PLATO Visual Occlusion Device: Technical Specifications

PLATO Spectacles

Weight:	About 100 gm (not counting cable)
Cable to electronic driving circuit:	May be extended using a simple audio extension cord
MRI compatibility:	
Spectacles:	Yes (spectacles held together with nylon screws and glue)
Electronic driving circuit:	No (extra audio cable must be spliced on, to remove from MRI field)

PLATO Electronic Driving Circuit

The data provided here pertain to model P-4, P-5, P-6 electronic driving circuits, shipped on or after July 2007.

Nominal output voltage to PLATO spectacles:	±110 volts square wave (i.e. 220 v peak-to-peak), 250 Hz
Typical current consumption (both lenses open):	160 ma (for 9 V input)
Input (battery) voltage:	9 V DC (±2 V)
External DC supply:	9 V (regulated), 600 ma (preferred), centre positive
Control signals:	TTL: (Low = Open; High = Closed)
Input connector for control signals:	RJ-14 phone jack

PLATO Liquid Crystal Lenses

The data provided here pertain to model S-3 and S-4 PLATO spectacles, shipped on or after February 2006.

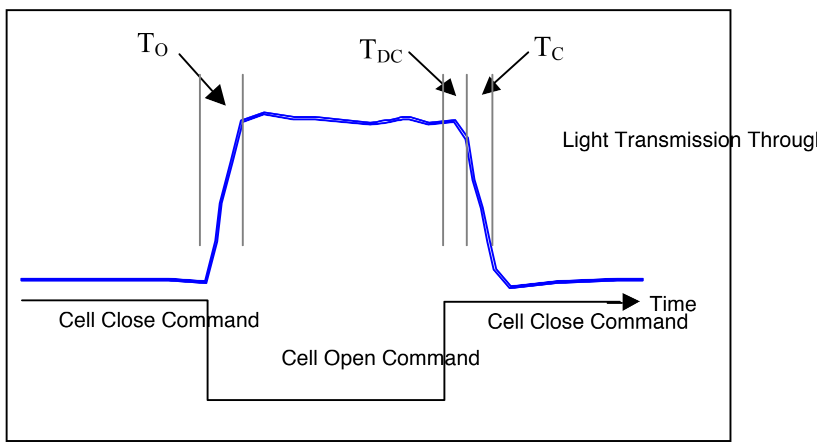
Light Transmission

PLATO l.c. lenses have been estimated to transmit approximately 80% of incident light.

Temporal Response [i]

The estimated parameters are illustrated in the accompanying figure, where the three timing parameters are as follows:

- T_O represents the time taken to switch to the Open state (from the Closed state).
- T_{DC} represents a Time Delay between start of the Close command and start of the transition from Open to Close.
- T_C represents the time taken to switch to the Closed state (from the Open state).



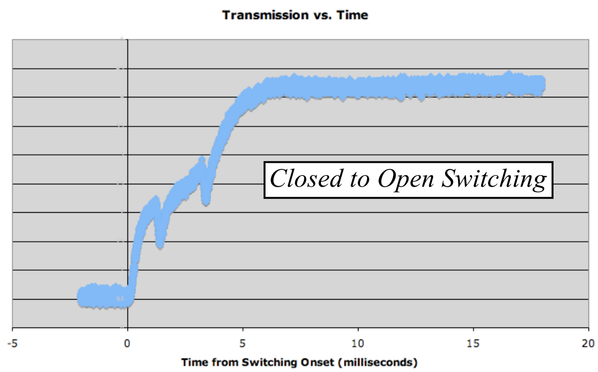
In the graphs below, the horizontal axes are scaled in milliseconds, as indicated.

