Detection Circuit

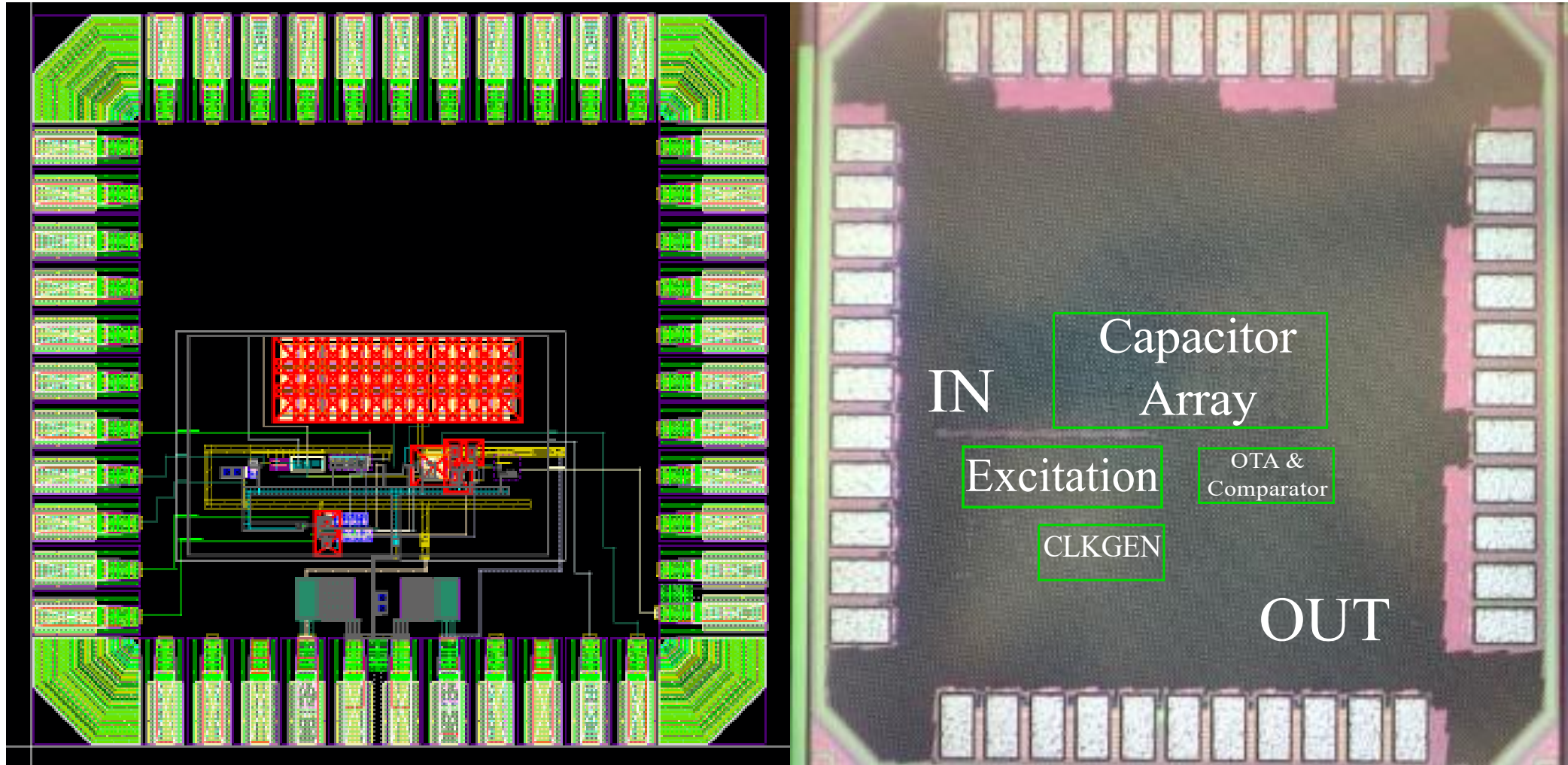# Raw log from measurement

Chip 1 - 2021

Tapeout 1

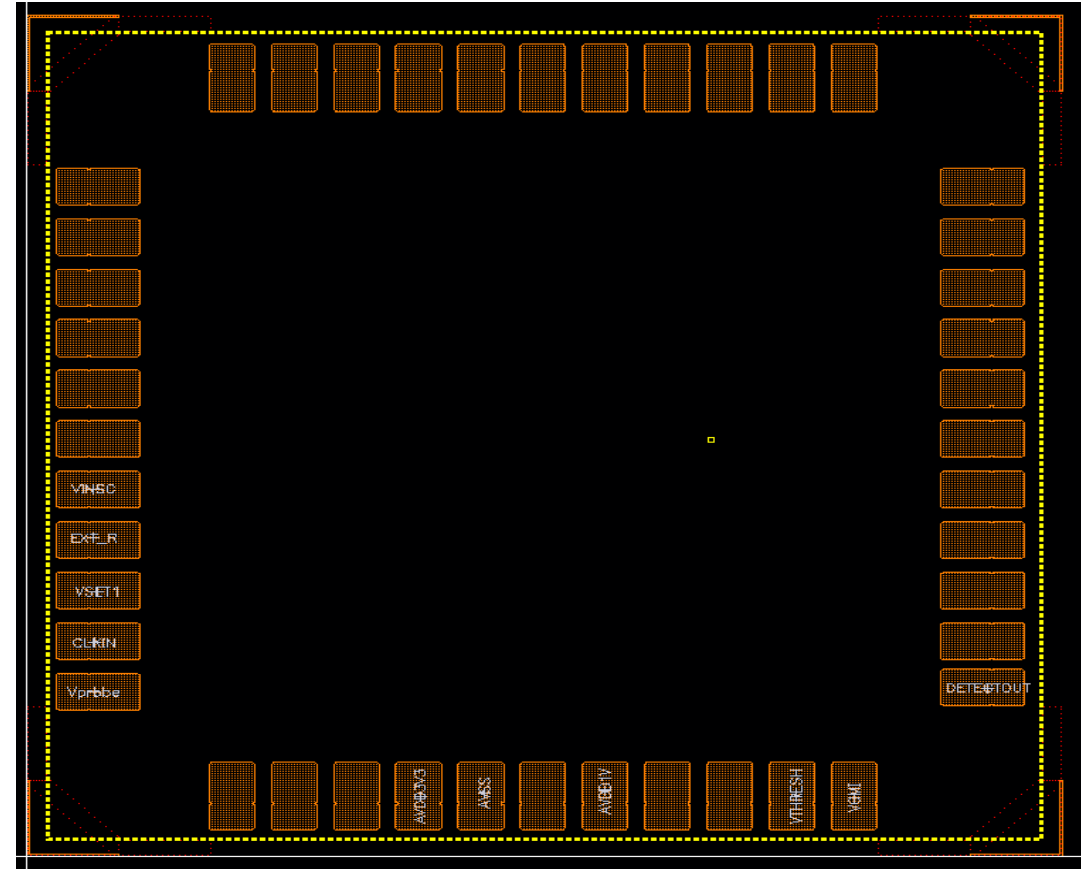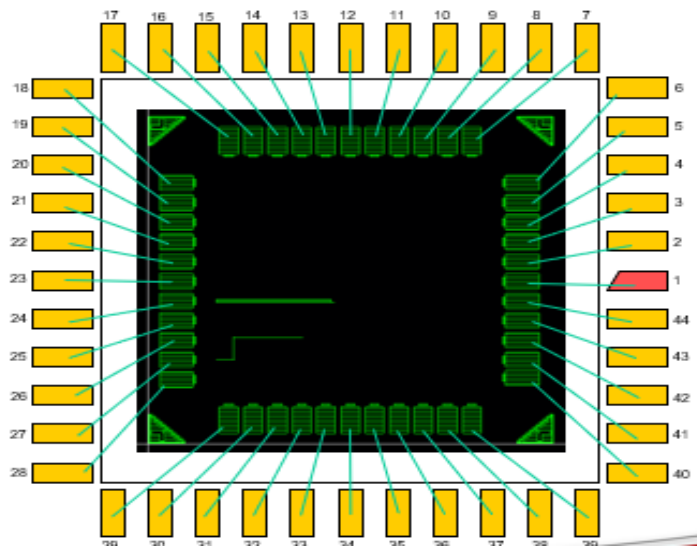Fig 11: a) Chip layout in the simulator b) Die photo
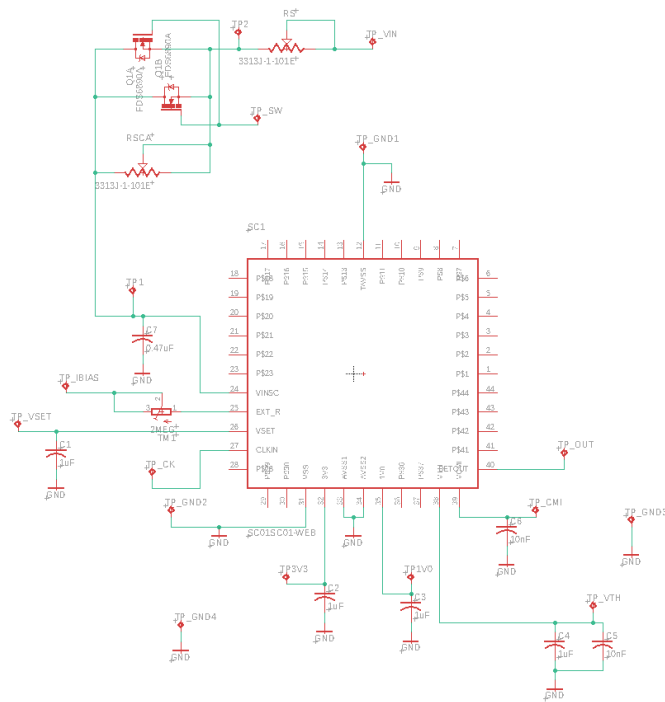
Bonding diagram

