KPol transmissivity test

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Abstract

The K-corona polarimeter (KPol) is based on a liquid crystal variable retarder (LCVR) for broad-band imaging of the visible-light continuum emission from the solar corona (K-corona). This polarimeter has no moving parts. This technical report describes the KPol transmissivity measurement at 633 nm. The result shows a good accordance with the component-level theoretical data at 633 nm wavelength.

Introduction

KPol is a liquid crystal-based polarimeter. The key optical element of the KPol is a Meadowlark Liquid Crystal Variable Retarder (LCVR). This electro-optical device uses nematic liquid crystal materials whose birifrangence can be controlled by changing the applied bias voltage. The schematic optical layout of the KPol is shown in fig.1. It consists of a fixed

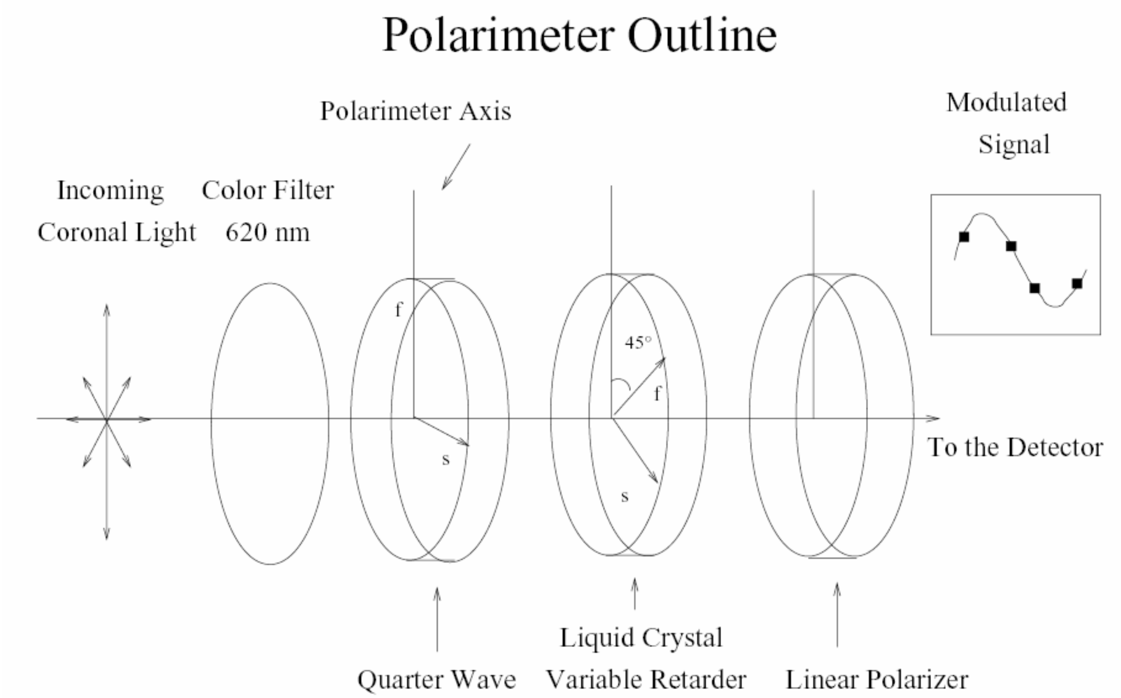


Fig. 1 – *Kpol schematic outline.*

$\lambda/4$ retarder with the fast axis aligned to the 0° axis of the system, a LCVR with the fast axis at 45° and a linear polarizer with its transmission axis at 0° . A narrow band color filter, centred at 620 nm, is placed in front of the polarimetric complex and selects the polarimeter bandpass, For the transmissivity tests at the HeNe, 633 nm, wavelength, we have removed the filter.

1. Set-up

The set-up for KPol transmissivity test is shown in fig. 2.

