ISSN: 2278 – 7798
International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 1, Issue 5, November 2012

Morse Code Decoder - Using a PIC Microcontroller

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***Abstrcat*---Morse code is designed to be read by humans without a decoding device, making it useful for sending automated digital data in voice channels. For emergency signaling, Morse code can be sent by way of improvised sources that can be easily "keyed" on and off.The design presented here is physically simpler, although the software is considerably more complex.The goal of this project is to produce a system that will decode Morse Code signals from apossibly noisy audio source, and display the decoded text on a LCD screen through a PIC microcontroller interface. The system might also produceMorse code signals via input from a keyboard. It consists of a handheld unit that can receive Morse code, via audio input (internal microphone) or direct signal connection, and translate it for display on an in-built liquid crystal alphanumeric screen. It consists of a PIC microcontroller which provides the interface between the Morse code input and the display unit.**

***Index Terms*—International Morse Code, Binary Format, Reception Rate, Circuit diagram.**

I INTRODUCTION

Morse code is a method of transmitting text information as a series of on-off tones, lights, or clicks that can be directly understood by a skilled listener or observer without special equipment.Each character (letter or numeral) is represented by a unique sequence of dots and dashes. The duration of a dash is three times the duration of a dot. Each dot or dash is followed by a short silence, equal to the dot duration. The letters of a word are separated by a space equal to three dots (one dash), and two words are separated by a space equal to seven dots. The dot duration is the basic unit of time measurement in code transmission.For efficiency, the length of each character in Morse is approximately inversely proportional to its frequency of occurrence in English. Thus, the most common letter in English, the letter "E," has the shortest code, a single dot.[8]
Morse code is most popular among amateur radio operators, although it is no longer required for licensing in most countries, including the US. Pilotsand air traffic controllers usually need only a cursory understanding.

Manuscript received on November, 2012.
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Aeronautical navigational aids, such as VORs and NDBs,constantly identify in Morse code. Compared to voice, Morse code is less sensitive to poor signal conditions, yet still comprehensible to humans without a decoding device. Morse is therefore a useful alternative to synthesized speech for sending automated data to skilled listeners on voice channels. Many amateur radio repeaters, for example, identify with Morse, even though they are used for voice communications. For emergency signals, Morse code can be sent by way of improvised sources that can be easily "keyed" on and off, making it one of the simplest and most versatile methods of telecommunication. The most common distress signal is SOS or three dots, three dashes and three dots, internationally recognized by treaty.

A typical "straight key." This U.S. model, known as the J-38, was manufactured in huge quantities during World War II, and remains in widespread use today. In a straight key, the signal is "on" when the knob is pressed, and "off" when it is released. Length and timing of the *dits* and *dahs* are entirely controlled by the operator.[8]

II LITERATURE REVIEW

In September 2000, Ming-Che Hsieh published a paper on Unstable Morse Code Recognition with Adaptive Variable-Ratio Threshold Prediction for Physically Disabled Persons. In this, he presented an efficient and reliable method for unstable Morse code recognition.Morse code could provide an effective alternative communication channel for individuals with physical limitations by simply using one or two switches. But most of the physically disabled persons have difficulties in maintaining a stable typing of Morse code. So he developed a method of automated recognition of unstable Morse code. In his study, he proposed an adaptive variable-ratio threshold prediction (AVRTP) algorithm to analyze the Morse code time series with variable unit time period and ratio. Two least-mean-square (LMS) predictors are applied to track the dot interval and the dot-dash difference concurrently, and then a predicted threshold based on a variable-ratio decision rule is used to distinguish between dots and dashes. To identify character spaces, the same method is applied. By the adaptive prediction of variable-ratio threshold, AVRTP has successfully overcome the difficulty of analyzing severely unstable Morse code time series and outperformed the previously proposed adaptive unstable-speed prediction (AUSP) algorithm and LMS and matching (LMS & M) algorithm. He also used a computer simulation and a preliminary clinical evaluation for this method that demonstrate AVRTP. [12]

In December 2003, Cheng-Hong Yang presented a Morse Code Application for Wireless Environmental Control Systems for Severely Disabled Individuals. The people, who are severely disabled and not able to write, type, and speak, require an assistive tool for purposes of augmentative and alternative communication in their daily lives. Here he designed and implemented a wireless environmental control system using Morse code as an adapted access communication tool. It consists of input-control module, recognition module, wireless-controlModule and electronic-equipment-control module. The signals are transmitted using adopted radio frequencies, which permits long distance transmission without space limitation. This system provides an easy-to-operate environment and allows a handicapped user to access an electronic facility by Morse code. Morse code was selected as the adaptive communication device. [13]