Fig 12: 40 pin CLCC package for the first iteration, design the frame for package and pinout

PCB Design
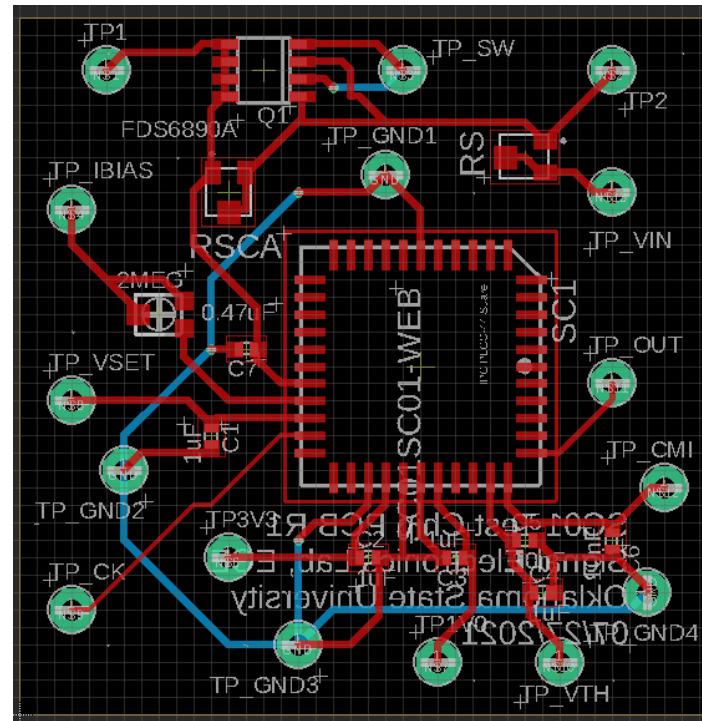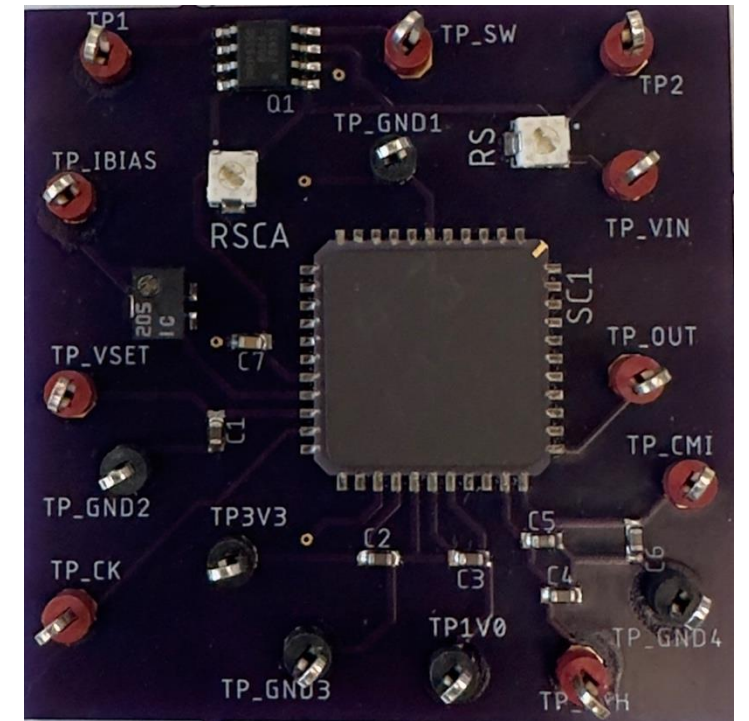
a)   b)   c)

Fig 13: PCB design for test chip in EAGLE a) Schematic b) Board layout c) Fabricated board

Tunable current with External Vref sweep

External Current test

Ext Current(uA	Voltage(V)	Current from Battery(uA)
1	1	51
1.1	1	55
1.2	1	60
1.3	1	65
1.4	1	68
1.5	1	73
1.6	1	76.8
1.7	1	82.2
1.8	1	86.7
1.9	1	91.2
2	1	87.1
2.1	1	91.2
2.2	1	95.3
2.3	1	98.8
2.4	1	102
2.5	1	106
2.6	1	109
2.7	1	113
3	1	123
5	0.999	164
7	0.99	181
10	0.998	194
15	0.813	203
17	0.676	205
20	0.481	208
23	0.295	210
25	0.174	211
27	0.057	212
30	-0.112	213
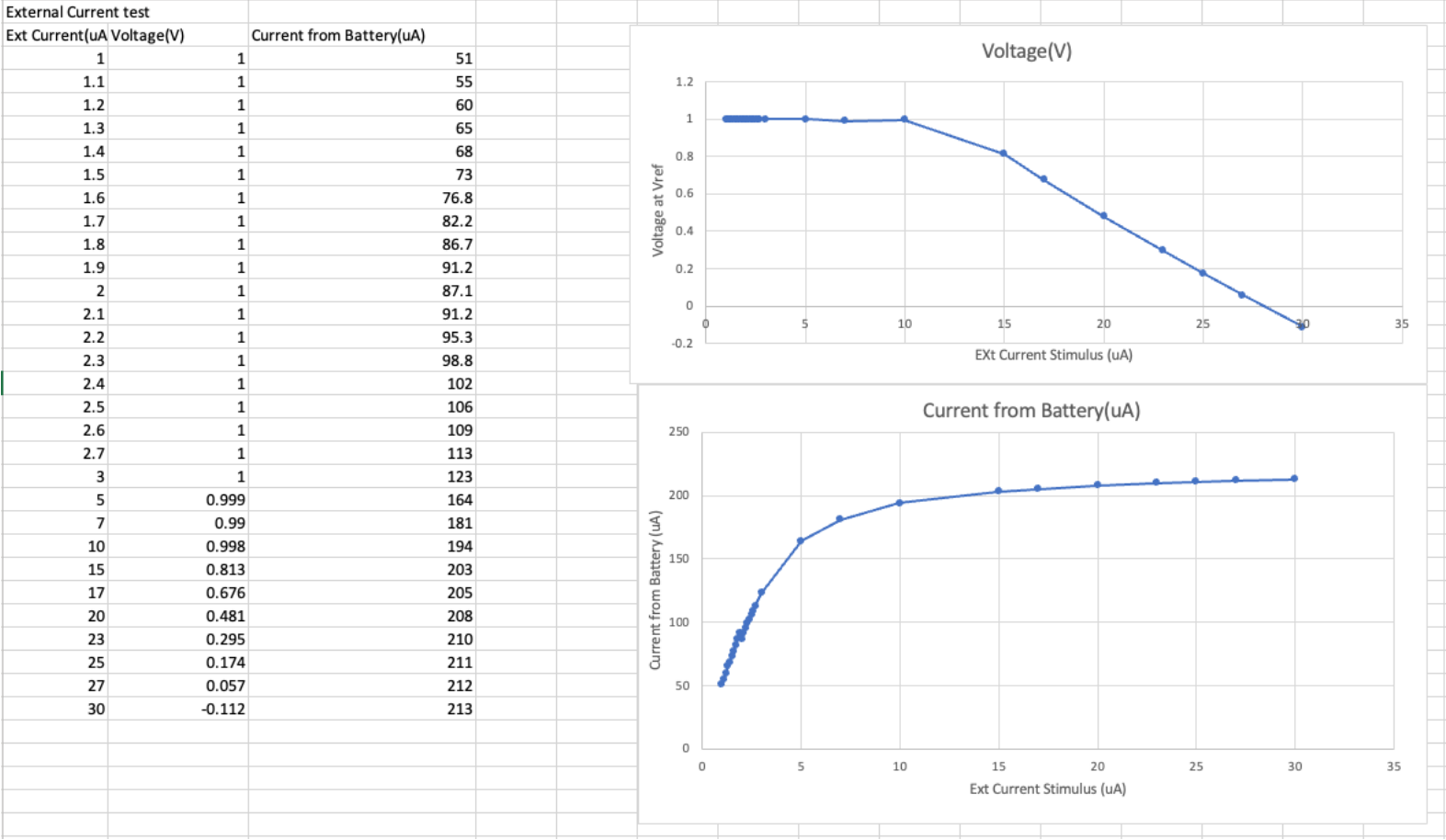
External averaging

