An advanced self-interference cancellation method for a 5G communication network in CCFD systems using an optimized LMS algorithm

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Abstract:
The objective of this paper is to explore 5G mobile communication technology. The core provisions of the fifth generation technology of mobile communication, which is considered as consumer oriented, are the main contribution of this article. In comparison to other technologies, the mobile consumer has given the highest emphasis to 5G technology. The goal of 5G technology is to employ mobile phones with extremely high bandwidth. Consumers have never had access to such high value technology as 5G. All types of advanced characteristics are included in 5G technologies, making it the most dominant technology in the near future. The DTV-LMS method is utilised in this paper. This algorithm's computing complexity is maintained to a minimum. The DTV-LMS algorithm is used to cancel the self-interference signal in the radio frequency domain of a full duplex system. The recommended algorithm has a higher ICR in the RF domain and a faster convergence speed than the examined approaches, according to the analysis and simulation results. Simultaneously, CCFD systems' channel tracking capability has been greatly increased.

***IndexTerms* -** Interference calculation ratio, self-interference self-cancellation, optimized least mean square algorithm, radio frequency domain.

I Introduction:

The 5G mobile communication system has generated a lot of controversy, and it promises to be far more capable than the present 4G system [1]. Traditional duplex approaches, such as time division and frequency division duplex, can't completely utilise electrical spectrum resources. As a result, future capacity development will be limited due to a lack of spectral efficiency. The utilization of spectrum has been improved by the revolution of full duplex [2]. It is the technology that sends and receives at the same time with the same range of frequency. The broadcast signal is recorded by the antenna used for receiving the signals in the CCFD transmitters. An effective self-interference cancellation process is required for CCFD transceivers [3, 4]. Air interface cancellation module, analogue cancellation module and digital cancellation module are the three modules in SIC [5]. Fortunately, microwave-photonics techniques can effectively address the drawbacks of electrical analogue cancellation methods. [6] Proposes a 5.5 GHz optical analogue SIC technique that achieves a 30 dB cancellation ratio. It is achieved by using two lasers that are externally modulated, a variable optical attenuator and a delay line. The tolerance to optical phase variation and the instability of polarization state induced by heat and mechanical disturbances are limited because of the two sources and the channels that are optical with different fiber lengths are required [7].All optical components including two directly modulated lasers, three semiconductor optical amplifiers and a pair of photo diodes that are balanced onto a single substrate are combined to solve the issues. In most real world applications, not only do the used optical and electrical components have uneven frequency responses, but they also have multi path effects. An optical delay line is used to compensate the uneven frequency response in the electrical components [8]. The reference signal is subjected to the digital pre-distortion technology to eliminate multiple path interferences. Meanwhile, optical components are used to create multi parallel AGC-delayer-subtract or structures in order to produce optical analogue multipath equalizers [9]. The multiple path equalizers in both digital and analogue signals are effective for unequal frequency response of the optical and electrical components. This paper proposes an advanced algorithm based on the attenuation of the convergence parameters that are used to tackle the above mentioned defects which are in the existing methods. The proposed algorithm is the DTV-LMS algorithm which is introduced to cancel the interference in the wireless networks by using some mathematical methods [10, 11]. The proposed method uses an arctangent function to change the step size using an error signal correlation value and the time parameters. The multiple path effects does not address about the elimination of non-linear distortions which are generated by the optical and the electrical components. As a result, at low computational complexity, this technique can preserve ideal properties [12].