In September 2004, Andrés Sole, worked on Morse Description and Geometric Encoding of Digital Elevation Maps. In this work two complementary geometric structures are developed for the topographic representation of an image. The first one computes a description of the Morse-topological structure of the image, while the second one computes a simplified version of its drainage structure. The topographic significance of the Morse and drainage structures of digital elevation maps (DEMs) suggests that they can be used as the basis of an efficient encoding scheme. This geometric representation is combined with an interpolation algorithm and lossless data compression schemes to develop a compression scheme for DEMs. This algorithm achieves high compression while controlling the maximum error in the decoded elevation map, a property that is necessary for the majority of applications dealing with DEMs.[14]

III INTERNATIONAL MORSE CODE

Morse code has been in use for more than 160 years longer than any other electrical coding system. What is called Morse code today is actually somewhat different from what was originally developed by Vail and Morse. The Modern International Morse code, or *continental code*, was created by Friedrich Clemens Gerke in 1848 and initially used for telegraphy between Hamburgand Cuxhavenin Germany. Gerke changed nearly half of the alphabet and all of the numeralsresulting substantially in the modern form of the code. After some minor changes, International Morse Code was standardized at the International Telegraphy Congress in 1865 in Paris, and was later made the standard by the International Telecommunication Union (ITU). Morse's original code specification, largely limited to use in the United States and Canada, became known as American Morse codeor *railroad code*. American Morse code is now seldom used except in historical re-enactments.[8]

International Morse Code

1. A dash is equal to three dots.
2. The space between parts of the same letter is equal to one dot.
3. The space between two letters is equal to three dots.
4. The space between two words is equal to seven dots.

A	• ▬	U	• • ▬
B	▬ • • •	V	• • • ▬
C	▬ • ▬ •	W	• ▬ ▬
D	▬ • •	X	▬ • • ▬
E	•	Y	▬ • ▬ ▬
F	• • ▬ •	Z	▬ ▬ • •
G	▬ ▬ •		
H	• • • •		
I	• •		
J	• ▬ ▬ ▬		
K	▬ • ▬	1	• ▬ ▬ ▬ ▬
L	• ▬ • •	2	• • ▬ ▬ ▬
M	▬ ▬	3	• • • ▬ ▬
N	▬ •	4	• • • • ▬
O	▬ ▬ ▬	5	• • • • •
P	• ▬ ▬ •	6	▬ • • • •
Q	▬ ▬ • ▬	7	▬ ▬ • • •
R	• ▬ •	8	▬ ▬ ▬ • •
S	• • •	9	▬ ▬ ▬ ▬ •
T	▬	0	▬ ▬ ▬ ▬ ▬

Table 1: International Morse Code Format

The problem for most people is the non-real time nature of the process, i.e., writing down the last character while listening to, and decoding the signature of the next character. Furthermore, when you make a mistake, the entire process collapses as your mind tries to perform error correction, trying to fill in the missing blanks, causing you to miss even more characters.

One way out of this design is to remove the burden of writing down the characters altogether during the process of building up your code speed. But to do this you need a device that copies and displays the code in parallel with you, which is what the stand-alone device described in this article, is designed to perform. The decoder is designed for code speeds ranging from about 6 words per minute (WPM) to greater than 36 WPM. The rate adaptive algorithm responds quickly to code speed changes, so you can copy both halves of a QSO, even when the parties transmit at different rates.

IVTRANSLATION REQUIREMENTS

International Morse code uses the dot-dash combinations listed in Table 1. Conventionally, a dot is known as "DIT", and a dash as "DAH".
Whilst the rate of code transmission is up to the Morse operator, the relative duration of the DITs, DAHs and associated spaces has been established by international agreement:

• The DIT is the basic unit of length
• The DAH is equal in length to three DITs
• The space between the DITs and DAHs within a character (letter) is equal to one DIT
• The space between characters in a word is equal to three DITs
• The space between words is equal to seven DITs