Try Averegaing if noise if is the limiting factor								
Chip 6	TS_sw1; Resistance							
All OUTP	All Out N		Threshold	Averaging	RSCA	TP_SW		
5.73E-01		4.20E-01	4.97E-01	16	No inserted	6V		
Not inserted								
All P	All N					chip 6, threshold based on 1000 samples		
594		424	509		Safe			
Inserted						ideal threshold		507
588		422	505		Attacked			
579		425	502					
Inserted					Safe			
OutP	OutN		Total	TP	OutP	OutN	Total	TN
51		48	99	51.51515152	48	51	99	51.51515
503		497	1000	50.3	497	503	1000	50.3

RSCA	20
CLK	2.00E+05

Chip	Iforce	All P	All N	Difference	Rsca		All P	All N	Difference	Rsca
1	0	466	454	12	Not inserted		467	457	10	Inserted
	1--E-6	486	334	152			500	335	165	
	4.00E-04	111								

RSCA	1
CLK	2.00E+05

Iforce	All P	All N	Difference	Rsca		All P	All N	Difference	Rsca
0	465	456	9	Not inserted		466	457	9	Inserted
1.00E-04	502	337	165			502	338	164	
2.00E-04	477	331	146			480	330	150	
3.00E-04	393	312	81			396	313	83	
4.00E-04	118	Doesn't Appear							

Current not going above 420uA in SC02

NOTE: For Iforce as 400 u. OUTN never appears across the threoshol from 0.1 to 0.9. OUTP stops below 110 and is all OUTP by 118mV. There is a range to increase Iforce to get output from comparator

RSCA	18
CLK	2.00E+05

Iforce	All P	All N	Difference	Rsca		All P	All N	Difference	Rsca
0	466	459	7	Not Inserted		465	459	6	Inserted
1.00E-04	475	348	127			477	349	128	
2.00E-04	450	340	110			451	340	111	
3.00E-04	375	316	59			375	316	59	

Even if only Rsca is increased along with current by trimming the 1Meg resistor, the negative flips disappear

OTA gets saturated after amplifying the signal. Idead current flowing in 1MEG is 1uA for 10By10 multiplication form the array

Tried to inject current but it seems to saturate at 1uA, next step is to charaterize the comparator using test mode.

R @VINSC	Rs	Rsca	Normal mode operation		Current	RSCA		VCM		RSCA			
2.2	1.1(Min)	1.1(Min)			600uA	Not inserted		500		Inserted			
All P	All N	Threshold	Difference							All P	All N	Threshold	Difference
499	489.5	494.25	9.5							498	489	493.5	9
R @VINSC	Rs	Rsca	Normal mode operation		Current	RSCA		VCM		RSCA			
2.2	1.1(Min)	1.1(Min)			700uA	Not inserted		500		Inserted			
All P	All N	Threshold	Difference							All P	All N	Threshold	Difference
499	490.5	494.75	8.5							498.5	491.5	495	7

Floating TP_Ibias comparator performance   (No current pulled from battery)

All P	All N	Threshold	Difference
498.5	489.5	494	9

Now trying increasing the resistance to increase signal level to perturb the comparator

R @VINSC	Rs	Rsca	Normal mode operation		Current	RSCA		VCM		RSCA
11.19	1.1(Min)	10			200uA	Not inserted		500		Inserted

All P	All N	Threshold	Difference
185.1	178.8	181.95	6.3

R @VINSC	Rs	Rsca	Normal mode operation		Current	RSCA		VCM		RSCA
19.74	1.1(Min)	18.6(Max)			200uA	Not inserted		500		Inserted

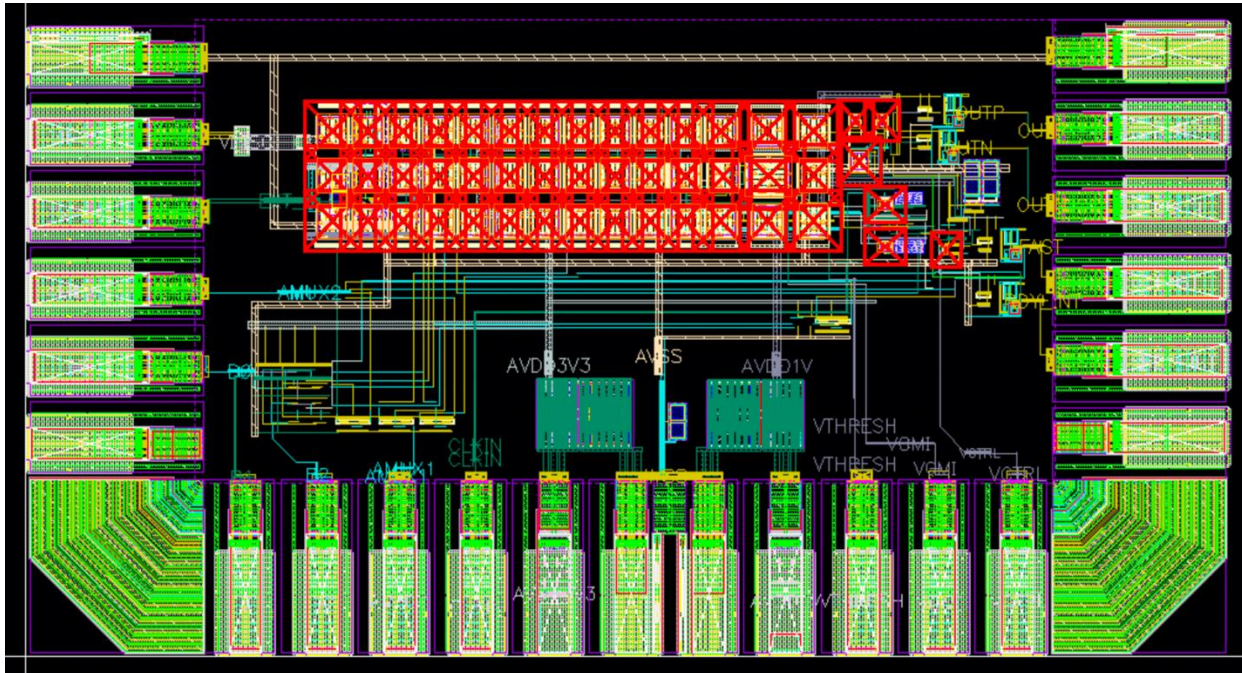| All P	All N	Threshold	Difference
185.5	179	182.25	6.5

Rsca	Resistance seen by Vinsc	Min achievable resistance on this board	Resistance in safe configuration	Drop of 2mV across Resistors when switch toggles ON/OFF					Chip 7	Rsca	Resistance seen by Vinsc	Min achievable resistance on this board	Resistance in safe configuration
10	11.2	2.2	1.6							10	11.2	2.2	1.6
All P	All N	Threshold	Difference	Config	200uA					All P	All N	Threshold	Difference
145	138	141.5	7	Safe							138	138	
145	139	142	6							No Result	139	139	
Decreasing the signal to 30mV - reduce current to 100uA				50% duty cycle						Decreasing the signal to 30mV - reduce current to 100uA			
591	377	484	214		No flipping					591	377	484	214
Increasing the signal to 45mV - increase current to 150uA										Increasing the signal to 45mV - increase current to 150uA			
500	348	424	152							453	393	423	60
Current	170uA									Current	170uA		
348	307	327.5	41							308	298	303	10
Current	180uA									Current	180uA		
288	276	282	12		1.82mV IR drop					277	271	274	6
276	261	268.5	15		@20KHz	1.82mV IR drop				274	265	269.5	9
Current	190uA									Current	190uA		
200	188	194	12		1.91mV IR drop					194	190	192	4

No flipping observed for both chips. The comparator decides faster with igher current(signal) but unable to flip even with 60mV signal swing at the input (Even after increasing and decreasing VCMI by from 400mV to 850mV)

Iforce	Rsca		Gain		Comparator output Signal
1.00E-04	1	1.00E-04	30	3.00E-03	
7.00E-04	1.1	7.70E-04	30	2.31E-02	
2.00E-04	10	2.00E-03	30	6.00E-02	
2.00E-04	20	4.00E-03	31	1.24E-01	
5.00E-03	20	1.00E-01	30	3.00E+00	

