LASER DIODE NONLINEARITY COMPENSATION USING FEED-FORWARD LINEARISATION IN A FIBER RADIO SYSTEM

T Ismail, A J Seeds
Department of Electronic and Electrical Engineering, University College London, London

Key words to describe this work: Laser, Intermodulation distortion, Feed-forward linearisation, Fiber Radio

Key Results: Intermodulation distortion of a directly modulated semiconductor laser at 2.4 GHz has been reduced using feed-forward linearisation for a fiber radio system.

How does the work advance the state-of-the-art?: Feed-forward linearisation allows the use of cheap commercial lasers rather then expensive linear lasers to be used in a fiber radio system.

Motivation (Problems addressed): Reduction of directly modulated laser distortion to improve the performance in a fiber radio system.

Introduction

With the increasing demand for broadband mobile services such as wireless local area network (LAN), the integration of wireless and optical networks is a potential solution for increasing capacity and mobility. Wireless LAN systems using the IEEE802.11b standard operate around the 2.4 GHz band, while the IEEE802.11a standard operates in the 5.2 GHz band. Propagation of signals at microwave frequencies require the radio base stations to be closely spaced. The greatly increased number of base stations required to cover a given geographical area and to make these systems commercially available it is important to keep the system cost as low as possible by having simple base stations.

Fiber radio (also known as radio over fiber) is an attractive technology which may be employed. The concept of radio over fiber is to transport information over optical fiber by modulating the light with the radio signal. The fiber radio architecture can give several advantages such as reduced complexity at the antenna site, radio carriers can be allocated dynamically to the different antenna sites, transparency and scalability since much of the processing is done at the central site.

Direct modulation of the laser in these systems gives rise to nonlinear distortion such as third order intermodulation distortion (IMD3) which fall in band to the required frequencies and cannot be filtered easily. Feed-forward linearisation technique is applied to a directly modulated laser to reduce the nonlinear distortion generated at 2.4 GHz for the IEEE802.11b WLAN band in a fiber radio system.

IMD3 suppression of greater then 20 dB is achieved at 2.4 GHz and 10 dB suppression in the frequency range of 2.2 GHz to 2.7 GHz.

In previous work predistortion has been used to remove laser distortion for CATV [1] and cellular applications [2]. However, feed-forward is a more effective technique since it can provide broadband suppression at microwave frequencies and also suppresses higher order distortion products as well as reduce laser relative intensity noise [3].

Feed-forward Experimental Arrangement

The circuit for the feed-forward is shown in Figure 1. The operation of the feed-forward circuit is based on two loops. The inner loop (also known as the error determination loop) and the outer loop (also known as the error injection loop). To test the system we performed direct modulation of the laser at 2.4 GHz. Two tone microwave signals at 2.4 GHz separated by 10 kHz were combined in the combiner. The signal is split at the input splitter. Considering the inner loop, the top path modulates the laser while the second path is the error free reference path. The output of the laser contains distortion due to nonlinearity of the laser. A sample of this signal is detected using a photodetector, amplified and combined with the reference path in the hybrid coupler which also provides 180 degree phase inversion. Since the two signals are out of phase the carriers cancel leaving only the distortion products. The output at the hybrid coupler is then amplified and modulates the second laser and combined with the first laser in the optical coupler and detected using a photodetector. This gives an output which has suppressed distortion products.
The amount of distortion cancellation achieved depends on the amplitude and phase matching of the two canceling signals at the hybrid coupler and at the final coupler.

Results

The output response of the feed-forward system is shown in Figure 2 and in Figure 3. The response in Figure 2 is without feed-forward and it is observed that the IMD3 are approximately 30 dB below the carrier. In Figure 3 feed-forward is applied and the IMD3 are reduced by 20 dB and are now about 50 dB below the carrier [4]. As mentioned earlier amplitude and phase matching is critical for maximum distortion cancellation.

Conclusion

Feed-forward linearisation has been shown as an effective technique for suppressing laser distortion. IMD3 reduction of 20 dB at 2.4 GHz has been achieved. Greater suppression of the distortion products is possible with a more accurate amplitude and phase matching. Further improvements to the feed-forward circuit will allow wideband suppression for the IEEE802.11b band.

References