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A Novel Non Linear Distortion Suppressed, Pre-Compensation for A 10.7-Gb/S System Employing A Directly Modulated Laser

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ABSTRACT

A Novel Framework for investing the electronic compensation for a 10.7-Gb/s system using a directly modulated LASER (DML) approach. The significant usage of digital signal processing and large signal rate equations helps in reducing the non linear distortion which outcomes from direct modulation of laser and to generate an appropriate modulating current. After successful generation of modulation current the proposed scheme is then utilized in a novel look up table optimization scheme for electronic dispersion pre-compensation. Finally the simulation results shows that the proposed theoretical work shows the compensation of 250km approximately using a 21.4GSa/s DIGITAL TO ANALOG CONVERTER and simultaneously 350km approximately using a 42.8GSa/s DAC. Finally the proposed work shows that approximately using a 42.8GSa/s DIGITAL TO ANALOG CONVERTER is sufficient forexploiting the full potential for ELECTRONIC PRE-COMPENSATION using a DML.

KEYWORDS: Electronic pre compensation, Directly modulated laser, Non linear distortion

INTRODUCTION

The usage of modulated semi conductor (direct) lasers is considered as logically proven cost effective mechanism for metro transmission by most of the researchers. The semi conductor lasers have some unique properties such as high output optical power, small output footprint, and low power dissipation which separate it from the remaining conventional approaches. It main contribution is yielding the high output optical power in comparison to external modulated lasers. The main problem which erupts in the metro transmission is that the direct modulated laser performance is limited by wavelength chirp and the limitation of performance shows its impact on transmission distance which is reduced significantly in the absence of inline dispersion compensation to below 30 km.

So many works are reported in the literature to address this problem and to increase the transmission distance and one such work is reported which is based on the fibers with negative dispersion which can increase the transmission speed by 100 km. Another approach is dispersion supported transmission (DST) which makes of low pass electrical filter at the receiver section mainly to compensate the fiber transfer function and the transmission distance is increased up to 250 km. The same 205 km transmission distance is achieved by directly modulating a chirp managed laser (CML). Th main difference between the dispersion supported transmission (DST) and directly modulating a chirp managed laser (CML) is DST requires optimizing the receiver for each transmission distance, while the CML requires an additional wavelength specific module.

Although many works related to the increase the transmission distance reported in the literature but every second approach mainly lacks in terms of performance which mainly impacts the overall system performance. Many research works reveals the fact that directly modulated laser is perfect approach to compensate the speed of the metro transmission. The work DIRECTLY the impact of non linear distortion and this non linear distortion is reduced by pre compensation. The DSP large signal optimization technique helps to mitigate non linear distortion to achieving the 10.7-Gb/s system employing a directly modulated laser. The significant usage of digital signal processing and large signal rate equations helps in reducing the non linear distortion which outcomes from direct modulation of laser and to generate an appropriate modulating current MODULATED LASER mainly depends on the amplitude of the optical filed phase. As a consequence the EDC approach used for externally modulated systems does not apply, as the DML drive current controls both phase and amplitude of the optical field simultaneously. The only thing which lacks in the DIRECTLY MODULATED LASER mechanism is the optimization techniques and this optimization is required to achieve the drive current for 10-Gb/s transmission which is presented in the proposed theoretical work.

The proposed work mainly investigates the electronic pre-compensation under direct modulation as advancement in technology decreases the circuit size which results the declining the cost of the respective circuits and one of the main reasons the proposed work mainly concentrates on the electronic pre-compensation is recent advances in the DSP technological wise. The non linear distortion which is the outcome of direct modulation of the laser is always an area of concern for

PROPOSED SYSTEM MODEL

The following figure:1 shows the proposed system model and in this model the discussion of optical fiber parameters and receiver filter characteristics is done which to design the system employs a non-return-to-zero (NRZ) on-off-keying (OOK) modulation format.