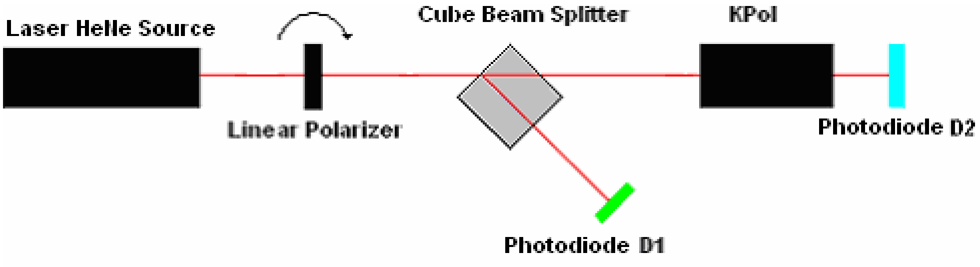


Fig. 2 – *Set-up for KPol transmissivity test.*

A HeNe laser is used as monochromatic light source at 633 nm wavelength, a linear polarizer, rotated at different values, polarizes the input light and a photodiode, D1, monitors the input intensity. Photodiode D2 measures the output intensity. LCVR temperature is fixed to 25°C.

2. Data Acquisition

Data acquired for different voltage applied to LCVR and for different input linear polarizer positions are reported in tab. 1.

V_{LCVR} (mV)	PL (deg)	I in (μW) [D1]	I out (μW) [D2]	I out/ I in
OFF	0	500	190	0,380
	45	517	109	0,211
	90	610	280	0,459
	135	520	65	0,125
	180	380	140	0,368
	225	520	110	0,212
	270	616	3	0,005
	315	530	68	0,128
	360	500	190	0,380
1500	0	453	174	0,384
	45	516	102	0,198
	90	586	1	0,002
	135	532	74	0,139
	180	444	171	0,385
	225	510	100	0,196
	270	620	1	0,002
	315	530	75	0,142
	360	383	148	0,386

Kpol transmissivity test

V_{LCVR} (mV)	PL (deg)	I in (μW) [D1]	I out (μW) [D2]	I out/ I in
2000	0	468	168	0,359
	45	521	53	0,102
	90	516	7	0,014
	135	514	115	0,224
	180	530	190	0,358
	225	525	52	0,099
	270	540	7	0,013
	315	526	117	0,222
	360	476	170	0,357
3000	0	450	164	0,364
	45	511	55	0,108
	90	630	6	0,010
	135	529	116	0,219
	180	380	139	0,366
	225	513	55	0,107
	270	620	6	0,010
	315	528	116	0,220
	360	449	164	0,365
4000	0	457	176	0,385
	45	520	104	0,200
	90	549	1	0,002
	135	520	72	0,138
	180	530	204	0,385
	225	520	104	0,200
	270	545	1	0,002
	315	529	74	0,140
	360	465	179	0,385
4500	0	510	183	0,359
	45	523	52	0,099
	90	565	7	0,012
	135	528	118	0,223
	180	457	164	0,359
	225	517	51	0,099
	270	550	7	0,013
	315	522	116	0,222
	360	510	183	0,359
6000	0	455	150	0,330
	45	520	139	0,267
	90	500	16	0,032
	135	529	31	0,059
	180	465	155	0,333
	225	518	138	0,266
	270	566	18	0,032
	315	528	32	0,061
	360	520	173	0,333

Kpol transmissivity test

V_{LCVR} (mV)	PL (deg)	I in (µW) [D1]	I out (µW) [D2]	I out/ I in
	0	500	178	0,356
	45	523	52	0,099
	90	599	8	0,013
	135	531	118	0,222
7000	180	520	185	0,356
	225	522	52	0,100
	270	593	8	0,013
	315	533	119	0,223
	360	400	144	0,360
	0	480	174	0,363
	45	520	55	0,106
	90	635	7	0,011
	135	548	119	0,217
8000	180	447	162	0,362
	225	520	55	0,106
	270	540	6	0,011
	315	530	116	0,219
	360	470	171	0,364
	0	438	169	0,386
	45	520	103	0,198
	90	500	1	0,002
	135	534	76	0,142
9000	180	500	192	0,384
	225	518	100	0,193
	270	620	1	0,002
	315	538	78	0,145
	360	446	172	0,386
	0	500	193	0,386
	45	517	110	0,213
	90	616	3	0,005
	135	536	68	0,127
10000	180	466	180	0,386
	225	520	110	0,212
	270	630	3	0,005
	315	523	66	0,126
	360	425	165	0,388
	0	440	125	0,284
	45	501	18	0,036
	90	640	33	0,052
	135	501	130	0,259
3300	180	430	120	0,279
	225	502	18	0,036
	270	548	28	0,051
	315	518	136	0,263
	360	430	122	0,284

