19 Morse Code

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In the UK and an increasing number of countries, it is no longer necessary to pass a Morse test in order to gain access to the bands below 30MHz. This might be thought to lead to an overall decline in Morse activity, but there has been a welcome influx of new operators trying their hand at Morse, at their own speed, and without the daunting hurdle of a formal test to overcome.

The Morse broadcast service of the RSGB, using the call GB2CW, has been rejuvenated and there are already a number of volunteers broadcasting on a regular basis, on VHF, UHF and also HF. Some Clubs are even offering their own Morse Proficiency Certificates.

The IARU band plans [1] reserve the bottom portion of most bands for Morse, with the faster ('QRQ') signals generally occupying the lowest 30kHz of each HF band, and slower stations higher up. By agreement within IARU, the 10MHz band is not to be used for SSB or other wide bandwidth modes, and is almost exclusively given over to Morse code.

Radio amateurs tend to use the terms 'Morse' and 'CW' interchangeably. This may seem strange, since CW stands for Continuous Wave, whereas Morse code is anything but continuous. However, almost all amateur Morse is sent by on-off keying of a continuous carrier so CW is widely used as a synonym for Morse.

Operators come to use Morse for a variety of reasons, and compulsion is no longer one of them. **Table 19.1** lists ten arguments in favour of the use of Morse:

HISTORY

Morse code isn't a code, and it wasn't invented by Morse. Strictly speaking, a scheme in which each letter is represented by a symbol (combination of dots and dashes in this case) is referred to as a cypher, not a code, and the basic idea of using dots and dashes was invented by Samuel Morse's assistant, Alfred Vail.

The Early Days

Experiments were being carried out with early telegraph systems since the discovery of the relation between electricity and magnetism, following the experiments of Oersted in 1819 and continued by Ampere in 1820. Ampere suggested using a wire and magnetized needle for each letter and by 1825 Schilling had constructed a single needle system based on the galvanometer invented by Schweigger in 1820, using a paper disk attached to the needle such that either a white or black face showed depending on the direction of the current. Schilling's code showed a considerable advance over earlier schemes.

This was followed by work on the magnetization of soft iron by Arago and Faraday in 1830 and the work of Henry in 1830 on electromagnetism. In 1834 Gauss and Weber constructed a crude electromagnetic telegraph by stringing a wire over the housetops in Gottingen to connect The Astronomical Observatory, Physical Cabinet and the Magnetic Observatory. The slow oscillations of magnetic bars to the left or right, according to the current, were viewed through a telescope. Obviously dreadfully slow, an improved version was introduced by Steinheil in 1837, incorporating many of the features of the later methods of Morse, Vail, Cooke and Wheatstone.

Advantages of using Morse code

1. **Simple equipment.** It is possible to build a simple CW transmitter using fewer than a dozen parts, and a direct conversion receiver can give acceptable performance on CW. The art of 'homebrewing' is alive and well, and building a CW transmitter and/or receiver can get an amateur onto the air on CW very easily and cheaply.

2. **International.** It is easy to get around the language barrier by the use of abbreviations such as *QTH* and *73*, so that two amateurs can have an elementary contact without knowing each other's language, and without accent or phonetic problems that may arise on phone.

3. **Silent operation.** Wearing headphones and using a straight key or bug, it is possible to operate CW silently, at night time without disturbing others sleeping in the house. Similarly, holiday operation on CW from a hotel can be done in 'stealth' mode.

4. **Morse gets through.** Cross-mode contacts aren't very common, perhaps because they're not valid for most awards, but when struggling to copy a weak phone station on a crowded band it's surprising how often a switch to CW will enable the contact to be completed.

5. **Spectrum efficiency.** The minimum bandwidth needed to copy an SSB signal is about 1.8kHz, and to sound natural the requirement is more like 2.5kHz. On the other hand IF filters for CW operation are typically only 500Hz wide, and if necessary CW can be copied through filters of 100Hz or less. Put simply, at least five times as many CW contacts can fit in the bandwidth required for SSB.

6. **Less breakthrough.** Those who operate both modes know that breakthrough problems are worse on SSB than CW. It is always better to try to resolve a TVI or RFI problem but if this is not possible it may be that switching to CW enables operation to continue when it is impossible on phone. And if power has to be reduced, CW comes into its own.

7. **More competitive.** The difference between 'big gun' and 'little pistol' seems to be accentuated on phone. The low power or antenna-limited operator may struggle for contacts on phone, whereas CW is a great leveller.

8. **Morse is a skill.** It's wrong to say that phone operation doesn't require skill, but the basic skill required is that of speech, which just about everyone has. On the other hand, a new skill has to be learned in order to be able to communicate using CW, and the sense of achievement can be considerable.

9. **Automation.** There are computer programs which make it possible to automate the transmission and reception of Morse code. This makes it possible under some conditions to engage in CW contacts without knowing the code, but this would be to miss the whole point: it would be much better to use a more efficient automated mode such as PSK31. In any case, a good human operator can easily outperform most computer techniques when copying a CW signal on a channel with even a moderate amount of interference or fading.

10. **Morse is easy.** The general public thinks that Morse is a language, and at special event stations Morse operation always proves fascinating to visitors. All that is needed to acquire Morse skills is to learn the symbols for 26 letters, ten numbers and a few special characters. This is a very great deal easier than learning a foreign language complete with all its grammar and vocabulary.

Table 19.1: Why operating using Morse is still popular, despite learning the code no longer being compulsory

Out of the sixty or more different early methods proposed for telegraphy, there emerged two most widely known ones; the needle telegraph of Cooke and Wheatstone, introduced in England and the electromagnetic telegraph of Morse and Vail, originating in the USA.

Dots and Dashes

Starting in 1837 and building on the work of Joseph Henry, the artist Samuel Finley Breese Morse worked to develop a practical electric telegraph.

Morse's idea was that common words in a message would be represented by numbers, and these numbers would be transmitted as a series of dots. At the receiving end, the dots would be marked by the equipment on paper tape.

The operator would then have to decode the dots to work out which numbers were being sent, and look up the number combinations in a dictionary to find the word. Less common words would be spelled out, with numbers again representing letters. At about the same time in England, Cooke and Wheatstone were also working on the development of an electric telegraph.

While Morse was working on his system in New York City, his partner Alfred Vail thirty miles away in Morristown, New Jersey made numerous improvements to Morse's equipment.

It was Vail's idea that instead of using a series of dots for numbers, the code could be made up of combinations of dots, dashes and spaces to represent letters directly. In this way a message could be spelled out without the need to look up code numbers in a book. Samuel Morse was an incurable self-publicist and failed to give Vail credit in his lifetime as the true inventor of the code that bears Morse's name. When developing his code, Vail visited a local printer in Morristown to find out which letters occurred most frequently in English text, and he assigned the shortest combinations of dots and dashes to these letters. At the time of the first public demonstrations of Morse code, the code was made up of four elements in addition to the standard space: dot, dash, long dash and long space. The code underwent further changes but remained in use as American Morse code until well into the 20th century.

The electric telegraph and Morse code started to be used in Europe in the mid to late 1840s. A German, Frederick Gerke, addressed the problem of distinguishing between standard and long dashes, and standard and long spaces, by reducing the code to the elements of dot and dash that we are familiar with today.

More changes were made and in 1865 the 'continental' or 'international' Morse code came into being, in very much the form that exists today. Small changes have been made to the code since then, the most recent being the adoption in 2004 of a new Morse code symbol for the '@' used in Internet addresses.

Both Vail and Morse intended that Morse characters should be printed onto paper tape and read as dots and dashes from there, but it soon became apparent that operators were learning to decode from the clicks of the machinery marking the tape. This led to the development of the sounder and now whenever Morse is written down it is always written down directly as letters, never as individual dots and dashes.

A modern exception to this is QRSS, or extremely slow Morse decoded using a FFT program (as used, for instance, on 136kHz and for very low power experiments) which is displayed as dots and dashes on a computer screen and decoded by eye.

