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SUBJECT	Frequency Accuracy and Spacing of Beacons		
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SUGGESTED AMENDMENTS TO IARU REGION 1 VHF MANAGERS HANDBOOK

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Introduction

The existing document section heading implies that the Table lays down the details for frequency accuracy and spacing. In fact the only parameter currently specified is the spacing between adjacent beacons for the various bands. At the recent Lillehammer Region 1 Conference held during September 1999 the C5 committee amended the spacing. However up to the present time the required frequency accuracy for the beacons has not been specified.

As this is an important issue it would be advantageous to clarify the position and lay down the stability and accuracy parameters for discussion and ratification at the Davos meeting in 2005.

Motivation

If the assumption is made that, for good frequency management, the maximum frequency error for each band should not exceed 20% of the spacing, this sets a stability and accuracy requirement of 200 Hz for the bands 50 to 144 MHz, 400 Hz for 432 MHz and 1 kHz for 1296 MHz. This is felt to be adequate for the time being but could be tightened if the need arises later.

It is common to specify frequency accuracy and stability in terms of PPM (parts per million), where an error of 1Hz for a 1MHz carrier equals 1 PPM.

For 50 MHz the required accuracy is	200 / 50	= 4 PPM
For 70 MHz the required accuracy is	200 / 70	= 2.8 PPM
For 144 MHz the required accuracy is	200 / 144	= 1.38 PPM
For 432 MHz the required accuracy is	400 / 432	= 0.95 PPM
For 1296 MHz the required accuracy is	1000 / 1296	= 0.77 PPM

These accuracy parameters are entirely feasible when utilising high quality crystal oscillators using either temperature compensated oscillators (TCXO) or oven oscillators (OCXO). *(A non-compensated oscillator can achieve no better than approx. 5 PPM from commercial grade crystals over the temperature range of -10 to +60°C).*

For information: A commercial oscillator featuring a stability of ±1ppm is a relatively low cost item and would be available for approx. $20 in units of 1 off. Oven oscillators are considerably more expensive, but many of the older LMR fixed station equipment types utilised crystal oven packages which only require a suitable crystal to be installed which is cut for an inversion temperature of +70°C. (These ovens are readily found on the surplus market from various manufacturers - Pye, Philips and Storno etc. and are available from several manufacturers of OEM parts). An oven oscillator of this type can readily achieve a stability of better than ±0,1 PPM. A 70 MHz beacon using such an oven oscillator maintained a stability of better than ±4Hz over a temperature range of 0 to +40°C and a long term stability of better than ±10Hz per year. Using a GPS derived master oscillator the figures improve to at least 1 part in 10^{10} for short term and 1 part in 10^{9} for long term.

Cognisance needs also to be taken of any unwanted emissions due to keying, oscillator phase noise, broad band noise or other causes. It is difficult to specify a global figure for these, the individual requirement will differ from beacon to beacon, nevertheless good engineering practices need to be followed to minimise interference to other users from these sources, especially in the case of high power beacons.
If the assumption is also made that the amateur receiving station is capable of setting the receive frequency to a high degree of accuracy then very narrow band IF and audio filters can be used to improve the sensitivity of a station attempting to listen to a very weak beacon station. For these reasons a higher accuracy for the beacon is advantageous. An overall frequency accuracy and stability of better than ±100 Hz is entirely feasible for 1296 MHz and below.

In view of the above it is proposed that the Table be amended to read as below: *(note that the exact PPM values have been rounded to assist in clarifying the position)*

Band MHz	Freq. Spacing Hz	Freq. Accuracy Hz	Freq. Stability PPM
50	1000	200	4.0
70	1000	200	2.8
144	1000	200	1.4
432	2000	400	1.0
1296	5000	1000	0.8

Using these parameters the worst case error for a beacon would be twice the specified accuracy under all conditions of supply voltage and temperature. These can be summarised below in Table 2 and are sufficient for the foreseeable future. Some thought needs to be given to what we need to specify for the higher bands.

Band MHz	Maximum Error - Hz
50	400
70	400
144	400
432	800
1296	2000

Table 2

These limits can be reviewed as and when the need arises.

Conclusion

Section D (Recommendation B.1) has clearly not been done and needs to be amended to comply with the above. Where the words "frequency tolerances have been tightened at recent conferences due to the requirements for a more efficient "packing" in the rather narrow exclusive beacon segments" are used this should of course read "frequency spacing".