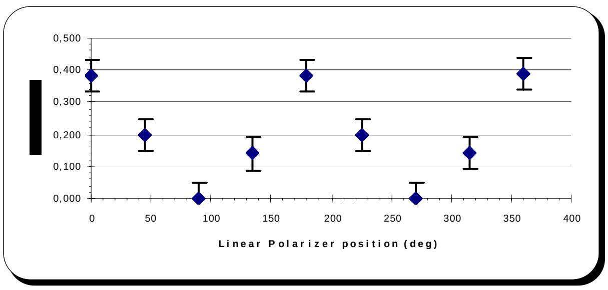
Kpol transmissivity test

VLCVR (mV)	PL (deg)	I in (µW) [D1]	I out (µW) [D2]	I out/ I in
	0	425	150	0,353
	45	481	48	0,100
	90	576	8	0,014
	135	494	110	0,223
3500	180	432	156	0,361
	225	489	48	0,098
	270	570	8	0,014
	315	503	113	0,225
	360	442	159	0,360
	0	382	150	0,393
	45	451	90	0,200
	90	515	1	0,002
	135	470	64	0,136
3800	180	412	160	0,388
	225	465	92	0,198
	270	560	1	0,002
	315	480	67	0,140
	360	420	163	0,388
	0	320	20	0,063
	45	417	91	0,218
	90	460	80	0,174
	135	425	13	0,031
5000	180	387	23	0,059
	225	424	93	0,219
	270	500	85	0,170
	315	453	14	0,031
	360	430	26	0,060

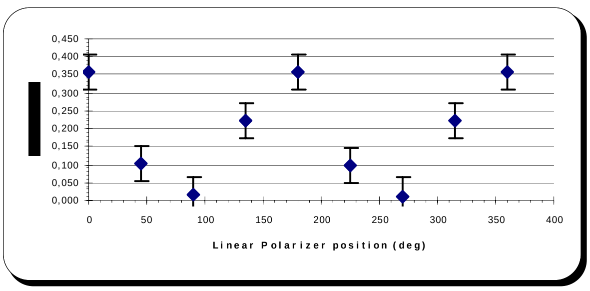
Tab. 1 – *Data Acquired.*

Plots of Iout/In in function of linear polarization position for different voltages are the follows. Error is estimate equal to 0,05.