THE CODE

Although Morse is composed of dots and dashes it is better to think of the elements as 'dits' and 'dahs'. These are in the correct proportions so that saying 'di-dah-di-dit' out loud is the correct

Alphabet

A	di-dah
B	dah-di-di-dit
C	dah-di-dah-dit
D	dah-di-dit
E	dit
F	di-di-dah-dit
G	dah-dah-dit
H	di-di-di-dit
I	di-dit
J	di-dah-dah-dah
K	dah-di-dah
L	di-dah-di-dit
M	dah-dah
N	dah-dit
O	dah-dah-dah
P	di-dah-dah-dit
Q	dah-dah-di-dah
R	di-dah-dit
S	di-di-dit
T	dah
U	di-di-dah
V	di-di-di-dah
W	di-dah-dah
X	dah-di-di-dah
Y	dah-di-dah-dah
Z	dah-dah-di-dit

Accented letters

à, á, â	di-dah-dah-di-dah
ä	di-dah-di-dah
ç	dah-di-dah-di-dit
ch	dah-dah-dah-dah
è, é	di-di-dah-di-dit
ê	dah-di-di-dah-dit
ñ	dah-dah-di-dah-dah
ö, ó, ô	dah-dah-dah-dit
ü, û	di-di-dah-dah

Abbreviated numerals

1	di-dah	6	dah-di-di-di-dit
2	di-di-dah	7	dah-di-di-dit
3	di-di-di-dah	8	dah-di-dit
4	di-di-di-di-dah	9	dah-dit
5	di-di-di-di-dit	0	daaah (long dash)

Full length numerals

1	di-dah-dah-dah-dah
2	di-di-dah-dah-dah
3	di-di-di-dah-dah
4	di-di-di-di-dah
5	di-di-di-di-di
6	dah-di-di-di-dit
7	dah-dah-di-di-dit
8	dah-dah-dah-di-dit
9	dah-dah-dah-dah-dit
0	dah-dah-dah-dah-dah

Punctuation and other codes

Full stop (.)	di-dah-di-dah-di-dah
Comma (,)	dah-dah-di-di-dah-dah
Colon (:)	dah-dah-dah-di-di-dit
Question mark (?)	di-di-dah-dah-di-dit
Apostrophe (')	di-dah-dah-dah-dah-dit
Hyphen or dash (-)	dah-di-di-di-di-dah
Fraction or slash (/)	dah-di-di-dah-dit
Brackets - open [(]	dah-di-dah-dah-dit
- close [)]	dah-di-dah-dah-di-dah
Double hyphen (=)	dah-di-di-di-dah
Quotation marks (")	di-dah-di-di-dah-dit
Error	di-di-di-di-di-di-di-dit
Message starts (CT)	dah-di-dah-di-dah
Message ends (AR)	di-dah-di-dah-dit
End of work (VA)	di-di-di-dah-di-dah
Wait (AS)	di-dah-di-di-dit
Understood (SN)	di-di-di-dah-dit
The @ in e-mails	di-dah-dah-di-dah-dit

Spacing and length of signals

1. A dash is equal to three dots.
2. The space between the signals which form 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.

Table 19.2: The Morse code and its sound equivalents

representation of the letter 'L'. Spacing and rhythm are essential to good Morse code. The inter-element space is the same duration as a dit length, while the length of a dah is three times the dit length. The space between letters of a word is three dit lengths and the space between words is seven dits.

As well as the letters and numbers, **Table 19.2** lists commonly used punctuation and procedural symbols ('prosigns') in common use on the amateur bands.

SPEED

For many years it was necessary in order to gain an amateur licence, to pass a Morse test at 12 words per. minute (WPM). This was, in the earlier days of amateur radio, followed by an enforced year on the air using Morse only, and proof had to be given of a number of contacts using Morse in order to be allowed to use ‘Phone’, as speech modes were called in those days. This is one reason why so many of the older licensees are excellent CW operators. In practice 12WPM is the minimum speed that is generally heard on the amateur bands. A word is defined as 50 dit lengths, and this is referred to as the Paris standard since the word 'PARIS', including the seven dit lengths at the end of the word, is exactly the right length. By coincidence the word 'MORSE' is also exactly the right length.

A simple method of measuring speed is repeatedly to send PARIS, including the correct inter-word gap, and count how many are sent in a minute. At a speed of 12WPM the word can be sent just once in five seconds. Another method of measurement which is simple to do but overstates the speed by 4 percent is to count the number of dashes in a five second period.

LEARNING MORSE CODE

Prior to trying to copy any Morse, it really is essential to commit the code to memory. The essential characters are obviously the alphabet and numbers, together with a few punctuation marks. One of the easiest ways of achieving this is to have a number of small pieces of paper, with the character on one side and the Morse equivalent in dit-dah mode, on the other. Picking these at random and then converting will make the learning curve that much easier, plus it can be done anywhere and at any time.

A later chapter in this book shows the extent to which the personal computer has become an integral part of the radio amateur's shack. There is a method of learning Morse code which goes back to the 1930s but has come into its own in the age of the computer. That is the Koch method.

Ludwig Koch was a German psychologist who carried out a systematic study of skilled Morse operators, and then conducted a series of trials to find the most efficient way of teaching Morse to new students. Existing methods at that time were based on learning the letters either visually, or audibly at a slow speed and then increasing speed by constant practice. This approach to learning Morse is fundamentally flawed. Learning all the letters at slow speed requires a conscious mental translation from the combination of dits and dahs to the corresponding letter. After all letters have been memorised, the student hears a combination of dits and dahs and searches in a mental lookup-table for the right one.

With a great deal of practice, speed increases but everyone who learns by this method experiences a 'plateau' at 8-10WPM where no more progress seems possible. Many aspiring CW operators give up in frustration at this point.

What is happening is that the process of responding to individual dits and dahs and looking them up in a mental table is hitting a natural upper speed limit. The student who can move beyond that limit has made the unconscious transition from the old 'lookup' method to a stage where the whole Morse character is recognised by reflex. Koch's insight was to see that it was essential that each character retain its acoustic wholeness and never be broken down by the student into dits and dahs. The essence of the Koch method is that the letters are learned one at a time, but with the correct rhythm and at full speed.

There is no process of decoding the dits and dahs, but from the beginning a reflex is built, so that when 'dah-di-di-dah' is heard, it is automatically recognised as X without any conscious decoding process. It's the same way that a touch typist knows where the letters are on a keyboard without having to think about it.

Another key feature of the Koch method is that it provides positive reinforcement. Once a letter has been learned, it has been learned at full speed and it is possible to measure one's progress towards mastery of the full alphabet.

Koch's technique was difficult to implement for classes of students in the 1930s but has come into its own in the day of the personal computer, when each student can learn at his or her own pace. A program written by Ray Goff, G4FON, implements the Koch method and can be downloaded from [2]. Much of the credit for rediscovery and promotion of the Koch method must go to N1IRZ, and the G4FON program follows his suggested implementation.

The student starts by learning just two letters, at a speed of 15WPM. The program sends random combinations of these letters for a fixed period, typically three to five minutes, and the student must copy them onto paper. At the end of the run the copy is compared with what the computer sent, as displayed on the screen. If 90 percent or greater correct copy is received, a third character is added to the set and another run started. It is up to the student how many runs to do in a day. When Ludwig Koch carried out his investigations in the thirties he was seeking to train commercial operators but found that too many sessions in a day gave diminishing returns and the amateur student is more likely to have to fit in training sessions around other activities.

As the training programme progresses and more and more Morse characters are added, the student gains a real sense of achievement, and proof that it is possible to master the copying of Morse characters at full speed. G4FON's program introduces new characters in the order suggested by N1IRZ which mixes easy and difficult letters, numbers and punctuation in an apparently random order.

Once all 43 characters have been learned the program lets the student practice with text files (**Fig 19.1**), or with simulated contacts. At this stage, most people would also have started to listen to real contacts on the amateur bands, though the quality of 'real' Morse code can be rather variable.

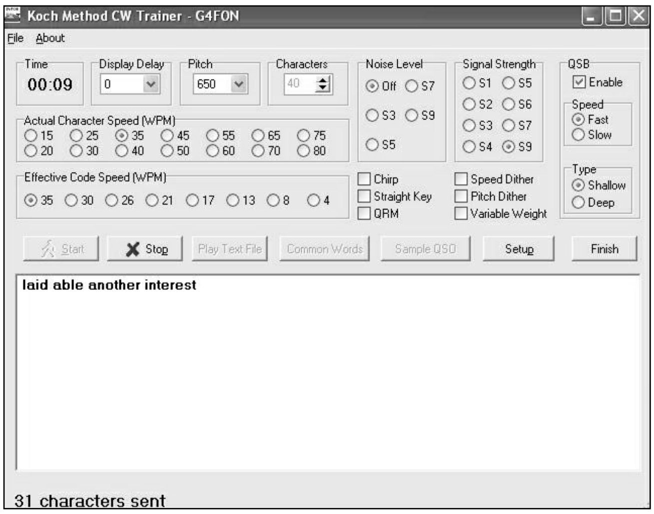


Fig 19.1: Part of the screen of the G4FON Koch Morse trainer program

VOLUNTEERS ARE ALWAYS NEEDED by the GB2CW service, so if you think you could help with this very worthwhile scheme, please give it some thought. It just takes one hour per week of your time and you will be promulgating the use of CW to a new generation of operators who probably don't even realise what they are missing.

Transmissions take place on both the 80 metre and 2 metre bands, so you can choose which band you wish to use. The uptake on HF seems to be slow and it looks like two metres might be a better option. If you have a lot of newly licensed members of your club, 2m FM would probably be a good choice, as it would be localised to your particular area. If you would like to take part, all you would need is a 2m transceiver and a computer. Contact the G2CW Coordinator via the RSGB [3, 4].

