

## How to make a Morse Code contact

Chris R. Burger ZS6EZ

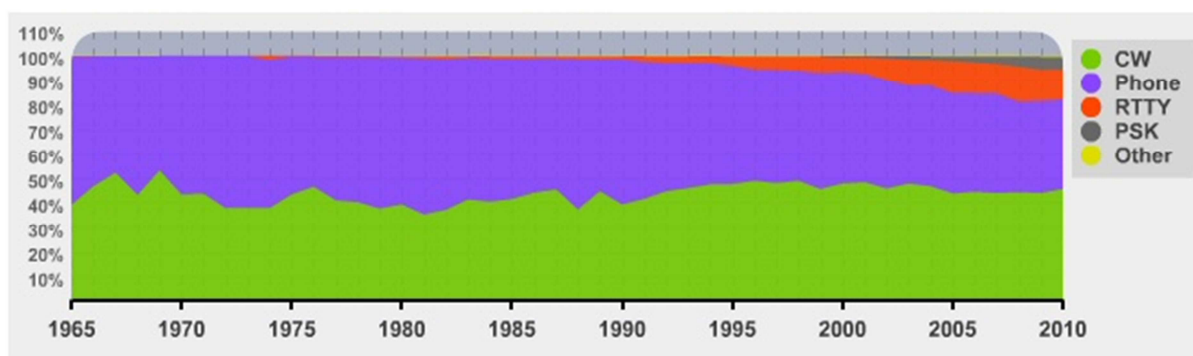
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*This tutorial has been on the Web since 1994. It has been widely quoted and used. It has even been shamelessly plagiarised in French! I've decided to turn it into a PDF with some graphics to make it even more useful. Feedback is always greatly appreciated.*

### Why Morse?

Many radio amateurs feel that Morse code is obsolete. Its use has been discontinued in commercial service, and most nations no longer test aspiring radio hams for Morse proficiency. Nevertheless, Morse code's popularity has not waned.

Although recent statistics have not been published, a 2010 graph from ClubLog<sup>1</sup> shows the composition of contacts uploaded to this database.



The trend is clear. Since the 1960s, Morse code has made up just under 50% of the total contacts made. Around 1990, RTTY started becoming more popular with the advent of personal computing. However, it seems to have eroded the share that Phone held, while telegraphy has held its own at just under 50%.

In the 2014 CQ World Wide DX Contest, more than 7500 stations submitted logs. Around 10 000 stations in 212 countries were worked.

Although Morse proficiency is no longer compulsory, it does provide access to a world of simple, reliable communications. Morse contacts require relatively little signal strength and very little bandwidth. If your antennas are modest and you are not running much power, you can still work the world with the simplicity of Morse code.

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<sup>1</sup> <http://clublog.org>

To be sure, the digital modes now offer similar or better efficiency, but most Morse operators agree that they would rather savour those signals coming through the headset from halfway round the world than watch their computer talking to some other guy's computer!

## Equipment

Any discussion on Morse code must commence with a discussion on tools.

I am very fond of telegraphy. Over the past 14 years, 58% of my contacts have been on this mode, with the remainder on SSB and RTTY. However, I would probably abandon telegraphy if I had to work with a hand key. A hand key is really hard work, and limits the speed at which you can send. Although you may feel that hard work is not a bad thing, the fatigue induced by a hand key limits your endurance. Sending with a hand key becomes strenuous even after an hour or two, while good operators with good equipment survive 48 hour contests and week-long DXpeditions!

A hand key is not a problem at 12 wpm (words per minute), at which most nations used to test their hams. Good operators can even send accurately at 20 wpm or more with a hand key. However, as you become more comfortable, you may find that you want to crank up the speed. Most ragchewers find a speed of 25 wpm most comfortable, but most pileups are run at between 32 and 35 wpm.

Many nations in Europe prefer to express code speed in cpm (characters per minute). A "word" is generally considered to contain five letters and a space, allowing simple conversion between the two systems.

In my case, I seldom chat on the air for any length of time, and generally only get on the air in contests and on DXpeditions. The short burst-type sending in contests is suitable for much higher speeds than one can maintain in a friendly chat, and most contest stations run around 32 wpm. I personally am fairly comfortable at 35 wpm, and when I'm in practice I can clip along fairly well at 45 wpm. However, when chatting for an extended period, even 30 wpm is at the very limits of my abilities. One definitely has to work at endurance.

