

# PIC10F Makes Beautiful Nano-Music

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MUSIC 101 – Read this before using the Nano-Lab 1000 Music Operating System.

MUSIC is an organized system of continuous sounds. The rules of a music system differ from culture to culture and are based upon tradition, habit and perhaps some innate physiological and emotional workings.

WESTERN MUSIC uses a 'chromatic scale' of tones that are indexed to the frequency 440 Hz. The 'middle A' key on a piano emits a tone of 440 Hz when struck. It is called 'middle' because it is approximately in the middle of the piano keyboard. It is called 'A' because the scale is defined as having 12 ascending frequency sounds, called tones, that are labeled as follows:

Tones:           A,   A#, B, C, C#, D, D#, E, F, F#, G, G#  
Frequency in Hz: 440, 466, 494, 523, 554, 587, 622, 659, 699, 740, 783, 830

A CHROMATIC SCALE is comprised of the above 12 tones. Each tone is called a 'half-tone' or a 'semitone' and every group of 12 tones, starting with the 'C' note', is called an 'octave'.

NOTES are notations that represent frequencies and durations. Notes are mathematically derived, based upon 'Middle A'. You start with the frequency of middle A, which is 440 Hz, and multiply by  $2^{(1/12)}$  to get the next higher note, A#.

(Example:  $440\text{Hz} * 2^{(1/12)} = 440\text{Hz} * 2^{(0.08333)} = 440\text{Hz} * 1.059463094 = 466.1637615\text{Hz}$

So, the frequency of A# is 466Hz. And the next higher tone, B, is similarly found by multiplying the frequency of tone A# by 1.059463094. To find the frequency of a next lower tone, divide by that tone's frequency by 1.059463094.

SHARPS & FLATS (Also called 'accidentals') are designations for the black keys on a piano keyboard. The early pianos only had white keys for the notes A, B, C, D, E, F and G. The black keys were added later to produce more colorful (chromatic) music. The black keys were placed between two white keys, and were designated 'sharped', by using the 'pound' (#) sign after the note of the white key to the left. Or, they were designated 'flatted', by using a lower-case 'b' after the note of the white key to the right. And, it was left to the discretion of the musician to call the black key, either 'a sharp' (#) or 'a flat' (b). For example, A# is the same tone as Bb, C# is the same tone as Db, D# is the same as Eb, etc.

An OCTAVE is a set of 12 tones (i.e.: half-tones, semitones). The next higher octave also has 12 tones of twice the frequency. For example, the note 'Middle A' has a frequency of 440Hz and in the next higher octave the 'A' note is 880Hz, twice the frequency.

TONE DURATION is the length of time the tone is played. Popular tone durations are: ½ beat, 1-beat, 2-counts and 4-counts, called respectively eighth, quarter, half and whole notes. A 'dot' following the tone symbol indicates that its duration is 50% longer. 'Rests' are silent periods between tones. Some tone and rest symbols are shown below:



Music 101 (Continued)

A STAFF is a structure of five lines, E,G,B,D and F (Mnemonic: Every good boy does fine), four spaces, F,A,C,E, and a 'Clef' (Translation: 'Key') symbol, upon which the notes appear.

A SIMPLE SCALE is a set of eight notes that begin on the 'key' note and is sung as the words: 'Do', 'Re', 'Mi', 'Fa', 'So', 'La', 'Ti', 'Do'. It covers one octave. The scale is sung to coordinate the singer 'pitch' (i.e.: tonal frequency) with the C, D, E, F, G, A, B and C notes on the scale.

The KEY of the music is the note that appears on the line under the bottom line of the staff. The music usually begins and ends with this note. A simple staff with a scale in the key of 'C' s shown below:



A 'G CLEF' marks the start of most staves. It is called 'G' because it encircles the 'G' line.

The TIME SIGNATURE above is '4/4'. The top '4' sets the number of beats in each measure, and the bottom '4' indicates that the basic tone duration is 4 'quarter-beats' long (i.e.: Equals one beat, like a quarter note). Popular time signatures are 4/4 for 'Common time', 3/4 for 'Waltz time' and 2/4 (or 1/2) for 'March' and 'Polka' time.

TRANSPOSITION is the act of shifting all semitones in a tune, to higher or lower frequencies, to better accommodate the frequency range of a singer or an instrument. This entails renaming all the notes on the staff according to the following table:

To transpose a song to any other key, select the desired key on the bottom line and use that column to rename the notes and spaces on the staff.

line	F4	G4	G4#	A4	A4#	B4	C5	C5#	D5	D5#	E5	F5
space	E4	F4	G4	G4#	A4	A4#	B4	C5	C5#	D5	D5#	E5
line	D4	E4	F4	G4	G4#	A4	A4#	B4	C5	C5#	D5	D5#
space	C4	C4#	D4	D4#	E4	F4	G4	G4#	A4	A4#	B4	C5
line	B3	C4	C4#	D4	D4#	E4	F4	G4	G4#	A4	A4#	B4
space	A3	A3#	B3	C4	C4#	D4	D4#	E4	F4	G4	G4#	A4
line	G3	A3	A3#	B3	C4	C4#	D4	D4#	E4	F4	G4	G4#
space	F3	F3#	G3	G3#	A3	A3#	B3	C4	C4#	D4	D4#	E4
line	E3	F3	F3#	G3	G3#	A3	A3#	B3	C4	C4#	D4	D4#
space	D3	D3#	E3	F3	F3#	G3	G3#	A3	A3#	B3	C4	C4#
line	C3	C3#	D3	D3#	E3	F3	F3#	G3	G3#	A3	A3#	B3

The 12 Major keys are: C, C#, D, D#, E, F, F#, G, G#, A, A# and B.

NOTE: The number following the note indicates the octave

NOTE: The columns on the left are only shifted up or down one half-tone from adjacent columns.

Using the Nano-Lab 1000 Music Operating System: A) Open the assembly file PIC10F200\_015, PIC10F202\_015, PIC10F204\_015 or PIC10F206\_015, that matches the PIC microprocessor you are using. B) Replace the code between 'main1' and the subroutines with the code for your new tune. The code will consist of a simple list of 'call' statements, no other instructions are used.

Writing PIC assembly code for the Nano-Lab 1000 Music Operating System: A) Pick your desired song from your sheet music. Call the notes as (Letter)(Octave)(sharp, flat or natural). Example: call C3, or call D3#. B) Call the notes duration every time it changes. Example: call eighth, or call quarter, or call half, or call whole. If a rest is required, call rest.

That is all there is to it. The PIC10F200/204 can hold ~100 notes, and the 202/206 ~ 350 notes.