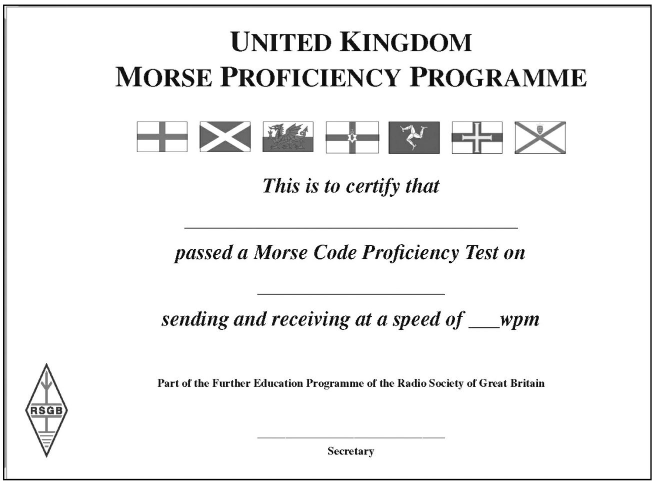
Another way of learning is the Farnsworth Method. With this method, you learn each character at 15 words per minute with large spacing in between characters. This has been proven to be the best method for long-range development. Once the characters are learned, copying speed is easily increased by decreasing the spacing between each character.

No matter if you learn quickly, or slowly, the key to learning is practice. With enough practice, just about anyone can learn Morse code. Sometimes, skipping a day or two of practice is helpful, and can get you back on track.

The ubiquitous computer can have its dangers, as well. The Koch method is the quickest means of learning the code but some students in their impatience have resorted to use of Morse decoding software as an aid to getting on the air on CW more quickly. This approach leads to reliance on the computer and the temptation must be resisted. However, there are small and portable Morse practice devices that can be carried in the pocket. They can be used anytime, anywhere.

GB2CW

This service is still going strong, despite one or two people dropping out for a variety of reasons. There is a busy schedule actively covering a lot of the UK already. This service is run by volunteer CW operators transmitting on a regular schedule, using VHF, UHF and even HF, usually 80 meters but topband is sometimes used too. They are usually interactive, and will accommodate all speeds, according to the needs of the listener. The broadcast schedule is published by the RSGB [3, 4]. If your local club does not run such a service, then suggest that it is about time it did!


UNITED KINGDOM
MORSE PROFICIENCY PROGRAMME

This is to certify that

____

passed a Morse Code Proficiency Test on

____

sending and receiving at a speed of ___wpm

Part of the Further Education Programme of the Radio Society of Great Britain

RSGB

____
Secretary

Fig 19.2: The RSGB's Morse certificate

Many newcomers to amateur radio do not realise the potential of CW, and look upon it as a mode that requires a lot of study and practice. In fact, Morse can give a lot of pleasure: a pride in the skill that it takes and the ease with which DX can be worked. If every radio club in the UK automatically had a GB2CW teaching program, there would soon be a new generation of good CW operators. All clubs are urged to instigate such a scheme and maintain it, encouraging all new licensees to take part. See the sidebar for how to volunteer as a GB2CW tutor.

Volunteer Morse Test Assessors are also needed. Full details of how to become an Assessor can be found in the Morse section of the RSGB website [5].

The RSGB also offer a Morse Certificate which is in the form of an award which you can gain by taking a Morse examination **Fig 19.2.** This starts at 5WPM and goes as high as you want to go. The intention of the Certificate of Competency is to provide a form of recognition for those who wish to have something to record their achievement in learning Morse code. It is not intended that it should be a national standard of proficiency similar to the licence examinations. However, it is still a target to aim for and achieve. More information is available from [5].

Morse Readers

It can be tempting to be lazy and read Morse without all that practice. This is possible, and there are Morse readers available. However, it should be emphasised that absolutely nothing can substitute for the human brain. There is no Morse reader on this planet that can do the same job as the brain, and that would be upheld by any good CW operator that you might speak to about this. However, in the interest of unbiased writing, take a look at the advertising 'blurb' for a Morse reader [6].

Relax and place this tiny pocket size portable Morse Code / CW Reader near your receiver's speaker. Then watch Morse code signals turn into text messages as they scroll across an easy-to-read LCD display. No cables to hook-up, no computer, no interface, no other equipment needed! Use it as a backup in case you miscopy a few characters.

This can help with your practice if you can find a suitable CW station on a reasonably clear frequency. However, the problem with these devises is that it can also detract from making the operator read the CW, always relying on the reader. It is also a fact that trying to get a machine to copy a weak, fading signal surrounded by interference is just about impossible, whereas the brain can pick out the 'needle in the haystack'. This skill is irreplaceable and it is what makes CW so attractive to the DX operator.

Learning to Send

Although the PC makes it possible for a student to learn Morse code without assistance, when it comes to sending by far the best approach is to get an experienced operator to listen to you and correct any bad habits at the earliest opportunity. This cannot be emphasised enough. Bad sending will lead to zero contacts because nobody will wish to converse with somebody sending badly, whereas properly sent Morse, from a very nicely keyed transmitter is a pleasure to listen to. The student who has learned using the Koch method may have fewer bad habits than most.

If no-one is available to listen in person then one method that can work is to make tape recordings and play them back to try and discover weaknesses. Only when the student's sending sounds perfect should it be tried on the air.

Morse Practice Oscillator

In order to practice sending off the air, a pleasantly keyed oscillator is needed. You can make one fairly easily on a piece of Vero

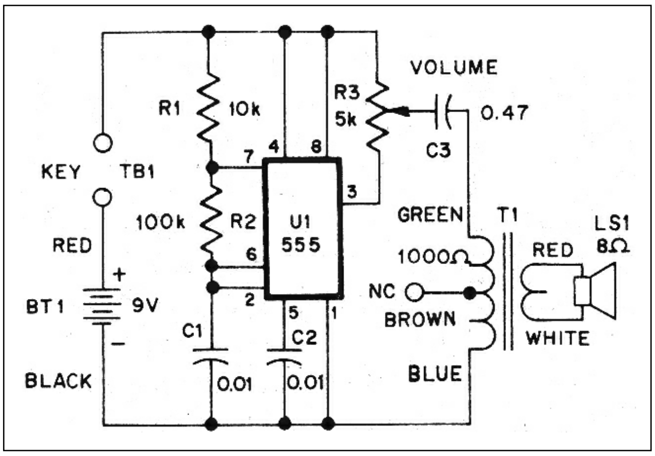


Fig 19.3: Simple Morse practice oscillator

board, using a 555 timer chip. A suitable circuit containing easily sourced components is shown in.**Fig 19.3**. It could form the basis of a club project and should not take too long to construct.

MORSE KEYS

It is important to start by getting a good quality straight key ('pump handle') such as the one in **Fig 19.4**, and position it correctly on the table. Adjust the height of the seat so that when not sending, the arm is resting horizontally, and it requires only a small lift of the forearm to hold the knob of the Morse key. This should be held with the forefinger on top of the knob, the thumb to the left and slightly underneath the knob, and the second finger either on top or to the right of the knob (assuming a right-handed operator). Dots are made by a small wrist movement whereas dashes require a more pronounced downward movement of the wrist. Think of the keying contacts being closed by the wrist joint. The hand is just the lever which happens to pull the key contacts together. Do not tap the key or push down on the key with the hand. The technique is best shown and then practised at length.

The forearm and the upper arm should make an angle of approximately 90º. When sending, movement of the key should come from a combination of the elbow and the wrist. Often the key is mounted at the edge of the table but if it is further back, the forearm should be slightly above the table, not resting on it.

It is possible to make your own key. Dick Biddulph, M0CGN designed a simple one that should be possible for those that enjoy construction [7].

Bugs and Elbugs

With practice it is possible to send at speeds over 20WPM on a straight key, but the operator who aspires to high-speed (QRQ) working will sooner or later wish to learn how to use a bug.

The semi-automatic key (**Fig 19.5**), generally known as the bug after the trade mark of the original maker, is a mechanical

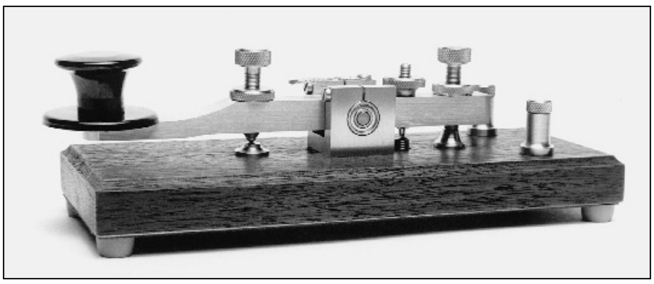


Fig 19.4: A modern straight key (photo: RA Kent (Engineers))

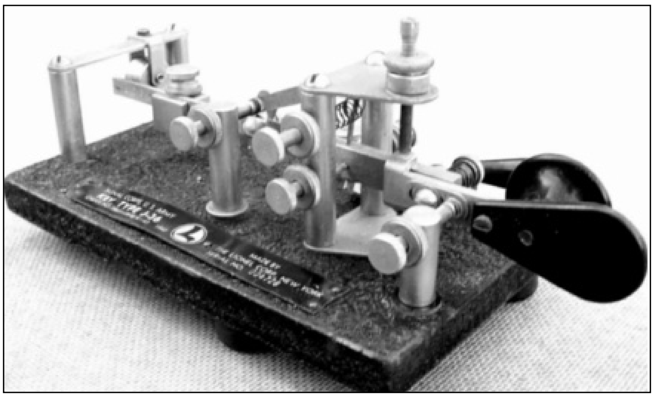


Fig 19.5: A mechanical bug key

key in which the arm moves from side to side instead of up and down. It has two pairs of contacts; dashes are made singly by moving the knob to the left, thereby closing the front contacts. A train of dots is produced by similarly moving the paddle to the right against a stop. This causes the rear portion of the horizontal arm to vibrate and close the rear pair of contacts. A properly adjusted bug key will produce at least 25 dots.

