

Course 7'

Echo control methods. Echo suppressing and canceling techniques

Echo control with attenuation

- The safety margin to oscillation (whistling) depends directly of the open-loop attenuation: $a_{\text{open-loop}} = a_{t-t} + a_{t-r} + a_{\text{bal-1}} + a_{\text{bal-2}}$ (1) (see fig.1);
 - each term depends on the frequency;
 - an increase with 1dB of attenuations a_{t-t} and a_{t-r} means an increase with 2dB of the safety margin to oscillation; the talker echo is supplementary attenuated with 2dB and the listener echo with 3dB
 - if the signal level have to be maintained an increase with 1dB of attenuations a_{t-t} and a_{t-r} induces 1dB attenuation of the talker echo and 2dB attenuation of the listener echo

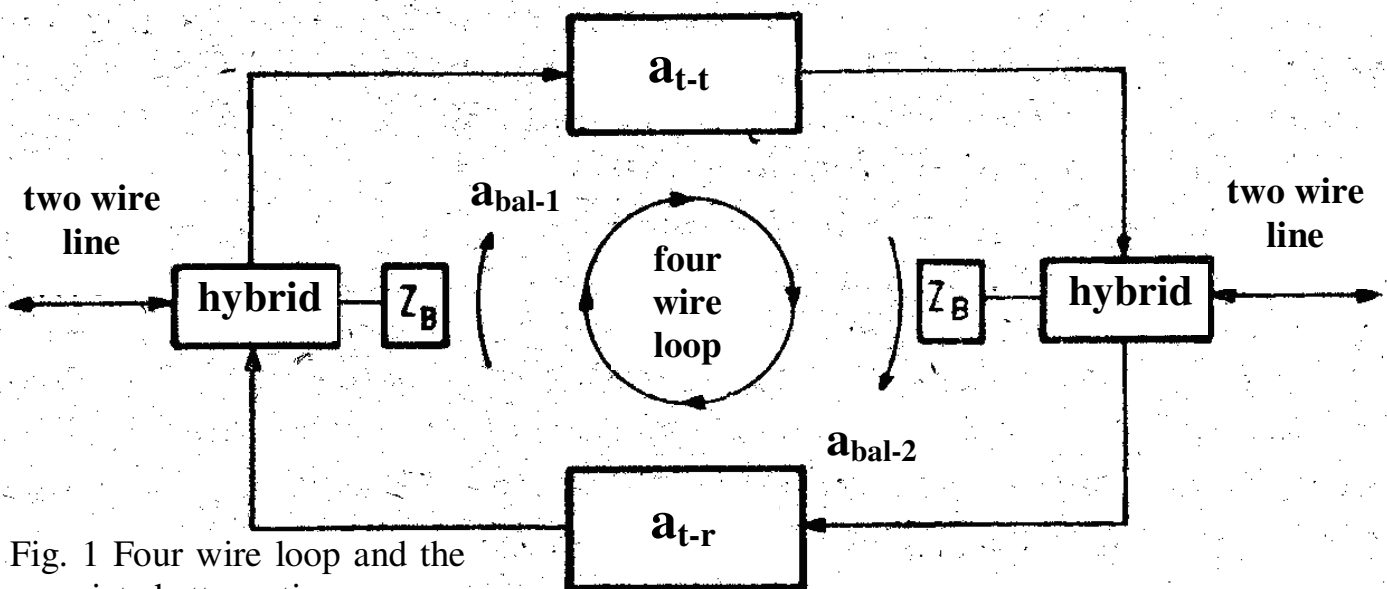


Fig. 1 Four wire loop and the associated attenuations

- A better approach is a controlled insertion of the attenuation – the effect of the echo increases with the increase of the global (transmit-receive) delay on the connection – attenuators are inserted on the distant transmission paths as the length of the path increases.
- The use of the attenuation for the echo control is an inadequate solution for high delays, because the attenuation of the transmitted signal becomes very large; the method may be used for sections up to 2000km.