External Current test

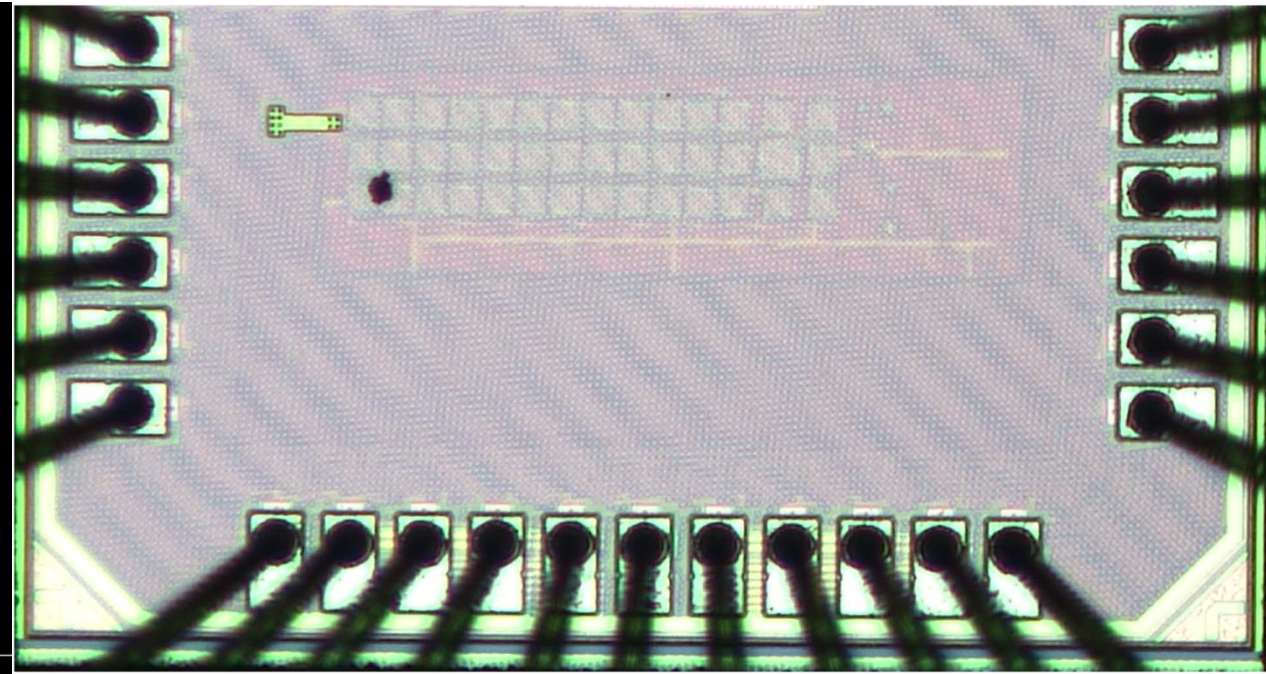| Ext Current(uA)	Voltage(V)	Current from Battery(uA)	
1	1	51	Nominal at 50% duty cycle; Target 100uA
1.1	1	55	
1.2	1	60	
1.3	1	65	
1.4	1	68	
1.5	1	73	
1.6	1	76.8	
1.7	1	82.2	
1.8	1	86.7	
1.9	1	91.2	
2	1	87.1	
2.1	1	91.2	
2.2	1	95.3	
2.3	1	98.8	
2.4	1	102	
2.5	1	106	
2.6	1	109	
2.7	1	113	
3	1	123	
5	0.999	164	
7	0.99	181	
10	0.998	194	
15	0.813	203	
17	0.676	205	
20	0.481	208	
23	0.295	210	
25	0.174	211	
27	0.057	212	
30	-0.112	213	

Voltage(V)

Current from Battery(uA)

Chip 2 - 2022
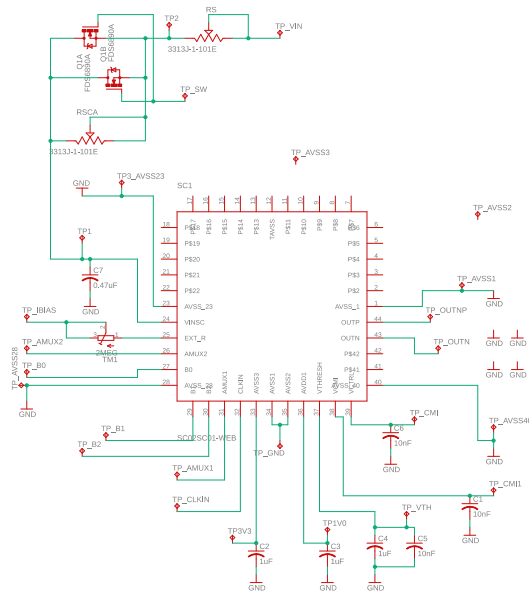
Tapeout 2
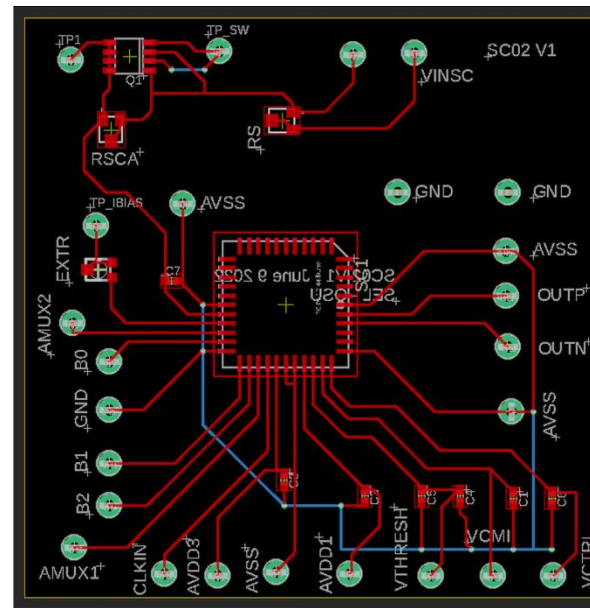

a) SC02 Chip Layout

b) Die photo

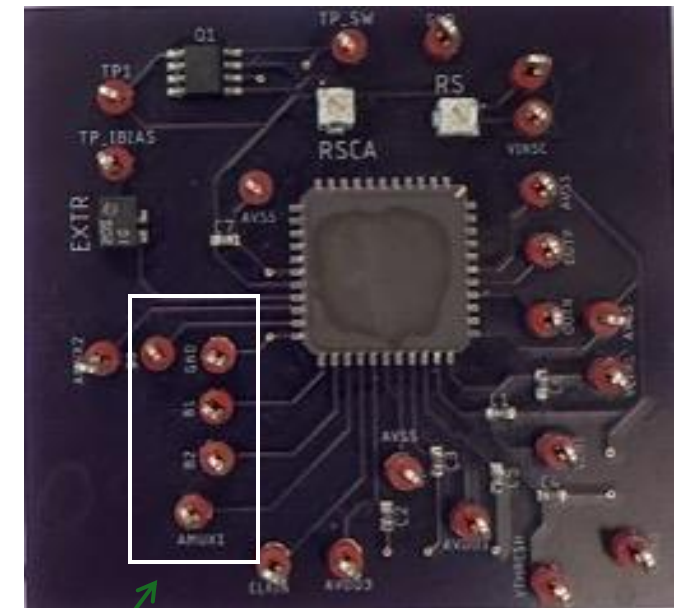Fig 16 : Second tapeout with corrections, design U-frame

PCB plan - 2

a)

b)

Test modes

c)

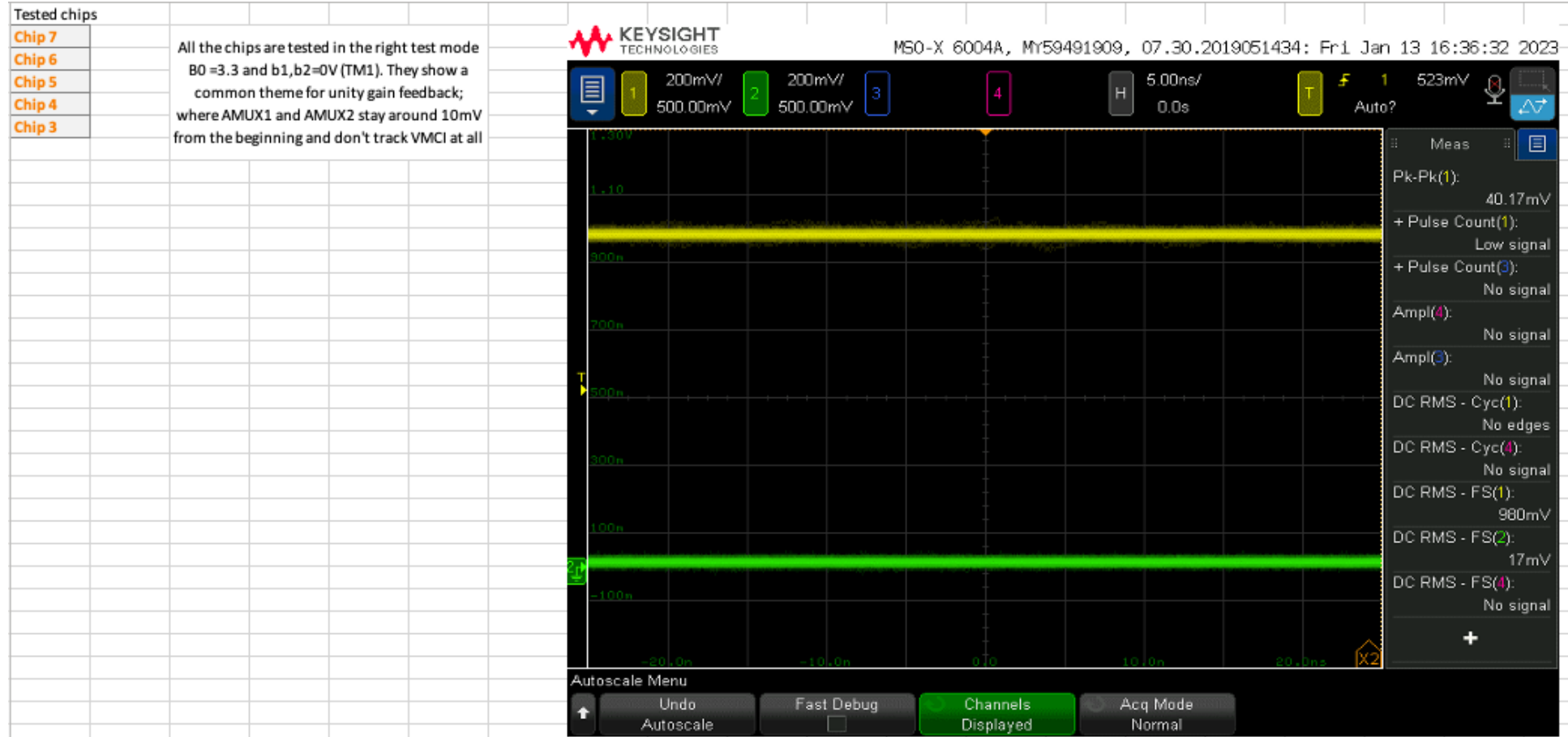Fig 17: PCB for second chip a) Schematic b) Board layout c) Fabricated PCB

