# Fractionally Spaced Adaptive Equalizer: A Review

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***Abstract:*** Due to non-linear channel behaviour, the bit error rate at the receiver side increases and receiver is not able to recognize the signal levels. Equalizer play an important role is such situations and is designed to have an impulse response which is reciprocal to the response of the channel, hence resulting in an overall linear response. As channel response is not static in nature, so equalizer should have adaptation property. Different adaptive equalizers have been quoted in literature, but due to their performance superiority and the availability of variants stochastic gradient algorithm that mitigate coefficient drift during decision-directed operation, fractionally spaced adaptive equalizers are gaining vital importance these days. This paper presents a detailed insight into the structure and superiority of fractionally spaced adaptive equalizers.

**Key Words:** *Adaptive, Bit Error Rate, Channel, Fractionally Spaced Equalizer, Signal to Noise Ratio.*

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## 1. INTRODUCTION

In communication, multi-path effect causes signal fading. Multi-path effect means that signals transmitted from a transmitter may have multiple copies traversing different paths to reach a receiver. Thus, at the receiver, the received signals should be the sum of all these multi-path signals. Because the paths traversed by these signals are different; some are longer and some are shorter. The one should be the shortest at the direction of light of signal (LOS) and interaction of these signals occur with each other. If signals are in phase, they would intensify the resultant signal; otherwise, the resultant signal is weakened due to out of phase. This phenomenon is called channel fading [1, 2].

Here, removing the channel's distortion has a vital importance. The ideal aim of the receiver is to recover the original symbols without error, the distortions or inter-symbol interference (ISI) caused by the channel, noise and other sources are tried to be minimized and this is done by equalizers. The channel has amplitude and phase dispersion which results in the interference of the transmitted signals with one another. To overcome this problem, the need of equalizers arise. The design of the transmitters and receivers depends on the assumption of the channel transfer function is known. But, in most of the applications of digital communications, the transfer function of the channel is not known at enough level to incorporate filters to remove the channel effect at the transmitters and receivers. For example, in circuit switching communications, the transfer function of the channel is usually constant, but, for every different path, it changes from the transmitter to the receiver. But, there are also non stationary channels such as wireless communications. The transfer functions of these channels vary with time, so that it is not possible to use an optimum filter for these types of channels. So, equalizers are designed in order to solve this problem. Equalizer is meant to work in such a way that BER (Bit Error Rate) should be low and SNR (Signal-to-Noise Ratio) should be high [1].

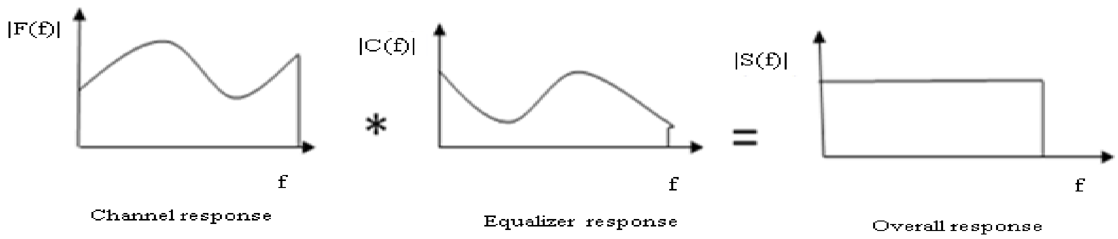


*Fig.1. Concept of equalizer*

Equalizer gives the inverse of channel to the Received signal and combination of channel and equalizer gives a flat frequency response and linear phase [2,3].

## 2. FRACTIONALLY SPACED ADAPTIVE EQUALIZER

A Fractionally Spaced Adaptive Equalizer [5] is a linear equalizer that is similar to a symbol-spaced linear equalizer. However, a Fractionally Spaced Equalizer receives say K input samples before it produces one output sample and updates the weights, where K is an integer. , The value K is 2 in many applications. The output sample rate and the input

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sample rate are 1/T and K/T respectively. The weight-updating occurs at the output rate, which is the slower rate.