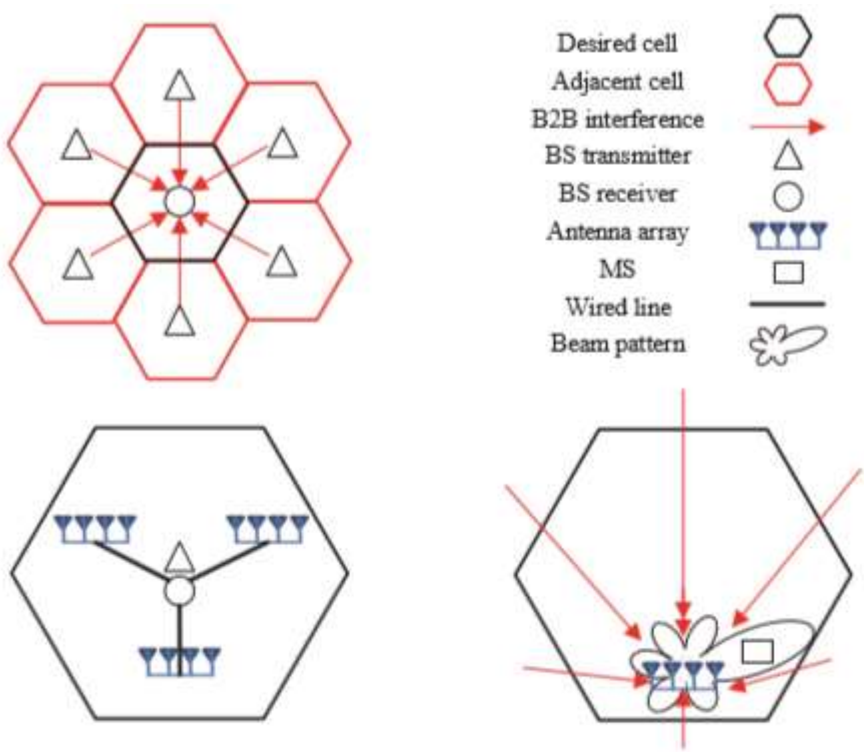

Fig 1: CCFD model

II Related work:

The Existing research in mobile communication is related to 5G technology. The researchers are related to the development of the world wide wireless web. Dynamic ad-hoc wireless networks and real wireless communication 5G technology is used to make mobile phones with very high bandwidth. Direct radio frequency coupling cancellation structures are now used in the majority of radio frequency self-interference cancellation research in the CCFD system. Self-interference with DRFCC works by using a portion of the RF channel as a reference signal, which is then directly connected to the transmitter. The self-interference signal is generated by altering the phase, latency and amplitude of the reference signal. The linear and non-linear self-interference signal can be suppressed by generating it. The radio frequency channel requires a separate transmitting channel. But the DRFCC does not requires a separate channel and additional runtime .It reduces the run time and the amount of memory that is required during the runtime. The Least Mean Square technique is a fast descent-based optimization application of the Wiener filtering theory. It benefits from a straightforward principle, minimal computational cost, and ease of implementation. The rate of convergence and the steady state error are the drawbacks of the LMS algorithm. To address the fault of the LMS algorithm the variable step size least mean square algorithm is designed. The VSSLMS algorithm adjusts the step size factor based on a prediction error signal. The applicability of the algorithm is limited, because steady-state misalignment is prevalent during convergence, which does not ensure precision. The sigmoid function is used. Apart from rapid convergence time the algorithm has a high complexity and high load computation and the size of error will fluctuate as the value nears zero. This is a problem for the stability of the algorithm. The system's ability to track channels was not fully exploited because it was focused on maximising the pace of convergence through efficient dynamic power allocation. The step and the mean square instantaneous error were shown to be linked. This method has good tracking capabilities and a fast convergence time, however it has poor anti jamming capabilities. To tune the parameters of the multiple self-interference cancellation signal a channel estimation approach is used. But there is no performance analysis. It is recommended to use a variable step size strategy with a larger value near convergence time to reduce SSM error and a smaller number near convergence time to increase convergence speed. Noise and other circumstances, on the other hand, might readily influence this approach.

III Proposed model:

The near end and far end nodes of a double node CCFD system are used to send and receive data in the same frequency spectrum on both ends of the link. The transceiver model for the system is presented below. At the transmitting end, the signal that is transmitted is converted to $s(n)$, and the output signal $s(t)$ is obtained via digital to analogue conversion. Not only does the signal received contain $r_0(t)$ the intended signal r_u (t) from the far end nodes, but it also contains the high power self-interference signal $r_{SI}(t)$ from the close end nodes. The settings of a multiple tap analogue SI canceller can be tuned using a channel estimate approach, but there is no performance analysis. To reduce SSM error and boost convergence speed, utilise a variable step size technique with a bigger value near convergence time and a lower number near convergence time.