Textmode setup

Testmode Definition												S1	Connected to Cs(PHI1ORPHI2 switch)
b2	b1	b0	Testmode	AMUX1	AMUX2	Condition				Goal		S2	Connected to Vcm
0	0	0	TM0	NC	NC	Normal Operation of the circuit				Normal Operation		S3	Switch in feedback
0	0	1	TM1	VOUT_OTA	VC2	S1,S2 = OPEN; S3=OPEN				IN and OUT of OTA accessible, feedback on PCB to test parameters		NC	Not Connected
0	1	0	TM2	VOUT_OTA	rdy_interna	S1=OPEN; S2=S3=CLOSE				Vout_OTA accessible, Vthresh accessible; Test Comparator, Vout_OTA shorts to Vx and VCMI			
0	1	1	TM3	VOUT_OTA	fast	S1=OPEN; S2=S3=CLOSE				Feed Vout_OTA from external source to set the fast threshold. OTA is shorted. Vout_OTA shorts to Vx and VCMI.			
1	0	0	TM4	NC	fast	Normal operation for all switches				Normal Operation; observe fast			
1	0	1	TM5	NC	fast_ext	Normal operation for all switches				Add a 2-1 MUX selecting between fast_ext and fast to be the "fast" for DDNR. TM5 is the "sel".			

TM	Delta Modulation	VCMI	Virtual Ground	Feedback		
	S1	S2	S3	S4		
TM0	--	--	--	--		--: normal operation
TM1	OPEN	OPEN	CLOSE	OPEN		
TM2	OPEN	CLOSE	CLOSE	CLOSE		
TM3	OPEN	CLOSE	CLOSE	CLOSE		
TM4	--	--	--	--		
TM5	--	--	--	--		

9-May Chip 7

Testmode Check

Chip 7
Chip 6
Chip 5
Chip 4
Chip 3

All the chips are tested in the right test mode B0 =3.3 and b1,b2=0V (TM1). They show a common theme for unity gain feedback; where AMUX1 and AMUX2 stay around 10mV from the beginning and don't track VMCI at all

Initial board setup

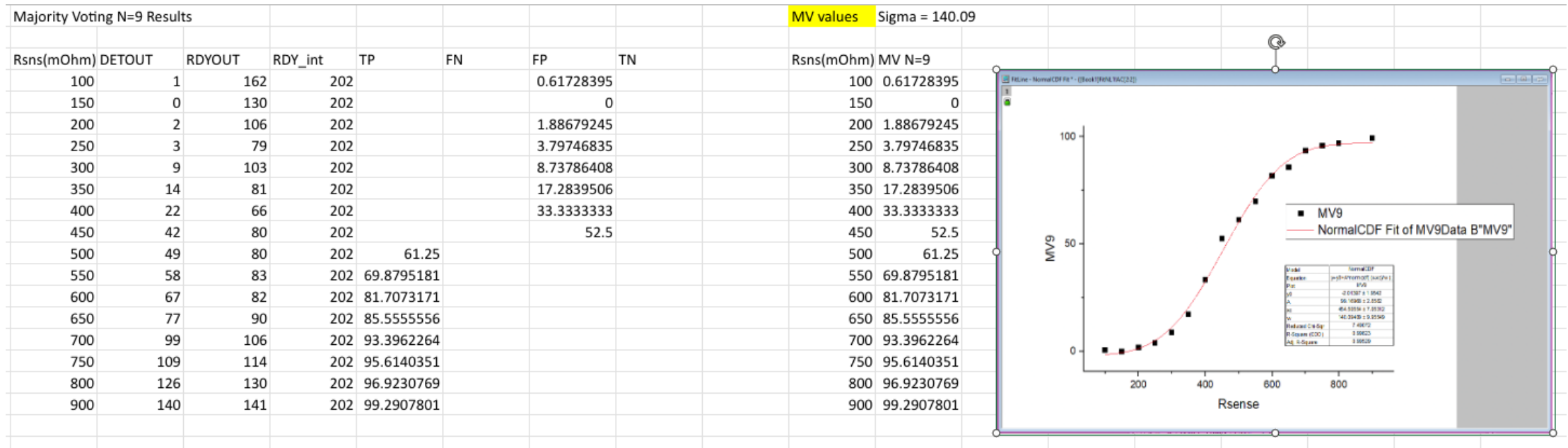| Chip 7									
Resitance from VINSC to TP1			resistors set to minimum			Battery Current			Setting initial state for the board with chip 7
TP_SW	ON(3.3V)	3.5 Ohm			CLK		3.3	100u	
TP_SW	OFF(1V)	2.5 Ohm			CLK		0	3nA	
					CLK@ 50%			48.5uA	

OTA Testing

Test the gain and functionality of OTA. Try a gain of unity with tracking and gain of 2 and 3 subsequently in the commom mode operating range

Chip 7	UG Tracking			Trying with a gain of 2		AMUX1		Vout OTA
	NO: Not Working					Rf		220K
						Ri		100K
Chip 5	In a range from 0 to about 380mV; the output terminal doesn't track VCMI and the difference starts increasing. Max value of Vout OTA at VMCI of 950mV is 480mV: Not Working			For VCMI at 300mV(within ICMR)		Inverting gain		2.2
						Vim =250m		50mV*2.2=110mV
						Vip=300m		
						gain=2.2		
						Expected output = 190mV		
Chip 6	UG Tracking							
	The negative terminal is saturated at 1V, the meet at 1V for VCMI: Not Working							
	Gain of 2 : ICMR rage at 1V, not enough space for gain of two							

Chip 4	UG Functionality			Gain of 2		Chip 3	UG Functionality		
	Behaviour similar to chip 5; ICMR starts dviating at 350mV and then the distance increases.			Vim =250rrnV*2.2=110mV					
				Vip=300m					
				gain=2.2			The negative terminal is saturated at 1V, the meet at 1V for VCMI: Not Working		
				Expected output = 190mV					
	The output shorts to VMCI and tracks it till 750 where it starts to deviate. Gain of two not observed as expected.						Gain of 2 : ICMR rage at 1V, not enough space for gain of two		

Simulation Results

VDD Variation and Accuracy

598 Samples

							Vth = 496.1			
							Normalized	598		
	VDD	TP	FP	FN	TN		TP	FP	FN	TN
	1.5	582	16	25	573		97.6588629	2.341137	4.180602	95.8194
	2	584	14	23	575		97.3244147	2.675585	3.846154	96.15385
	2.5	582	16	18	580		97.3244147	2.675585	3.010033	96.98997
	3	582	16	15	583		96.4882943	3.511706	2.508361	97.49164
	3.5	577	21	13	585		96.4882943	3.511706	2.173913	97.82609

Rmin vs Sigma Analysis with different averaging techniques

Majority Voting N=9 Results

MV values | Sigma = 140.09

Rsns(mOhm)	DETOUT	RDYOUT	RDY_int	TP	FN	FP	TN		Rsns(mOhm)	MV N=9
100	1	162	202			0.61728395			100	0.61728395
150	0	130	202			0			150	0
200	2	106	202			1.88679245			200	1.88679245
250	3	79	202			3.79746835			250	3.79746835
300	9	103	202			8.73786408			300	8.73786408
350	14	81	202			17.2839506			350	17.2839506
400	22	66	202			33.3333333			400	33.3333333
450	42	80	202			52.5			450	52.5
500	49	80	202	61.25					500	61.25
550	58	83	202	69.8795181					550	69.8795181
600	67	82	202	81.7073171					600	81.7073171
650	77	90	202	85.5555556					650	85.5555556
700	99	106	202	93.3962264					700	93.3962264
750	109	114	202	95.6140351					750	95.6140351
800	126	130	202	96.9230769					800	96.9230769
900	140	141	202	99.2907801					900	99.2907801

