www.qmac.com

Q-MAC ELECTRONICS

HF TRANSCEIVERS & ANTENNA SYSTEMS

FREQUENCY HOPPING FAQ

HF HELP FILES

Q-MAC Electronics Pty Ltd

HF HELP FILES

FREQUENCY HOPPING

FREQUENTLY ASKED QUESTIONS

HEAD OFFICE 142 Hasler Road, Osborne Park WA 6017. Australia
Telephone: +618 9242 2900, Facsimile: +618 9242 3900
Email: info@qmac.com
Web: www.qmac.com

1 Frequency Hopping Description

Q - How does hopping work?

A - All radios in a hopping net change frequency 5 times per second. They change together at exactly the same time and follow a pattern, called a pseudo random pattern, which repeats every 457 million years. The hopping occurs on 1kHz spaced channels within a 256kHz wide hop band. One station only is designated as a Base (or Master) Station. This station sends out synchronisation bursts, which allow all the Slave stations to know the precise position in the pseudo random pattern at that point in time, plus ensures that all frequency changes occur correctly and simultaneously.

Q - What is the speech quality of hopping?

A - As SSB is used in frequency hopping mode (for voice transmissions) the speech quality is better than when using either band splitting or digital encryption. The frequency changing every one fifth of a second is virtually inaudible. Periodically (on average once every 26 seconds) a brief synchronization burst can be heard. In comparison, speech encryption methods tend to result in muffled or metallic sounding speech.

Q - What does hopping sound like when listened to on a fixed frequency radio?

A - The hopping net hops over 256 1kHz spaced channels at a hop rate of 5 hops per second, so perhaps once every 26 seconds (approx) a sub-syllabic burst of speech may be heard. These bursts contain no discernable intelligence and in a normal HF environment would pass unnoticed.

HEAD OFFICE 142 Hasler Road, Osborne Park WA 6017. Australia
Telephone: +618 9242 2900, Facsimile: +618 9242 3900
Email: info@qmac.com
Web: www.qmac.com

2 Frequency Hopping Implementation

2.1 Ease of Use

Q - Isn't frequency hopping mode complex and difficult to use?

A - Hop mode operation is as simple as pressing a single button to enter the hop mode. Thereafter synchronization is automatic and operation is the same as in fixed mode; pressing PTT to speak and releasing PTT to listen.

2.2 Code Management

Q - What determines the hopping pattern?

A - This is determined by the combination of the channel frequency, the sideband selected, and the 11-digit hop code. The 11-digit hop code is common to all channels. Radios in a hopping net must be on the same channel with the same sideband selected, and have the same hop code programmed, in order to communicate.

Q - How frequently should the hop code be changed?

A - During peacetime the code can be changed as seldom as once a month, or even once every six months. During wartime a more frequent code changing regime is advisable. Code distribution is the same as for any other direct entry crypto devices.

Q - Will a captured radio yield its codes?

A - The HF-90 has an Erase Function whereby the operator can delete all the codes and channels (apart from channel 1). This renders the radio useless to an enemy.

In the event of a radio being captured with channels and codes intact, there is no way of reading the hop code. When entering a hop code, the old hop code is not shown and it is stored in encrypted form.

Q - Can two hopping nets, using different hopping codes, hear one another?

A - No, unless radios have been programmed with the same channel, sideband and hop code they will not follow the same pseudo random pattern. Consequently they will not hear one another.

2.3 Net Management

Q - How should the reference frequency be chosen?

A - Choosing which reference frequency should be used is the same as for fixed frequency operation. The time of day, range, and antenna should be considered, and an appropriate frequency chosen in the same way as for fixed frequency operation.

Q - Which station should be chosen as Base (or Master) Station?

HEAD OFFICE 142 Hasler Road, Osborne Park WA 6017. Australia
Telephone: +618 9242 2900, Facsimile: +618 9242 3900
Email: info@qmac.com
Web: www.qmac.com

A - The Base should be the station which is transmitting the strongest signal to all the other Slave Stations. It should also be less vulnerable, since it is important that it radiates synchronizing information. A local HQ or command post station with an elevated wire antenna makes an excellent Base Station.

Q - How many Slave Stations can be used?

A - Any number, from 1 to 9999 can be used.

Q - How many different nets (with different hop codes) can operate within the same hop band?

A - In excess of 20 nets can operate within the same hop band without significant mutual interference. This number can be higher if there is geographical separation.

Q - Is the reference frequency at the centre of the hop band?

A - No, it is simply one frequency within a determined hop band.

Q - Can hopping be used within broadcast bands?

A - This is not specifically disabled. It may, under certain circumstances, be useful to 'hide' a hopping net at the edge of a broadcast band. However operating within a crowded broadcast band, will lead to a large number of blocked channels despite Smart Hopping.

