

D F METHOD

In standard direction finding techniques a target radio source is located by means of using at least two fixed direction finding (DF) receiving sites with directional antennas as shown in Figure 1.

From these two sites measurements of the bearing to a transmitter target can be made using the directional antennas at the sites. The intersection on the bearings from sites X and Y gives the estimated position of the target T.

Two further techniques may be applied for locating the target T from X and Y.

First, measurement of the signal strength from the target T simultaneously at X and Y can give a measure of relative distance of T from the two receiver sites X and Y and thus give two possible positions for the target T (see Figure 2). The ambiguity of the two possible target positions may be resolved by using either directional antennas at X and Y or a third receiving site Z.

Second, the time of arrival (TOA) of a uniquely identifiable part of the transmission from T at the receiving sites X and Y can be measured. This as in the former case gives a measure of the relative distances of the target T from the receiving stations X and Y. The ambiguities may be resolved by the use of either directional antennas or a third receiving site as above.

The latter two techniques require accurate synchronization of the timings between receiver sites, although this can be overcome using differential and calibration techniques.

In practice, either one or a combination of these techniques will be applied.

In all of these cases the accuracy with which the target is located is dependent on the accuracy of the receiver site locations and orientations and for practical operation at high accuracy these receiver sites are normally surveyed.

The need for surveying of fixed tracking station position and the difficulties of adequately map reading the position of a mobile tracking station can introduce substantial errors. These errors may be multiplied by the DF process.

The invention is defined in the appended claims to which reference should now be made.

A preferred embodiment of the invention provides for the automatic measurement of position and orientation of the DF receiving sites to allow the use of transportable and mobile DF receivers to give automatic and continuous target tracking. The illustrated embodiment may be used in a system designed for tracking stolen vehicles such as trucks or lorries.

The invention will be described by way of example with reference to the drawings, in which:

Figure 1 (referred to above) is a basic diagram of a tracking system;

Figure 2 (referred to above) shows how the system resolves an ambiguity;

Figure 3 is a block diagram of a receiving station embodying the invention; and

Figure 4 shows a system incorporating several such receiving stations.

The system layout for a receiving station is shown in Figure 3.

The DF receiver 1 is connected to a directional antenna array 2. The DF receiver outputs the bearing ϕ of the target relative to the DF platform and also outputs other relevant parameters such as signal strength s and time of arrival information t . This information is passed to the data processor 3.

An automatic heading device 4 gives the heading of the DF platform with respect to North, θ . This heading may be derived by any heading sensor (for example, a magnetic compass or a gyro compass) provided the value θ is available as an output to the data processor 3.

The data processor combines the bearing output from the DF receiver, ϕ , with the heading device output, θ , to form the azimuth to the target from the DF antenna, ψ , as

$$\psi = \phi + \theta$$

This combination and measurement process is done in real time.

In accordance with this invention, an automatic location device 5 provides the real-time location of the DF antenna in terms of suitable co-ordinates (x, y); for example, these may be either latitude and longitude or grid co-ordinates. The location device could for example, be based on any form of radionavigation system, inertial navigators or other means provided an output of position is available in real-time. The location co-ordinates are provided to the data processor 3.

A time measuring device 6 may be used optionally with the system to provide a means of accurately time-stamping information with the time T. The timing device provides an output of the time T to the data processor 3.

The timing device may derive its time from the location device in some circumstances (for example if the Global Positioning System is used for location).

The data processor 3 obtains the information from the DF receiver, the automatic heading device, the automatic location device and optionally the time device and provides an output in real-time of the DF azimuth ψ , and other relevant DF parameters such as signal strength s, and time of arrival information t. In addition the output also contains the position information (x, y) obtained at the same time as the DF information. The output also may contain the time information T to determine when the DF information was gathered. Otherwise the time of gathering is derived from the time when the data is output from the data processor. The output from the data processor is transmitted to the control point via a communications link 7.

The overall system configuration is shown in Figure 4.

A number of receiving stations 10 send their DF data to the control point 11. Information from at least two stations is necessary to compute a target position.

The information from the stations about the target is of the form:

ψ_i Azimuth from receiving station i to target.
 (x_i, y_i) Position of receiving station.
 s_i, t_i DF information.
 T_i Time.

Because the positions of the receiving stations are accurately known at the instant of measuring the target signal and the azimuths ψ_i are also known at that instant, conventional DF techniques may be applied using these position baselines to determine the target position.

It is important to note that the positions (x_i, y_i) can change dynamically, as can also the orientation of the DF antenna. The positions are measured directly and the antenna orientation is compensated for using information from the real-time heading device.

The position information about the target is computable at the control point whenever the target is transmitting whether the receiving stations are either in motion or stationary. The present system therefore also removes the need to perform a separate accurate survey of the DF receiver position and orientation.



CLAIMS

1. A mobile or transportable direction finding receiving station, comprising a DF receiver with directional antenna for determining the direction of the target in relation to the DF receiver, an automatic heading device for compensating for changes in the receiver orientation, an automatic location device for determining in real-time the position of the DF receiver, and means for transmitting the DF receiver position and information concerning the target position to a control point.
2. A receiving station according to claim 1, further comprising a time device.
3. A receiving station according to claim 1 or 2, in which the receiving station is mounted on a land vehicle.
4. A target tracking system comprising a plurality of stations according to claim 1, 2 or 3, connected to a control point where computations of target position are performed.
5. A system according to claim 4, in which the control point is integrated with one of the receiving stations.
6. A system according to claims 4 or 5, in which target positions can be calculated when the receiver stations are moving.
7. A system according to claims 4 or 5, in which target positions can be calculated when the receiver stations are stationary and have not been separately surveyed in position and orientation.



8. A method of tracking a transmitting target with the use of plurality of mobile or transportable direction finding receiving stations, in which each receiving station provides a measurement of target position, characterized by automatically determining the instantaneous location of each receiving station in real-time by means of an electronic location device at the receiving station.
9. A method according to claim 8, including receiving stations which are mounted on land vehicles.
10. A target tracking system substantially as herein described with reference to Figures 3 and 4 of the drawings.