Echo suppressor

- This device inserts a high attenuation (even interruption) in a connection on one of the transmission directions;
 - the result is that the echo signal has a high attenuation;
 - the purpose is to insert a high attenuation in the opposite direction of the currently active voice path, supposing that at a given moment the voice signal is transmitted just in a single direction;
 - inevitably an amplitude limitation is inserted during the time when both person speak, or even the telephone circuit is forced to function in half-duplex mode;
 - in the case of data transmissions the echo suppressor is deactivated with a signal transmitted by the modems (2100Hz) ensuring in this way a full-duplex transmission
- The functioning principle is explained in a simplified manner in fig. 2. ;
 - the most difficult problem is to chose a correct strategy for the double speaking periods;
 - when the propagation delay is high it is difficult to detect and handle in an appropriate manner the double speaking;
 - it is not possible to cascade two suppressor because it could happen a blocking of the circuits during the double speaking.

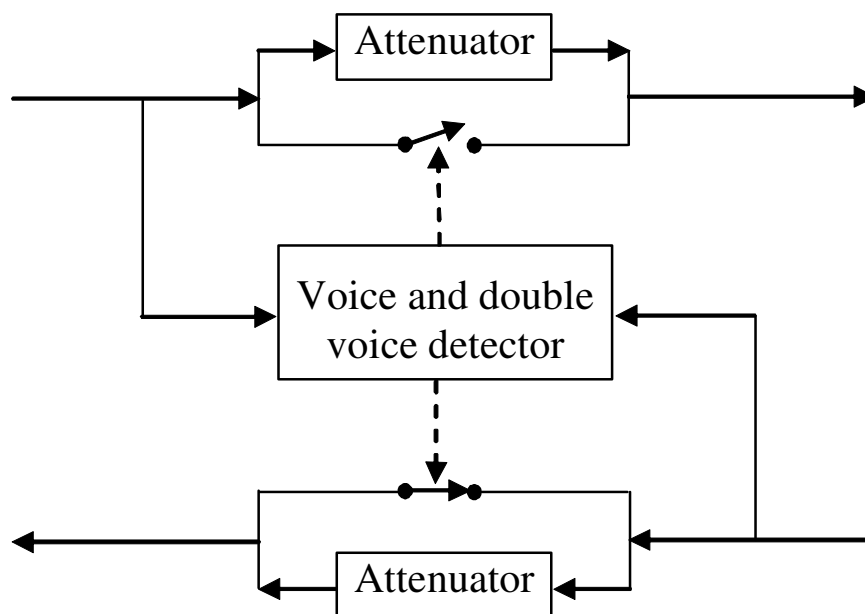


Fig. 2 Working principle of the echo suppressor

Echo compensator (echo canceller)

- The functioning of this circuit is based on the estimation of the echo path characteristics, from the input point (a), through the differential system and up to the output point (b);
 - this function is implemented by the so called echo estimator – it generates a signal identical with the one created on the echo path and the estimated signal is subtracted from the transmitted signal affected by the echo (fig. 3).