There are not many in use today, although they are the last resort of being able to identify the sender by just listening to his keying, or his 'fist'. It was often common practice to add emphasis to a CQ for example by sending extra long dashes. With an electronic keyer, this type of personality on the key is not possible. Semi-automatic paddles, such as the old Eddystone Bug, are now collectors items and have increased in value over the last few years.

Bugs were in widespread use until the advent of the electronic keyer, or 'elbug'. The first elbugs were cumbersome affairs using combinations of relays and valves. Transistor types followed, giving way to IC-based keyers and now PIC and other microprocessor keyers. Most modern transceivers incorporate an electronic keyer, and station logging and computer logging programs provide a CW keyer as standard. Many programs support both paddle input and keyboard input so the operator can choose whether to use the program either as a keyer taking input from a paddle, or as a keyboard sender.

Paddles

The key or 'paddle' (**Fig 19.6**) used with an electronic keyer is a derivative of the mechanical bug key, with movement from side to side instead of up and down. For the right-handed operator, moving the paddle to the right with the thumb produces a train

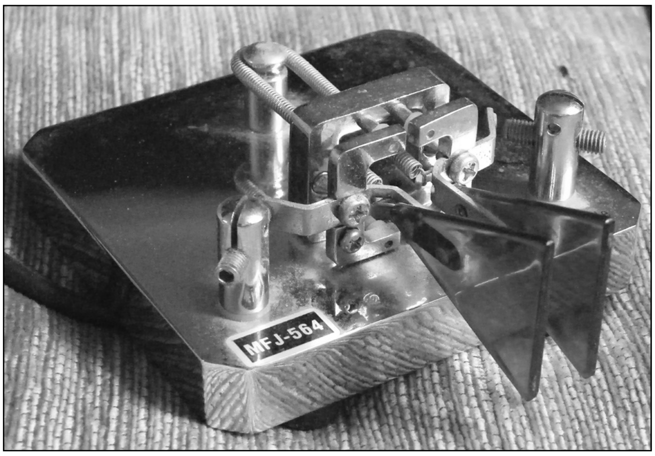


Fig 19.6: A paddle for use with an electronic keyer

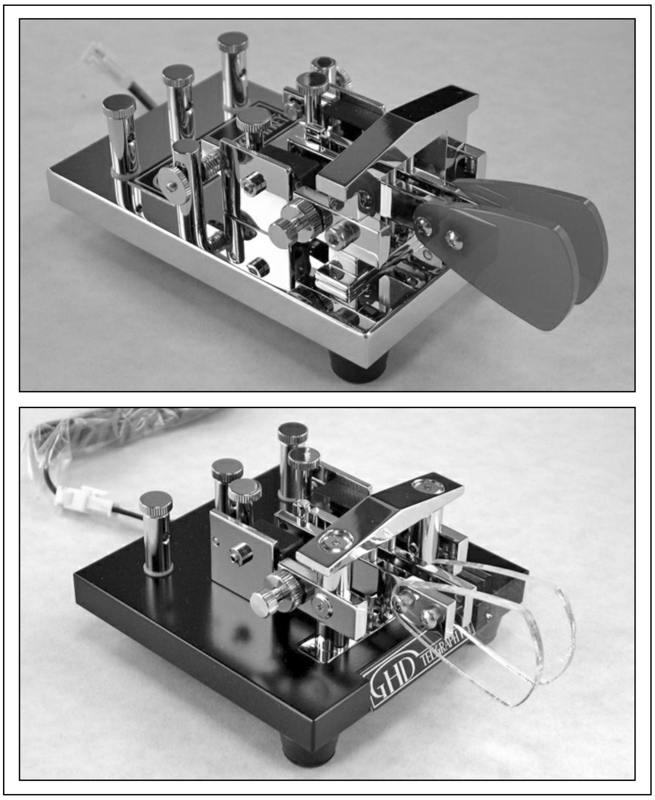
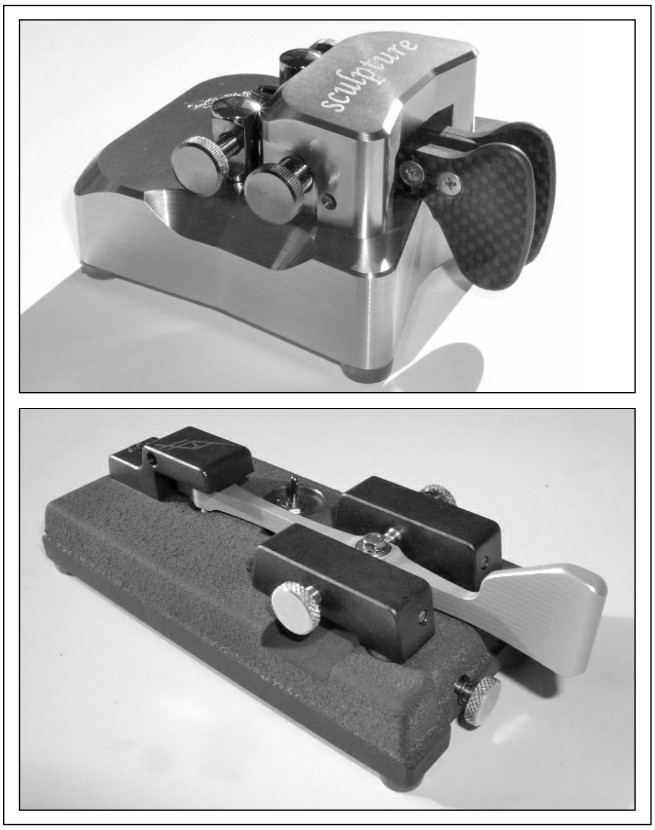


Fig 19.7: Two GHD keys by Toshihiko Ujiie



19.8: Two of the keys manufactured by Begali

of dots. Moving the paddle to the left with the side of the index finger produces a train of dashes.

An iambic or 'squeeze' keyer requires a twin paddle key, and as well as movement of each paddle separately; they can be

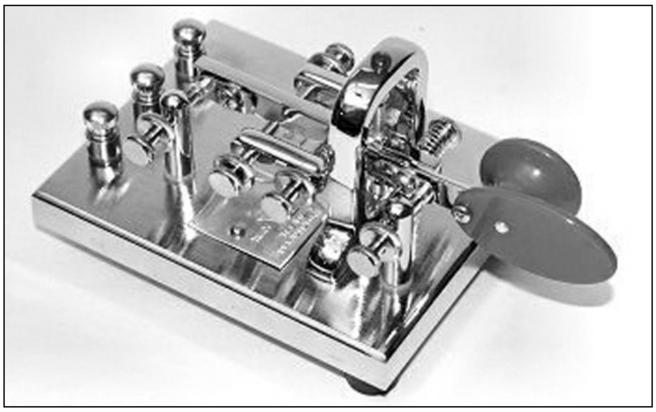


Fig 19.9: A presentation key made by Vibroplex

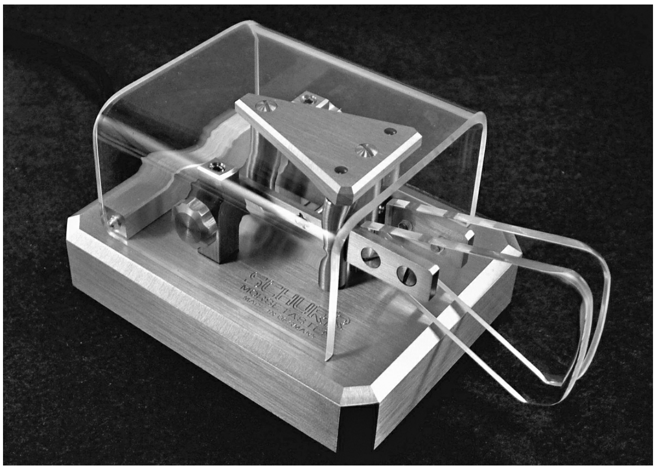


Fig 19.10: A paddle by Gerhard Schurr

Fig 19.11: A UK-made paddle from Kevin Gunstone, M0AGA

squeezed together, hence the name. According to which contact is closed first, a train of either di-dah-di-dah or dah-di-dah-dit is produced.

It is possible to make a paddle if you have good engineering skills, indeed some amateurs have produced some very nice home made paddles. Access to an engineering workshop is necessary in order to produce a well-engineered and attractive paddle.