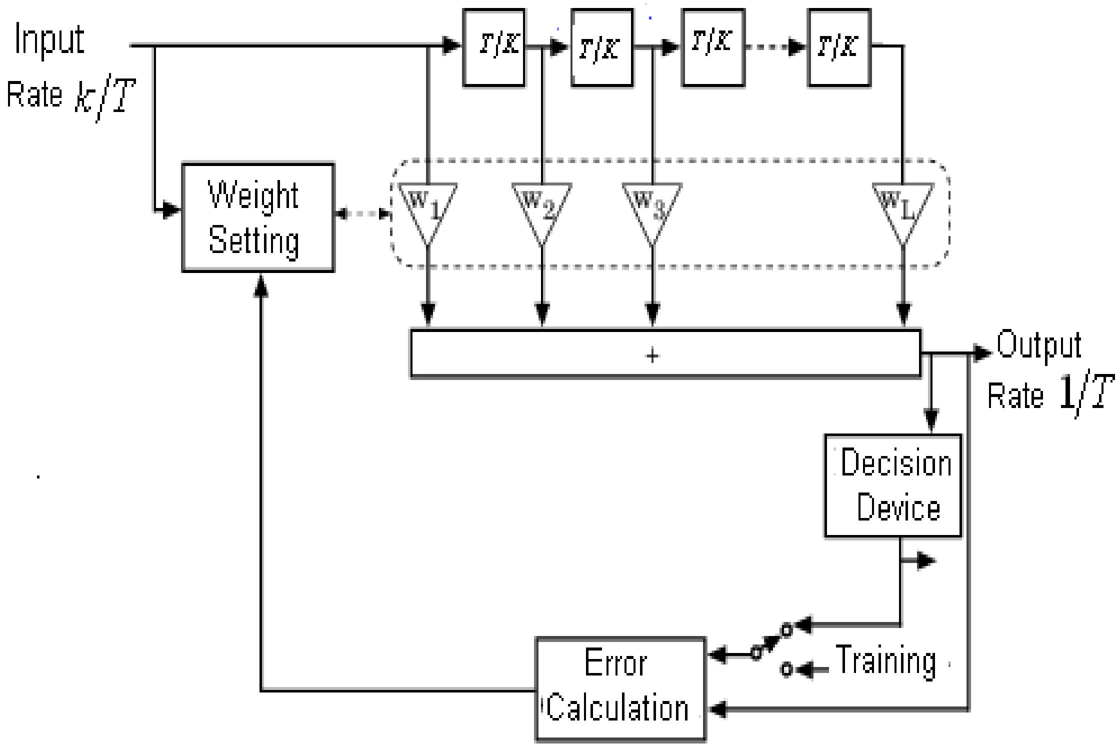


*Fig.2. Fractionally Spaced Adaptive Equalizer [5]*

Sometimes the input to the equalizer is oversampled such that the sample interval is shorter than the symbol interval and the resulting equalizer is said to be Fractionally Spaced Adaptive Equalizer. Equalizer Taps are spaced closer than the reciprocal of symbol rate. FSE have advantages such as it has ability to be not affected by aliasing problem, it shows fast convergence and it's sample rate is less the symbol rate.

## 3. SUPERIORITY OF FRACTIONALLY SPACED ADAPTIVE EQUALIZER

More recently, Fractionally Spaced Adaptive Equalizers (FSE's) have assumed an increasing presence, especially in the area of voice band data transmission. This is the technological shift which is based upon at least two factors: first, the performance superiority of FSE's relative to that of Conventional equalizer and second, the availability of variants on the conventional stochastic gradient algorithm that mitigate coefficient drift during decision-directed operation. With regard to the former, many studies have clarified the performance attributes of FSE's. It is known, for example, that Conventional equalizer operates on an aliased spectrum of the received signal, thus rendering performance acutely sensitive to timing phase of the receiver. However, FSE's are far less sensitive to timing phase provided the delay line tap spacing $T'$ is less than or equal to the reciprocal of twice the highest frequency component present in the transmitted signal. Due to which fractional equalizers compensate for timing phase offset or channel delay within the limits of their finite tapped delay lines (TDL).

As an additional attribute, FSE's theoretically approach the properties of an optimal receiver. Operating in the presence of Gaussian noise, the mean-square distortion between the estimated binary data and actual sampler output is minimized, as is the average error probability. Theoretically, the performance of infinite fractional equalizers can also be shown to be independent of channel phase or timing phase. To the extent that FSE's can operate on the unaliased input spectrum and thus permit operation with Nyquist channel spectra up to the baud frequency, they can also be used to minimize the timing jitter's effects relative to that of Synchronous equalizer, offering more robust operation.

FSE performance for voice band channels has been extensively studied. In simulations reported by [6], 48 tap, "$T/2$" $(T')$ fractional equalizers were compared to 24 tap Conventional equalizer in a 9.6 kb/s 4-level QAM system and were found to offer superior performance. In the earlier work of [7], simulations for somewhat different channels and system characteristics showed FSE's almost as good as or better than Conventional equalizer counterparts, although

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the numbers of taps were the same in each equalizer. In spite of their advantages, only lately have FSE's been seriously considered for high-speed digital radio where they can improve the effects of dispersion caused by not normal propagation.

Probably, The tardy application is due to the satisfactory operation of Synchronous equalizer for low-level QAM systems and the complexity of implementing the least mean-square (LMS) algorithm. It should be mentioned that in spite of the widely cited advantages of the linear LMS algorithm relative to zero-forcing (ZF), the latter is almost universally used in digital radio systems.

**4. CONCLUSION**

Among the equalizers like Fractionally Spaced Adaptive Equalizer (FSE)**,** Blind Equalization**,** Decision-Feedback Equalization**,** Linear Phase Equalizer,T-Shaped Equalizer**,** Dual Mode EqualizerandSymbol spaced Equalizer, the Fractional Spaced Adaptive Equalizer shows better performance. Because it has ability to be not affected by aliasing problem, shows fast convergence and sample rate is less the symbol rate and better ISI mitigation over the other equalizers. Thus fractionally spaced equalizers can be explored in the design of adaptive equalizer in a fast fading environment.

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