ProMag FeLC Alignment Plan, Rev. 2

Introduction:

Ferroelectric liquid crystals have been characterized for retardation and cone angle vs. wavelength, temperature and drive voltage. Based upon initial measurements a set of 6 FeLCs were ordered from Displaytech. These are to be combined into two Pancharatnam plates, one half wave consisting of three half wave parts, and one about quarter wave consisting of two quarter wave parts and one half wave part. These parts were characterized and a suitable solution for an achromatic modulator was achieved using the Build_Promag.pro IDL procedure. IDL functions were created to model retardation and cone angle vs. the several parameters. The results of that solution gives three important angles, the angle of the center retarder of each Pancharatnam plate relative to the orientation of the first and last elements, the relative orientation of the two Pancharatnam plates, and the orientation of both of these relative to the polarization analyzer (Wollaston prism). This document specifies the plan for aligning the FeLCs to these angles.

Since the original version of this plan, the FeLC with the incorrect material failed and has been replaced by an element of the correct LC compound (serial # 803). The table below reflects this change.

Setup:

The alignment will be done by eye using a null technique. Here is the optical setup:

6V incandescent light source → Opal w/ removable red filter →Clockable linear polarizer → (single) FeLC element in rotatable mounting plate on registration fixture→ Clockable linear polarizer→ Eye

Procedure:

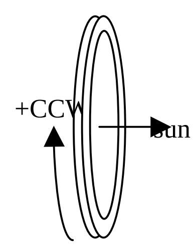
FeLCs are glued to a circular holder and are arbitrarily clocked. The circular holder fits within a mounting ring. Clocking of the holder within the mounting ring is locked using a setscrew. The holder is pin registered to a temporary registration plate for this exercise. The object is to set the clocking of FeLCs in their mounting rings and to ensure that the phasing and rotation of the FeLC's optical axes with applied voltage is correct.

Three separate conditions are required to be met: 1) As the voltage is switched, the fast axis moves through an angle of ~50 degrees. The axis which bisects the two fast-axis positions defines the FeLC's orientation and must be aligned to the angles as shown in the table below. 2) It is possible to miss-identify the axis of the FeLC. This happens if you choose a FeLC axis which bisects a fast-axis and slow-axis. You need to confirm that your FeLC axis bisects the two fast-axis states. 3) You need to identify the fast axis of each FeLC and confirm that it rotates in the same direction for each FeLC element. 3.5) If everything above is done correctly, each element will act as a shutter (transmit between crossed polarizers) with the same voltage and test condition. What follows is the actual procedure:

1. Realize the optical setup. Experience shows that the FeLCs should all have the same face towards the light source. We adopt the standard that the connection of the black lead to the FeLC will face the light source. For steps 1-7 use the red filter glass.
2. Set the first polarizer to the desired FeLC axis angle (see table below).
3. Cross the second polarizer with the first.
4. Connect the FeLC to the National Instruments breakout box making sure that the negative (ground) lead is connected to the black lead of the FeLC. Run the computer calibration software, which drives a 1Hz square wave to the FeLC.
5. Set the drive amplitude to 6V. Rotate the FeLC in the mounting ring until the intensity transmitted to your eye doesn't change as the voltage switches. This is a very sensitive test. You want to get the FeLC oriented within 1º of the optimal position. Lock the FeLC lightly in place with the setscrew. This is your preliminary best guess of the correct orientation. Now you test to make sure you've found the correct FeLC axis.

6. Rotate the first and second polariod together in the CCW direction (see figure below) such that you get the maximum extinction in half of the switching cycle. This should be about 25º from the nominal orientation for the FeLC. You need to find the best light/dark switching to about +/-3º. Change the drive amplitude to 2V. The dark part of the cycle should now appear a little less dark. If you have the right FeLC axis, a CW rotation of the two polarizers by a few degrees will make the dark cycle dark again. If you need to rotate the polarizers further CCW to get a dark switching again, you are on a 'false axis': loosen the set screw and rotate the FeLC by ~45º and redo steps 5 & 6. Next are the DC phasing tests.
7. With the polaroids still rotated for maximum switching, leave the square-wave generator program and start the National Instruments 'test panel' program. Set the FeLC drive voltage to +5Volts. The FeLC should go either light or dark (in my calibrations the FeLCs went light for the ~25CCW polaroid offset and a positive voltage). Make a note of the light/dark state. All the other elements need to behave the same way in this test condition. Set the drive polarity so the plate transmits.
8. This step finds the orientation of the fast axis. This step requires a reference ¼ wave plate with a known orientation of the fast and slow axes. This will be held by hand between the polarizers, on the 'eye' side of the FeLC element. If the fast axis of the FeLC is aligned with the slow axis of the reference ¼ plate, they will tend to cancel. If the fast axis of the reference is aligned with the fast axis of the FeLC they will combine and increase the birefringence. The results are slightly different for single and dual element FeLCs: FOR SINGLE ELEMENTS, aligning the slow axis of the reference to the fast axis of the FeLC will decrease the light transmission. Find the angle that minimizes the transmission through the FeLC and make a note of the reference wave plate's orientation (you only need this to +/- 10º – I used a clock dial reference). Now change the polarity of the drive voltage and rotate the polaroids ~25º CW of the nominal FeLC reference angle. The FeLC should be transmitting again. As above, use the reference wave plate to find the angle of the fast axis. It should have moved ~40-50º. Note which direction the fast axis rotated going from a negative to positive drive voltage. This sense of rotation must be the same for all the elements. In my testing the fast axis rotated in the CW direction for a positive voltage. FOR DOUBLE ELEMENTS remove the red filter glass and use only the white opal diffuser. Since the ¼ reference wave plate has less retardance than a double FeLC, we use a color-based technique. Rotate the reference wave plate so that it has a maximum transmission between the polarizers (looking around the sides of the FeLC). If the fast axis of the FeLC is aligned with the fast axis of the test plate, the light transmitted through the FeLC will have a strong color (blue or purple). If the fast FeLC axis is aligned with the slow test plate axis, the light transmitted will have a much more neutral color. Determine the direction of the fast axis and measure how it rotates with changing drive polarity (as was done for the single element FeLCs).
9. If all FeLCs have the correct orientations and sense of rotation with drive voltage, tighten the setscrew to a final tightness. Mark the FeLC mounts for which side is sunward.

FeLC	Orientation	Voltage	Type	Thickness	LC
647101	0º	3.0	Dual	1.5	9295
647102	53.0º	4.2	Dual	1.5	9295
647103	0º	7.0	Dual	1.5	9295
647105	22.5º = 0º + 22.5º	6.0	Single	2.0	8068
647104	93.4º = 0º + 22.5º + 70.9º	3.0	Dual	1.5	9295
677803	22.5º = 0º + 22.5º	7.0	Single	2.0	8068



- End -