification states "at least" instead of a hard specification for identification interval." Actual recordings of NDB audio output reveal a 6.3 second identification interval.

Figure 2, NDB Identification Interval



## 2.4 MARKER BEACON

Figure 3, Marker beacon Light Panel shows what the panel often looks like in the aircraft. There are three lights representing the Outer Marker (O), Middle Marker (M), and Inner Marker (I). Each light flashes in synchronization with the tone. The brightness of the lights are also a function of the audio tone level, so that as the aircraft approaches the marker, the light becomes brighter.

Figure 3, Marker beacon Light Panel



### 2.4.1 Marker Beacon Light Sync

As the above section explains, the lights and therefore the tone, exhibit an overall brightness level or volume level as a function of range to the marker. The marker can only be heard in a very small area around the marker antenna. However, this brings up a problem in Simulators. The audio system usually drives the marker beacon on request of a host computer, which is also controlling the light.

#### 2.4.1.1 Marker Beacon Light Sync Output to Host

The SimPhonics audio system has the capability to send the light intensity to the host computer along with a variable used to adjust the timing to match the transport delay of the host computer and light I/O system exactly.

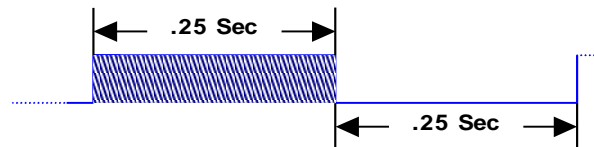
### 2.4.2 Marker Beacon Tone Tolerance

The ICAO specification requires that all marker tone frequencies must be +/- 2.5% of specified frequency.

### 2.4.3 OUTER MARKER

The outer marker tone is 400Hz, two dashes per second. Note that after 2001, ICAO recommends 3000Hz for new installations.

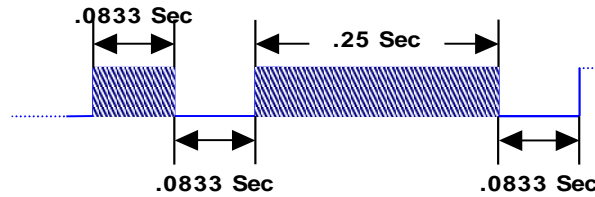
Figure 4, Outer Marker Audio Timing



### 2.4.4 MIDDLE MARKER

The Middle Marker tone is 1300Hz, alternate dots and dashes, dashes are two dashes per second, dots at 6 dots per second. Note that after 2001, ICAO recommends 3000Hz for new installations.

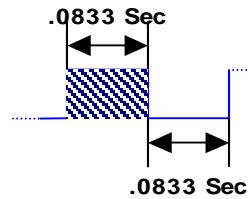
Figure 5, Middle Marker Audio Timing



### 2.4.5 INNER MARKER

The Inner Marker tone is 3000Hz, Continuous dots at 6 dots per second.

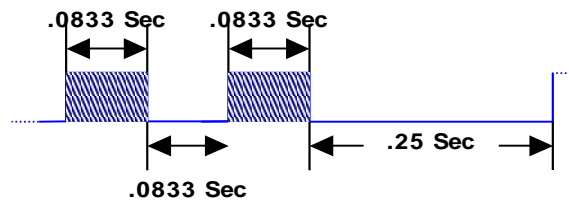
Figure 6, Inner Marker Audio Timing



### 2.4.6 BACK COURSE MARKER

The Back Course marker audio is two dots repeating, 400Hz.

Figure 7, Back Course Marker Audio Timing

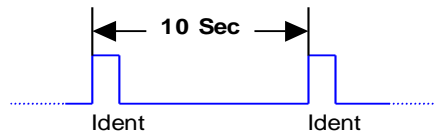


## 2.5 INDEPENDENT VOR

"An International Morse Code identification tone at seven words per minute, 1020 Hz, +/- 50Hz."

Three identification signals evenly spaced in a 30 second interval. One of these identifiers may be a voice identifier. The ICAO recognizes that some VOR stations may transmit at 10 words per minute. A VOR designated as a VOT generates a constant tone.

Figure 8, Independent VOR Audio Timing



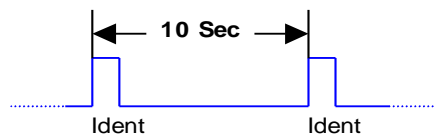
## 2.6 VOICE IDENTIFIER SPECIFICATION

For those navigational aids that use voice, the voice specification is 300 to 3000 Hz bandwidth +/- 3db referenced at 1000Hz.

## 2.7 LOCALIZER

An International Morse Code Identification of two or three Letters, and may be preceded by an "I" followed by a short pause where it is necessary to distinguish it from other navigational signals in the area. Seven words per minute keying equal intervals not less than six per minute. Tone frequency is 1020Hz +/- 50Hz. The keying timing is the same as the independent VOR.

Figure 9, Localizer Audio Timing



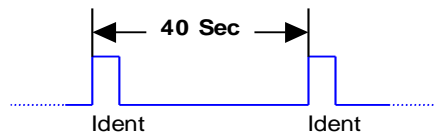


## 2.8 INDEPENDENT DME

International Morse Code once each 40 seconds at 1350 pulses per second (Hz) at least six words per minute. The identifier lettering characteristics shall conform to the following to ensure that the maximum total key down time does not exceed 5 seconds per identification code group.