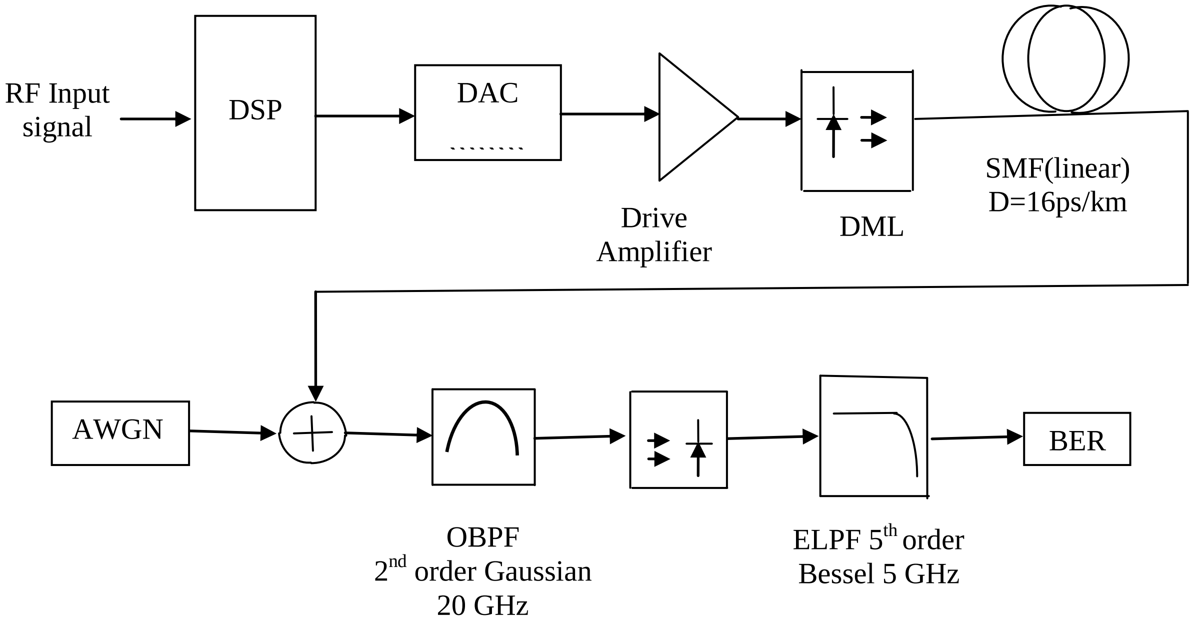


Fig: 1 propos lectronic pre compensation using a DML.

RF: radio-frequency

DSP: digital signal processing

DAC: digital-to-analog converter

DML: directly modulated laser

SMF: single-mode-fiber

AWGN: additive white Gaussian noise

OBPF: optical band pass filter

ELPF: electrical low pass filter

BER: bit-error-rate.

The above all terms are used to built the system model to achieve electronic pre-compensation for a 10.7-Gb/s system employing a directly modulated laser and to reduce non linear distortion which helps to achieve the high transmission distance which lacks in the conventional frameworks. The system models follows as a flow as an algorithm, initially generation of modulation current is a challenging task which can be achieved by following certain DSP steps followed by DAC. After DAC the synthesized modulated current is then applied to the distributed feedback laser with a multi-quantum-well active layer operating at 1535.5 nm in order to exhibit threshold current of 21.1mA. The obtained modulated optical signal generated at the output of the DML is transmitted over a fiber named single mode fiber (SMF) with a dispersion parameter D= 16ps/km/nm, Note that in this non linear behavior is totally neglected. In order to acquire the required OSNR in 0.1 nm resolution bandwidth for a specified BER initially the system must loaded with additive white Gaussian noise (AWGN). The BER was calculated using an exhaustive approach assuming Gaussian noise statistics and taking inter-symbol interference into account. At high modulation frequencies (GHz), the signal from a DML is distorted attributable to the intrinsic resonance within the optical maser cavity. These nonlinear distortions area unit manifested as damped periodic oscillations within the output optical power and chirp many techniques, like feed-forward compensation, optical injection lockup, electronic pre-distortion dual-parallel modulation are planned to suppress these nonlinear distortions. However, these solutions area unit sophisticated to make need electrical or optical feedback and don\'t absolutely adjust the relation between the modulating input current and output optical power. during this section, electronic pre-compensation is employed to mitigate the nonlinear modulation dynamics of a DML transmitter.