These are the basic requirements that any human operator or translation software must observe.[8]
The sending of Morse signals can take many forms, ranging from audio and radio transmission, modulation of light (e.g. Aldis lamps and torches), varying electrical pulse levels (e.g. sending to a computer), to bashing the water pipe if the sender is incarcerated at "Her Majesty's Pleasure"! In audio and radio transmission, the technique is to turn the modulation of a carrier frequency (CW - continuous wave) on and off at the required rate. In audio work, the received signal is already within the audio range of the listener. Radio signals must, of course, be demodulated to become an equivalently pulsed audio signal. There are no set rules regarding the audio frequency of Morse signals, but they must, naturally, lie in the range most likely to be heard clearly, at about 1kHz, for example. Automatic decoding equipment, therefore, must be able to accept Morse signals as a pulse-modulated frequency. It must also be able to recognized unmodulated pulse levels originating from a voltage simply being switched on and off.
The equipment must be capable of differentiating DITs from DAHs, and letter spaces from word spaces, irrespective of the rate at which the Morse signals are being received. Ideally, it should detect if the transmission rate changes and then readjust its DIT-DAH criteria correctly recognized DIT-DAH ratios. The unit described now makes its own adjustment, typically within about eight to 16 key presses (DITs and DAHs) being received.[8]
Thus, all you need to do is place the unit near the loudspeaker of a radio receiver, or directly plug it into the coded signal source, and observe the unit displaying the received code as an intelligible text message.
The term "intelligible" is used loosely, of course. The unit won't translate from Swahili into English, for instance! It will simply show the letters being received.

V BINARY FORMAT

If you examine Morse codes as though DITs are logic 0 and DAHs are logic 1, a binary coded pattern will be seen. Converting from binary to decimal reveals a snag, however. There are some Morse codes that have one or more "leading" DITs, i.e. leading zeros. For example, take the letters E, I. S and H. which are Morse coded as DIT, DIT-DIT. D1T-DIT-DIT and DIT-DIT-DIT-DIT (the phrase *Elephants In Straw Hats Ten Miles Off* was that taught to the author to remember these four and their three DAH counterparts T, M, O - DAH. DAH-DAH, DAH-DAH-DAH!).With each DIT as logic 0, the binary value of each of the first four letters converts to zero decimal. Not a helpful fact if regarding Morse codes as being true binary symbols.[5][8]
The answer is to also take note of the number of key presses (DITs or DAHs -call them binary bits) in a coded letter. Now each code can be allocated two decimal numbers, its length as well as its binary value. Separate lookup tables can now be used, each dedicated to a particular code length, and then to the binary value. Table 2 illustrates the idea.

Symbol	Code	Binary	Count	Number	
E	.	0	1	0	
T	-	1	1	1	
I	. .	00	2	0	
A	. -	01	2	1	
N	- .	10	2	2	
M	- -	11	2	3	
S	. . .	000	3	0	
U	. . -	001	3	1	
R	. - -	011	3	3	
D	- . .	100	3	4	
K	- . -	101	3	5	
G	- - .	110	3	6	
O	- - -	111	3	7	
H	. . . .	0000	4	0	
V	. . . -	0001	4	1	
F	. . - .	0010	4	2	
#U	. . - -	0011	4	3	U-umlaut (double-dot)
L	. - . .	0100	4	4	
#A	. - . -	0101	4	5	A-umlaut (double-dot)
P	. - - .	0110	4	6	
J	. - - -	0111	4	7	
B	- . . .	1000	4	8	
X	- . . -	1001	4	9	
C	- . - .	1010	4	10	
Y	- . - -	1011	4	11	
Z	- - . .	1100	4	12	
Q	- - . -	1101	4	13	
#O	- - - .	1110	4	14	0-umlaut (double-dot)
#C	- - - -	1111	4	15	character Ch
5	. . . . .	00000	5	0	
4	. . . . -	00001	5	1	
*	. . . - .	00010	5	2	"understood"
#E	. . - . .	00100	5	4	E-acute
2	. . - - -	00111	5	7	

*	.-...	01000	5	8	"wait"
+	.-.-.	01010	5	10	
#A	.---.	01110	5	13	A-acute
1	.----	01111	5	15	
6	-....	10000	5	16	
=	-...-	10001	5	17	
/	-..-.	10010	5	18	
*	-.-.-	10101	5	21	"starting"
(	-.--.	10110	5	22	(bracket)
7	--...	11000	5	24	
#N	--.--	11011	5	27	N-tilde
8	---..	11100	5	28	
9	----.	11110	5	30	
0	-----	11111	5	31	
*	...-.-	000101	6	5	"End of work"
3	...--.	000110	6	6	
?	..--..	001100	6	12	
!	..--.-	001101	6	13	
"	.-..-.	010010	6	18	(double quotes)
.	.-.-.-	010101	6	21	(stop)
'	.----.	011110	6	30	(apostrophe)
-	-....-	100001	6	33	(dash)
)	-.--.-	101101	6	45	(bracket)
,	--..--	110011	6	51	(comma)
;	---...	111000	6	56	(semi-colon)
*	....	00000000	8	0	"error"

Table 2: Binary Format of Morse Code

It will be seen that some letters appear to be repeated but having different Morse codes, A, O and U, for example. This is because some languages (e.g. German) have letters that look similar to our "English" ones but have a double-dot above them *(umlaut)*, e.g. A, 6, U. Some letters also have "acute" and "tilde" signs as well, e.g. E and N.