Whether in ragchewing or contesting, I extensively use my keyer memories to send routine stuff, like CQ calls and my callsign. The latter is valuable, as one does not want to make an error when sending a callsign. My code is a little rusty at the best of times, and Mr Murphy dictates that the one error I make will be the one hole in the QRM during which the other operator will clearly hear the callsign!

The best tools to use are a good paddle and a good electronic keyer, with memories. These days, most radios include good memory keyers, so you may be able to get away with only a paddle.

## Paddles

You have to buy an iambic (twin-lever) paddle. Iambic sending involves just a single squeeze to send any letter, except “P” and “X”. Single-lever paddles require to-and-fro motions for every non-repetitive element. To send a “C”, you need to move the lever four times. With an iambic paddle, you just squeeze once.

Iambic keying is a lot less effort in the long run. Just be aware that there are two different iambic timings, and if you’re used to one, you cannot use a keyer that uses the other. “B” timing has gradually become the standard, and I have no reason to believe that it is a bad choice. There are also other timings, like Accukeyer timing, and other keying schemes, such as Dot Preference and Single Lever. Sophisticated keyers like the WinKeyer offer all of these options, selectable in software. Do yourself a favour and standardise on the default option, “B” timing.

The Bencher paddle is a good choice, but many operators swear by various home-made and commercial designs. Talk to a friendly CW operator about a good choice. You can pay exorbitant amounts like € 540 for a Begali paddle, but you have to ask yourself if some subtle perceived difference in a paddle is worth paying more than the price of a decent transceiver. If you’re into labels, you can hardly do better, though! The ubiquitous Bencher BY-1 is used by over 100 000 operators, and starts at around \$ 170 from the Vibroplex company. MFJ sells some paddles starting at about \$ 80.

An affordable option is the VidiPaddle, locally manufactured and supplied by Vidi la Grange ZS1EL<sup>2</sup>. Pricing starts at around \$ 50. If you can, get a double base plate, as the greater stability afforded by more weight is well worth it. You can even have your paddle done in a combination of funky colours.



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<sup>2</sup> <http://qrz.com/db/zs1el>

## Keyers

If one has to obtain a keyer, possibly the best choice is the WinKeyer USB from Hamcrafters<sup>3</sup>. Now that Windows computers can no longer control realtime processes, an external processor is required to key the transmitter with the exact timing required. This keyer can be used as a standalone keyer, or characters can be downloaded by the computer for sending. In standalone mode, the keyer has up to 12 memories and every imaginable feature. You have to assemble the \$ 90 kit yourself, using clear step-by-step instructions.

Hamcrafters also offer other options, such as the K16 keyer IC for \$ 8 and a complete K16-based kit for \$ 20.

If you want a standalone keyer, you can also consider something based on the CMOS SuperKeyer III or the Curtis chips. MFJ makes several keyers for around \$ 70. To make your own keyer, you can order the Curtis chip from them (MFJ-8045ABM) for about \$ 30.

If you have an experimental bent, you can make yourself a keyer. YACK (Yet Another CW Keyer) by DK3LJ is an open-source project that allows you to programme all the needed functions on an ATtiny45 chip, in a DIP8 package. QRPkits sells the Simple Keyer Chip for home construction. K3NG has an Arduino-based open-source keyer that can do everything the WinKeyer does, and more. It also allows CW sending using a standard keyboard. Arduino development systems, including a suitable board, start at about \$ 60. Simple boards (without the development system) start at \$ 5. Once you have the code, you can programme the same firmware into an Atmel IC to make a cheap standalone keyer. Of course, you can customise the functions to your taste before compilation.

PA3BWK has links to lots of interesting keyer-related sites.<sup>4</sup>

## Keyboard sending

Another option is a keyboard. Purists cringe at the thought, but we are in the twenty-first century. You can buy a special sending tool that works with a standard keyboard, or use one of the myriad of PC software packages that can send Morse code. Your favourite logging software probably already does CW. If you go for the PC option, you'll need something like the WinKeyer, though, to key the radio.

If you don't want to hold down a PC for the job, MFJ sells a suitable box for about \$ 180, or a Morse reader with a built-in keyboard interface for about \$ 200. You simply plug a standard keyboard into the box and let rip.

