IEEE 802.3aq Task Force
Dynamic Channel Model Ad Hoc
Task 2 - Time variation & modal noise
9/15/2004 con-call

Time variance in MMF links – initial test results

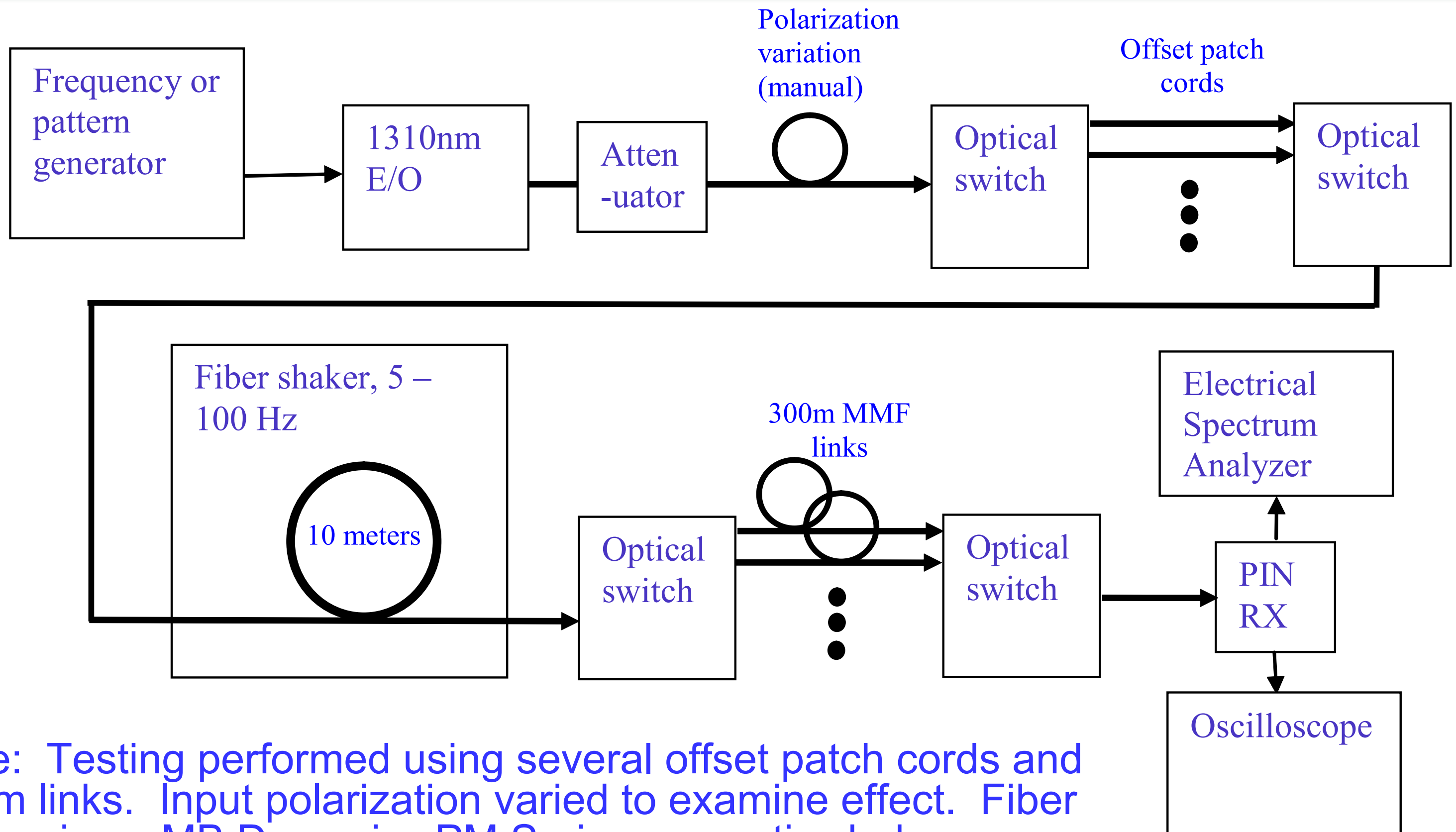
Rob Coenen

Overview

Based on the formulation presented at the August 18th 2004 con-call, measurements were made of the maximum dynamic channel variation rate in response to a vibration at a known frequency .