$$s(t) = \sqrt{2P_n s(n)\cos(2\pi f c t + \varphi_n)} \qquad (1)$$

$$r_o(t) = r_{SI}(t) + r_u(t) + n(t) \qquad (2)$$

$$r_{SI}(t) = h_{SI}(t) * s(t) \qquad (3)$$

$$r_{SI}(t) = h_{SI}(t) * s(t) = k_n s(t - t_n) \qquad (4)$$

$$e(t) = r_0(t) - r_1(t) = r_{SI}(t) + r_u(t) + n(t) - r_1(t) \qquad (5)$$

Where r_1(t) is the estimated SI signal

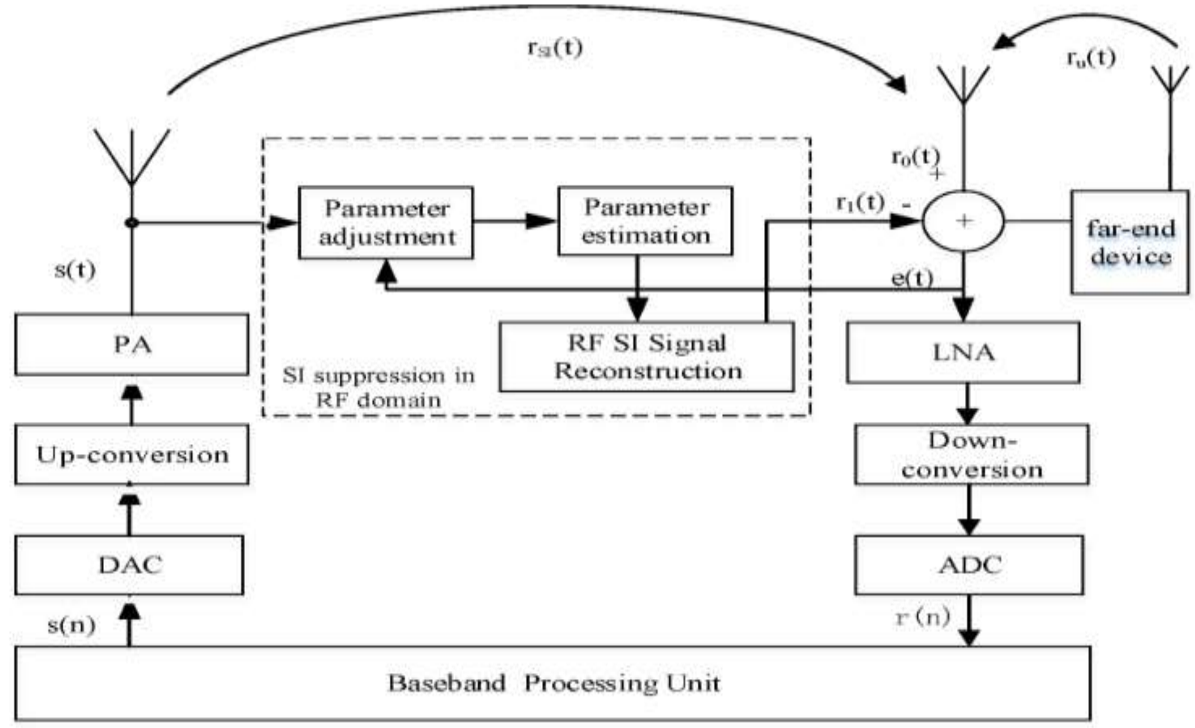

Fig 2: The proposed system model.

3.1 Mathematical model:

By synthesizing a vector with the same information properties the self-interference signal can be neutralized. After a group delay the transmitting signal in the near end is divided into two branches. The delay block represents the estimated interference signal's group delay.