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<sup>3</sup> <http://k1el.tripod.com/>

<sup>4</sup> <http://www.morsecode.nl/commercial%20links.html>

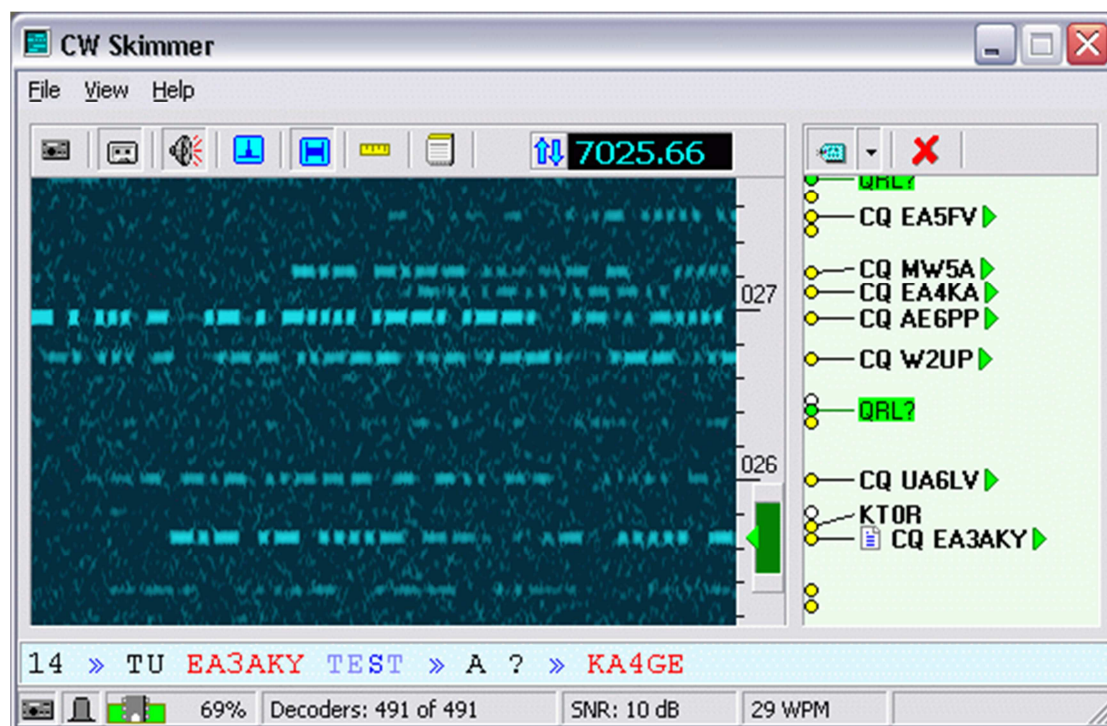
The K3NG Arduino keyer also includes keyboard sending capability.

I personally use a Bencher paddle and WinKeyer, but in contests I use N1MM+ for the majority of sending. I use my left hand on the paddle, as I want to leave my right hand available for operating the radio and making notes as required. However, if you are using a keyboard for logging, it makes more sense to put the paddle near your best hand. My choice was made in a different time, when paper logging was the order of the day.

## Readers

What I'm offering here (at least to my mind) constitutes sacrilege. Real men and women read code in their heads. However, an increasing number of operators use automatic readers.

The Rolls Royce of Morse readers is the CW Skimmer by Alex Shovkopyas VE3NEA. Running in a PC, it can read more than 700 signals in a 100 kHz band simultaneously.



This picture from their Web site<sup>5</sup> shows a standard 3 kHz bandwidth, with eight callsigns fully decoded and a visible history of all the code that existed in that bandwidth in the past few seconds. You can actually visually read the code on each frequency separately.

<sup>5</sup> <http://www.dxatlas.com/cwskimmer/>

You can look for other free software on the Internet. Like the Skimmer, they run with standard sound cards and can be used with a standard communications receiver or transceiver, requiring only simple cables.

Various other alternatives exist. MFJ sells a Morse reader, which includes keying capability, for about \$ 200.

In a South African context, QRV Technology used to sell MorseMate, a reader/keyer combination that offered great value for money. About 80 of them are floating around, and you may be able to find one on the used market.