The test set-up is shown on the following slide.

Time variance test set-up.



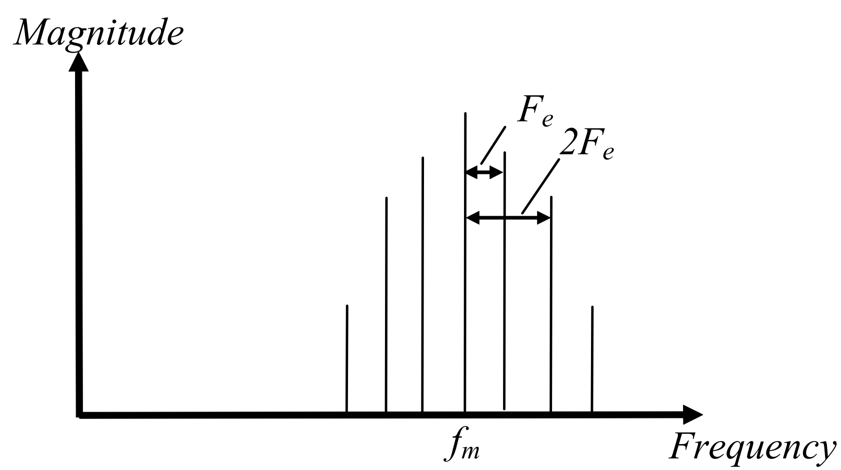
Note: Testing performed using several offset patch cords and 300m links. Input polarization varied to examine effect. Fiber shaker is an MB Dynamics PM Series magnetic shaker

Review of conclusions of contribution *"Measuring channel variation in MMF"*

- The contribution states that the equation for the channel time variation due to mechanical vibration will take on the form:

$$P_{out}(t) = [P_o + P_m \cos(\omega_m t)] \left\{ \begin{array}{l} (I_{11}a_1)^2 + (I_{21}a_2)^2 + (I_{31}a_3)^2 + (I_{12}a_1)^2 + (I_{22}a_2)^2 + \ldots \\ 2(I_{11}a_1 I_{21}a_2)\cos((\theta_1 + \sigma_1) - (\theta_2 + \sigma_1)) + \\ 2(I_{11}a_1 I_{31}a_3)\cos((\theta_1 + \sigma_1) - (\theta_3 + \sigma_1)) + \\ 2(I_{21}a_2 I_{31}a_3)\cos((\theta_2 + \sigma_1) - (\theta_3 + \sigma_1)) + \\ 2(I_{11}a_1 I_{12}a_1)\cos((\theta_1 + \sigma_1) - (\theta_1 + \sigma_2)) + \\ 2(I_{11}a_1 I_{13}a_1)\cos((\theta_1 + \sigma_1) - (\theta_1 + \sigma_3)) + \ldots \end{array} \right\}$$

- For the case of a sinusoidal input to the E/O, the channel variations due to mechanical vibration will result in sidebands upon the resulting received signal spectrum at multiples of the mechanical vibration frequency.



Testing

- Using the test set-up shown, the 10m fiber coil was mechanically shaken on two axis (laid flat and hanging upright). Various frequencies between 10 and 100 Hz were examined with a shaker deflection of up to 5mm.
- As of this writing, only time-domain oscilloscope observations and measurements were taken. Test equipment issues prevented inclusion of spectral analysis results. These will be included in a future contribution.

Test results, Observations:

- Only vibrations with the coil hanging upright produced significant time variations, as this configuration results in significant fiber deflection.
- Inclusion of the FC connectors at either end of the coil did not noticeably increase the magnitude of the channel variations.
- Over the measured 10-100 Hz range, frequencies that resonated with the fiber coil caused the greatest amount of fiber deflection and appeared to create the greatest magnitude of channel variation. Thus, the higher vibration frequencies can result in less channel variation than the lower frequencies.