As with the straight key, the newly acquired bug or electronic key should not be tried on the air until the operator has gained confidence through practice. Some electronic keys provide auto-spacing in an attempt to enforce the three or seven dit gaps between characters and words, but it is still just as easy to send

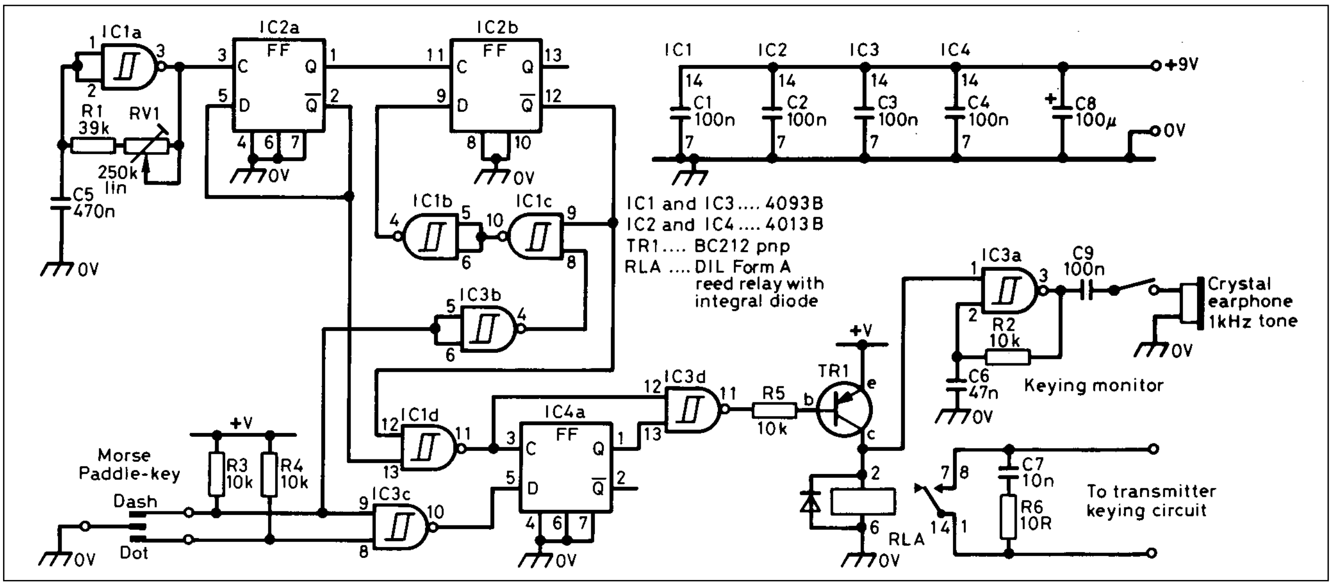


Fig 19.12: The G3BIK simple keyer uses four ICs for precision Morse

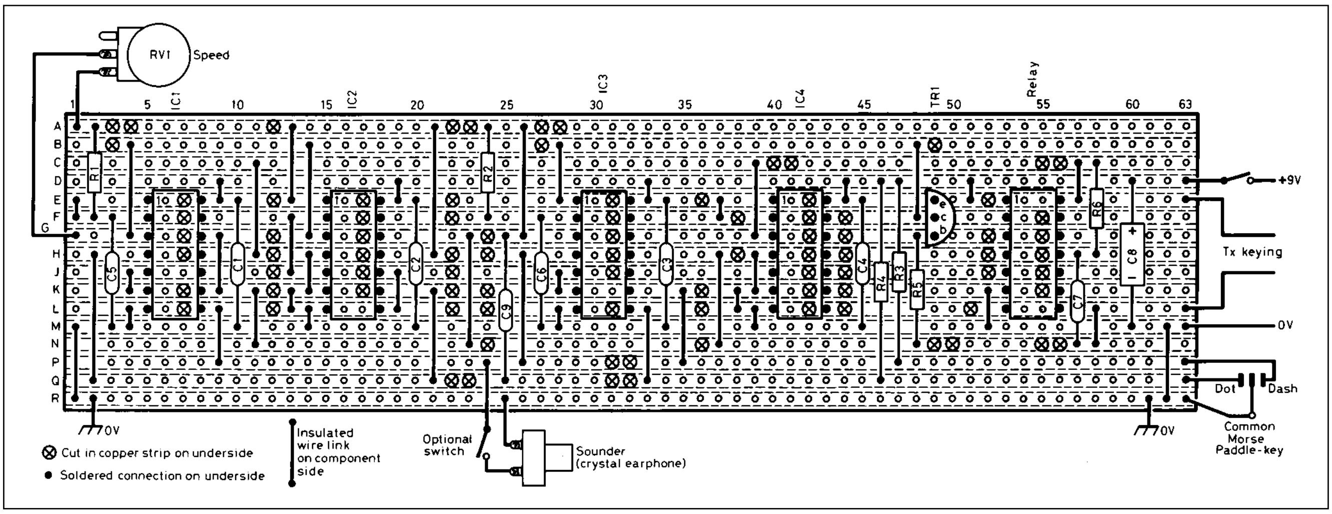


Fig 19.13: Construction of the G3BIK keyer is easy using strip board. The component side is shown

bad Morse on an elbug as on a straight key. Again, lots of practice is the answer and is very advisable.

Commercial paddles are the only route for most people and the quality of a paddle is, of course, proportional to its price. However, if you are keen on CW and intend to use the mode a lot, it is much like a pianist owning a piano. If he has an old, out-of-tune upright with some notes missing, there is no incentive to play. The better quality paddle leads to a much better quality Morse, as it will always be a pleasure to use it. Here are some examples.

GHD keys, made by Toshihiko Ujiie (JA7GHD) [8] in Sendai City, are beautiful, practical and innovative. There is a large range of straight keys, bugs and paddles (**Fig 19.7**) An interesting innovation on one paddle is the ability to convert it from a dual lever to a single lever model.

Begali is an Italian manufacturer who also has several paddles available. **Fig 19.8** shows a popular one, the Sculpture, and a recent addition, the High Speed single lever model. These are available from [9].

Vibroplex is an old established American manufacturer and they, too, have lots of models available, including a single lever one [10]. I have owned one of these for 51 years now! The presentation model is shown in **Fig 19.9**.

Schurr keys are not so well known in the UK, but again are a quality product. Made by Gerhard Schurr, DH2SAA, [11], his motto is "If you stop trying to be better, soon you will stop being good." This is a good motto to adopt when learning and practising Morse! His Profi paddle can be seen in **Fig 19.10**

Last but not least is a paddle made in the UK. It is hand made by Kevin Gunstone, M0AGA, and his engineer Alan, G4HCD, of Chevron Morse Keys [12]. Shown in **Fig 19.11** it is a UK 'Rolls Royce' of paddles. It is not cheap, but the quality is superb. At the time of writing they do not make a single lever paddle!

Simple Electronic Keyers

BIK simple electronic key

This keyer designed by Ed Chicken, G3BIK, is of basic design in that it uses only four integrated circuits and does not include the iambic facility. According to which side the paddle is moved, a train of dots or dashes is produced. The speed is adjustable in the range 5-35WPM. A small sounder is included as a side tone (keying monitor). The circuit diagram is shown in **Fig 19.12**, and the stripboard layout is in **Fig 19.13** . Details of the paddle key are contained in the full article [13].

Fig 19.14: Winkey single chip Morse keyer

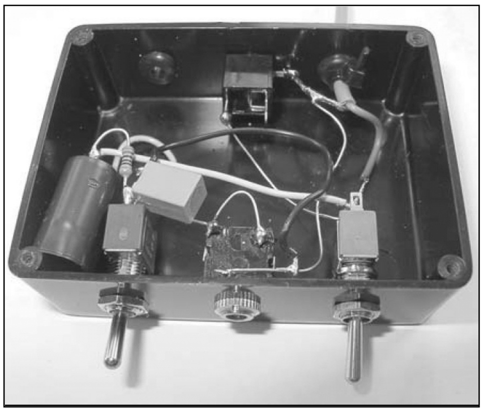


Fig 19.16: The deluxe version of G4BJM's two-component filter includes switches to connect a loudspeaker, and to bring the filter in and out of circuit

K1EL Winkey

WinKey [14] is a single chip Morse keyer using a PIC IC. Powered from the PC, the keyer is designed to attach to a PC's external port and provide accurate transmitter keying for numerous Windows™-based logging programs and other ham radio software.

Due to timing latency inherent in the multi-threaded Windows operating system, it is difficult to generate accurately timed Morse. The host PC communicates to WinKey over a simple interface. Letters to send, along with operational commands, are sent from the host to the keyer over the serial link.

WinKey buffers ASCII characters sent by a Windows™-based software application. It then translates them to Morse, directly keying a transmitter or transceiver. In addition, WinKey has paddle inputs so that an operator can break-in and send using paddles at any time. A speed potentiometer interface is provided so that an operator can instantly dial any speed desired. The user can tailor WinKey's keying characteristics precisely to a particular transmitter.

A PCB board with a component kit is available from [14]. Don't be fooled by the appearance (**Fig 19.14**), good things come in small packages!

CW TRANSMISSION AND RECEPTION

A crystal-controlled QRP transmitter for CW can be made with fewer than a dozen components, and give many contacts under favourable conditions. There are many designs for simple CW-only homebrew transmitters or transceivers and several kits are available that offer CW-only transmission.

