VLASS Project Memo 9

Recent Observational Values of Polarization Calibrators at S-band

Frank Schinzel (NRAO)

April 19, 2017

This document serves as reference for observational values of usual polarization and D-term calibrators at S-band. Observations are based on the irregularly executed TPOL0003 project.

1. Observations

The relevant parameters of the TPOL0003 observations discussed in this document are listed in Table 1. There are typically two blocks observed. The targets contained in a particular observing block are listed in Table 1.

Table 1: TPOL0003 observations between January 1st, 2014 and February 3rd, 2017.

Date Start	Config.	Block	EVPA Cal.
2014-01-12 05:23:46	B	1	3C 286
2014-01-12 23:45:25	B	2	3C 48
2014-02-12 05:41:40	BnA→A	1	3C 286
2015-02-09 03:24:52	B	1	3C 286
2015-02-10 03:20:53	B	1	3C 286
2016-09-02 07:15:03	B	2	3C 48
2017-01-31 04:50:32	A→D	1	3C 286
2017-02-03 22:02:48	A→D	2	3C 48

All datasets were calibrated and imaged with CASA 5.0.0-169 pre-release following standard procedures for VLA polarization calibration using primarily the VLA CASA pipeline with the newly implemented polarization calibration scheme. The calibration includes correction for ionospheric Faraday rotation, as well as disperive delays by taking into account spatial TEC variations across the duration of the observation. The flux density

Table 2: TPOL003 targets per block.

J2002 Name	RA	Dec	Block	Comment
J0136+4751	01h 36m 58.59481s	47d 51' 29.10006"	2	D-term
J0137+3309	01h 37m 41.299431s	33d 09' 35.13299"	2	PA/Flux
J0319+4130	03h 19m 48.160102s	41d 30' 42.10305"	2	
J0359+5057	03h 59m 29.747262s	50d 57' 50.16151"	2	
J0555+3948	05h 55m 30.805608s	39d 48' 49.165"	1	
J0713+4349	07h 13m 38.164129s	43d 49' 17.20698"	1	
J0739+0137	07h 39m 18.033894s	01d 37' 4.61803"	1	
DA240 North	07h 49m 48.000000s	55d 54' 19.00001"	1	
J0854+2006	08h 54m 48.874925s	20d 06' 30.64088"	1	D-term
J0927+3902	09h 27m 03.013916s	39d 02' 20.85195"	1	
J1256-0547	12h 56m 11.16656s	-5d 47' 21.52458"	1	
J1310+3220	13h 10m 28.663845s	32d 20' 43.78295"	1	
J1331+3030	13h 31m 08.287984s	30d 30' 32.95885"	1	PA/Flux
J2136+0041	21h 36m 38.586299s	00d 41' 54.21335"	2	
J2202+4216	22h 02m 43.291377s	42d 16' 39.97994"	2	
J2232+1143	22h 32m 36.408914s	11d 43' 50.9041"	2	
J2253+1608	22h 53m 57.747932s	16d 08' 53.56089"	2	
J2355+4950	23h 55m 09.458169s	49d 50' 8.34"	2	

and polarization angle calibrators were 3C 286 or 3C 48[1], the instrumental polarization calibrators were J0136+4751 or J0854+2006. On 2015, February 9th the derived values for J0739+0137 are not reliable due to bad phase calibration in the first spectral window skewing the flux scaling, thus the results from the second spectral window were used as noted in Table 3. Also, on 2017, February 3rd, for the entire dataset the solutions were significantly noisier than in previous datasets, which is denoted in larger flux density errors. Table 3 lists the entire set of derived flux densities, peak polarization flux density, linear polarization fraction, and polarization angles.

It is important to point out that most observed objects show significant variability in their polarization properties. The most stable between 2014 and 2017 of the non-calibrator sources have been:

- **J0359+5057** (NRAO 150) with PA range of -70.42 – -75.29°, however its linear polarization fraction has been steadily decreasing from 2.5% to 1.0%.
- **J0739+0137** with a PA range from 42.2 – 46.5°, and a high linear polarization fraction of 5.2–7.7%.

[1]For 3C 48 the rotation measure and changes in polarization fraction were provided to the setjy task through polynomial fits on data described in Perley & Butler (2013, ApJS, Volume 206, Issue 2, article id. 16).

- **J2232+1143** (CTA 102) with a linear polarization fraction of 3.3-4.1% and a polarization angle of 21.5–28.5°.

However, since these objects are quasars, significant variability can be expected during times of high episodic intrinsic source activity. The currently, least polarized sources are J0319+4130 (3C 84), J0713+4349, and J2355+4950.

Table 3: Values at S-band (3.1 GHz) of polarization calibrators. The Stokes I errors are based on the image rms, whereas the polarization errors are 1σ thermal noise errors reported by the casa polarization imaging task. The '*' behind the polarization angle value indicates that this source was used to calibrate the polarization angles.