The key construct is mistreatment DSP to get a pre-compensated modulating current that produces a prime quality output optical wave

$$\frac{dS(t)}{dt} = \Gamma G\,(N(t) - N_0)\,S(t) - \frac{S(t)}{\tau_p} + \frac{\Gamma\beta_{sp}N(t)}{\tau_p} \quad (1)$$

$$\frac{dN(t)}{dt} = \frac{I(t)}{qV} - \frac{N(t)}{\tau_e} - G\,(NT) - N_0)\,S(t) \quad (2)$$

$$\frac{d\phi(t)}{dt} = \frac{1}{2}\beta_e\left[\Gamma g_0\,(N(t) - N_0) - \frac{1}{\tau_p}\right] \quad (3)$$

$$G = g_0\,/1+\epsilon\,S(t)) \quad (4)$$

Where Γ denotes the mode confinement factor, $N_0$is the carrier density at transparency, τ_p and τ_e are the photon and electron lifetimes respectively, β spis the fraction of spontaneous emission coupled into the lasing mode, q is the electron charge, V is the active layer volume, g_0 is the gain slope constant, ϵ is the line width enhancement factor and is the gain compression factor. The large signal rate equations can be modeled with a constant or coefficient based electron carrier lifetime model for τ_e . The latter approach is adopted in this study as it better approximates the laser dynamics. The spontaneous carrier lifetime is given by τ_e form. The modulation dynamics of a semiconductor optical Laser are determined by suggests that of the big signal rate equations presumptuous a quiet system with oscillations in a very single longitudinal mode higher than threshold. These equations relate the carrier density N(t), photon density S(t) and optical phase ϕ(t)to the modulating current.

$$\tau_e = (A+BN+CN^2)^{-1} \quad (5)$$

Where A is the non radioactive recombination rate, B is the radioactive recombination coefficient and C is the Auger recombination coefficient. The optical power P(t) at the output of the DML is given by

$$P(t) = \frac{S(t)Vn_0\,h(v)}{2\Gamma\tau_p} \quad (6)$$

A fourth-fifth Runge–Kutta algorithm is used to numerically integrate the coupled first order differential. An algebraic back-substitution can be performed to find the ideal required input current which produces a specific target output power profile $P_{tar}(t)$.

$$N_{bc}(t) = \frac{\frac{dS_{tar}(t)}{dt} + \frac{S_{tar}(t)}{\tau_p} + \Gamma GN0Star(t)}{\Gamma GS_{tar}(t) + \frac{\Gamma\beta sp}{\tau_e}} \quad (7)$$

Where $N_{bc}(t)$ denotes the back-calculated carrier density. Note that (7) assumes a constant electron lifetime model for to simplify isolating for $N_{bc}(t)$. In particular τ_e assumes the value elevated at threshold. The non linear distortion which is the outcome of direct modulation of the laser is always an area of concern for researchers and so many literature works proposed in the literature in order to reduce the impact of non linear distortion and this non linear distortion is reduced by pre compensation. The DSP large signal optimization technique helps to mitigate non linear distortion to achieving the 10.7-Gb/s system employing a directly modulated laser. The significant usage of digital signal processing and large signal rate equations helps in reducing the non linear distortion which outcomes from direct modulation of laser and to generate an appropriate modulating current