Almost all commercial transceivers are designed with SSB in mind, and sometimes give the impression that CW has been added as an afterthought. Even top of the range Yaesu transceiver, the FT1000MP, is known for its key clicks and several modifications have been developed - by individuals and not the manufacturer - to address this shortcoming in the design of an otherwise excellent piece of equipment.

In many transceivers a dedicated IF filter for CW is an optional extra. Some rigs incorporate passband tuning which can be used to narrow the receive bandwidth without the expense of buying additional internal filters. There are occasions under crowded band conditions when it is extremely difficult to separate the many CW signals that can pass together through an SSB filter, which may have a bandwidth of up to 2.5kHz. IF filters most commonly available to fit in a transceiver for CW reception have a bandwidth of 500Hz though 250Hz filters can sometimes be obtained.

In cases where IF filtering is not available, CW filtering can be done at audio frequencies, and combinations of IF and AF filtering can be extremely effective. The problem with audio filtering on its own is that any filtering done after the AGC detector will result in 'pumping' whereby strong signals which are not heard by the operator because of the audio filter nevertheless are let through by the IF filter and cause desensitisation of the receiver. More recent designs using IF DSP (digital signal processing) can help to address this problem by implementing the filter before detection, though the dynamic range of the DSP system may then become an issue.

Different operators have different styles, and some of the best contest and DXpedition operators like to use relatively wide filters and do most of the separation of CW signals in their head: it is sometimes said that the best CW filter is between the ears. This practice is necessary in contests because often the calling station will be way off frequency. Nevertheless there are times when a narrow IF filter is essential for pileup and weak signal CW work.

A very simple add-on audio filter which provides some selectivity as well as helping to clean up the hiss, clicks, hum and thumps which spoil the audio of some rigs, has been described by Fraser Robertson, G4BJM [15]. In its simplest form it consists of a simple series-resonant circuit and with the inductor and capacitor values shown in **Fig 19.15** it resonates at around 730Hz. The components can simply be wired inline as a headphone extension lead, and covered with self amalgamating tape or heat-shrink tubing to provide some mechanical stability. Alternatively, it can housed in a small box as in **Fig 19.16**.

One of the more sophisticated filters around is the DSP-599zx by Timewave. **Fig 19.17** This is a very versatile digital signal processor and for CW use it is extremely useful for enhancing a weak signal, especially under adverse conditions, such as high noise. Using this on top band where my noise level is usually around S-8 to S-9, coupled with the filters on the transceiver can mean the difference between a contact or no contact. It takes some time to set it up properly and also to become accustomed to using it, but once done a filter of this type is indispensable.

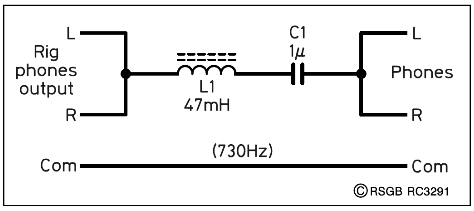


Fig 19.15: Circuit diagram of the two-component CW filter

Fig 19.17: The Timewave DSP-599zx is an add-on DSP filter which can improve CW reception

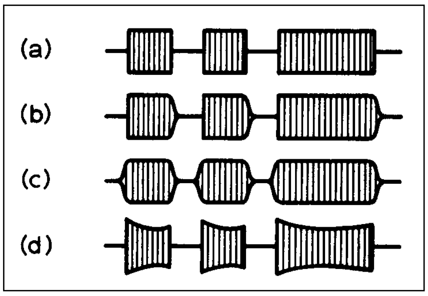


Fig 19.18: Keying envelope characteristics. (a) Click at make and break; (b) click at make, click at break suppressed; (c) ideal envelope with no key clicks; (d) affect on keying envelope of poor PSU regulation

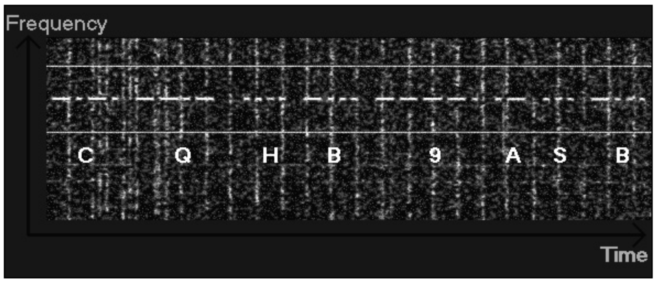


Fig 19.19: A QRSS signal on a curtain display. The translated letters have been added to the picture; they are not present on the original display. The vertical lines are static crashes [pic: ON7YD]

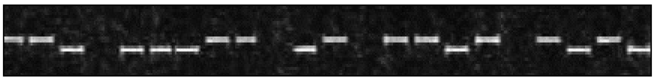


Fig 19.20: DFCW uses different frequencies instead of dots and dashes. This says "G3AQC" [pic: ON7YD]

Most transceivers incorporate semi break-in or 'VOX' keying on CW. This means that the user does not have to operate a separate transmit/receive switch, but transmission starts automatically almost at the instant that the key is pressed. The equipment returns to receive a short period after the key is opened, and this period can usually be varied. The intention is to ensure the rig stays in transmit between Morse characters, but returns again to receive without the operator having to throw a switch.

Full break-in ('QSK') is also frequently implemented, with a varying degree of success. Full break-in means that the operator can listen between the individual dits and dahs of a Morse character, right up to 40WPM and beyond. With careful transceiver design this goal can be achieved, but design compromises and shortfalls generally mean that a number of manufacturers' implementations are far from perfect. Ten-Tec and Elecraft have, however, really understood the design principles involved. Although it is achievable, QSK is not commonly used and can be very distracting so is a personal choice.

When examining the keying waveform of many amateur transceivers, the correct 1:1:3 ratio between spaces, dits and dahs is not always maintained or if it is, this is at the expense of reduced receive time when using full break-in. A common feature of poorly designed rigs when using semi break-in is a short first dit, because of time taken in the transceiver to switch between transmit and receive. If this is used to drive an amplifier which itself has a slow T/R relay, the overall effect in extreme cases can be to lose the first dit of a transmission altogether.

If an oscilloscope is available it can be used to display the outline of the pattern made by the signal, this is called the keying envelope. The keyed RF signal is fed to the Y-plates or vertical amplifier of a slow-scan oscilloscope, with the timebase set in synchronism with the keying speed. The square shape in **Fig 19.18(a)** is a very 'hard' signal and will radiate key clicks over a wide range of frequencies. The hard leading edge in **Fig 19.18(b)** will also cause clicks.

The transceiver design should ensure that the rise and fall times are lengthened such that interference is no longer objectionable, but without impairing intelligibility at high speed. The goal should be to achieve rise and fall times of about 10% of the dit length (**Fig 19.18(c)**).

The characteristics of the power supply may contribute to the envelope shape, as the voltage from a power unit with poor regulation will drop quickly each time the key is closed, and rise when it is released. This can lead to the shape in **Fig 19.18(d)**.

QRSS AND DFCW

Not all Morse used on the amateur bands is intended for reception by ear. When a signal is transmitted over fairly stable paths, such as on 136kHz, it can be received well below the threshold of audibility by using a computer's sound card and software [16] that displays the signal as dots and dashes on the screen.

QRSS is extremely slow speed CW, with dot lengths typically from three to 120 seconds. The name is derived from the Q-code QRS (reduce your speed). To take advantage of the very narrow bandwidth of the transmitted signal an appropriate filter at the receiver end is needed. Making a 'software filter' using Fast Fourier Transform (FFT) [17]] has some advantages over the old fashioned hardware filter. One of the main advantages, when using it for reception of slow CW signals, is that FFT does not provide a single filter but a series of filters with which it is possible to monitor a complete spectrum at once. This means that it is not necessary to tune exactly into the signal, which can be very delicate at sub-Hertz bandwidths. Also it is possible to monitor more than one QRSS signal at the same time.

At first glance it looks as if it is complicated to do this, even if FFT presents you this nice multi-channel filter it might be difficult to monitor all these channels. Further the long duration of the dots and dashes is unfavourable for aural monitoring.

A solution to the above problems is to show the outcome of the FFT on screen rather than making it audible. The result is a graphic where one axis represents time, the other axis represents frequency and the colour represents the signal strength. If the vertical axis represents time it is called a waterfall display, while a curtain display is where the horizontal axis represents time (**Fig 19.19**).

A variant of QRSS is Dual Frequency CW (DFCW) where the dots are transmitted on one frequency, and the dashes on a slightly higher frequency (**Fig 19.20**). This saves time as the dashes can be the same length as the dots. In fact, a time reduction of better than 50% can be achieved, which can be very important at these extremely slow speeds, especially when trying to have a contact in the relatively short duration ionospheric propagation window.

QRQ OR HIGH SPEED CW

Some amateurs spend a lot of time using QRQ, or high speed CW. The main use for this mode is communications using the ionised trails of meteorites. These hit the Earth's atmosphere and radio waves can be reflected off the ionised tail. This phenomenon only lasts a finite period of time, but high speed Morse can be used to communicate with others involved in the same activity.