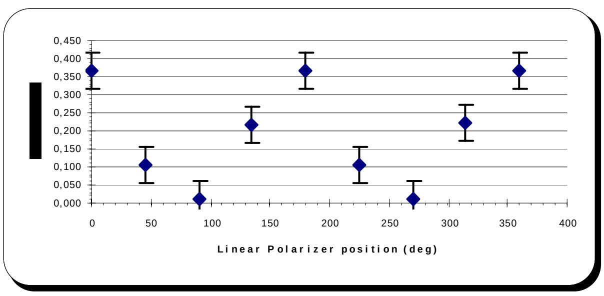
1500 mV



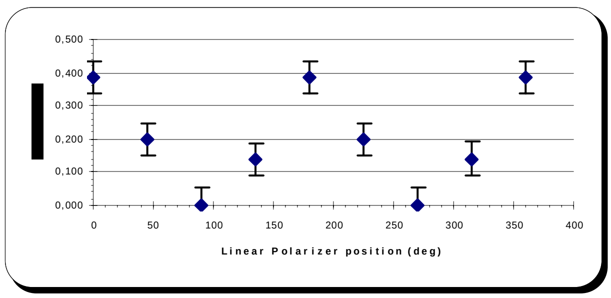
2000 mV



3000 mV

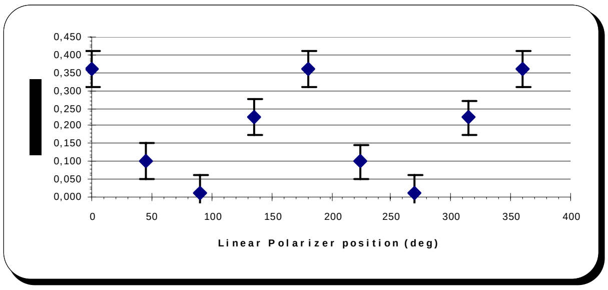


4000 mV

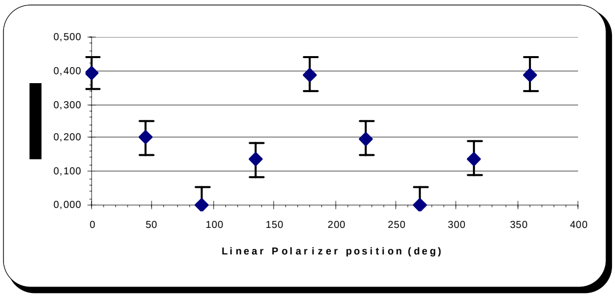


Kpol transmissivity test

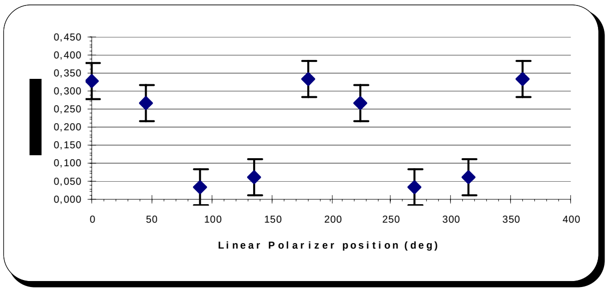
4500 mV



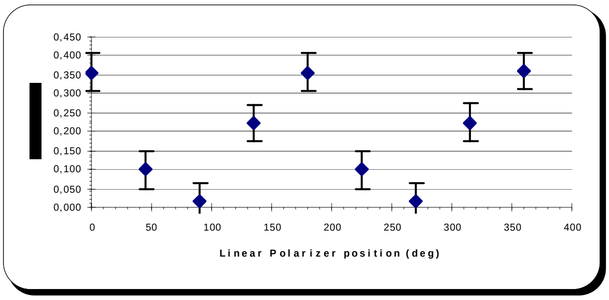
5000 mV



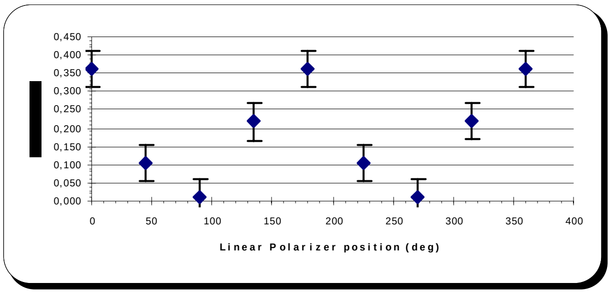
6000 mV



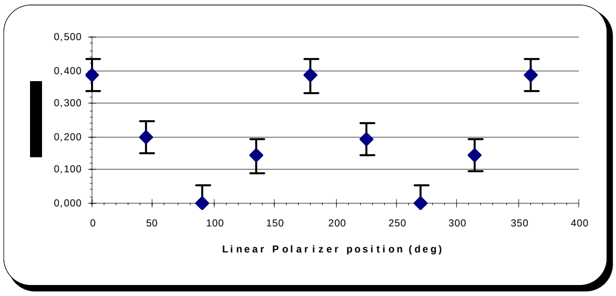
7000 mV



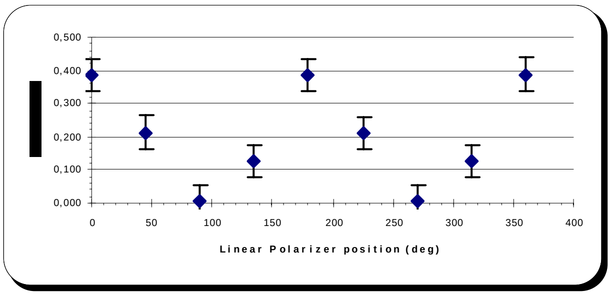
8000 mV



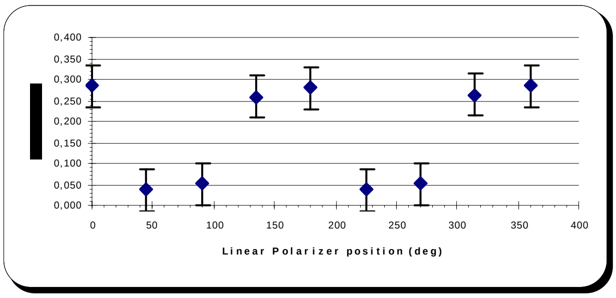
9000 mV



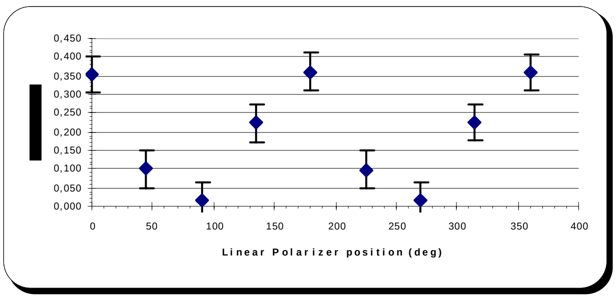
10000 mV



3300 mV



3500 mV



3800 mV

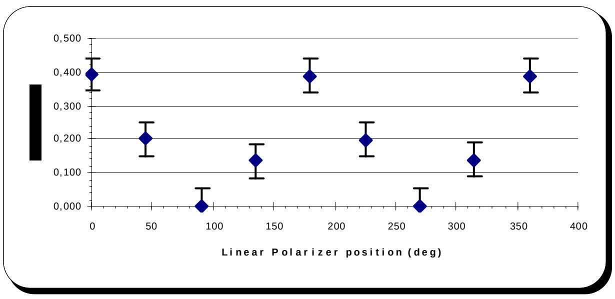


Fig. 3 – *Iout / Iin vs. Linear Polarizer position plots at different voltages of LCVR.*

3. Transmissivity evaluation