2.4 Synchronisation

Q - How does synchronization work?

A - The Base Station determines the position in the pseudo random pattern and periodically sends a burst of data to the Slaves to allow synchronization.

Slaves may be in any of three states.

- Unsynchronized: In this state the Slave is polling for sync information only and communication is not possible until the information is obtained. As sync is sent out on average every 26 seconds, acquisition of sync is usually rapid. When a Slave is unsynchronized the synchronized indicator (decimal point) is extinguished.
- Synchronized: In this state the Slave has recently received valid sync information and communication is possible. When a Slave is synchronized, the synchronization indicator (decimal point) is illuminated.
- Synchronized but not receiving sync data: In this state the Slave is still synchronized and communication is still possible. However, at least five minutes has elapsed since a valid sync burst has been decoded. A net can continue to communicate in this state for up to two hours. When a Slave has not recently received sync data, the synchronization indicator (decimal point) flashes. This state may occur without a problem in noisy conditions and will not lead to communication disruption. It may also occur if the Base Station has gone off the air. After two hours without receiving a valid sync burst the Slaves revert to the unsynchronized state since the internal clock will have drifted to its limit by this time. Slaves without a Base should elect a new Base, and resynchronize to the new Base if the old Base has gone off the air.

HEAD OFFICE 142 Hasler Road, Osborne Park WA 6017. Australia
Telephone: +618 9242 2900, Facsimile: +618 9242 3900
Email: info@qmac.com
Web: www.qmac.com

Q - What happens if a station is talking during the sync burst?

A - This is not a problem. Slaves will sync whilst the Base is talking during sync. If a Slave is talking during sync, then the talking Slave will not update its synchronization state, but this is of no consequence since the frequency of valid syncs can fall to lower than 1 in 50 without penalty.

Q - What happens if one Slave cannot hear the Base?

A - That Slave will not synchronize. It is important that the Base Station is situated in such a manner to transmit a strong signal to all stations.

Q - Can a Base which has gone off the air resynchronize to its Slaves?

A - No, the Base cannot resynchronize to Slaves. Furthermore, if the Slaves have elected a new Base then the old Base should be programmed as a Slave and resync to the new.

2.5 Comparison with Scrambler and Encryption Devices

Q - If security is a problem then why not use scrambler or voice encryption?

A - A voice encryption unit is quite useless against jamming. Using a voice encryption unit immediately draws attention to a link as being of importance, and if it cannot be intercepted it will almost certainly attract jamming. Frequency hopping is both secure and resistant to jamming.

Q - Is it necessary to use scrambling or voice encryption with hopping?

A - No, the 64 bit DES algorithm used to determine the hopping sequence, yields a very high degree of security. Voice encryption units or scramblers tend to degrade the speech quality so no real advantage is obtained by using encryption.

2.6 Electronics Warfare

Q - How will I know if someone is trying to jam my hopping net?

A - Unless a concerted effort is made to jam a net, because of the HF-90s use of Smart Hopping a jamming attempt may go unnoticed. If a significant number of channels in the 256 kHz wide hop band are blocked due to jamming, the occasional 1/5 second gap will appear in received speech. This is not a significant problem and messages can be passed without impediment.

Q - Will a 1kW spot jammer be effective in jamming a hopper?

A - A single frequency jammer at any power will have no effect on an HF-90 hopping net since Smart Hopping will rapidly avoid the blocked frequency.

Q - If the 1kW jammer is ‘swept’, will it then prevent communication in hopping mode?

HEAD OFFICE 142 Hasler Road, Osborne Park WA 6017. Australia
Telephone: +618 9242 2900, Facsimile: +618 9242 3900
Email: info@qmac.com
Web: www.qmac.com

A - No, sweeping 'dilutes' the effect of the jamming. A 1kW sweeping jammer is not at all the same as 256 x 1kW spot frequency jammers. The effect of the sweeping diminishes the jamming by 23dB.

Q - Does knowing the hop-band in use give the jammer a significant advantage?

A - No, because of the difficulty in effectively jamming ¼ MHz of spectrum the advantage of knowing the hop-band is not significant.

Q - Does knowing how the radio hardware and software is constructed make it easier to jam or intercept?

A - No, the strength of the system resides in the hop code. Unless the hop code is found out by the enemy the system is secure.

Q - Why can't the enemy use 256 separate receivers to intercept the signal?

A - Well it can try, but it won't work since the signals from all 256 receivers have to be combined. All 256 channels have noise or signals on them, so when all 256 are combined, the 255 channels which don't have the wanted signal completely bury the wanted signal in noise.

Q - Can the synchronization be attacked?

A - Because of the pseudo random nature of the sync and the frequency diversity, attacking the sync is very difficult. Once a net has acquired sync it will hold onto sync for up to two hours.