Source	Obsdate	I Flux D. (Jy)	I peak (mJy/bm)	P peak (mJy/bm)	% Pol	Pol. angle (deg.)
J0136+4751	20140113	2.25±0.14	2215±141	35.29±0.05	1.59±0.002	-11.81±0.05
	20160902	1.81±0.11	1800±115	36.79±0.05	2.04±0.003	47.678±0.037
	20170203	1.56±0.84	1778±835	28.56±0.09	1.60±0.005	33.60±0.18
J0137+3309*	20140113	7.52±0.47	7350±469	172.53±0.22	2.35±0.03	83.6388±0.0032
	20160902	8.14±0.51	7956±510	178.13±0.24	2.24±0.003	83.561±0.034
	20170203	6.6±3.2	7258±3199	166.68±0.61	2.30±0.008	83.41±0.10
J0319+4130	20140113	12.26±0.85	12184±854	12.47±0.29	0.10±0.002	-2.8±1.3
	20160902	13.02±0.87	12724±874	3.41±0.29	0.023±0.002	18.1±3.8
	20170203	10.0±4.8	10840±4769	10.47±0.73	0.097±0.007	7.8±6.3
J0359+5057	20140113	5.46±0.37	5266±368	368.10±0.13	2.54±0.003	-70.42±0.05
	20160902	6.71±0.41	6458±413	85.35±0.16	1.32±0.003	-72.674±0.063
	20170203	5.0±2.6	5614±2508	55.6±1.5	0.99±0.027	-75.29±0.85
J0555+3948	20140112	4.29±0.27	4208±268	24.73±0.14	0.56±0.003	46.15±0.27
	20140212	3.99±0.24	3890±243	21.75±0.18	0.56±0.005	46.15±0.20
	20150209	4.12±0.25	3959±252	15.59±0.23	0.39±0.006	24.95±0.32
	20150210	4.26±0.27	4220±269	22.94±0.14	0.54±0.003	35.69±0.22
	20170131	3.4±1.3	4047±1264	20.48±0.24	0.506±0.006	37.37±0.31
J0713+4349	20140112	1.93±0.12	1882±120	2.97±0.10	0.15±0.006	-67.9±3.7
	20140212	1.83±0.11	1775±111	0.89±0.12	0.050±0.007	-38.5±3.7
	20150209	1.86±0.11	1782±114	2.21±0.11	0.12±0.006	-81.9±1.8
	20150210	1.87±0.12	1836±117	1.00±0.10	0.54±0.0052	-88.4±3.4
	20170131	1.74±0.37	1731±371	0.25±0.23	0.014±0.013	-7±40
J0739+0137	20140112	0.93±0.06	936±60	66.11±0.11	7.06±0.01	46.48±0.06
	20140212	0.811±0.054	802±54	61.53±0.10	7.67±0.01	46.254±0.046
	20150209†	1.14±0.08	1127±77	70.08±0.086	6.22±0.008	45.16±0.04
	20150210	1.130±0.077	1113±77	63.357±0.086	5.69±0.008	44.300±0.043
	20170131	0.87±0.22	852±218	44.61±0.16	5.24±0.019	42.18±0.10
DA240 North	20170131	0.32±0.27	451±267	105.14±0.14	23.29±0.03	67.598±0.032
J0854+2006	20140112	3.17±0.20	3157±200	41.80±0.07	1.32±0.002	-13.09±0.08
	20140212	2.61±0.19	2697±185	48.26±0.10	1.79±0.004	-33.275±0.056
	20150209	3.29±0.21	3221±205	135.78±0.12	4.22±0.004	-6.028±0.016
	20150210	3.26±0.20	3197±204	127.06±0.12	3.97±0.004	-6.76±0.017
	20170203	3.31±0.37	3208±372	139.11±0.16	4.34±0.005	3.877±0.043