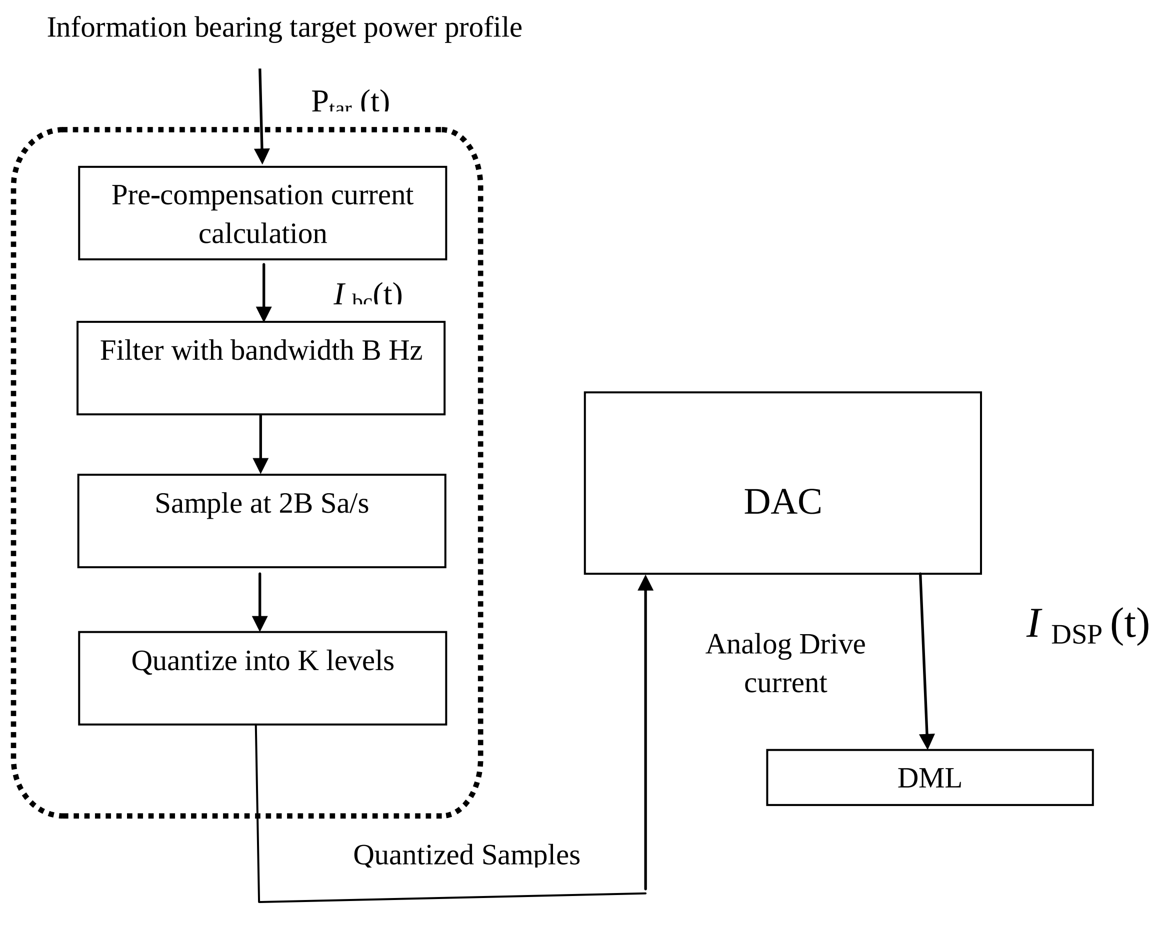


Fig2:DSP Steps involved in Electronic Pre-Compensation

To practically generate the modulating current without analog circuits a sequence of DSP steps is performed as outlined in Fig. 2. Finally, the quantized samples are applied to the DAC. The DAC generates an analog RF signal which is mapped to the DSP generated drive current of the DML denoted I_{DSP}

RESULTS

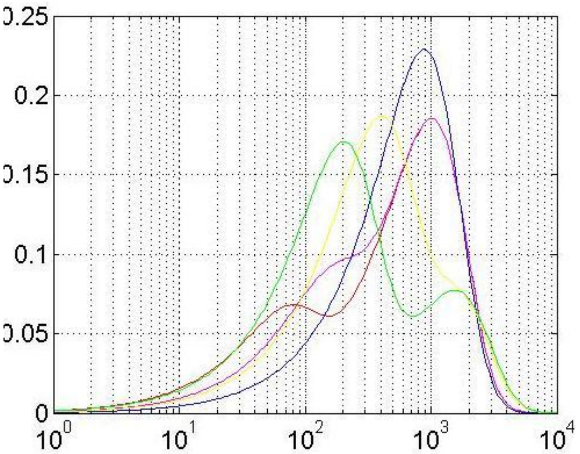


Figure 1: Received electrical eye-diagram (plotted on different scales for clarity)(X-Axis=frequency Offset From Carrier,Y-Axis=optical Power(dbm))

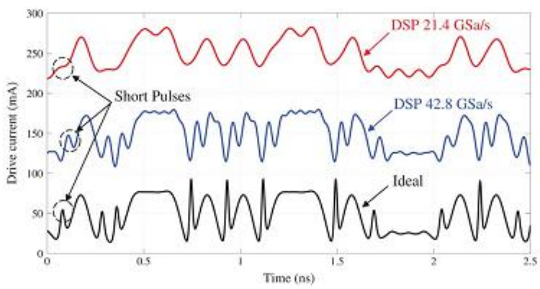
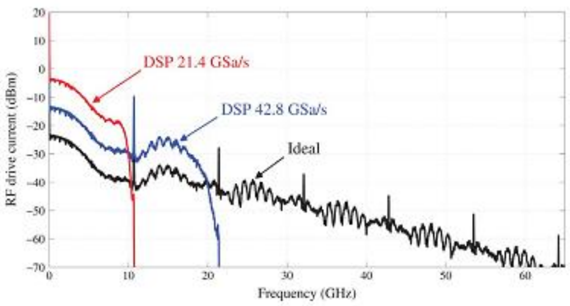


Figure 3: Time domain trace of the ideal drive current required for nonlinear distortion pre-compensation at 10.7-Gb/s