In this unit the codes for accented letters are recognized, but the translation is to the "standard" letter form.

Some Morse codes can have meanings that are specific phrases. For instance, DTT-DAH-DIT-DIT-DIT (01000) means "wait" and DAH-DIT-DAH-DAH-DIT (10110) means "starting". This unit's software ignores such expansions, although the optional PC interface software recognizes some.

VIRECEPTION RATE

It will be obvious that the software must have a "base-timing" value against which it assesses DIT, DAH and space lengths. Such lengths depend on the sending operator's keying speed, which can varyconsiderably between operators. A novice might send at, say, only five words per minute (WPM). An experienced operator could even be sending at 50 WPM (about 25 WPM is a more typical rate).

The software assesses the sending rate by looking for the shorter pulses (the DITs). Initially, a temporary reference value is set to a high timing number, greater than the expected incoming pulse lengths. For a cycle covering the next 16 keypress pulses, each pulse timing length is compared with this reference. If it is less, the reference is set to the same value as the pulse.

The comparison is repeated for all 16 keypresses. It is then assumed that the reference value is that representing a DIT. The DAH and space values referred to earlier are then set in respect to this value. Again the reference value is set higher than the expected incoming pulse lengths and the cycle repeats.

Simultaneously with the reference value comparisons, each incoming keypress is compared against the current DIT, DAH and space lengths, and each code sequence compiled as an equivalent binary value and in relation to its bit count. During the letter spaces the equivalent character is found from the respective lookup table and displayed on screen. If a word space is found, a space character is also sent to the screen.

DIT length comparison, of course, is not fool-proof and noise or sporadic changes of operator keying rate may cause temporary misinterpretation of incoming codes, probably signified by a sequence of the letter T being seen. Usually, a recovery from such instances is made within 16 keypresses.

It was also found that when feeding the unit with computer-generated codes, slippage could still occasionally occur.

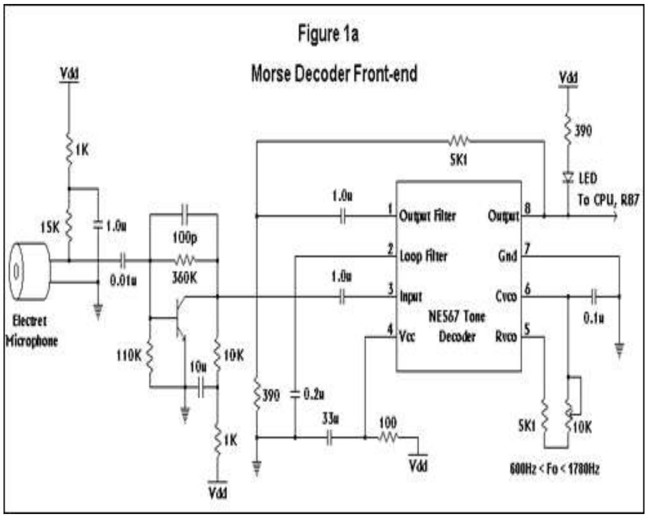
This is due to the PC monitoring other aspects of its system even though it is also running the Morse program. One PC in particular was excessively prone to this.

VIICIRCUIT DIAGRAM

The implementation of this decoder circuit is shown in figures 1a and 1b. It consists of four major parts. All parts are powered from a set of four AA batteries. The first part contains a miniature electret type microphone and a common emitter transistor amplifier. This part provides a wireless connection to radio receiver or code practice oscillator. The electrets microphone is biased with a 15 KΩ resistor. Transistor amplifier provides the maximum gain to the signals. It also acts as afirst order band pass filter.The cut-off frequencies are depend on the value of coupling capacitor and feedback capacitor connected between the base and collector terminal of transistor.[11]