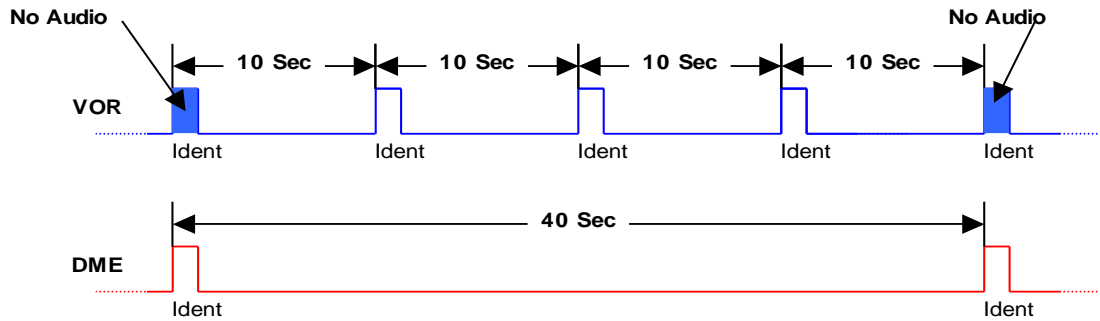
The dots shall have time duration of .1 second to .160 second. Dashes are three times that of dots. The duration between dots and or dashes shall be equal to that of a dot plus and minus 10-%. The time duration between letters shall not be less than three dots. The total duration for the transmission of a code group shall not be greater than 10 seconds. In order to meet this specification, we will use the seven words per minute standard.

Figure 10, Independent DME Audio Tone Timing



## 2.9 CO-LOCATED DME

“When associated with a VOR (co-located) The DME identifier shall be synchronized with the VOR identifier. The 40-second identifier interval will be divided into four equal intervals with the DME identifier in one of the intervals only.” When the DME identifier is active the VOR identifier is inactive as shown.



## 2.10 VOT & AVOT

A VOT is a VOR test facility located at selected airports, which enables a pilot to check the accuracy of a VOR receiver. VOT stations emit only two bearings, 0 degrees From and 180 degrees To. An AVOT is simply a VOT that may exceed 2 watts of transmitter power. The station emits a tone of 1020Hz as a series of Morse code letter “E”, or a series of dots.

## 2.11 TACAN

The TACAN identifier tone is the same as the DME tone. See co-located DME and Independent DME.

## 2.12 Valid Morse Code Characters

The table below lists valid Morse code characters and their associated ASCII values.

| MORSE CODE | ASCII LETTER | VALUE |
|------------|--------------|-------|
| .-.-.      | 34           | "     |
| .-.-.      | 39           | '     |
| -.--.      | 40           | (     |
| -.--.      | 41           | )     |
| --..-      | 44           | ,     |
| -...-      | 45           | -     |
| .-.-.      | 46           | .     |
| -.--.      | 47           | /     |
| .-.-.      | 49           | 1     |
| ..-.-      | 50           | 2     |
| ...--      | 51           | 3     |
| ....-      | 52           | 4     |
| .....      | 53           | 5     |
| -....      | 54           | 6     |
| --...      | 55           | 7     |
| ---..      | 56           | 8     |
| -....      | 57           | 9     |
| ---...     | 58           | :     |
| ..-..      | 63           | ?     |
| .-         | 65           | A     |
| -...       | 66           | B     |
| -.-        | 67           | C     |
| -..        | 68           | D     |
| .          | 69           | E     |
| ..-        | 70           | F     |
| --.        | 71           | G     |
| ....       | 72           | H     |
| ..         | 73           | I     |
| .-.-       | 74           | J     |
| -.-        | 75           | K     |
| .-..       | 76           | L     |
| --         | 77           | M     |
| -.         | 78           | N     |
| ---        | 79           | O     |
| .-.        | 80           | P     |
| ---.       | 81           | Q     |
| .-.        | 82           | R     |
| ...        | 83           | S     |
| -          | 84           | T     |
| ..-        | 85           | U     |
| ...-       | 86           | V     |
| .-.-       | 87           | W     |
| -..-       | 88           | X     |
| -.--       | 89           | Y     |
| ---..      | 90           | Z     |
| .-         | 97           | a     |

## Navigational Aids Audio Characteristics

| MORSE CODE | ASCII LETTER | VALUE |
|------------|--------------|-------|
| -...       | 98           | b     |
| -.-        | 99           | c     |
| -..        | 100          | d     |
| .          | 101          | e     |
| ..-        | 102          | f     |
| --.        | 103          | g     |
| ...        | 104          | h     |
| ..         | 105          | i     |
| .---       | 106          | j     |
| -.-        | 107          | k     |
| ...-       | 108          | l     |
| --         | 109          | m     |
| -.         | 110          | n     |
| ---        | 111          | o     |
| ..-.       | 112          | p     |
| --.-       | 113          | q     |
| .-.        | 114          | r     |
| ...        | 115          | s     |
| -          | 116          | t     |
| ..-        | 117          | u     |
| ...-       | 118          | v     |
| .-.-       | 119          | w     |
| -..-       | 120          | x     |
| -.--       | 121          | y     |
| --..       | 122          | z     |

### 2.13 References

"International Standards and Recommended Practices, Aeronautical Telecommunications, Annex 10 to the Convention on International Civil Aviation", Volume 1, July 1996.

"Federal Aviation Regulations/Aeronautical Information Manual FAR/AIM", 1999