For the purpose of measuring the transmissivity, we analyze measurements performed at 10000 mV, when the LCVR retardance is minimum. The maximum value of Iout/Iin is the KPol polarimeter transmissivity.

From data reported in tab.1 we obtain:

$$\mathbf{T_{KPol}} = 0.39 \pm 0.01$$

The flight configuration of KPol includes an hot mirror and a color filter (450-600 nm). Transmissivity for this components at 550nm wavelength are (cfr. fig. 4):

$\mathbf{T_{HotMirror} \sim 0.92}$ **;** $\mathbf{T_{ColorFilter} \sim 0.9}$.

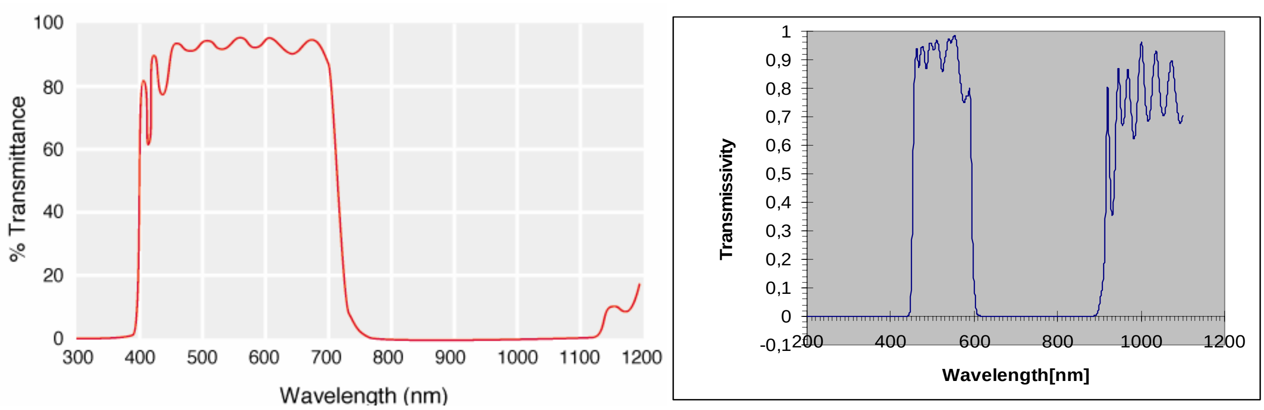


Fig. 4 – *Hot Mirror(left) and color filter (right) transmissivity.*

Then, KPol transmissivity is estimate equal to:

$$\mathbf{T_{KPol}\ (flight\ configuration) = T_{KPol} * T_{HotMirror} * T_{ColorFilter}} \sim 0.32$$

