TAMING THE DOPPLER SHIFT

Franck Tonna, F5SE[*]

In the following development, it is supposed that two EME stations, respectively called A and B, are using equipment allowing receiving and transmitting on different frequencies.

Theory

Parameter definition table

F_A : transmitting frequency of station A (further on shorted as "A").
Δ_A : one-way (up to Moon or down from Moon) Doppler shift of A[1].
F_{AA} : receiving frequency of A's echo by A itself.
F_B : transmitting frequency of station B (further on shorted as "B").
Δ_B : one-way Doppler shift of B.
F_{BB} : receiving frequency of B's echo by B itself.
F_{AB} : frequency of A as received by B.
F_{BA} : frequency of B as received by A.

Frequency of A's echo[2] as received by A itself:

$$F_{AA} = F_A + 2\Delta_A \tag{1}$$

Frequency of A's echo as received by B:

$$F_{AB} = F_A + \Delta_A + \Delta_B \tag{2}$$

B tunes its receiving frequency such as $F_{BB} = F_{AB}$. This is the frequency displayed by B's receiver.

$$F_{BB} = F_B + 2\Delta_B \tag{3}$$

If B wants to hear its own echo on the same frequency as that of A, its transmitting frequency F_B must be tuned as follows, in order to take into account the two-way (or round trip, or Earth-Moon-Earth trip) Doppler effect as observed by B.

$$F_B = F_{BB} - 2\Delta_B \tag{4}$$

Then, A will receive B on the frequency F_{BA}, such as:

$$F_{BA} = F_B + \Delta_B + \Delta_A \tag{5}$$

which can be re-written as follows, replacing F_B by its value given by (4):

$$F_{BA} = F_{BB} - 2\Delta_B + \Delta_B + \Delta_A \tag{6}$$

$$F_{BA} = F_{BB} - \Delta_B + \Delta_A \tag{7}$$

but as $F_{BB} = F_{AB}$ [see comment between (2) and (3)], (3) can be modified such as:

$$F_{BB} = F_A + \Delta_A + \Delta_B \tag{8}$$

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1) Algebraic (signed) values – *not* absolute values – of Doppler shift are taken into account here.

2) For complete information, see *High accuracy computing of Doppler-Fizeau effect*, Franck Tonna F5SE, proceedings of the 11th EME conference, Trenton, NJ, USA, 2004. The author can directly send copies of the paper upon request.

replacing F_{BB} in (7) by its value given by (8), we finally get:

$$F_{BA} = F_A + \Delta_A + \Delta_B - \Delta_B + \Delta_A \quad (9)$$

$$F_{BA} = F_A + 2\Delta_A \quad (10)$$

which reduces to:

$$\boxed{F_{BA} = F_{AA}} \quad (11)$$

In plain language, it means B is received by A ***on the same frequency as that of its own echo.*** Reciprocally, A is received by B ***on the same frequency as that of its own echo too.***

Taming the Doppler shift: the practical way

In order to operate on the right frequencies as discribed above, it is recommended to know in advance the amount of Doppler shift on both A's and B's echoes. Today's tracking softwares now deliver precise Doppler data for a given station located on a given place at a given time.

Several solutions are possible for proper "taming".

1) If the transceiver is fitted with a frequency offset control (called "RIT", "clarifier" or else according to various manufacturer's breeds), first tune the rig on any frequency. Then turn the offset control up or down according to Doppler data. In most cases, the frequency offset control adjusts the receiving frequency of the transceiver. In other words, the displayed frequency is the transmitting frequency, and the receiving frequency is corrected by the offset control. In that case, the control goes in the same sense as that of the Doppler data ("–" sign for "down", "+" sign or <blank> for "up").
2) If the transceiver can operate on so-called split receiving and transmitting frequencies, or if separate receiver and transmitter are used, take the transmitter's frequency as the reference and tune the receiver's frequency up or down around TX value, according to estimated or computed (whenever available) Doppler data.
3) If the rig can be computer controlled – the "top of the top" case – then, there is no Doppler problem any longer !! The computer reads the receiving frequency from the rig and sends the accordingly Doppler corrected transmitting frequency to the rig whenever required.

Note that in the first two cases, it is not necessary to know in advance the amount of Doppler shift on the lower bands (50, 144, 432 and 1296 MHz). Searching the echo by moving up or down the frequency offset control still remains easy for finding the echo, but on the higher bands, the knowledge of the accurate Doppler amount becomes more and more "badly needed" as the frequency goes up.

Remember ! If both stations A and B can hear themselves on the same frequency as one's own respective echo, this does not mean their respective rig is tuned on the same frequency !

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* kozton@free.fr