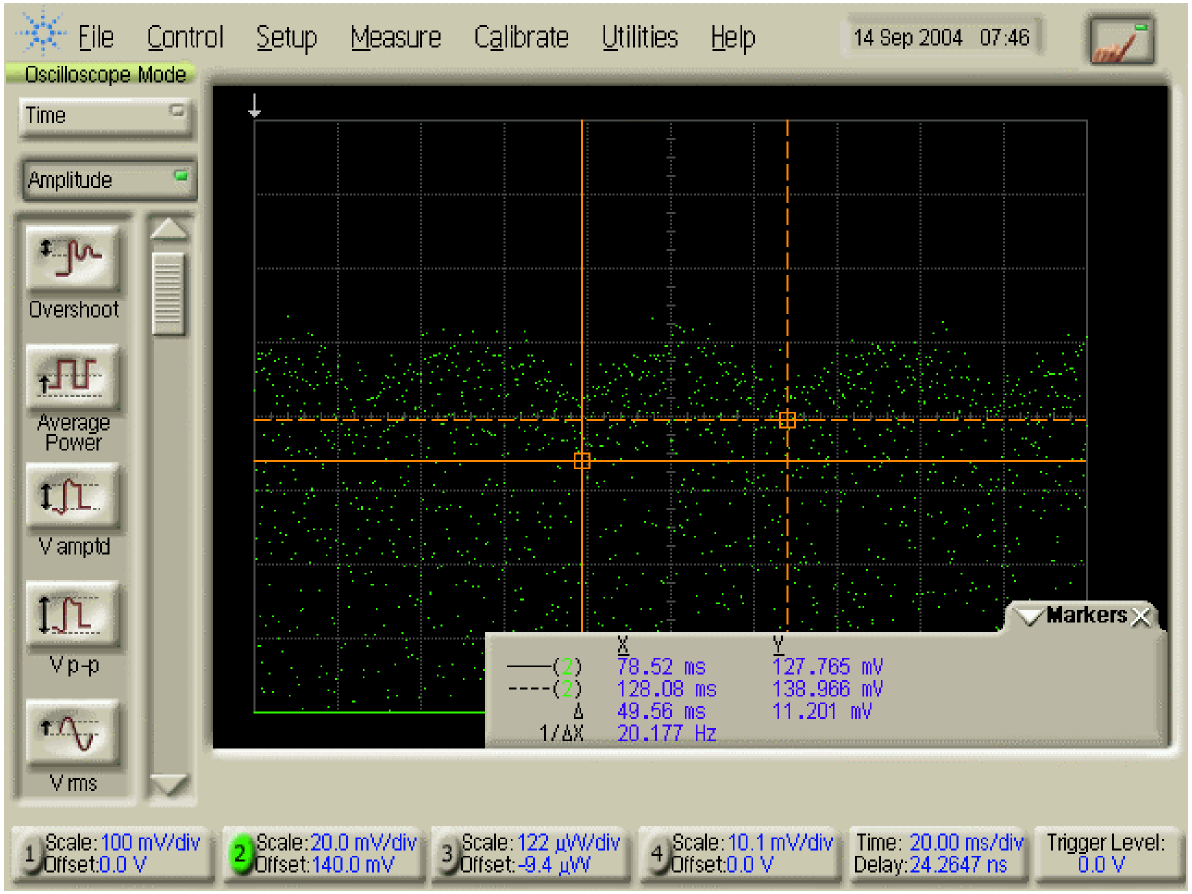
Test results, Observations:

- The degree of the channel variations due to these small deflection vibration tests, even when vibrated very forcefully at “high” (100Hz) frequencies, appears to be significantly less than those produced by mechanically twisting the fiber coil.

Maximum channel time variation results

- In lieu of spectral analysis, the impact of the mechanical vibrations upon the time domain signal was examined.
- In the time domain, the sidebands due to the channel variation will appear as an AM envelope on the received sinusoidal signal.
- As predicted, this AM envelope was clearly visible at the mechanical vibration frequency as shown in the next slide.