Continued on next page

Table 3 – continued from previous page

Source	Obsdate	I Flux D. (Jy)	I peak (mJy/bm)	P peak (mJy/bm)	% Pol	Pol. angle (deg.)
J0927+3902	20140112	6.01±0.38	5904±377	23.95±0.23	0.26±0.004	77.5±1.7
	20140212	8.71±0.54	7723±539	16.91±0.33	0.22±0.004	69.27±0.36
	20150209	6.72±0.41	6397±408	40.48±0.38	0.19±0.006	-47.4±3.7
	20150210	6.17±0.38	6037±384	111.74±0.33	0.20±0.006	32.5±4.3
	20170131	5.9±1.5	6249±1475	53.29±0.77	0.85±0.012	-67.50±0.52
J1256-0547	20140212	9.00±0.85	8393±855	861.6±1.0	3.41±0.012	-73.51±0.39
	20150209	12.43±0.86	12756±864	260.3±1.6	2.04±0.013	-63.272±0.038
	20150210	12.30±0.87	12505±874	296.9±1.5	2.37±0.012	-65.292±0.035
	20170131	12.9±1.4	12629±1358	168.26±0.69	1.32±0.005	24.74±0.13
J1310+3220	20140112	1.54±0.11	1648±109	43.03±0.20	1.31±0.010	22.8±1.1
	20140212	1.71±0.11	1628±112	21.70±0.13	1.33±0.008	12.23±0.15
	20150209	1.58±0.11	1559±112	29.27±0.10	1.87±0.006	11.27±0.11
	20150210	1.50±0.10	1481±104	28.09±0.10	1.86±0.007	11.01±0.16
	20170131	0.98±0.13	958±129	23.54±0.15	2.46±0.016	15.41±0.17
J1331+3030*	20140112	9.16±0.57	8978±569	1034.73±0.67	11.52±0.008	32.99±0.007
	20140212	9.75±0.61	9590±608	1044.40±0.28	10.89±0.003	32.89±0.006
	20150209	9.75±0.64	9608±641	1028.27±0.28	10.70±0.003	32.87±0.006
	20150210	9.73±0.63	9594±634	1041.91±0.32	10.86±0.003	33.12±0.007
	20170131	9.7±1.1	9592±1096	1051.26±0.27	10.96±0.003	33.00±0.0068
J2136+0041	20140113	8.48±0.55	8425±550	72.27±0.21	0.858±0.002	63.83±0.05
	20160902	8.67±0.61	8760±608	52.60±0.34	0.60±0.004	59.569±0.078
	20170203	8.5±2.0	8471±1975	60.60±0.26	0.715±0.003	58.48±0.15
J1256-0547	20140112	13.03±0.79	12223±787	539.57±0.45	4.41±0.04	-71.97±0.01
	20140212	10.06±0.58	9222±578	919±0.96	3.78±0.01	-73.76±0.66
	20150210	15.32±0.97	151804±966	425.19±0.56	2.80±0.004	-65.95±0.02
J2202+4216	20140113	4.61±0.29	4504±287	246.24±0.19	5.47±0.004	88.42±0.01
	20160902	1.95±0.12	1926±123	52.41±0.091	2.72±0.005	-35.266±0.045
	20170203	1.84±1.01	2111±1006	19.82±0.090	0.94±0.004	-30.27±0.14
J2232+1143	20140113	5.09±0.31	4951±307	162.62±0.17	3.28±0.004	21.496±0.021
	20160902	5.15±0.31	4848±311	191.64±0.20	3.93±0.004	24.928±0.020
	20170203	4.36±1.81	4585±1834	188.76±0.32	4.12±0.007	28.491±0.051
J2253+1608	20140113	9.26±0.54	8859±535	649.77±0.44	7.33±0.005	-9.085±0.007
	20160902	13.80±0.92	14610±923	676.69±0.60	4.63±0.004	-10.640±0.014
	20170203	13.2±5.3	13821±5256	585.7±1.7	4.24±0.012	-9.104±0.057
J2355+4950	20140113	1.60±0.10	1586±103	0.673±0.075	0.042±0.005	-41.7±3.2
	20160902	1.68±0.10	1625±104	0.204±0.083	0.0077±0.0051	-21±20
	20170203	1.38±0.77	1590±765	1.08±0.13	0.0675±0.008	-75.8±4.7

Notes: † indicates that the data from 3.2 GHz was used instead of 3.1 GHz due to interference.

The derived values for the above stable polarized and unpolarized sources were compared to historic S-band values derived by Steve Myers[2]. For ease of comparison these historic values are listed in Table 4. The historic and current values are in good agreement.

[2]http://www.aoc.nrao.edu/∼smyers/evlapolcal/polcal_all.html

Table 4: Historic values from the polarization calibrator monitoring program: http://www.aoc.nrao.edu/∼smyers/evlapolcal/polcal_all.html.

Source	Date	Config.	I (Jy)	P (Jy)	Frac. Pol.	RL phase (deg.)
J0319+4130	20120408	C	13.4182	0.0003	0.0000	-165.473
J0359+5057	20120408	C	5.9485	0.1212	0.0204	-141.970
J0713+4349	20110304	B	1.9054	0.0001	0.0000	-41.760
J0739+0137	20110304	B	0.9300	0.0585	0.0644	91.534
J2232+1143	20120408	C	5.4073	0.1984	0.0367	47.228
J2355+4950	20120408	C	1.7590	0.0004	0.0002	66.211

Revision History

Revision	**Date**	**Author(s)**	**Description**
1.1	2017-04-19	Frank Schinzel	Corrected Stokes I values, changed D-term calibrator, ionosphere corrections, updated text
1.0	2017-03-15	Frank Schinzel	First complete version.