4. Comparison with component-level transmissivity data

KPol comprises a linear polarizer, LCVR and quarter wave. The estimated system-level transmissivity is the product of the component-level transmissivities [1].

The MLO linear polarizer transmissivity curve is reported in fig. 5. At 633 nm wavelength:

$\mathbf{T_{LP} \sim 0.4}$ **(parallel 0.8);**

$\mathbf{T_{LCVR} \sim 0.97}$**;**

$\mathbf{T_{QW} \sim 0.97}$**.**

The estimated system-level transmissivity is:

$$\mathbf{T_{KPol}\ (flight\ configuration) = T_{LP} * T_{LCVR} * T_{QW} * T_{HotMirror} * T_{ColorFilter} \sim 0.31}$$

In good accordance with test results

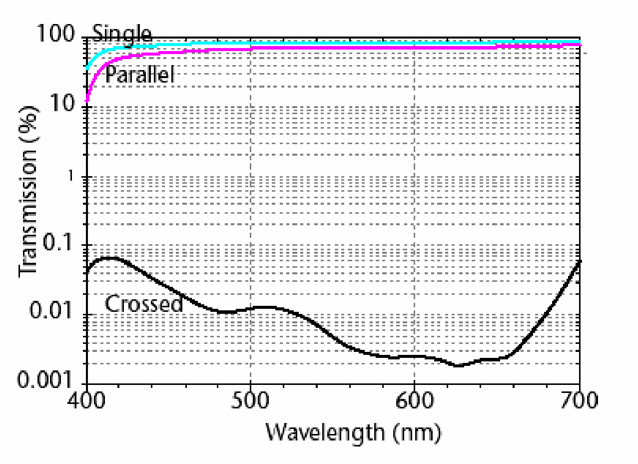


Fig. 5 – *MLO Linear Polarizer Transmission curve [1].*

5. Fourier's Analysis

We have performed the Discrete Fourier Transform of the data series (fig.6) for frequencies analysis. The power-spectrum has only one non-zero frequency is at 180 deg. The Nyquist frequency of this analysis is 90 deg. For frequencies less that, we observe the aliasing effect.