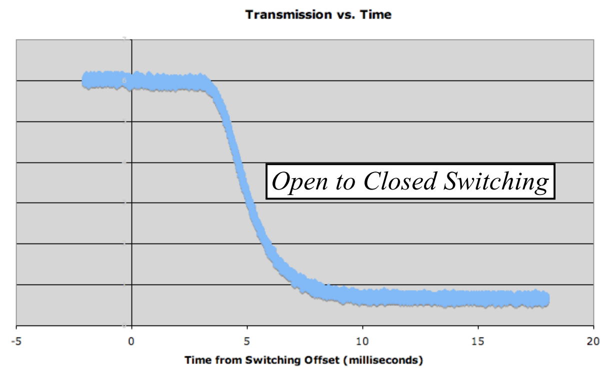
The vertical axis represents light transmission; however, units have intentionally been omitted, to emphasise the fact that this measurement should be interpreted as representing temporal switching response only.[ii]

Closed to Open Switching (T_O)

The figure on the left shows the temporal response for switching from the Closed to the Open state, initiated through application of a high voltage square wave at time t=0. (See technical specifications for electronic driving circuit.) [iii]

Keeping in mind the cautionary comment regarding switching time definition, a proposed estimate of the transition time from the closed (scattering) state to the open (transmissive) state is: $T_O \approx 4$ ms.





Open to Closed Switching (T_{DC} and T_C)
The figure on the right shows the temporal response for switching from the Open state to the Closed state. This transition is initiated through removal of the high voltage electrical field at time t=0. (Because the electrical field is not present during the transition, we do not see the same discontinuities in this graph.)

The first feature to note is that the transition from scattering to clear does not commence immediately upon reduction of the driving voltage. Rather, there appears to be a pure time delay of $T_{DC} \approx 4$ ms before the transition begins.

The second feature to note is that (keeping in mind the cautionary comment about defining switching times), a proposed estimate of actual transition from scattering to clear is: $T_C \approx 3$ ms.

The implication of the two phase transition noted above is that there are two possible ways in which the Open to Closed transition may be reported: a) ≈ 7 ms or b) ≈3 ms .

For many who use the PLATO spectacles with Open and Closed durations along the order of 100's or 1000's of milliseconds, the first figure of 7 ms is expected to be quite satisfactory.
For those for whom milliseconds are important, the justification for the second figure of 3 ms is that it is entirely feasible, for a great number of cases, simply to program one's TTL driving signal to tell the lenses to close 4 ms earlier than actually desired. With such a strategy, the 4 ms advance will cancel out the 4 ms switching delay, leaving an effective transition time of ≈ 3 ms.

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[i] The temporal measurements presented here were obtained by shining a laser perpendicularly through a sample l.c. lens, while recording the transmitted light using a high speed photodetector, sampled at 500 KHz. The lens was triggered on and off using a pulse generator. Low transmission measurements represent the closed state, where light incident on the sensor is due to scattered laser light plus ambient reflected light. High measurements represent the open state, where the sensor measurements are due primarily to transmitted laser light.

[ii] Caution is recommended when estimating absolute switching times from these data, based on the fact that human perception of contralateral visual information does not necessarily vary linearly with the amount of light transmitted. In other words, even though it is straightforward to objectively measure the amount of light being transmitted through and reflected from the surface of the l.c. cell as it is switched between the clear / transmissive state and the scattering / occluding state (using for example a 10% to 90% transition criterion), it is not straightforward to conclude at what point during the transition between clear to scattering a human observer will reach a threshold of scattering, above which features on the other side of the lens can no longer be reliably perceived. A similar challenge exists with regards to transition from scattering to clear; it is not straightforward to estimate the level of decreasing scattering that corresponds to the threshold below which reliable perception begins. In both cases, it is (arguably) reasonable to assume that the actual effective switching times are *less than* the times that would be estimated simply on the basis of an objective measurement of the time taken for minimal-to-maximal scattering or for maximal-to-minimal scattering.

[iii] The two discontinuities in the transition curve can be attributed to the cell's transient response to the 250 Hz electrical field. The switching of the polarity of this carrier wave every 2 ms is therefore manifested through the two 'bumps' at 2 ms and 4 ms.