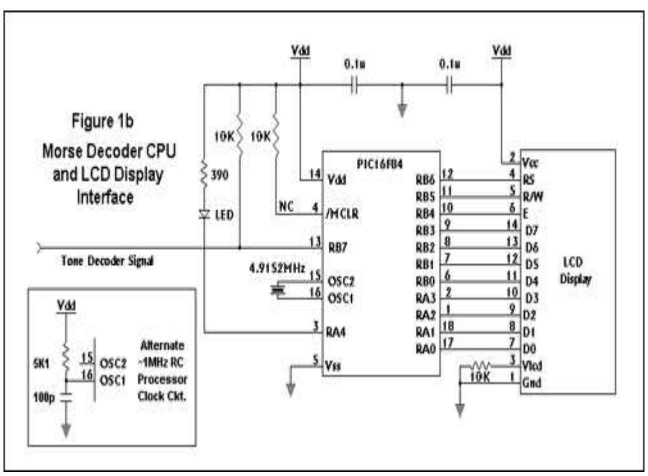
We can also use an op-amp IC instead of transistor to provide the gain to the signal.

ISSN: 2278 – 7798
International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 1, Issue 5, November 2012



The second part of the circuit consists of a NE567 tone decoder. It is a PLL based narrowband tone detector. It is highly stable with synchronous AM lock detection and power output circuitry.Its primary function is to drive a load whenever a sustained frequency within its detection band is present at the self-biased input. It has a narrowband detection capability and it easily discriminate one signal from another.

The output of decoder produces a one-zero patterns (Binary numbers) according to the incoming morse signals. A dot is converted to binary'0' and dash is converted to binary'1'. This output of tone decoder drives PIC 16F84 microcontroller. This output is also given to the LED which serves as an additional monitor for received signal.



The third part consists of PIC 16F84 microcontroller.It measures the duration of binary input string from the tone decoder and translate the pattern into DITs, DAHs, symbol spaces or character spaces. Under varying signal condition, there is a possibility of missing a bit sometimes. The microcontroller has this capability to perform the input signal debounce. By performing a running average on the various components of the signal in real time, the microcontroller performs the operation of code speed adaptation. The symbol averages are then used to compute time threshold levels for correct symbol interpretation. When a character or symbol is received, a code is assembled by microcontroller and used to convert to its ASCII equivalent character for display on LCD screen. The microcontroller also drives an LED in synchronization with input. The last part is the LCD display which is having the interface with microcontroller. In the figure 1a,a crystal oscillator is used to generate the clock for CPU.[11]

Themorse code decoder consists of two separate parts. This will keep the microcontroller and LCD away from the receiver and reduces the digital noise introduced in the receiver. It also keeps the clock noise of microcontroller and LCD away from the sensitive front end of the electret amplifier and PLL.The 10KΩ variable resistor off pin 5 of the NE567 provides frequency adjustment capability so that the frequency of a code practice oscillator can be tuned.You can also tune it to a comfortable pitch to copy signals off the airwaves. The CPU and LCD are interconnected using a 14 pin plug and socket arrangements made for easy connect and disconnect.A three pin header socket is used to make the connection to the front-end consisting of power, ground, and the decoder output.

The code for microcontroller is written in Microchip's native assembly language. It uses only 365 instructions for implementation. It has two running average buffers that keep tabs on the length of the four previous DIT and DAH interval samples. Due to this speed adaptation appears almost instantaneous. The three subroutines drive the LCD display interface written at the end of the code.

VIIIAPPLICATIONS

Representation of SOS-Morse code:

An important application is signaling for help through SOSor ...---... . This can be sent many ways: keying a radio on andoff, flashing a mirror, toggling a flashlight, and similarmethods.[8]

Morse code as an Assistive Technology:

Morse code has been employed as an assistive technology,helping people with a variety of disabilities to communicate. Morse can be sent by persons with severe motion disabilities, as long as they have some minimal motor control. In some cases this means alternately blowing into and sucking on a plastic tube ("puff and sip" interface). People with severe motion disabilities in addition to sensory disabilities (e.g. people who are also deaf or blind) can receive Morse through a skin buzzer.[8]

IX CONCLUSION

The difficulties occur in sending and receiving data manually can be overcome by using this design. In this project, the Morse code data is decoded accurately and directly displayed on LCD screen. This will help to reduce the errors made by human operators. Also it improves the data transmitting speed. The most popular current use of Morse code is by amateur radio operators, although it is no longer a requirement for amateur licensing in many countries. It also continues to be used for specialized purposes, including identification of navigational radio beacon and land mobile transmitters. Morse code is designed to be read by humans without a decoding device, making it useful for sending automated digital data in voice channels. For emergency signaling,Morse code can be sent by way of improvised sources that can be easily "keyed" on and off.

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