Q - Can the synchronisation be fooled by recording and retransmitting valid sync bursts?

A - No, the HF-90 sync system is designed to reject that type of attack.

Q - Can the HF-90 hop sequence be "cracked" and then followed and intercepted?

A - In order to crack a code, information on different values in the sequence must be obtained. For a frequency hopping net this means that it is necessary to log a long series of frequencies which have been hopped over. The following issues make this task insurmountable:

The HF spectrum is crowded and identifying one specific net is very difficult among all other signals.

A hopping net is actually silent a lot of the time resulting in missed sequence values as far as an interceptor is concerned.

Due to the fact that SSB is used for voice transmissions, there will be no output between syllables and consequently no sequence value for an interceptor.

As there is no carrier with an SSB channel, identifying which frequency is being hopped on is difficult for an interceptor.

All of the above make the task of cracking the code much more difficult than on a wire line system.

HEAD OFFICE 142 Hasler Road, Osborne Park WA 6017. Australia
Telephone: +618 9242 2900, Facsimile: +618 9242 3900
Email: info@qmac.com
Web: www.qmac.com

2.7 Smart Hopping

Q - What is Smart Hopping and how does it work?

A - Smart Hopping is a technique whereby blocked channels within the hop band are avoided. The Base acquires data on the channel occupancy within the hop band and periodically sends data to the Slaves instead of sync, allowing the net to avoid occupied channels. The Smart Hopping cycle comprises of 9 minutes where all channels are hopped over, followed by 24 minutes where channel avoidance is activated.

Q - When should Smart Hopping be enabled?

A - Smart Hopping is turned on and off by the Base Station. It is most effective in situations where there are strong blocking signals from broadcast signals or jammers and the wanted signal is of normal signal strength.

Q - When should Smart Hopping be disabled?

A - In situations where the wanted signals are very weak or noisy it is better to turn Smart Hopping off. Also in situations where very frequent late-entries occur smart Hopping is less available since stations will not acquire Smart Hopping information for up to 15 minutes.

2.8 Selcall

Q - Is Selcall available in hopping mode?

A - Yes, four digit Selcall is available in hopping mode.

Q - Is Beacon available in hopping mode?

A - Yes, four digit Beacon is available in hopping mode.

Q - Can a fixed station Selcall a hopping net or vice versa?

A - No, hopping Selcall uses a different baud rate and protocol to fixed frequency Selcall.

2.9 Operating Range

Q - What range is obtainable in hopping?

A - The range is similar to that in fixed frequency. Performance in hopping tends to the average of all the channels in the hop band.

Q - Are there any built-in limits on range due to hopping?

HEAD OFFICE 142 Hasler Road, Osborne Park WA 6017. Australia
Telephone: +618 9242 2900, Facsimile: +618 9242 3900
Email: info@qmac.com
Web: www.qmac.com

A - The hopping system can synchronise over distances up to 4000km (subject to equipment, installation and propagation). Beyond this there will be some degradation in speech quality.

2.10 Use of SSB for Voice Transmissions

Q - Isn't SSB an old method of transmission? Why use it in hopping?

A - SSB has many advantages when used on hopping. As it only radiates power when a voice signal is active, and radiates zero power between syllables, it has a low probability of intercept. It stands out less than a digital signal on a monitoring receiver. Consequently cracking the hop sequence is made much more difficult. Furthermore because it radiates power only on active speech it is more current efficient than digital speech.

Q - Can I use LSB on hopping?

A - Yes, LSB channels can be used on hopping.

HEAD OFFICE 142 Hasler Road, Osborne Park WA 6017. Australia
Telephone: +618 9242 2900, Facsimile: +618 9242 3900
Email: info@qmac.com
Web: www.qmac.com

3 Antennas

Q - Which antennas can be used on a hopping HF-90?

A - These antennas, offered by Q-MAC, are compatible for use in hopping mode:

- QM7005/6 – Portable Broadband Antennas
- QM2001 & QM7301 –TM-90 Tuner & 6-Section Collapsible Whip Antenna
- QM2001 & QM7302 –TM-90 Tuner & 2-Section Collapsible Whip Antenna
- QM2001 & QM7310 – TM-90 Tuner & Long Wire Antenna Kit
- QM7001 – Fixed Broadband Dipole Antenna – single wire
- QM7002 – Fixed Broadband Dipole Antenna – multi wire
- QM7112 – TA-90 Auto-Tune Antenna System (from 4 to 20MHz)
- QM2101 & QM7301 –TA-99 Tuner & 6-Section Collapsible Whip Antenna
- QM2101 & QM7302 – TA-99Tuner & 2-Section Collapsible Whip Antenna
- QM2101 & QM7310 – TA-99Tuner & Long Wire Antenna Kit

Q - How is the antenna tuned for frequency hopping?