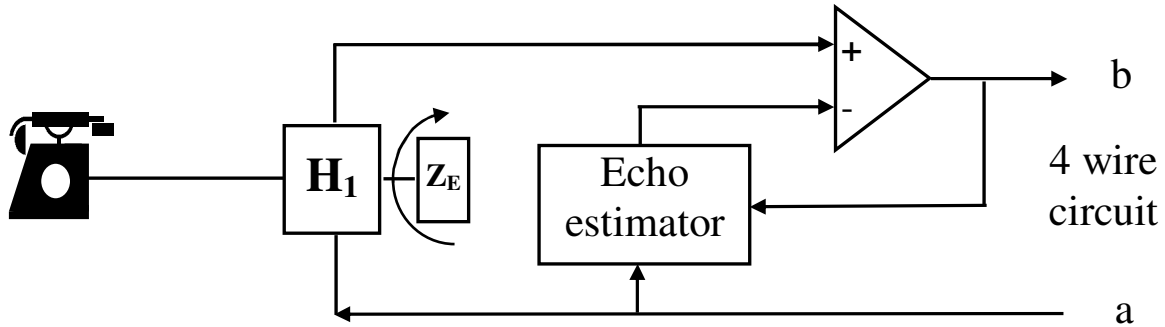


Fig. 3 Functioning principle of the echo compensator

- The block schematic and more details related to the functioning of the echo compensator are given in fig. 4
 - the signal of the distant speaker is $y(t)$, the unwanted echo is $r(t)$, the signal of the proximate speaker is $x(t)$; $y(t)$ is the reference signal for the echo compensator and it is used to generate a replica of the echo $r(t)$ – this replica is subtracted from the signal composed of the proximate speaker signal plus the echo.

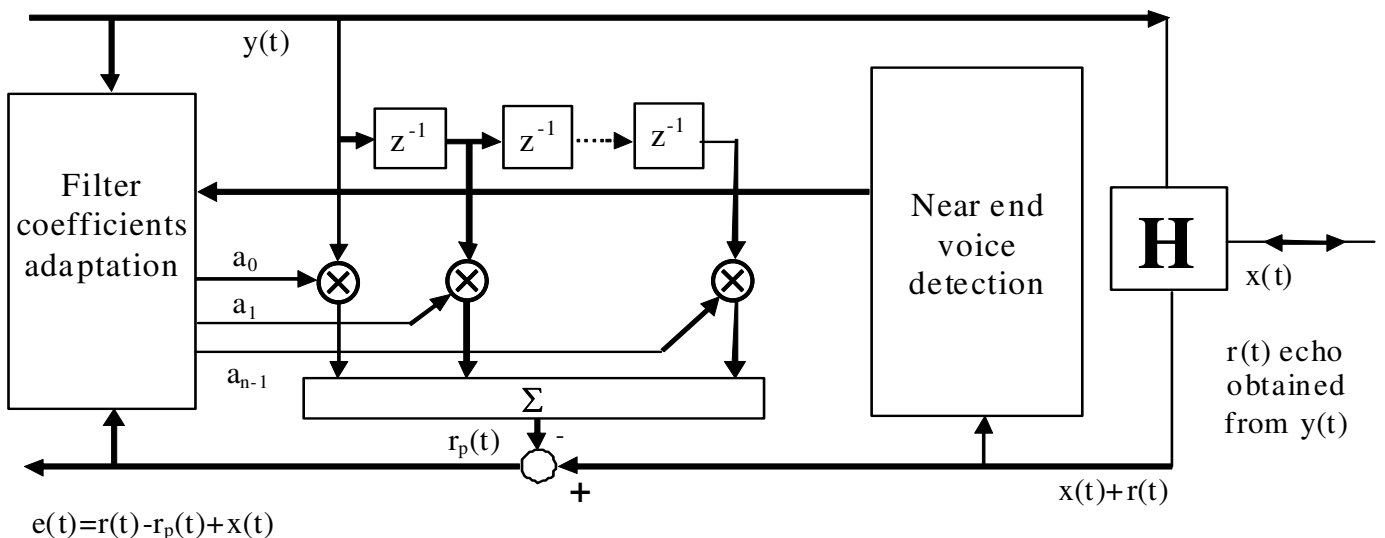


Fig. 4 Block schematic of the echo compensator

- the echo replica, $r_p(t)$, is generated applying the reference signal to a digital transversal filter – the filter coefficients are adapted to the echo transfer function.
- the compensator coefficients are modified in such a way to decrease the error $e(t)$; $e(t) = r(t) - r_p(t)$ - coefficient adaptation is possible only if $x(t) = 0 \Rightarrow$ near end voice detection is necessary.