Sigma with DDNR

Rsns(mOhm)	OUTP	RDY_int			DDNR N=5 Results								DDNR N=5	Sigma = 158.16
100	214	202			Rsns(mOhm)	DETOUT	RDYOUT	TP	FP				Rsns(mOhm)	DDNR N=5
150	209	202			100	1	192		0.52083333				100	0.52083333
200	206	202			150	2	178		1.12359551				150	1.12359551
250	193	202			200	2	163		1.22699387				200	1.22699387
300	180	202			250	9	147		6.12244898				250	6.12244898
350	164	202			300	15	138		10.8695652				300	10.8695652
400	138	202			350	20	116		17.2413793				350	17.2413793
450	119	202			400	41	118		34.7457627				400	34.7457627
500	105	202			450	59	118		50				450	50
550	88	202			500	65	117	55.5555556					500	55.5555556
600	67	202			550	85	125	68					550	68
650	53	202			600	94	120	78.3333333					600	78.3333333
700	47	202			650	121	145	83.4482759					650	83.4482759
750	35	202			700	137	152	90.1315789					700	90.1315789
800	30	202			750	147	157	93.6305732					750	93.6305732
900	19	202			800	156	161	96.8944099					800	96.8944099
					900	175	177	98.8700565					900	98.8700565

Majority Voting

Majority Voting N=16						NO MV						MV N=16 Results		
Rsns(mOhm)	RDYOUT	DETOUT	TP	FP		Rsns(mOhm)	OUTP	RDY_int	TP	FP		Rsns(mOhm)	MV N=16	NO MV
100	122	1		0.81967213		100	1	202		0.4950495		100	0.81967213	0.4950495
150	72	0		0		150	6	202		2.97029703		150	0	2.97029703
200	72	0		0		200	9	202		4.45544554		200	0	4.45544554
250	53	3		5.66037736		250	22	202		10.8910891		250	5.66037736	10.8910891
300	57	5		8.77192982		300	36	202		17.8217822		300	8.77192982	17.8217822
350	39	5		12.8205128		350	52	202		25.7425743		350	12.8205128	25.7425743
400	40	11		27.5		400	78	202		38.6138614		400	27.5	38.6138614
450	44	19		43.1818182		450	97	202		48.019802		450	43.1818182	48.019802
500	54	28	51.8518519			500	111	202	54.950495			500	51.8518519	54.950495
550	56	42	75			550	128	202	63.3663366			550	75	63.3663366
600	40	30	75			600	149	202	73.7623762			600	75	73.7623762
650	56	48	85.7142857			650	163	202	80.6930693			650	85.7142857	80.6930693
700	72	65	90.2777778			700	169	202	83.6633663			700	90.2777778	83.6633663
750	72	68	94.4444444			750	181	202	89.6039604			750	94.4444444	89.6039604
800	104	99	95.1923077			800	186	202	92.0792079			800	95.1923077	92.0792079
900	99	98	98.989899			900	197	202	97.5247525			900	98.989899	97.5247525

Rmin vs Sigma with different techniques

DDNR N=5						DDNR Results			MV N=9						MV N=9 Results		
Rsense	RDYOUT	DETOUT	TP	FP		Rsense	N=5	No. DDNR		Rsense	RDYOUT	DETOUT	TP	FP	Rsense	N=9	No. MV
100	191	1		0.52356021		100	0.52356021	0.49751244		100	250	2		0.8	100	0.8	3.46820809
150	177	2		1.1299435		150	1.1299435	2.98507463		150	207	4		1.93236715	150	1.93236715	6.06936416
200	162	2		1.2345679		200	1.2345679	4.47761194		200	162	4		2.4691358	200	2.4691358	9.8265896
250	146	9		6.16438356		250	6.16438356	10.9452736		250	168	18		10.7142857	250	10.7142857	15.8959538
300	137	15		10.9489051		300	10.9489051	17.9104478		300	165	26		15.7575758	300	15.7575758	22.2543353
350	116	20		17.2413793		350	17.2413793	25.8706468		350	106	31		29.245283	350	29.245283	31.7919075
400	118	41		34.7457627		400	34.7457627	38.3084577		400	107	43		40.1869159	400	40.1869159	40.4624277
450	117	58		49.5726496		450	49.5726496	47.761194		450	123	63		51.2195122	450	51.2195122	51.1560694
500	116	64	55.1724138			500	55.1724138	54.7263682		500	130	82	63.0769231		500	63.0769231	59.2485549
550	124	84	67.7419355			550	67.7419355	63.1840796		550	122	96	78.6885246		550	78.6885246	69.6531792
600	119	93	78.1512605			600	78.1512605	73.6318408		600	130	115	88.4615385		600	88.4615385	76.300578
650	144	120	83.3333333			650	83.3333333	80.5970149		650	140	133	95		650	95	84.1040462
700	151	136	90.0662252			700	90.0662252	83.5820896		700	164	161	98.1707317		700	98.1707317	91.0404624
750	156	146	93.5897436			750	93.5897436	89.5522388		750	194	188	96.9072165		750	96.9072165	93.6416185
800	160	155	96.875			800	96.875	92.039801		800	230	226	98.2608696		800	98.2608696	96.2427746
900	176	174	98.8636364			900	98.8636364	97.5124378		900	321	319	99.376947		900	99.376947	98.5549133

Continued

Rsense	RDY_int	POSEDGE	TP	FP	Rmin	RDYOUT	DETOUT	Confidence
100	201	1		0.49751244	750	157	147	93.6305732
150	201	6		2.98507463	760	158	151	95.5696203
200	201	9		4.47761194	770	158	152	96.2025316
250	201	22		10.9452736	780	159	153	96.2264151
300	201	36		17.9104478	790	157	152	96.8152866
350	201	52		25.8706468	800	161	156	96.8944099
400	201	77		38.3084577				
450	201	96		47.761194				
500	201	110	54.7263682		Rmin_fine	RDYOUT	DETOUT	Confidence
550	201	127	63.1840796		755	152	145	95.3947368
600	201	148	73.6318408		756	154	146	94.8051948
650	201	162	80.5970149		757	159	150	94.3396226
700	201	168	83.5820896		758	156	148	94.8717949
750	201	180	89.5522388		759	159	150	94.3396226
800	201	185	92.039801					
900	201	196	97.5124378					
					Without Avging			
					Rmin	POSEDGE	RDY_int	Confidence 90%
					750	184	201	91.5422886
					760	186	201	92.5373134
					770	187	201	93.0348259
					780	188	201	93.5323383
					790	189	201	94.0298507
					800	190	201	94.5273632

Rsense	RDY_int	POSEDGE	TP	FP	Rmin	RDYOUT	DETOUT	Confidence
100	346	12		3.46820809	600	116	97	83.6206897
150	346	21		6.06936416	610	130	109	83.8461538
200	346	34		9.8265896	620	138	121	87.6811594
250	346	55		15.8959538	630	128	115	89.84375
300	346	77		22.2543353	640	120	113	94.1666667
350	346	110		31.7919075	650	128	119	92.96875
400	346	140		40.4624277				
450	346	177		51.1560694				
500	346	205	59.2485549		Rmin_fine	RDYOUT	DETOUT	Confidence
550	346	241	69.6531792		631	120	110	91.6666667
600	346	264	76.300578		632	120	112	93.3333333
650	346	291	84.1040462		633	128	119	92.96875
700	346	315	91.0404624		634	128	118	92.1875
750	346	324	93.6416185		635	128	118	92.1875
800	346	333	96.2427746		636	136	125	91.9117647
900	346	341	98.5549133		637	136	125	91.9117647
					638	120	111	92.5
					639	128	117	91.40625

Continued

Rsense	RDYOUT	DETOUT	TP	FP		Rsense	RDYOUT	DETOUT	TP	FP	Sigma
100	95	1		1.05263158		100	167	1		0.5988024	124.15
150	79	3		3.79746835		150	159	2		1.25786164	
200	73	4		5.47945205		200	149	5		3.3557047	
250	55	7		12.7272727		250	141	6		4.25531915	
300	46	10		21.7391304		300	129	15		11.627907	
350	40	22	55			350	113	20		17.699115	
400	48	31	64.5833333			400	104	24		23.0769231	
450	41	36	87.804878			450	101	46		45.5445545	
500	49	46	93.877551			500	106	64	60.3773585		
550	73	71	97.260274			550	105	76	72.3809524		
600	88	87	98.8636364			600	112	93	83.0357143		
650	112	112	100			650	112	103	91.9642857		
700	132	131	99.2424242			700	134	128	95.5223881		
750	147	147	100			750	144	142	98.6111111		
800	163	163	100			800	154	152	98.7012987		
900	175	175	100			900	170	169	99.4117647		