High speed CW can also be used for conventional communications. The human brain has limits, however, and for general conversation on the air, speeds of more than 40WPM become very difficult. 'Rag-chewing' at around 30WPM is commonplace however.

Then there are those whose interest is to test their ability to the limit. There are annual speed contests in which proponents

High Speed Morse World Records

Guinness World Records Ltd has recognized the high-speed telegraphy achievement of Andrei Bindasov, EU7KI.

"On 6 May 2003 Andrei Bindasov (Belarus) transmitted 216 marks of mixed text per minute during the 5th International Amateur Radio Union World Championship in High Speed Telegraphy in Belarus," the Guinness database listing states.

Witnessing the accomplishment in Minsk were HST International Referee Oscar Verbanck, ON5ME, Region 1 Executive Committee member Panayot Danev, LZ1US, and IARU Region 1 HST Coordinator Oliver Tabakovski, Z32TO.

Bindasov also sent 271 letters per minute and 230 figures per minute during the phases of the 2003 HST competition [18]

can show off their expertise. The world record is in *The Guinness Book of Records*. There are several levels of achievement, measured according to the number of errors made (see sidebar).

USING COMPUTERS . . .

The ubiquitous computer is now an essential part of an amateur radio station. It not only helps with functions such as all the modern digital modes, logging, DXCC record-keeping, satellite tracking, and so on, it is also used for contesting, whatever mode is used.

Some stations have several computers, networked together, all performing different tasks but available on the LAN (Local Area Network).

. . . for Learning

Learning Morse has become a whole lot easier with the PC. There is a plethora of Morse programs aimed at the beginner through to the advanced CW operator who just wishes to hone his skills with a bit of practice. Before the computer era, it usually meant a weekly trip to night school or a local amateur, and then listening to whatever could be found on the receiver.

The two learning methods discussed earlier are catered for by several programs. A computer is ideal for learning by using the Koch method and suitable software can be found at [19]. If you wish to try the Farnsworth method, take a look at programs by ZL1AN or AA9PW. The ZL1AN software [20] is useful for plain text, has a very nice keying tone, and you can enter your own mixed text into a file and use that. AA9PW [19] allows you to set up a huge number of options, including call signs, and punctuation.

Mobile phone app

One of the many applications (or apps) for the Apple Iphone is very useful for someone trying to learn Morse. This Morse code tutor for the IPhone/IPod touch is called *Dah Dit - Morse Code Tutor*. It is written by Stephen Breen and is available in the online app store at modest cost.

Most people have their mobile phone with them all the time, so wherever you are and at whatever time, you can use this app on your phone. It will give you the spoken character

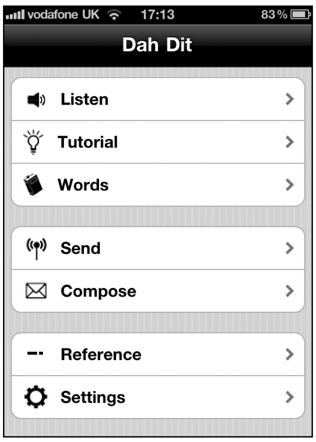


Fig 19.21: *Dah Dit*, a Morse code practice app for the IPhone

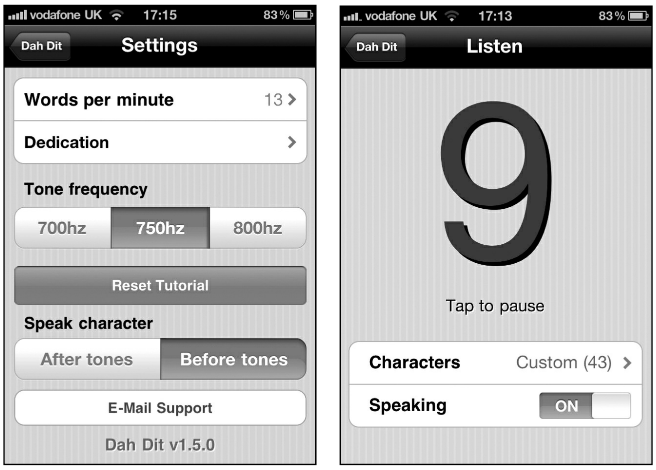


Fig 19.22: More screens from Stephen Breen's Morse code app for the Apple IPhone

then the Morse code or the Morse code and then the spoken character.

It has a progressive tutorial feature that gradually introduces new characters into the letters/numbers/punctuation you are learning until you have learned them all. Once you have achieved that, the program has a 1000 common word list to send for you to copy and type back into it. It will even give statistics on which characters you are struggling with! The screens you see on your phone are illustrated in **Figs 19.21, and 19.22**.

RufzXP

RufzXP is another Morse program designed for practice at reception. Written by DL4MM and IV3XYM, it is by Tancredi and is free to download (from [21]) and use. It sends a chosen number of true amateur radio calls, randomly selected and the user has to type the call on the keyboard. In effect, it is good for two purposes, receiving the call and also improving your typing skill on the keyboard. If the call has been typed in correctly, the speed then increases. If the call is typed in with errors, the speed decreases.

The last call heard can be repeated by hitting F6, for which you receive a 50% penalty. The number of points for each call is primarily related to the speed that the call is sent, the number of errors and the length of the call. The time you take to type the call also has an influence.

At the end of the test you are given a score and your call is inserted into a rate table. There are four modes of operation, toplist, trainer, contest and HST, the high speed trainer.

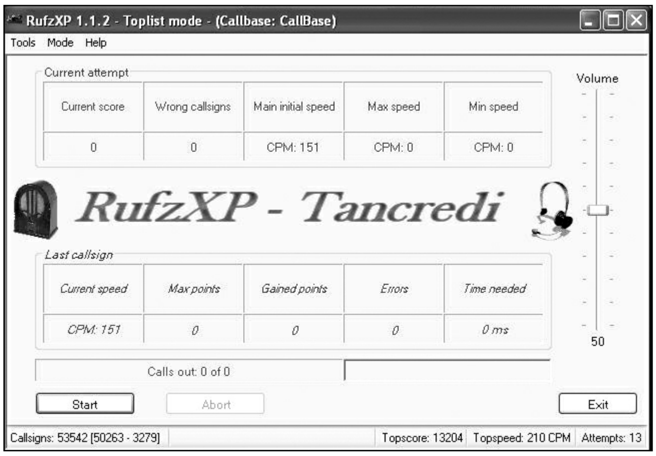


Fig 19.23: Morse practice program *RufzXP*

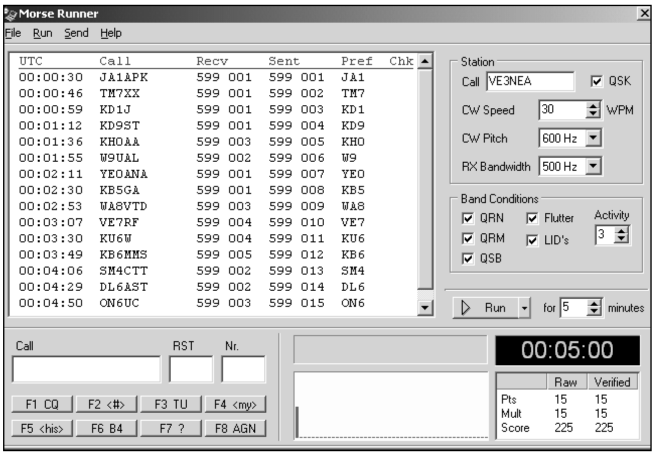


Fig 19.24: A *MorseRunner* screen

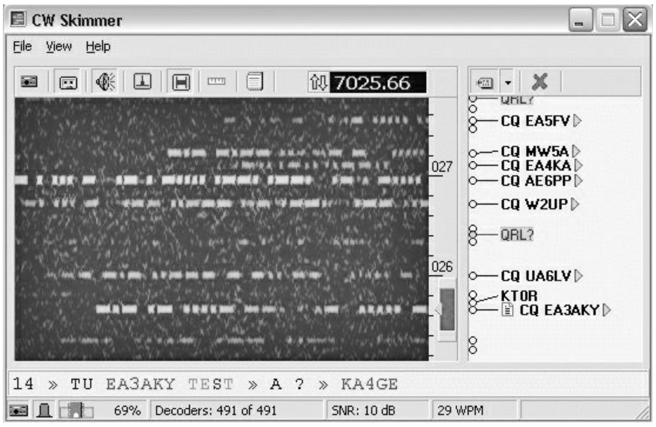


Fig 19.26: *CW Skimmer* can decode a pile-up or, with the right receiver, an entire band of stations

Just like *Morserunner* (see below) it can be addictive. It is quite interesting to see the score improving each time you use the program. A screen shot can be seen in **Fig 19.23**.

. . . for Contesting

Getting started

Once you become more proficient with Morse code, you might wish to enter a few contests. The RSGB Cumulative Club contests occupy just 90 minutes of an evening. They use three modes, CW, RTTY and SSB. In the CW section, there is a QRS corral, where beginners can try their luck. Being thrown into the deep end of the 30WPM+ brigade is what dissuades a lot of new licensees, but the QRS corral can encourage more activity because they find it is not impossible.