- The echo compensation in both directions can be achieved using the configuration presented in fig. 5;
 - the echo compensation for a speaker is made at the other end of the connection;
 - it is desirable a two block configuration to ensure the same delay for both echoes – the number of coefficients of echo compensator depends on the echo delay – in the presented configuration the delay between the reference signal and the echo is minimum.

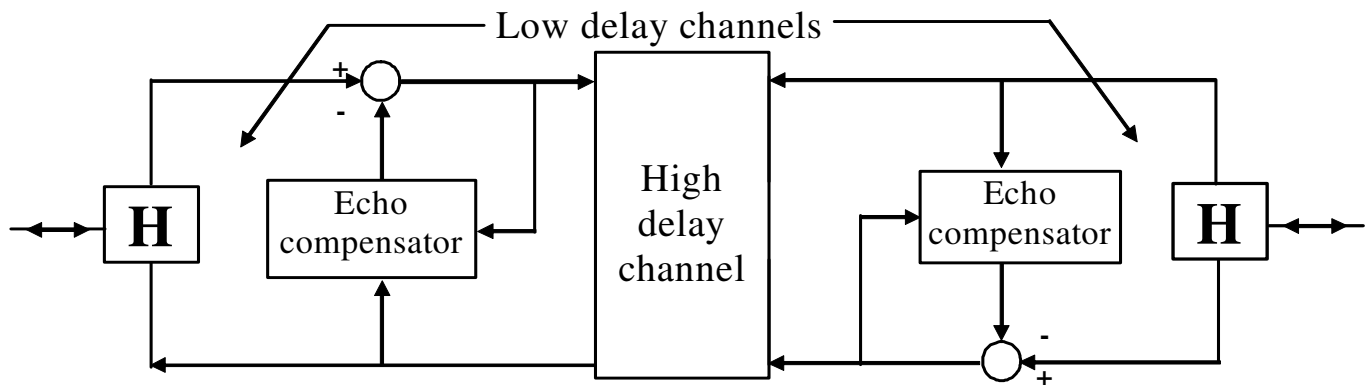


Fig. 5 Echo compensation in both directions

- The echo compensators are connected to the input of long distance channels – for ex. channels used in international connections
 - in a digital network the echo compensators could be connected to the input of the channels included in a PCM multiplex used in international connections.
- In fig. 6 it is presented a continuous time echo compensator (uses analog signals);
 - practically it is the schematic of the electronic hybrid which includes two voltage dividers controlled by the error signal;
 - it is a simple and economic structure with only two freedom degrees, but in voice applications can achieve a proper compensation of the echo.
 - it can be used in analog long distance connections or in digital transit exchanges which connect analog transit exchanges

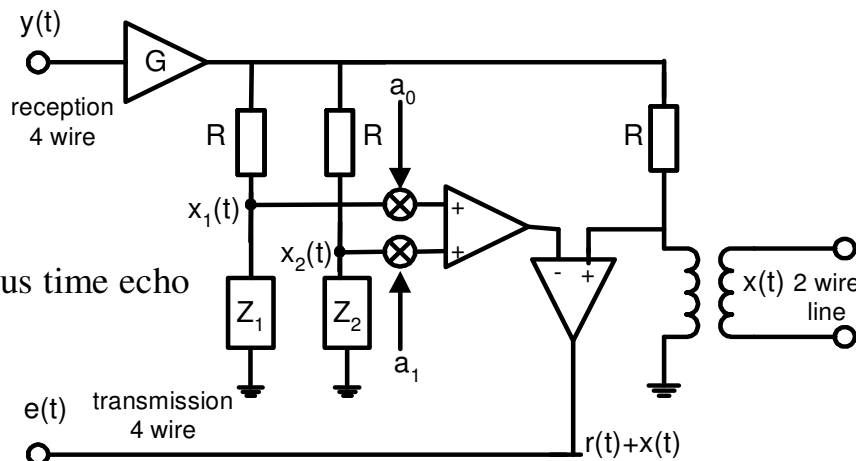


Fig. 6 Continuous time echo compensator