### Practical tips

If you're going to copy code on paper, use a pen or pencil that writes effortlessly. A felt-tipped pen or a soft pencil (not less than 0,7 mm) works well. Anything that occasionally refuses to write or occasionally gets stuck in the paper won't work.

Learn to write in italic lower case letters. Some people are compulsive CAPITAL-LETTER WRITERS, but it's almost invariably poor practice. It's harder to read, and is a lot slower to write.

If you're a competent touch typist, you might decide to open a word processor on your PC and take down the incoming text that way. As long as you don't plan to operate away from your PC, it's a very good strategy. However, remember that your eventual aim is to copy the code in your head, without having to take down every letter. If you are copying text (i.e. taking down every letter), try to lag a word or two behind, so that you first assemble every word mentally before committing it to paper. You'll make less corrections, and will also progress more rapidly towards pure mental copy. Mental copy is definitely the final goal!

### How to tune a received signal

Many moons ago, when people were still using separate transmitters and receivers, one could listen to one's own signal to hear if one was on the same frequency as the other station. These days, with virtually universal use of transceivers, the technique has changed. However, it is imperative that one learns how to tune stations accurately.

With the bands becoming fuller and fuller, most operators now use a 500 Hz bandpass filter. Some use even sharper filters, often DSP or audio filters of 150 Hz or less. In the latter case, a signal that is only 100 Hz off frequency is already substantially attenuated, and 200 Hz is probably enough to make the operator blissfully unaware of one's presence.

Most modern transceivers, post-1985, use the transmitter sidetone to spot the receiver. If your radio does not have sidetone, most keyers also provide a sidetone.

Some fiddling may be required to select the proper sidetone to match your radio's BFO offset. The basic idea is simply to listen to one's own sidetone, and to turn the dial until the incoming signal has exactly the same pitch. Anyone who has trouble with this procedure can solicit help from someone who plays music. Tuning a station is not dissimilar to tuning a musical instrument!

To obtain sidetone to compare the incoming signal to, could be difficult. Most transmitters will activate the sidetone when the keyer is keyed, without transmitting, if Break-in and VOX are turned off. If the radio doesn't allow sidetone without transmit, it is unfortunately necessary to transmit while tuning in a station. A single "dah" should suffice. One should obviously try to minimise transmitting in this way, as it creates interference to those listening.

Fortunately, the designers of late-model transceivers have addressed this problem. Some new transceivers have a "Spot" button, which activates the sidetone without transmitting.

My FT1000MP has a Spot switch, while my IC746 doesn't. On this radio, I use a footswitch for T/R control. When the receiver is on (i.e. I'm not stomping on the footswitch), I can just touch the paddle to hear the sidetone. The radio doesn't transmit until the footswitch is pressed.

Many transceivers offer variable sidetone pitch. Choose a sidetone that is comfortable to the ear. A lower tone is preferred, as it offers better discrimination between stations. To understand this statement, one must understand that musical pitch works by frequency ratios. An "octave" is defined by a 2:1 frequency ratio. The greater the difference in perceived pitch, the easier it is to distinguish between tones (or signals!). Let's assume that we are trying to listen to a station, and there are interfering signals only 500 Hz off frequency, on both sides. If we are using a 500 Hz sidetone, and we tune the desired signal correctly, the one interfering signal will be zero-beat (inaudible), while the other will be an octave above the desired signal. One will easily be able to hear the desired signal and mentally exclude the interference. If, on the other hand, we choose a sidetone frequency of 2 kHz, we will hear both interfering signals, and there will be less than three tones (or a quarter of an octave) of separation to help us mentally reject the interference.

In practice, a choice of 700 Hz or so is a good one. I would prefer to go down to 500 Hz, but my radios won't let me.

Finally, many modern transceivers have visual tuning indicators. Just follow the blinking arrow which shows you which way to tune. Great, except that you may want to be concentrating elsewhere (like on your logging screen or rotator) while tuning a signal. I highly recommend learning how to tune aurally.

## Where in the band?

When you start off on telegraphy, you will hear a bewildering array of machine-gun type Morse on the bands. Don't be intimidated. It's merely a question of practice, and just as a five-year-old eventually turns a daunting array of squiggles into a natural reading process, you can learn to understand Morse comfortably and effortlessly. It's merely a matter of practice and exposure.