Channel variation envelope on received sinusoidal signal. 1GHz sinusoidal input signal, 20Hz mechanical perturbation.

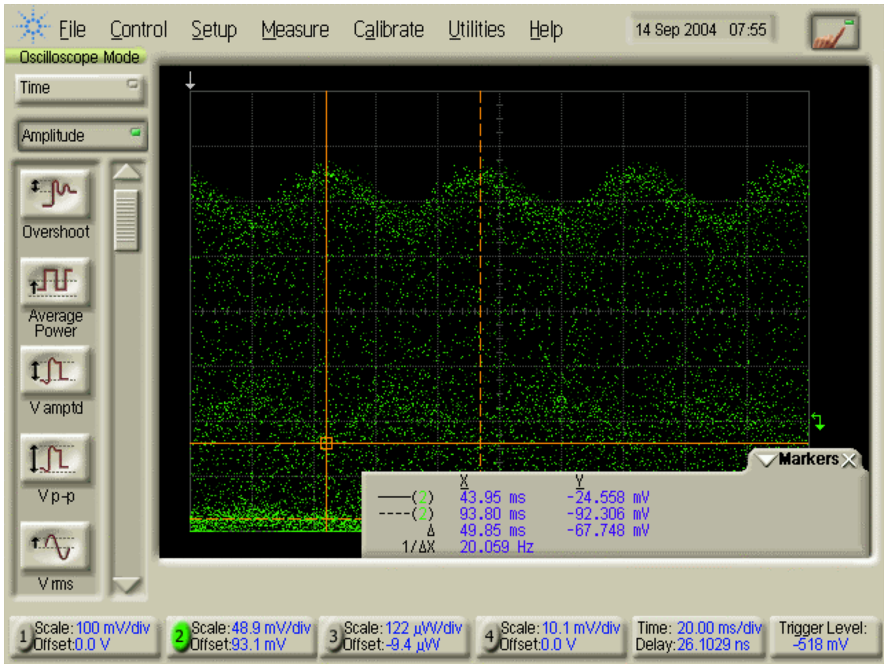


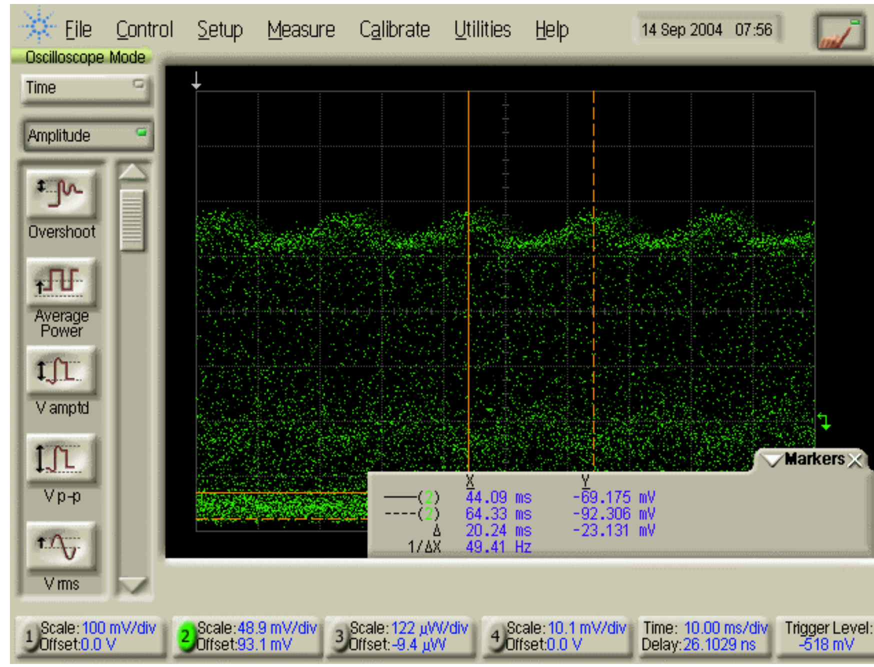
Maximum time variation results con't

- 1 MHz, 100 MHz and 1 GHz sinusoidal input signals were tested. The frequency of the input signal did not appear to have any impact upon the dynamic channel variation measurement.
- Also discrete 5.15 Gbps pulses, pulse trains and 1010 patterns were employed with similar results.