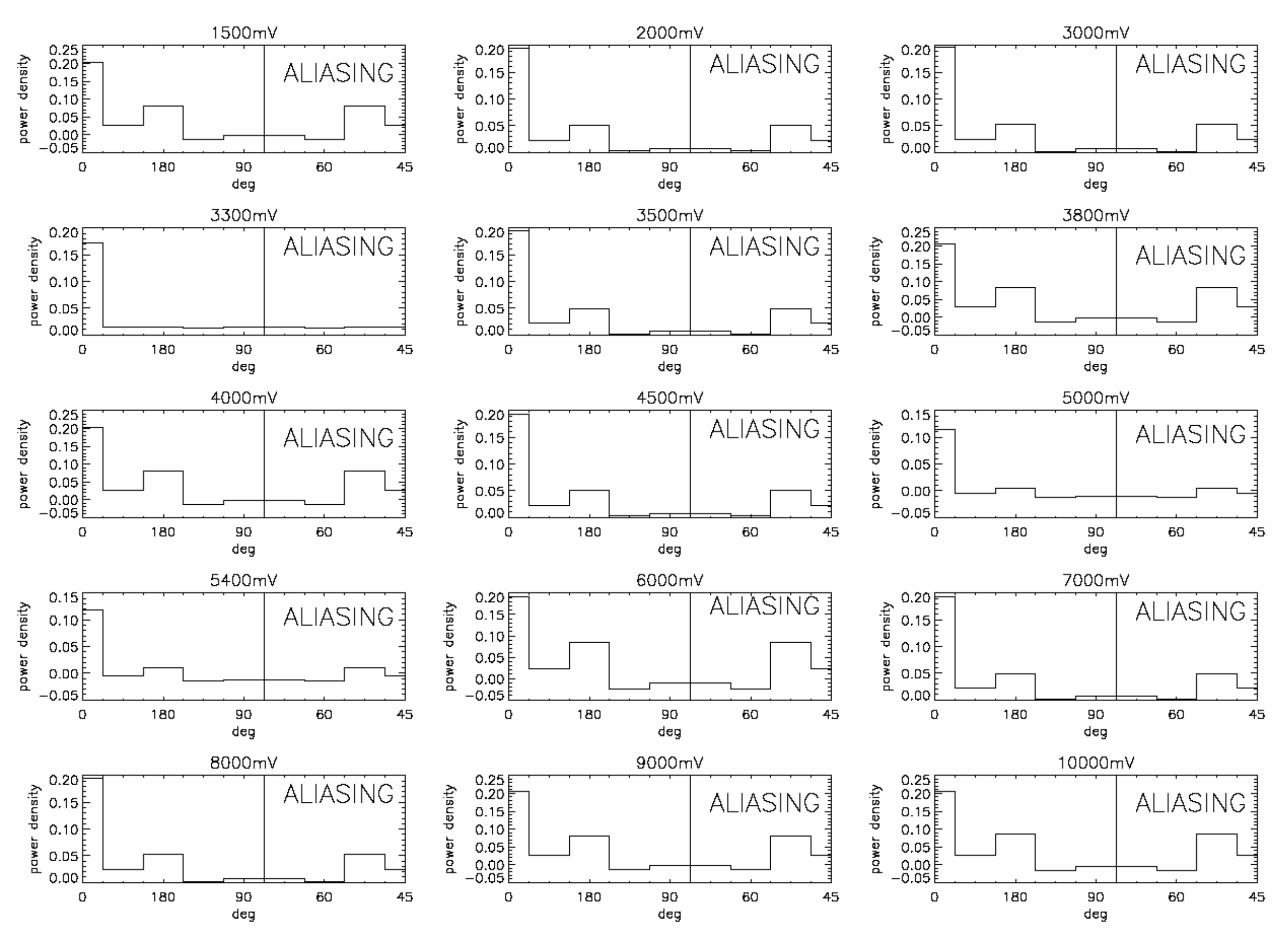


Fig. 6 – *DFT over all modulation curves.*

6. Light Source Intensity Stability

The set-up for this test included the monitoring of the light source stability. The intensity vs. time is reported in figure 7. The intensity values are registered for the 0 or 360 deg position of the linear polarizer.

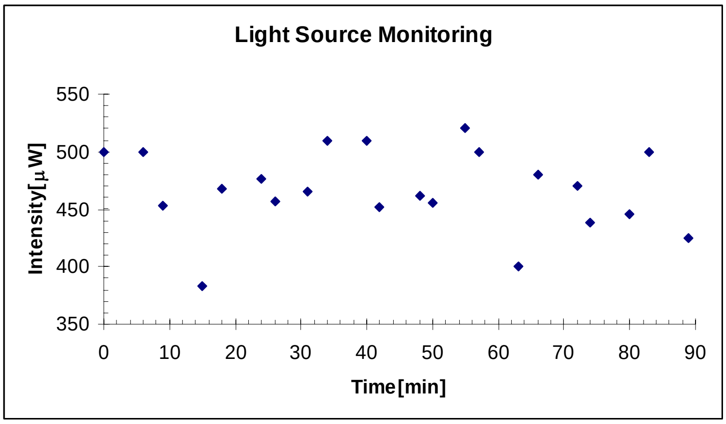


Fig. 7 – *Light Source Intensity vs. time.*

Correlation value is equal to (-0,13).

Conclusions

The measured KPol transmissivity is in good accordance with that derived from the component-level transmissivities. Analysis of light source intensity variation in the time, shows the importance of our monitoring.

References

[1] Meadowlark Optics
Official on-line catalogue
http://www.meadowlark.com