In most cases, the speed merchants hang out in the first 25 kHz of each band. You will find big pileups there, and around '025 you will often hear long ragchews at breakneck speed.

However, as you move up the band, you will encounter more sedate QSOs, with people exchanging ideas about life, the universe and everything. This is where you will also find someone to talk to at your preferred speed.

Some countries limit novices by law to frequencies high in the band. You will often find really slow chatting high in the band, perhaps above 28 100 or 21 100 kHz. Experienced operators with a philanthropic side also often prowl high in the band, providing excellent practice when they slow down to a novice's speed.

If you cannot find anyone who can maintain your speed, find a clear frequency. The first step is always, always, always to find out if the frequency is occupied. Someone may be transmitting, inaudible to you, and you may trample on top of the hapless listener if you start calling CQ. As you are bound to be one of the slower stations on the band, you will cause a huge amount of frustration.

On Phone, one should simply ask something like "Is this frequency in use?". On telegraphy, the term "QRL?" is used. Someone might respond "QRL" or "C", and you will have to move. If no-one responds within about two seconds, you should ask "QRL?" again. If you still hear no response, you can commence the CQ. Keep it relatively short, rather than a long, tedious CQ. You can always call again if there is no response. Emphasise your callsign, rather than the CQ. Everyone can recognise a CQ at first pass, but your callsign is not so obvious. Example:

*CQ de ZS6EZ ZS6EZ CQ de ZS6EZ ZS6EZ K.*

Send at a slightly slower speed than you can copy. Most operators are comfortable at a higher speed than you are, so they will tend to come back at a slightly higher speed than you're sending at. You must leave some headroom, otherwise you'll always find yourself unable to copy what's coming back.



## What to say

At 12 wpm, you can say precious little in a QSO. However, you'll find that very little is said in most Phone QSOs too (especially on repeaters!), and by using abbreviations you can say things at a rate close to that of phone QSOs.

In a contest, most QSOs consist of a callsign sent once at 35 wpm and a number, also sent once at 35 wpm. That being the case, you have to accept that good operators do not require repetition, especially if signals are good. Do not say anything more than once, unless requested, or unless you are dealing with a poor or inexperienced operator or the other operator is not hearing your signals well.

If the operator asks for a repeat, you might decide to send things twice, as clearly the operator isn't hearing you clearly.

If you make a mistake, just send a string of dits (six or more), or "III" (i.e. di-dit di-dit di-dit). Then backtrack one word and continue.

Finally, try to learn to copy in your head, rather than writing everything down. Most experienced operators only jot down notes to enable them to respond to remarks, and make the necessary log entries (callsign, name, QTH and QSL information). Copying in your head frees you from the limitations imposed by your own writing speed, and is essential if you ever want to go beyond 20 wpm or so. Very few people can write at 35 wpm, yet that speed is commonplace on the air.

Relax, and get on the air. Pretty soon you'll find yourself enjoying it, and you'll find that the CW crowd is a lot more fun than the hooligans who often inhabit the Phone sub-bands.

Incidentally, while one hears a high percentage of "599"-type QSOs on the bands, ragchewing (or just chatting) is also an extremely satisfying pastime. As your proficiency grows, you'll find yourself able to sit back and enjoy a long QSO about this, that and the other thing. There are clubs (such as the CW Operators' Club<sup>6</sup> and the FOC<sup>7</sup>) that promote such operating, and their members and others can often be heard exchanging ideas at relatively high speed. I personally find myself out of my depth, as I cannot send good quality code for a long period, but I sometimes join in, and occasionally just listen. Besides, unlike on Phone, you can even have lunch while you're chatting...

I would even go as far as saying that the content of ragchew QSOs on Code is superior to that of typical Phone QSOs. Perhaps it's just that the kind of individual who will go to the effort to learn something like Morse code properly, is someone who will make more of an effort in other fields too, and acquire informed and

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<sup>6</sup> <http://www.cwops.org/>

<sup>7</sup> <http://www.g4foc.org/>

considered opinions that are worth listening to. You might well find common interests, or discuss travels through the other guy's country, or even just personal experiences in operating, station construction or anything else.