Continued

Rsense	RDY_int	POSEDGE	TP	FP	DA	Rsense	RDYOUT	DETOUT	TP	FP	DA	Sigma with MV3	125.71
100	183	4		2.18579235	2.18579235	100	165	1		0.60606061	0.60606061	Sigma No Avg	161.34
150	183	5		2.73224044	2.73224044	150	155	2		1.29032258	1.29032258		
200	183	11		6.01092896	6.01092896	200	143	6		4.1958042	4.1958042		
250	183	23		12.568306	12.568306	250	137	10		7.29927007	7.29927007		
300	183	35		19.1256831	19.1256831	300	121	17		14.0495868	14.0495868		
350	183	50		27.3224044	27.3224044	350	109	26		23.853211	23.853211		
400	183	70		38.2513661	38.2513661	400	105	39		37.1428571	37.1428571		
450	183	91		49.726776	49.726776	450	95	53	55.7894737		55.7894737		
500	183	116	63.3879781		63.3879781	500	102	71	69.6078431		69.6078431		
550	183	135	73.7704918		73.7704918	550	107	86	80.3738318		80.3738318		
600	183	152	83.0601093		83.0601093	600	114	101	88.5964912		88.5964912		
650	183	165	90.1639344		90.1639344	650	124	118	95.1612903		95.1612903		
700	183	173	94.5355191		94.5355191	700	136	132	97.0588235		97.0588235		
750	183	178	97.2677596		97.2677596	750	152	150	98.6842105		98.6842105		
800	183	179	97.8142077		97.8142077	800	158	157	99.3670886		99.3670886		
900	183	183	100		100	900	172	172	100		100		

Continued

MV5							NoAvging					
Rsense	RDYOUT	DETOUT	TP	FP	DA	RDY_int	POSEDGE	TP	FP	DA	Sigma MV5	149.52
100	286	3		1.04895105	1.04895105	346	8		2.31213873	2.31213873	Sigma No Avg	211.51
150	266	4		1.5037594	1.5037594	346	16		4.62427746	4.62427746		
200	234	8		3.41880342	3.41880342	346	31		8.95953757	8.95953757		
250	215	15		6.97674419	6.97674419	346	52		15.0289017	15.0289017		
300	204	26		12.745098	12.745098	346	70		20.2312139	20.2312139		
350	192	40		20.8333333	20.8333333	346	99		28.6127168	28.6127168		
400	183	64		34.9726776	34.9726776	346	127		36.7052023	36.7052023		
450	151	65		43.0463576	43.0463576	346	158		45.6647399	45.6647399		
500	158	91	57.5949367		57.5949367	346	199	57.5144509		57.5144509		
550	162	117	72.2222222		72.2222222	346	226	65.3179191		65.3179191		
600	186	152	81.7204301		81.7204301	346	265	76.5895954		76.5895954		
650	210	182	86.6666667		86.6666667	346	275	79.4797688		79.4797688		
700	226	211	93.3628319		93.3628319	346	296	85.5491329		85.5491329		
750	232	226	97.4137931		97.4137931	346	317	91.6184971		91.6184971		
800	260	253	97.3076923		97.3076923	346	326	94.2196532		94.2196532		
900	286	286	100		100	346	341	98.5549133		98.5549133		

Continued

Rmin	RDYOUT	DETOUT	Confidence 90%
650	210	182	86.6666667
660	198	177	89.3939394
670	210	188	89.5238095
680	206	186	90.2912621
690	210	194	92.3809524
700	226	211	93.3628319
Rmin	680 MV5		

Continued

MV N=9					MV N=16 Results		
Rsense	RDYOUT	DETOUT	TP	FP	Rsense	N=16	No. MV
100	412	7		1.69902913	100	1.69902913	3.9184953
150	316	6		1.89873418	150	1.89873418	6.42633229
200	265	10		3.77358491	200	3.77358491	9.56112853
250	162	8		4.9382716	250	4.9382716	14.7335423
300	159	31		19.4968553	300	19.4968553	21.9435737
350	155	36		23.2258065	350	23.2258065	31.661442
400	124	41		33.0645161	400	33.0645161	40.1253918
450	133	70		52.6315789	450	52.6315789	50
500	150	84	56		500	56	58.1504702
550	134	103	76.8656716		550	76.8656716	67.5548589
600	188	161	85.6382979		600	85.6382979	75.2351097
650	188	168	89.3617021		650	89.3617021	83.2288401
700	205	198	96.5853659		700	96.5853659	89.4984326
750	268	260	97.0149254		750	97.0149254	92.9467085
800	316	310	98.1012658		800	98.1012658	95.6112853
900	478	474	99.1631799		900	99.1631799	98.7460815

Continued

Rsense	RDY_int	POSEDGE	TP	FP	Rmin	RDYOUT	DETOUT	Confidence
100	638	25		3.9184953	660	188	169	89.893617
150	638	41		6.42633229	670	172	158	91.8604651
200	638	61		9.56112853	680	189	172	91.005291
250	638	94		14.7335423	690	237	216	91.1392405
300	638	140		21.9435737				
350	638	202		31.661442				
400	638	256		40.1253918	Rmin_fine	RDYOUT	DETOUT	Confidence
450	638	319		50	691	205	193	94.1463415
500	638	371	58.1504702		692	237	219	92.4050633
550	638	431	67.5548589		693	237	218	91.9831224
600	638	480	75.2351097		694	205	196	95.6097561
650	638	531	83.2288401		695	205	196	95.6097561
700	638	571	89.4984326		696	237	225	94.9367089
750	638	593	92.9467085		697	205	196	95.6097561
800	638	610	95.6112853		698	205	197	96.097561
900	638	630	98.7460815		699	205	197	96.097561

F(a,b)		Confidence	Z	Sigma	Rmin(No Avg)
1.65	(0.5.0.5)	95%	3.29	208.95	687.4455
2.33	(0.1,0.1)	99%	4.66	208.95	973.707
	(0.1,0.5)		3.98		831.621
	(0.5,0.1)		3.98		831.621

Continued

TT sim	Temp=25	Rs =1ohm	Vthr=496.14m	Samples	24			
Rs	TP	FN	FP	TN	TP	FN	FP	TN
75	22	2	1	23	91.66666667	8.333333	4.166667	95.83333
100	22	2	1	23	91.66666667	8.333333	4.166667	95.83333
150	22	2	1	23	91.66666667	8.333333	4.166667	95.83333
200	22	2	2	22	91.66666667	8.333333	8.333333	91.66667
250	23	1	3	21	95.83333333	4.166667	12.5	87.5
300	23	1	3	21	95.83333333	4.166667	12.5	87.5
350	24	0	4	20	100	0	16.66667	83.33333
400	24	0	5	19	100	0	20.83333	79.16667

100

Samples	424									Rs	TN-after	TP-after	TP	TN
Rs	TP	FN	FP	TN	TP	FN	FP	TN						
75	398	26	21	403	93.86792453	6.132075	4.95283	95.04717		75	74.24	0.95455	0.93868	0.95047
100	401	23	25	399	94.5754717	5.424528	5.896226	94.10377		100	0.7273	0.95455	0.94576	0.94104
150	409	15	42	382	96.46226415	3.537736	9.90566	90.09434		150	0.7121	0.95455	0.96462	0.90094
200	412	12	62	362	97.16981132	2.830189	14.62264	85.37736		200	0.7121	0.95455	0.9717	0.85377
250	416	8	78	346	98.11320755	1.886792	18.39623	81.60377		250	0.6667	0.95455	0.98113	0.81604
300	420	4	98	326	99.05660377	0.943396	23.11321	76.88679		300	0.6364	0.95455	0.99057	0.76887
350	422	2	129	295	99.52830189	0.471698	30.42453	69.57547		350	0.6212	0.9697	0.99528	0.69576
400	422	2	146	278	99.52830189	0.471698	34.43396	65.56604		400	0.6212	0.9697	0.99528	0.65566
450	424	0	167	257	100	0	39.38679	60.61321		450	0.62121	0.9697	1	0.60613
500	424	0	190	234	100	0	44.81132	55.18868		500	0.62121	0.9697	1	0.55189
550	424	0	215	209	100	0	50.70755	49.29245		550	0.59091	0.9697	1	0.49293
600	424	0	228	196	100	0	53.77358	46.22642		600	0.54546	0.9697	1	0.46226
650	424	0	250	174	100	0	58.96226	41.03774		650	0.54546	0.95455	1	0.41038
700	424	0	274	150	100	0	64.62264	35.37736		700	0.51515	0.9697	1	0.35377
750	424	0	297	127	100	0	70.04717	29.95283		750	0.48485	0.9697	1	0.29953
800	424	0	314	110	100	0	74.0566	25.9434		800	0.45455	0.9697	1	0.25943
850	424	0	335	89	100	0	79.00943	20.99057		850	0.42424	0.95455	1	0.20991

Continued

	For 95% Confidence	
	Rmin(mOhm)	
DDNR N =5	755	159.25
MV N=9	650	144.08
MV N=16	694	144.59
No Avg	751	208.95
For 90% Confidence		
	R sense (mOhm)	Sigma(mOhm)
DDNR N =5	700(DDNR5)	159.25
MV N=9	631	144.08
MV N=16	670	144.59
No Avg	750	208.95
MV5	680	149.52

