OPTICAL CLOCK DISTRIBUTION USING A MODE-LOCKED SEMI-CONDUCTIOR LASER DIODE SYSTEM

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Optical clock distribution has been achieved by using a modelocked semiconductor laser diode system as the master timing device. The optical clock has demonstrated a fanout of 1024, while maintaining less than 12 psec of jitter on the recovered clock signal for periods of over one hour.[1] This type of clock distribution technique demonstrates a method to overcome fundamental problems associated with conventional electronic clock distribution techniques.

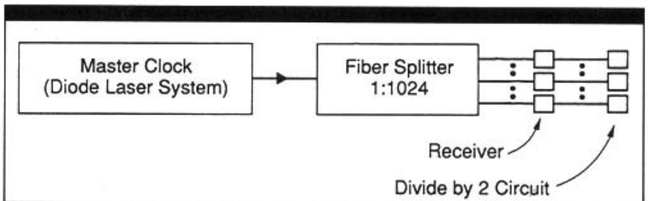
The distribution of the master clock in high speed digital switching machines is a long-standing problem. Design difficulties emerge when typical distances between synchronously clocked integrated circuits become comparable to the product of the signal propagation velocity and the clock rise time. Additional difficulties arise at high clocking rates, where typical integrated circuit gate delays are a significant fraction of the clock period. In this case, impedance matching issues of transmission lines become extremely important.

Photonics offers new insight into the solutions of these problems. The optical clock can be considered as a transformation of a wide baseband electrical clock signal to a narrowband optical signal, thus eliminating impedance matching problems and other difficulties of generating and propagating wide bandwidth electrical signals.[2]

The experimental arrangement is diagrammed schematically in the figure. The master clock is a hybrid modelocked semiconductor laser system operating at 830 nm. This laser system is used as a source of extremely low jitter intense optical pulses. It produces a train of 460 fsec optical pulses with over 70 watts of peak power at 302 MHz. The pulse duration and peak power of the generated optical pulses are both the shortest and the most intense ever produced from an all semiconductor laser diode based system.[3] The optical pulse train produced by this system was distributed to 1024 ports using an optical fiber splitter. At the output of the fiber splitter, the optical pulse train was detected and amplified using a commercial 700 MHz OE receiver, with a 1V/mW sensitivity at 850 nm. The output of the receiver was then used to drive a divide-by-two ECL logic circuit to generate the square wave clocking waveform.

The pulse to pulse timing jitter of the modelocked pulse train was first measured to determine the lower bound of the timing jitter. This was accomplished by using standard frequency domain techniques[4] and was measured to be less than 0.5 psec in a 100 second interval. The extremely low timing jitter and high power contained in the optical pulse train are the key features that enable this optical source to be used as a master clock in an optically distributed clocking network.

We have performed electrical measurements of the total dynamic clock jitter between any two outputs over a period of time. Measurements of this kind yielded a total pulse to pulse jitter of approximately 12 psec over periods of approximately 1 hour. This 12 psec result represents total excursion ($>6\sigma$) and includes all sources of jitter, correlated and uncorrelated, rapidly varying and slowing varying, including optical reflections, possibilities of modal noise, and temporal and thermal variations of the electronics. To our knowledge, these results represent the largest fanout with the minimum amount of timing jitter for an optical distributed clocking network.



SCHEMATIC DIAGRAM OF THE OPTICALLY DISTRIBUTED CLOCKING NETWORK.

REFERENCES

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