You may just find that SSB holds less attraction for you in future, and you may never get onto your local repeater again!<sup>8</sup>

If you continue growing, you may eventually be pleasantly surprised to find yourself nominated to one of the CW clubs. Apart from the CW Ops and FOC mentioned before, there is also a High Speed Club (HSC), as well as a VHSC and other derivatives. The FOC is originally British and the various HSC derivatives originally German, but all these organisations now have world-wide membership. Their activities also include much in-person fraternising, and you might well find that a few life-long friendships develop through this medium.

### Some abbreviations

Don't let the magnitude of this list scare you off. Most of these abbreviations are very easy to remember once you've seen them, and you can probably master their use in an afternoon. You don't need to be able to use all of them. Any particular operator may only use a few of these, but you may hear all of them in your lifetime. As long as you can recognise them, you're fine.

ABT	about
AF	Africa
AGN	again
ANT	antenna
AS	Asia
B4	before
BK	break, back
BN	been, being
BND	band
BTW	by the way
C	correct, yes (Spanish "si"!)
CBA	Callbook address
CFM	confirm
CL	callsign (also used as ending signal: Clear)
CLG	calling
CONDX	conditions (propagation)
CPI	copy
CPY	copy
CS	callsign
CU	see you
CUL	see you later
CUZ	because
DCT	direct
DE	this is
DWN	down
DX	distance
EL	element(s)
ES	and

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<sup>8</sup> In my case, it's not quite true. I've been on a VHF repeater as recently as 1996...

EU Europe  
 FB fine business (used by old fogies and non-native English speakers)  
 FER for  
 FM from  
 FU I don't agree (you may hear this; don't use it!)  
 GA good afternoon, go ahead  
 GD good day, good  
 GE good evening  
 GL good luck  
 GM good morning  
 GUD good  
 HI laughter (sometimes sent HEE)  
 HLO hello  
 HNY happy new year (often used in December!)  
 HR here  
 HRD heard  
 HV have  
 HW how  
 LID poor operator  
 LOTW Logbook of the World  
 LP long path  
 MX merry Christmas (often used in December!)  
 NA North America  
 NW now  
 OC Oceania (i.e. Australia and environs)  
 OM old man (used by old fogies and non-native English speakers)  
 OP operator (e.g. Op Chris)  
 PAC Pacific  
 PIX pictures  
 PSE please  
 PWR power  
 R roger (i.e. "everything understood"), decimal comma (3R503)  
 RCV receive  
 RCVR receiver  
 RGR roger  
 RPT repeat, report  
 RPRT report  
 RST signal report (readability, signal strength, tone)  
 RX receiver  
 SA South America  
 SP short path  
 SR sunrise  
 SS sunset  
 STN station  
 SUM some  
 TEST contest  
 TMW tomorrow  
 TNX thanks  
 TU thank you  
 TX transmitter  
 UR your, you're  
 VY very  
 WL will  
 WRK work  
 WX weather  
 XCVR transceiver  
 XYL wife  
 YDY yesterday  
 YDAY yesterday  
 YL young lady (i.e. girl friend, woman)  
 YR year, your  
 YRS years, yours

= dah-di-di-di-dah, used as a pause to collect thoughts

## Q signals

Q signals can be sent with or without a question mark. With the question mark, the Q signal is a question. Without, it's an answer. "QRM?" means "are you being interfered with?", while "QRM" means "I am being interfered with". Both refer to man-made interference. Here are some common uses you should know:

QRM	Man-made interference
QRN	Natural interference (static etc.)
QRQ	Send faster
QRS	Send more slowly (very useful for beginning telegraphists!)
QRT	Stop transmitting
QRU	I have nothing more for you
QRZ?	Who is calling me?
QSL?	Do you acknowledge receipt?
QSL	I acknowledge receipt (could also refer to QSL cards)
QSY	Move frequency
QTH	My location is...

## Ending signals

These ending signals are sent as one character, not as separate letters. Example: [SK] and [VA] are the same thing (sent as one string, di-di-di-dah-di-dah).

[AS]	Stand by
K	Go ahead (anybody)
[KN]	Go ahead (only one area or station)
[AR]	End of message
[SK]	Signing off

## Signal reports

The RST system uses three digits and a possible suffix:

**R** is readability. 1 is uncopiable, 5 is effortless copy.

**S** is signal strength. 1 is puny weak, 9 is plenty loud.

**T** is tone. One does not often hear anything but T9 these days.

599 is the best possible signal.

