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PRECISION FREQUENCY ANALYSIS FOR THE MEDIUM-WAVE DX-ER

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Any DX'er who has ever wasted his time relogging old catches or who has strained his patience on weak, poorly modulated carriers will appreciate precision frequency analysis. PFA can be used to identify the slightest trace of the faintest signal on the band - in far less time than it takes to wait for some elusive ID in a strange language.

But PFA goes further than the usual efforts at precision frequency measurement; if a PFM is to be reliable for future reference, then something must accompany the reading in order to account for any change in frequency between the time the measurement is taken and the time it is referenced in the course of the hobby; the statistical methods of PFA gather the necessary data to compute such a "frequency integrity figure" (FIF).

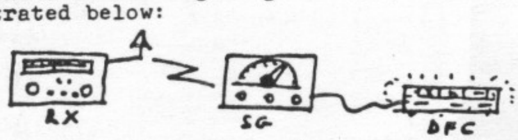
A station's exact frequency and the manner in which it changes is like a fingerprint or a signature; no two are exactly alike. A PFM-FIF combination, if compiled with sufficient accuracy, is such a fingerprint, and as long as no other station has a similar reading it may be acceptable for ID purposes and, with the coöperation of a sophisticated chief engineer, even for verification!

PFA, in its coarsest form, is the recognition that a signal on 834 kHz can only be Radio Belize, since no other station uses such an odd channel, but this is hardly "precision". Were another station to claim Belize's channel, then the reading would have to be accurate to the point that a difference would be noted in the two frequencies. To the nearest Hertz, Belize has been running steadily for a year on 834044 Hz; even if ten more stations were to occupy that channel, the chance of any one of them repeating Belize's frequency would be extremely remote. This is a radical example, however; on the average crowded channel a PFM to the Hertz is necessary in order to come up with a unique reading among the others present.

Methods of Frequency Measurement

PFA officially recognises only two methods of accurately measuring station frequencies to the nearest Hertz; other methods are inefficient or subject to intolerable error (e.g., use of the BFO or local oscillator.) One such acceptable method is indirect counter measurement (ICM), the other is called the "heteroscope" method (HSM).

1) Indirect Counter Measurement (ICM). Special instruments required are a digital frequency counter (One of Heathkit's "IB" series is recommended) and a stable signal generator. The set-up is illustrated below:



Note that there is no direct connexion to the receiver; the generator signal is "broadcast" to it.

Before beginning, warm up everything for at least a half hour. Calibrate the clock of the DFC with the highest WWV frequency available (usually 15 MHz at night).

The author has noted that even the primitive IB-101 has a very stable time base that will easily restrict its deviations to within one Hertz for several hours, even at the 15-MHz level; this means only a maximum error of +/- .07 Hz at MW frequencies, an ignorable factor if readings are only to be taken to the Hertz.

Measure the frequency in question by zero-beating the generator signal against that of the station; either steady the needle on the S-meter or form a circular lissajou on the oscilloscope. To insure accuracy, take several such readings, starting from scratch each time.

An alternative variation does not zero-beat the two signals, instead they are offset just enough to cause a very-low sub-audible heterodyne (SAH) which is then read against a watch "pulse-taking" fashion and either added or subtracted from the counter reading. Many find this method to be the easier of the two.

The average total error inherent in the ICM method is slightly over a Hertz in deviation, but the "mean" error is somewhat less than that figure.

2) Heteroscope Method (HSM). Special instruments required are an oscilloscope and a crystal calibrator. Again, warm things up, then align both the calibrator and the o'scope sweep scale against WWV.

As the reader can guess, the calibrator is used to form a heterodyne, which is then read on the scope by counting sine-wave peaks against the sweep scale. The HSM can be quite accurate, approaching that of the ICM method, but greater care is required in WWV alignment since there are more factors present for inherent error.

One definite advantage of the HSM is that it can measure the deviation limits of FM'ed signals, such as Rumbo-525; this is impossible with the ICM method. FM'ed signals may be recognised on the o'scope as a blurred sine wave, and on the counter as an inability to zero beat.