A - On the TM-90 Tuner the antenna can be tuned whilst in fixed mode prior to pressing the hop button. Alternatively the antenna can be tuned in hop mode on voice (the tune button is inactive in hop). The antenna fractional bandwidth is adequate to pass the entire hop band.

HEAD OFFICE 142 Hasler Road, Osborne Park WA 6017. Australia
Telephone: +618 9242 2900, Facsimile: +618 9242 3900
Email: info@qmac.com
Web: www.qmac.com

4 Other Issues

4.1 Compatability with other Frequency Hopping Radios

Q - Is the HF-90 compatible with any other hoppers such as Racal Panther H or Thompson Skyhopper?

A - No, the HF hoppers tend to use propriety algorithms and are mutually incompatible.

4.2 Interference

Q - Can fixed nets and hopping nets coexist at the same location?

A - So long as normal antenna separation rules are followed, it should be possible to operate fixed and hopping nets at the same time. If the fixed net is in the same band as the hopping net occasional interference will occur to the fixed net.

4.3 Programming

Q - Can I use my current HF-90 PC Programming Package to program hopping radios?

A - Yes, all the channel, Selcall, sideband, power and tune status information can be programmed. The hop code, master/Slave and Smart Hopping status must be programmed from the microphone.

Q - Can I use split frequency on hop?

A - No, this is not possible, since hopping is meant for a multi member net, and split frequency is only possible for one-to-one communication. Programming a channel for split frequency will result in obtaining a “CLOSED” message when pressing the hop key.

Q - Can hopping channels be programmed with Selcall off?

A - No, disabling Selcall will disable hopping on that channel resulting in a “CLOSED” message when pressing the hop key.

HEAD OFFICE 142 Hasler Road, Osborne Park WA 6017. Australia
Telephone: +618 9242 2900, Facsimile: +618 9242 3900
Email: info@qmac.com
Web: www.qmac.com

5 Sales Information

5.1 Upgrading

Q - I have older non-hopping HF-90s. How easily can I upgrade these to hoppers?

A - For radios below S/N 3500 the upgrade consists of simply replacing the internal RXMP module (PCB). For radios above S/N 3500 the upgrade consists of fitting a new chip to the internal RXMP module (PCB). The upgrade takes only 15 minutes. If customers have very early version HF-90s (below S/N 1300), refer to Q-MAC Electronics before upgrading.

5.2 Demonstrating Frequency Hopping

Q - How can I demonstrate the secure nature of frequency hopping to a customer?

A - Firstly set up a net of frequency hoppers, consisting of 3 or more HF-90 Manpacks/Portables, separated by 1-5km. Establish communication in fixed mode, then in hopping mode. Leave one radio in fixed mode, whilst the others are hopping. Note that no intelligence is heard on the fixed radio. Now try to jam the net using the fixed radio (talk, whistle and send Selcalls). Note that this has no effect on the hopping net. The above can be repeated on a 300km skywave path.

HEAD OFFICE 142 Hasler Road, Osborne Park WA 6017. Australia
Telephone: +618 9242 2900, Facsimile: +618 9242 3900
Email: info@qmac.com
Web: www.qmac.com

6 Other Information

6.1 Author

Mr Rod Macduff BSc, BA, MIEEE, MIEE, FIEAust

Rod Macduff is Managing Director of Q-MAC Electronics which is a specialist supplier of HF Communications to the Humanitarian, Aid & Relief and Military organisations. Rod Macduff worked with Racal BCC for 10 years on the Jaguar V tactical hopping radio and travelled extensively consulting with armies on their secure communication issues. The Q-MAC HF-90 hopping radio is in service in 75 nations and has been adopted by Humanitarian, Aid & Relief, Army, Police and Intelligence organisations.

6.2 About Q-MAC Electronics

Q-MAC Electronics is specialist designer and manufacturer of HF Transceivers. The flagship product the HF-90 is the world's smallest high performance HF SSB Transceiver. The HF-90 and Q-MAC Electronics have been awarded many accolades and is currently used by thousands of users in over 80 countries worldwide. The HF-90 is one of the most versatile HF transceivers available and is suited to military, paramilitary and humanitarian aid and relief applications.

Q-MAC offers the HF-90 in a variety of configurations suited to manpack, vehicle and base station applications. A full complement of accessories is also offered for use with the HF-90; including antennas, field battery charging accessories, carry packs/cases and more. All Q-MAC products are backed by the company's strong commitment to after sales service, support and certified ISO9001 quality standards.

6.3 Contact Details

For Further Information Contact;

Q-MAC Electronics Pty Ltd

142 Hasler Road

Osborne Park, WA

Australia 6017

Phone + 618 9242 2900

Fax + 618 9242 3900

Email: info@qmac.com

Web: www.qmac.com