339 is hard to copy, and weak.

489 is strong, but hard to copy (either distorted or QRM?)

There are also suffixes that can be appended to RST, such as X for crystal-type tone, C for chirp. The C is the only one still in common use, but not many signals warrant a C these days.

Because reports on CW are often 599, and a 9 takes forever to send, the 9 is normally abbreviated to N. Examples: 56N, 5NN. Contest and DXpedition stations that make thousands of contacts in a day often send only "5NN" reports.

In other numbers, 0 is often abbreviated to T. Example: *Pwr 1TT W* means that your power is 100 W.

### Some example QSOs

#### Example 1:

*CQ de ZS6EZ CQ de ZS6EZ K*

*ZS6EZ de ZS4TX ZS4TX [KN]*

*ZS4TX de ZS6EZ GM = TU fer cl = Name Chris QTH Pretoria = RST 599 = Hw cpi? ZS4TX de ZS6EZ [KN]*

*ZS6EZ de ZS4TX TU Chris = RST 599 plus = Name Bernie QTH Bloemfontein = Nice meet u fer 1st time = Ant 3 el Yagi up 30 m = Pwr 100 W = Wx hr fb temp 30 C = ZS6EZ de ZS4TX [KN]*

*ZS4TX de ZS6EZ Name agn? BK*

*BK Bernie Bernie BK*

*BK Thanks Bernie = Sri had QRM = Hr 2 el up 22 m es 1TT W = Wish I had ur 3 el = hr no space fer big ants = Wx hr also fine temp 26 C = hv bn ham 1 yr, still getting used to cw = condx rotten past few days = hv hrd vy few stns on 40 m = only sum W6 on LP b4 sunset = hvnt had much luck wrking them tho = ok must run hv to do sum chores arnd house = 73 cul bernie [AR] ZS4TX de ZS6EZ [SK] CL*

*ZS6EZ de ZS4TX OK Chris = Yes 3 el lot of fun = Wrk W6 on LP all the time = Condx rotten hr too but wrked FO stn on SP at SS = OK 73 tnx QSO es QSL via buro es LotW= ZS6EZ de ZS4TX [SK]*

Notice how the term “BK” was used to quickly pass the transmission back to the other station.

#### Example 2 (a directional CQ):

*CQ Oc de ZS6EZ CQ Oc de ZS6EZ ZS6EZ Oc [KN]*

*de IK1XYZ*

*CQ Oc de ZS6EZ CQ Oc de ZS6EZ ZS6EZ Oc [KN]*

*de IK1XYZ*

*IK1XYZ pse qrt ur not in Oc = CQ Oc de ZS6EZ CQ Oc de ZS6EZ ZS6EZ Oc  
[KN]*

### Example 3 (a complete contest-style QSO):

*CQ ZS4TX ZS4TX TEST*

*ZS6EZ*

*ZS6EZ 5NN13N*

*5NNTT1*

*TU ZS4TX TEST*

ZS4TX was calling CQ. ZS6EZ answered. 'TX sent number 139. 'EZ responded with number 001. Done.

In contests, ending signals, the “de” and other niceties are generally dispensed with. Notice how the example QSO includes no ending signals, and no instances of the “de” signal.

### Example 4 (planning for your first QSO):

For your first few QSOs, write down everything you are going to send, in advance. When the other station sends, just write down what he/she is sending. Keep the abbreviation list handy. Don't get too adventurous initially; just stick to the standard script until you find your feet. Here is a suggested first QSO:

*QRL?*

*CQ de ZS6XYZ ZS6XYZ K*

*ZS--- de ZS6XYZ GM = Name Bill QTH Pretoria = RST 599 = Hr vy nervous cuz my 1st QSO on CW HI = ZS--- de ZS6XYZ [KN]*

*ZS--- de ZS6XYZ OK --- = Cpied all OK = Hr dipole es 100 W = 73 tu QSO es pse QSL via buro = ZS--- de ZS6XYZ [SK]*

### Feedback please

Please let me know if you use this tutorial. I'd love to know if there is something that needs more clarification, or that needs to be re-written.

### Thanks!

Thanks to G3MXJ, ZS1EL and ZS4TX for constructive feedback that improved this article tremendously!