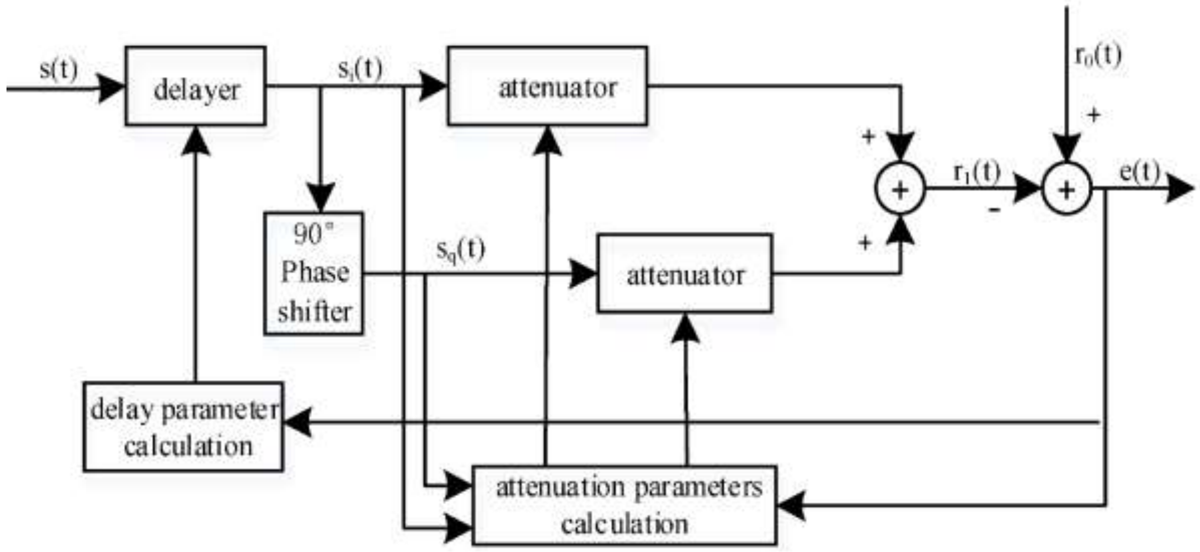

Fig 3: Self-interference cancellation diagram.

Changing the value of W (t) in the above-mentioned cancellation technique can change the amplitude of the in phase and orthogonal components, and the self-interference signal can then be reconstructed. As a result, the weight vector has the greatest influence on self-interference cancellation performance. The following is how the weight vector is modified using the least mean square error criterion.

$$\min\{E(|e(t)|^2)\} = \min\{E(|r_0(t) - r_1(t)|^2)\} \qquad (6)$$

3.2 DTV-LMS algorithm:

In a classical least mean square algorithm, the value of constant is fixed with a convergence range of [0, 1/ max], and max is the input signal's autocorrelation matrix's largest eigenvalue. The LMS algorithm's convergence speed improved with an increase in, however increasing SSM causes an issue. This study proposes the DTV-LMS algorithm, which is an optimised LMS method. To decrease SSM, this method changes the value of the step factor over time.

$$\mu(t) = \alpha \tan^{-1}(-\beta|e(t)e(t-\Delta t|) + 0.4\mu(t-1) \qquad (7)$$

$$W(t+\Delta t) = W(t) + \left[\frac{\mu(t)}{\rho + S^T(t)S(t)}\right] e(t)S(t) \qquad (8)$$

The following steps are used in cancelling the self-interference in the radio frequency domain.
Step1: The training sequence calculates the broadcast and received signals' group delay time.
Step2: Various parameters of the CCFD system model are used to identify the optimal values of parameters α, β.

Step3: When t < 0, set the starting value of the weight vector $W(o)$ to $e(t)$ = r_0(t).
Step4: At intervals of time Δt, the μ (t) is determined, and the weights are modified.
Step5: Determine error signal, e (t) in real time.
Step6: Go to (4).

IV Result analysis:

The statistical analysis of the transmitting signal and the modification of the weight vector is controlled. To put it another way, the algorithm adjusts the weight based on the statistical features of the sending signal. The step generates a mutation as the slope increases, just as the error approaches 0, so α should not be too great. In the same way, 'β' must be carefully chosen.

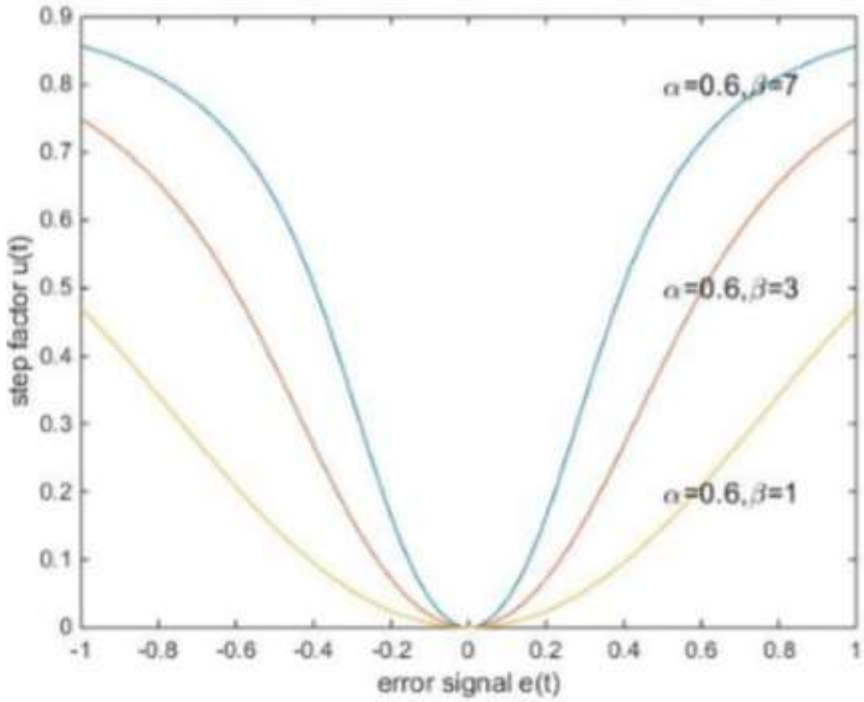

Fig 4: The variation of curves when β changes.