Statistical Analysis of Measurements

The frequency integrity figure (FIF) that forms an integral part of any PFA reading consists of at least four bits of data. We will use Titania-825 to illustrate the derivation of this data:

Titania	4 Nov 74	824 983
"	11 Nov 74	824 985
"	18 Nov 74	824 987
"	25 Nov 74	824 989

The average reading is 824 986.

The highest reading is 824 989 (+3).

The lowest reading is 824 983 (-3).

The standard deviation, to the nearest Hertz, is 3 (S3).

The readings cover a period of three weeks (3w).

And the frequency tends to increase at a rate of 2 Hz per week (+2w).

Putting the data together:

"Titania (PFA): 824 986 / +3,-3;S3;3w;+2w"

Of course, most stations don't show a steady drift in frequency, so the "+2w" is a "miscellaneous" figure. Note a second sample:

"Rumbo (PFA): 525 18. / +18,-18;S13;3w;F60"

Here the "F60" indicates that the frequency is modulated by a 60-Hz hum.

Other sample PFA's follow:

Artemisa (PFA):	1 158 585 / +4,-2;S2;4w
CMHK (PFA):	1 306 523 / +3,-4;S3; 4w
S.R.S. (PFA):	724 972 / +1,-3;S2;3w
Belize (PFA):	834 043 / +1,-2;S1;3w
Orientales (PFA):	1 155 241 / +2,-3;S2;3w
Omega (PFA):	625 479 / +15,-15;S9;5w
WSM (PFA):	650 000 / +0,-0;S0;2y

Obviously, a PFA is far more useful to the DX'er than a singular PFM, since the FIF gives an indication of what a frequency can and will do. Omega may easily be found 9 Hz off its stated frequency, but certainly not Belize, and definitely not WSM! In fact, you can almost bet your life on WSM's exact frequency!

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In the case of WSM, it may serve as a "standard reference frequency" (SRF) by which other signals may be measured.

By the way, the indication "(PFA):" should accompany each reading (as above), so that it may be distinguished from similar systems. Appropriate dates are also a must to include.

Referencing PFA Data

At present, few DX'ers have the necessary equipment to make good use of PFA's, let alone measure and compile such data, but we would like to describe two possible systems that are both fairly accurate as well as inexpensive.

1) Sub-Audible Heterodyne Analysis (SAHA). These are the heterodynes that oscillate your S-meter. The object is to count the complete swings of the needle over a period of time, compute the frequency, then to compare it with published PFA's. E.G., station A has a PFA of 1484 007, and that of station B is 1483 998. If your S-meter dips at the rate of 9 Hz, then stations A and B are the likely culprits. § SAHA is already a widely-used technique among trans-atlantic DX'ers.

2) Heterodyne Pitch Analysis (HPA). Credit to Edmunds and Taylor (NJ) for first publicising this "poor man's frequency meter";i.e., a guitar, piano, pitch pipe, etc. Here the object is to determine what musical note corresponds to the heterodyne in the speaker, then reference the table below:

A	.0275	.055	.110	.22	.44	.88	1.8
B♭	.029	.058	.117	.23	.47	.93	1.9
B	.031	.062	.123	.25	.49	.99	2
C	.033	.065	.131	.26	.52	1.05	2.1
C#	.035	.069	.139	.28	.55	1.11	2.2
D	.037	.073	.147	.29	.59	1.17	2.35
E♭	.039	.078	.156	.31	.62	1.24	2.5
E	.041	.082	.165	.33	.66	1.3	2.6
F	.044	.087	.175	.35	.70	1.4	2.8
F#	.046	.092	.185	.37	.74	1.5	3
G	.049	.098	.196	.39	.78	1.6	3.1
G#	.052	.104	.208	.42	.83	1.7	3.3
A'	.055	.110	.22	.44	.88	1.8	3.5

The figures are in kiloHertz; they are to be added or subtracted as appropriate to determine the approximate frequency, which is then referenced to a published list of PFA's.