MMA Project Book, Chapter 8, Section 3

PHOTONIC SYSTEMS

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Revision History
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Summary

The relatively new field of microwave photonics may have several applications in the MMA apart from the local oscillator generation described in 7.1. There are two further possible applications.

1) A round-trip phase measurement system for the local oscillator distribution.

2) A phase and amplitude calibration system.

Table 8.3.1 Principal milestones for photonic systems applications.

	Task	Completion Date
1)	Demonstration of round-trip correction over 1 Km of fiber	1999-04
2)	Demonstration of calibration system at 80-100 GHz	1999-03

8.3 Photonic Systems

8.3.1 Introduction

The possible application of microwave photonics to the MMA local oscillator system is dealt with elsewhere in this project book (Chapter 7.1, *Photonic Local Oscillator*). However, there are at least two more possible applications of this fast growing field for the MMA. The first is a system to continuously measure the delay in the propagation of the local oscillator signal by measuring the round-trip distance. The second is the calibration system by which a coherent signal is generated and transmitted into the receiver system. This system is described in the section on calibration hardware (Chapter 3.2, *Calibration: Hardware*).

8.3.2 Round Trip Optical Phase Correction

8.3.2.1 Introduction

As with any coherent interferometer, changes in phase of the local oscillator (LO) at all antennas must be measured and accounted for. In the conventional system, the high frequency LO is phase locked to a low (around 10 GHz) reference signal distributed to the array elements via optical fiber. Changes in the path length of this fiber, due to, for example, temperature changes or mechanical stress, result in apparent path length changes to the radio source. The specification for these path length changes is that they be measured to an accuracy of 17 microns. In this section, a method is outlined for measuring the lengths using a purely optical method that uses recently developed, commercially available optical components.

8.3.2.2 Principle of Method

The principal of the method is shown in Figure 8.3.1. Although the principal is shown here as applied to the laser LO system, the method is applicable to the conventional LO system also. The key recent technological advance here is the availability of highly stable, very narrow line-width lasers. For example, erbium doped fiber lasers are now available that have linewidths of less than 10 KHz and frequency stabilities of better than 10 MHZ per hour. With this coherence length and stability, it becomes possible to continuously measure the length of the fiber from the central location to the receiver to a precision of better than one wavelength at 1.5 microns.

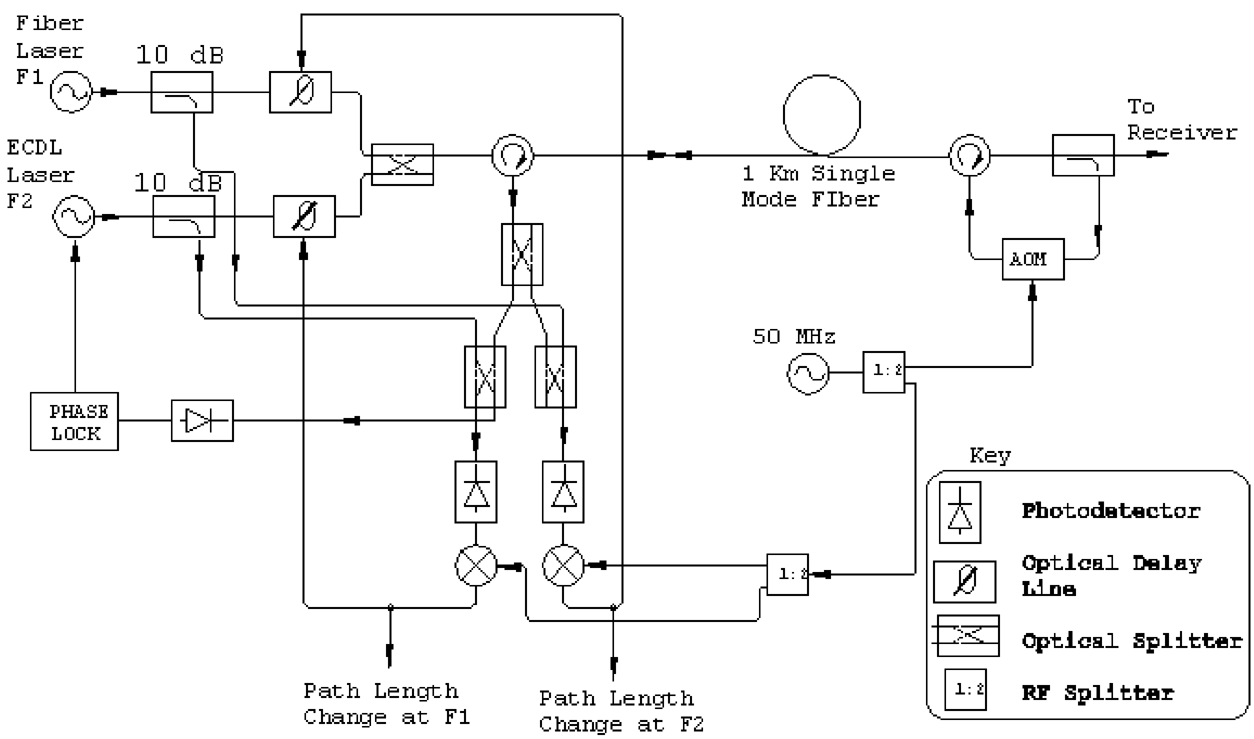

Figure 8.3.1 Local Oscillator Generation with Round-trip Correction

8.3.2.3 Details of the Method

Refer to Figure 8.3.1, which shows the principal applied to the laser LO system previously described. The two lasers at frequencies F1 and F2 are combined after a small amount of signal is coupled from each. The phase locking circuitry described in MMA Memo #200, *Photonic Local Oscillator for the MMA* results in the difference frequency equaling the desired LO frequency. At the far end of the fiber, probably within the receiver, a portion of the optical signal is frequency shifted about 50 MHz and is returned to the central location where the frequency-shifted optical signal for each laser is mixed with the outgoing un-shifted signal. The phase of the resulting beat note for each laser frequency is then used to close a servo loop for each laser frequency with a piezo line stretcher. The electrical input to each line stretcher is then a direct measure of twice the change in path length through the fiber at each optical frequency.

8.3.2.4 Development Goal

We hope to demonstrate this system and measure the effectiveness of the correction at an LO frequency of 50 GHz using all commercial components by early 1999.

8.3.3 Phase and Amplitude Calibration.

This method of calibration is described more fully in Chapter 3.2, *Calibration: Hardware* . The method consists of radiating a coherent signal from a small broad-band antenna in the center of the subreflector. The signal will be generated in the manner outlined in 8.3.2 above with the round-trip measurement system incorporated.

8.3.3.1 Development Work

Combined with the development work described in 8.3.2., we hope to be able to demonstrate the transmission of a phase-stable tone at 100 GHz into a receiver by 1999-03. If successful, we will focus on the design of an integrated photo-diode/quasi-optical combination with the goal of achieving maximum frequency coverage.