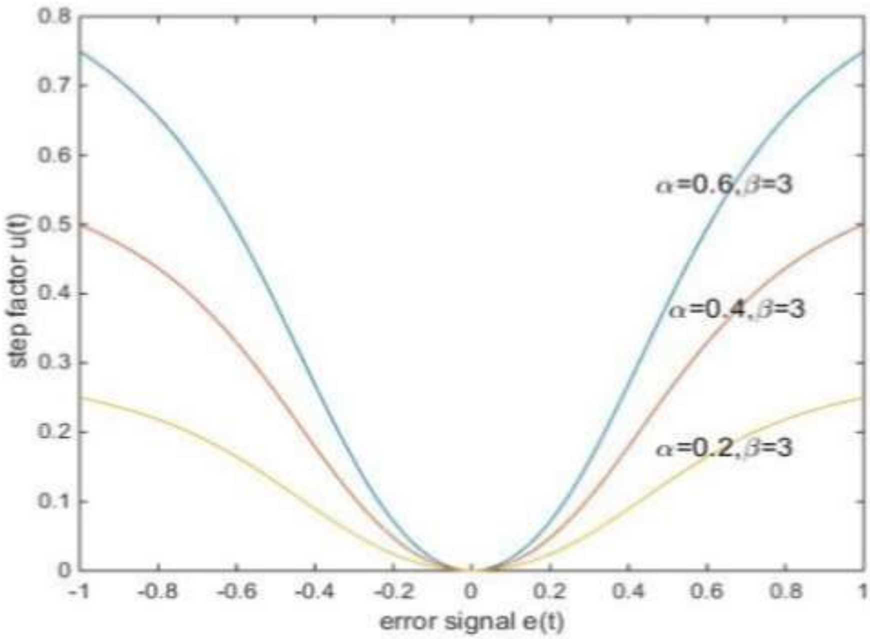

Fig 5: The variation of curves when α changes.

Under the circumstance of parameter 1, all other parameters remained unaltered. The DTV-LMS algorithm's convergence speed lowers as the time interval for the system's feedback control gets longer.

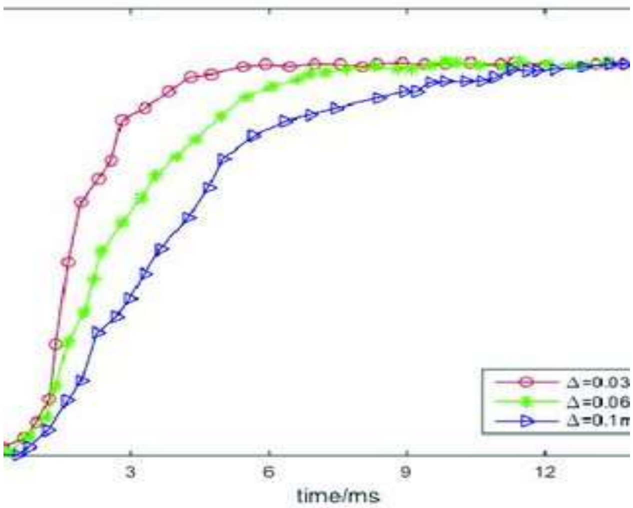

Fig 6: The influence of time intervals on ICR

Conclusion:

The DTV-LMS algorithm, which is an improved LMS approach. For various loading scenarios, the algorithm provides voltage regulation help. The proposed approach solves the CCFD system's radio frequency domain problem. The suggested approach maintains grid system stability while also improving electricity quality. To take advantage of the increase in connected devices, communication networks will need to be substantially upgraded to supply the massive computational and communications power required. From the modest sensor to the complex device, 5G networks will be smarter and more efficient to handle each type of radio spectrum and each type of device. As a result, in a 5G wireless communication environment, it will perform better.

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