Practice being the name of the game, it would be a good idea to obtain some before taking part in a contest. Try downloading a program called *MorseRunner* [22]. It is a very addictive program however, enabling the user to take part in a pseudo contest on the computer. It provides a window on the screen (**Fig 19.24**) that is very similar to the *N1MM* contest program. Using *MorseRunner* improves your operating skills as well as your speed.

Advanced

There are several contest programs available, for instance *N1MM* [23], *SD* [24], and *Writelog* [25]. *N1MM* is gaining popularity and is used by a large number of contesters. It is free but takes some setting up. There may be somebody who can help you to do that. The on-screen display can get complicated (**Fig 19.25**) but that is variable and up to the individual as to how many windows are used. Other programs are listed at [26].

One program that has caused quite a stir among the avid contesters is called *CW Skimmer*. This is a new development by Afreet Software Inc. This is software created by Alex Shovkoplyas, VE3NEA, who also produced *Morse Runner*, *DX Atlas* and so on. *CW Skimmer* is a Morse reader with a difference. It uses a very sensitive CW decoding algorithm based on the methods of Bayesian statistics and is capable of decoding all stations within the receiver passband. Not only that, but as you see from **Fig 19.26**, it produces a waterfall type display with all the calls displayed as well. Love it or hate it, it is yet another addition to the stable of software available to make life easier for the operator [27]

Although the contest programs do send your CW for you, it is still necessary to be able to use the paddle, so it is a good idea to have one wired in parallel to enable you to interject comments.

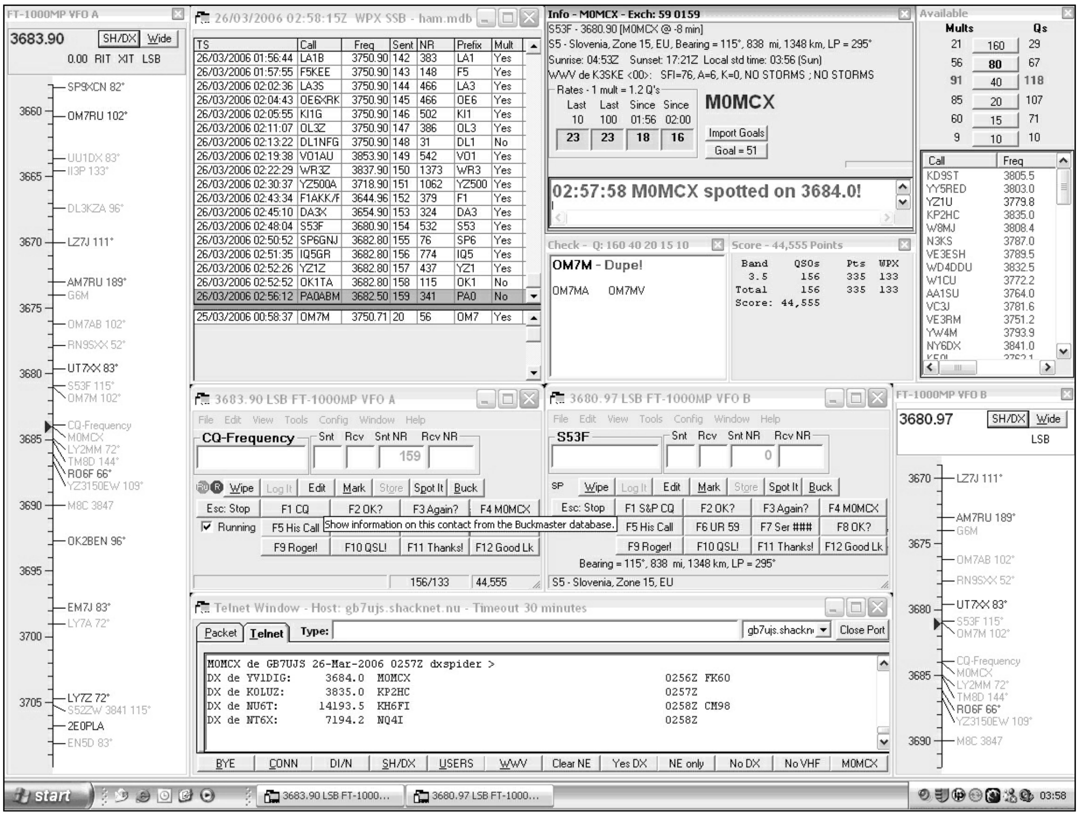


Fig 19.25: The complex screen of the *N1MM* contesting program

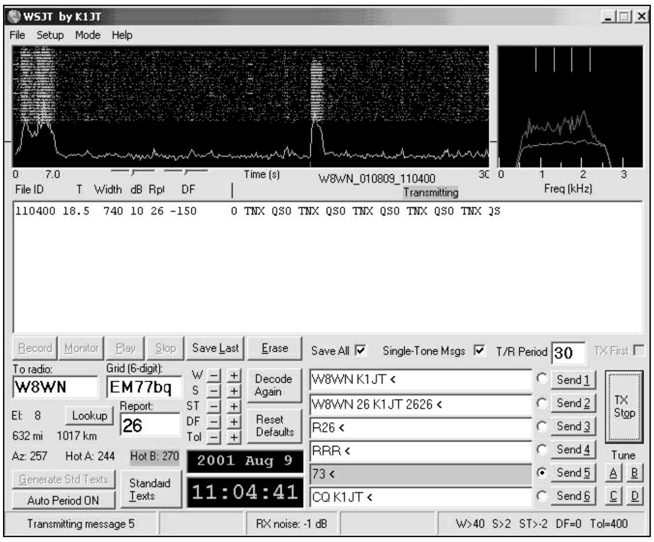


Fig 19.27: The *WSJT* high speed CW program

Contest programs are fine for logging, 'duping' and so on, but nothing replaces the brain, so use the practice programs on a regular basis and you will maintain your own level of speed and will gradually increase it too.

Going Faster

A very useful program is one that is regularly used for MS (Meteor Scatter) communications. It is called *WSJT* and can be downloaded for your own use from [28].

It can decode fraction-of-a-second signals reflected from ionized meteor trails, as well as steady signals more than 10 dB weaker than those required for conventional CW. One of its operating modes is optimized for amateur EME (Earth-Moon-Earth) communications (see the chapter on space communications).

WSJT is open source software and is licensed under the GNU General Public License. To use the program you will need a computer equipped with a sound card and running the Microsoft Windows, Linux, or FreeBSD operating systems.

Pings from meteor trails with 'underdense' ionization are nearly always available in usable numbers. Even 100W, single-Yagi stations at suitable distances can usually hear several pings from each other in a 10 to 20 minute period. At typical high speed CW speeds, around 8000 letters per minute, a ping lasting 0.1 second contains about 13 characters-just about enough for your callsign, the other station's call, and perhaps a signal report. With coordinated timing, good frequency calibration, and some diligence, operators who take the time to learn the technique can easily complete contacts this way. It's a fascinating way to work a bunch of new grid locators, or DXCC entities. It can also work wonders for fattening your multiplier total in a VHF contest. You do not need an EME-class station, and best of all, you don't need to wait for a meteor shower or for one of those all-too-elusive band openings.

The screen-capture in **Fig 19.27** shows the main *WSJT* screen during a meteor scatter contact between K1JT and W8WN. Thunderstorms were present to the west of K1JT at the time, explaining the two static crashes near the beginning of the displayed 30-second recording as well as the noisier-than usual baseline of receiver background noise (the green line). The signal about 18 seconds into the record is a ping from an underdense meteor trail, and the message it conveyed is displayed in the central text box.

SUMMARY

In summary, Morse should not be seen as daunting. Millions of people have mastered the use of Morse code over the years and many amateurs continue to use it on a daily basis both for routine and state-of-the-art communication methods.

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[20] ZL1AN Morse program: http://www.qsl.net/zl1an/ Software/teach4software.html
[21] *RufzXP* Morse Practice program: http://www.rufzxp.net/
[22] MorseRunner by VE3NEA: www.dxatlas.com/
[23] N1MM logging program: http://n1mm.hamdocs.com/
[24] *SD* by EI5DI: www.ei5di.com/
[25] *Writelog*: www.writelog.com/
[26] Contest Programs: www.ac6v.com/logging.htm#CON
[27] Skimmer CW program: www.dxatlas.com/CwSkimmer/
[28] *WSJT* Meteor Scatter program: www.vhfdx.de/wsjt/

About the Author

***Roger Cooke** spent 32 years as a TV/Video technician. He has written numerous articles for* Practical Wireless, Radcom *and* 73*, on various subjects. Author of* Morse Code for Radio Amateurs *and* RTTY and PSK31 for Radio Amateurs *(both RSGB). Edited the 'Data' column in* RadCom *a few years ago.*

Taught Morse for the amateur radio test for decades, both at home and at night school. Still teaching Morse, at home with a class each year to prepare them for working DX, contests and enjoying the mode. He is also the RSGB's GB2CW *co-ordinator and uses that call regularly on the air each week. Now 72 years young, still enjoying Morse after 55 years using it on the air.*