- In addition to a channel variation envelope at the mechanical perturbation frequency, channel variations at multiples of 2x and 3x of the vibration frequency were also measured as shown in the following slides.

Channel variation envelopes. 5.15 Gbps pulse train input

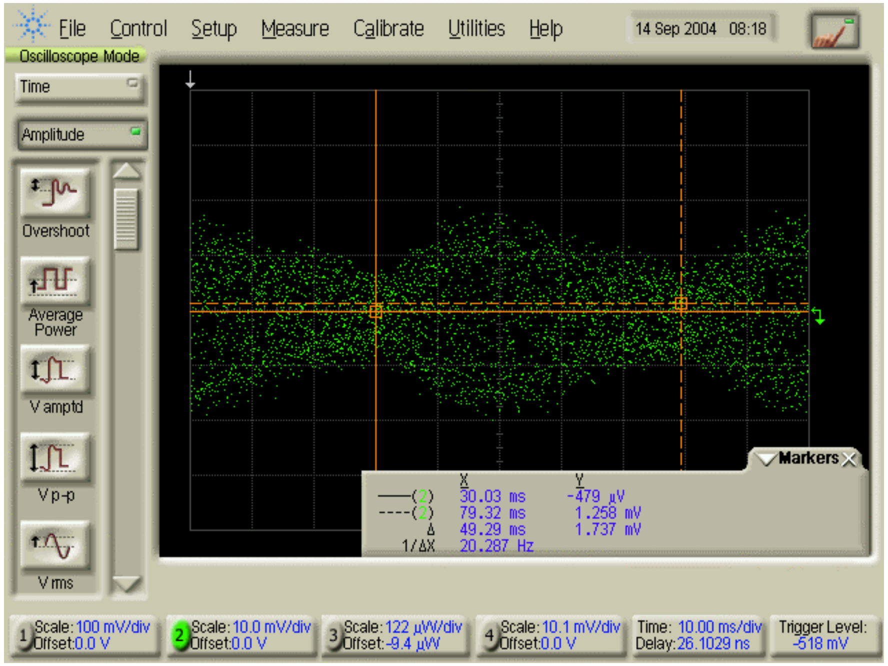


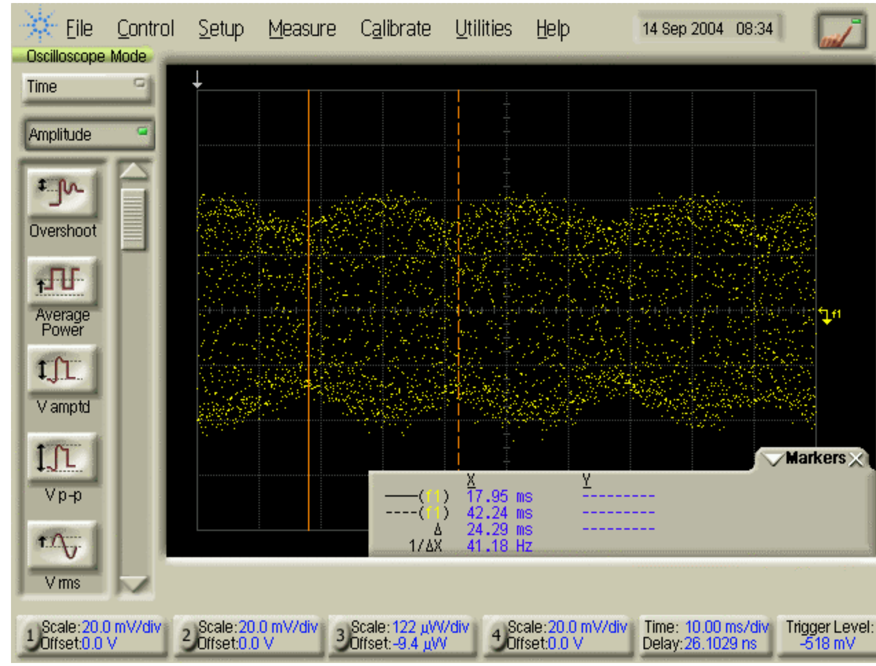


20 Hz vibration frequency, 20 Hz channel variation

50 Hz vibration frequency, 50 Hz channel variation

Channel variation envelopes. 5.15 Gbps 1010 pattern

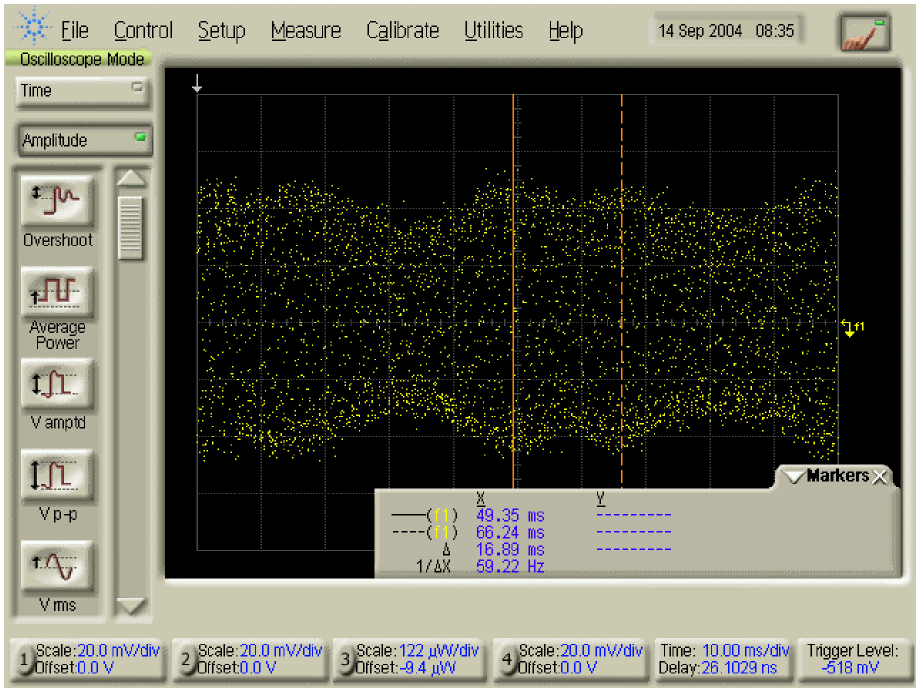




20 Hz vibration frequency, 20 Hz channel variation

20 Hz vibration frequency, 40 Hz channel variation

Channel variation envelopes. 5.15 Gbps 1010 pattern



20 Hz vibration frequency, 60 Hz channel variation

- Channel variations at harmonics of the mechanical vibration frequency are visible in the time domain.

Maximum time variation conclusions.

- From time-domain measurements, the channel variations due to the mechanical vibration at the vibration frequency and harmonics are visible.
- Observations of the channel variation envelope showed that the dominant channel variation frequency tended to be the mechanical vibration frequency, with only occasionally showing harmonics.
- Changing the input polarization changes the channel response, varying the magnitude of the channel variations (and thus the magnitude of the visible envelope) but it did not appear to vary the maximum channel variation frequency in any deterministic way.

Maximum time variation conclusions.

- Preliminary conclusions based on the current data are that the maximum significant channel variation frequency is up to 3x the maximum vibration frequency. As stated in GR-63-CORE, the maximum vibration frequency is 100 Hz, and thus the maximum channel variation frequency is 300 Hz.
- Further testing using a spectrum analyzer will refine these results further, to determine the relative strengths of the channel variation harmonics and channel variation magnitudes.