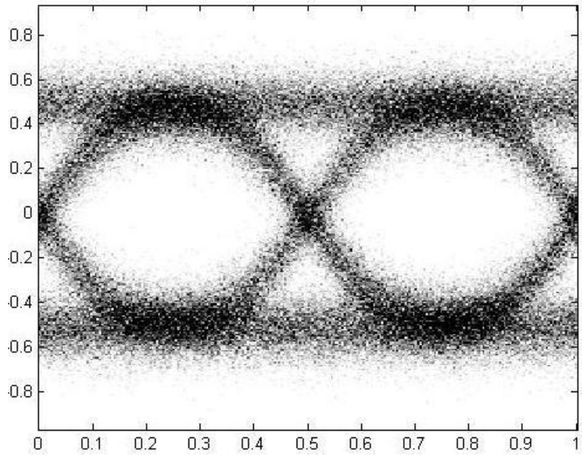


Figure 2: Optical power spectra at the output of the DML (X-Axis=Time,Y-Axis=Amplitude)

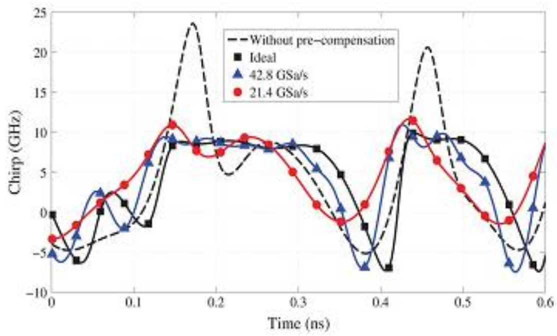


Figure 4: RF spectra of the ideal drive current required for nonlinear distortion pre-compensation at 10.7-Gb/s

Figure 5: Time domain trace of the chirp at the output of the DML, when the laser is driven by the standard RC NRZ signal and DSP generated drive currents

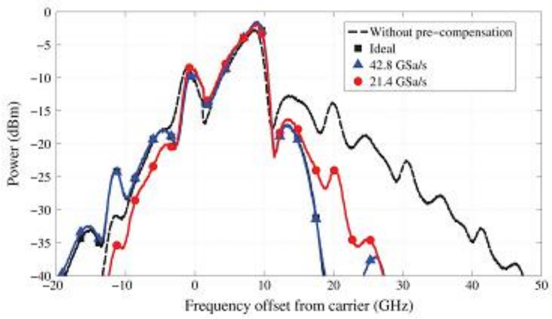


Figure 6: Time domain trace of the chirp at the output of the DML, when the laser is driven by the standard RC NRZ signal and DSP generated drive currents

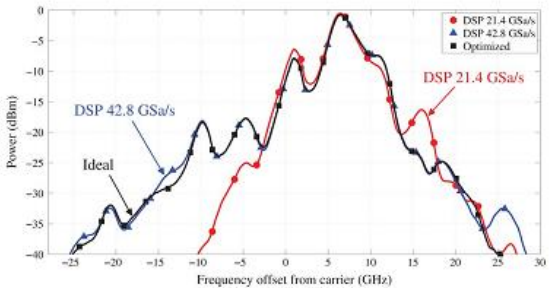


Figure 7: Optical power spectra at the output of the DML, when the laser is driven by the optimized and DSP generated EDC currents for 200 km

ELAPSED TIME IN MINUTES	TIME FOR PROPAGATING EACH SAMPLE IN SECONDS
3	0.4783
4	0.3482
5	0.13982
6	0.03368

nMAX	3
aLIN	0.25
Bknm	7x4x4 double

BPQLC WITH PROPERTIES

CONCLUSION

The non linear distortion that is that the outcome of direct modulation of the optical device is usually a part of concern for researchers and then several literature works planned within the literature so as to cut back the impact of non linear distortion. a completely unique approach is bestowed during this paper that primarily presents the theoretical presentation of f electronic pre-compensation for a ten.7-Gb/s system using a directly modulated optical device. The pre-compensation usage will with success mitigates the impact of non linear distortion and helps to get the modulating current and also the pre-compensation that square measure victimisation here square measure primarily depends on the usage of DSP and reversal of medium to giant signal rate equations that is that the outcome of direct modulation of the optical device. Finally the simulation results shows that the planned theoretical work shows the compensation of 250km more or less employing a twenty one.4GSa/s DAC and at the same time 350km more or less employing a forty two.8GSa/s DAC. Finally the planned work shows that more or less employing a forty two.8GSa/s DAC is enough for exploiting the total potential for EDC employing a DML.

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