Continued

Rmin	Sigma
631	144.08
670	144.59
750	208.95
680	149.52
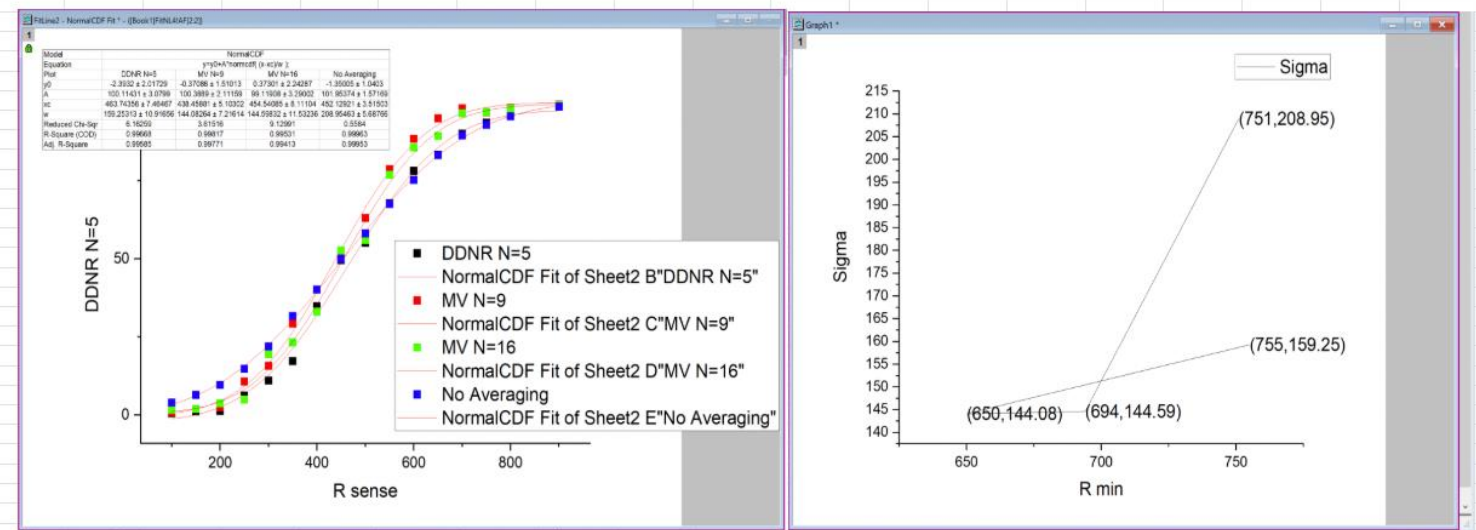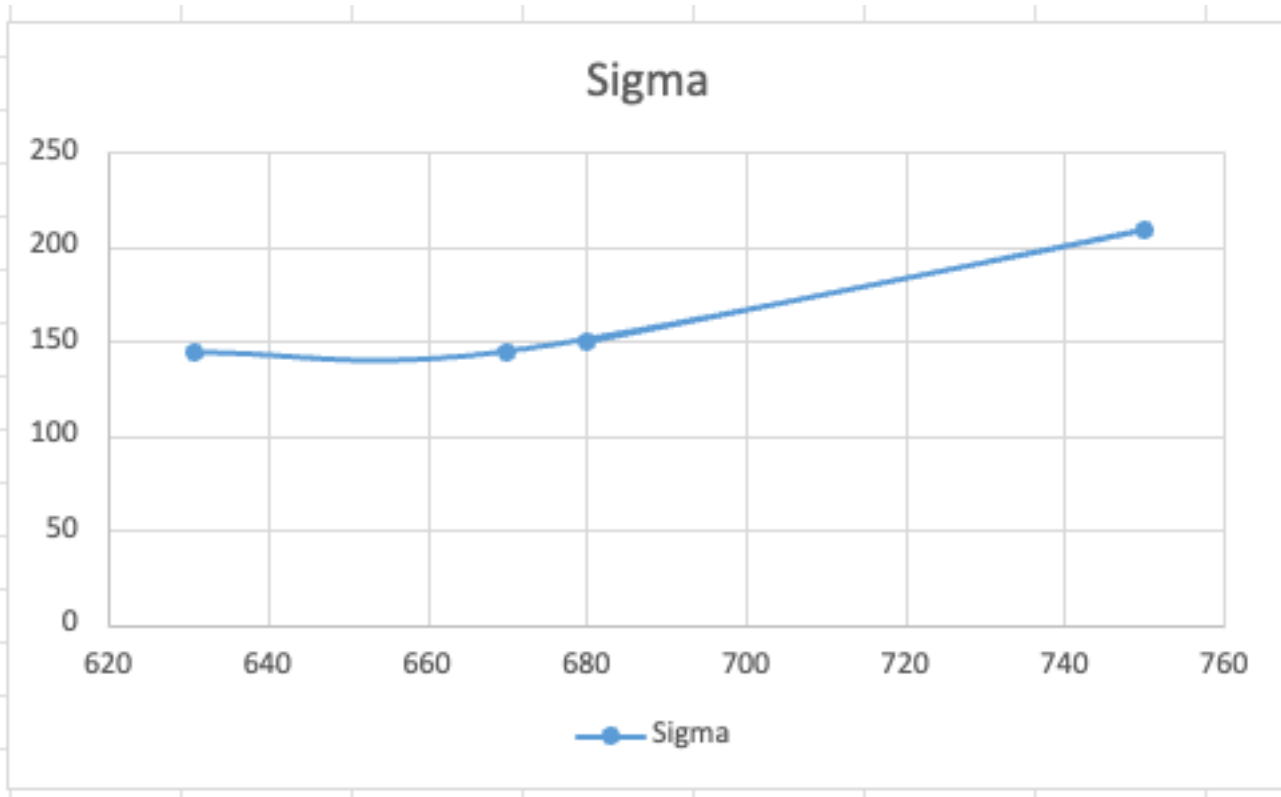
Temp Variation

Matirx with Temperature Coeffcients included for Rs and Rsns

Samples	598	Vthresh	495.87	Based on TT corner 25C								
	Value(Ohm)	TempCO	Source									
Rs	1	0.0001	https://www.digikey.com/en/products/filter/through-hole-resistors/53?s=N4IgTCBcDallwAID2ALAtggTgUwM4EtcAXJTEAXQF8g									
Rsns	0.15	0.00393	Source: https://www.cirris.com/learning-center/general-testing/special-topics/177-temperature-coefficient-of-copper									
									Normalized			
	Temp	TP	FN	FP	TN	mu0(mV)	mu0(sigma)uV	mu1(mV)	mu1(sigma)uV	TP	FP	FN	TN
	-40	555	43	4	594	496.51	460.67	494.23	460.92	92.8093645	7.19063545	0.66889632	99.3311037
	0	553	45	17	581	496.83	484	494.59	485.28	92.4749164	7.52508361	2.84280936	97.1571906
	25	532	66	25	573	497.01	498.32	494.81	500.43	88.9632107	11.0367893	4.18060201	95.819398
	50	506	92	31	567	497.22	512.35	495.06	514.25	84.6153846	15.3846154	5.18394649	94.8160535
	85	440	158	41	557	497.54	535.92	495.46	537.86	73.5785953	26.4214047	6.85618729	93.1438127
	125	376	222	48	550	497.97	559.44	495.99	561.51	62.8762542	37.1237458	8.02675585	91.9732441

Continued

Temp	mu0(mV)	mu1(mV)
-40	496.51	494.23
0	496.83	494.59
25	497.01	494.81
50	497.22	495.06
85	497.54	495.46
125	497.97	495.99

Temp	mu0(sigma)u	mu1(sigma)uV
-40	460.67	460.92
0	484	485.28
25	498.32	500.43
50	512.35	514.25
85	535.92	537.86
125	559.44	561.51
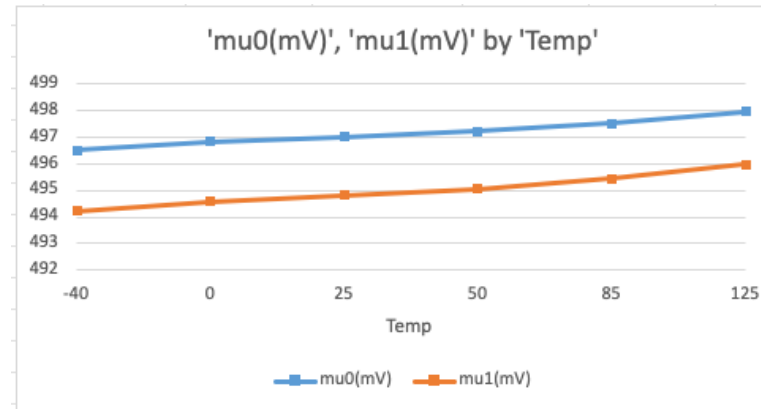
After caliberation
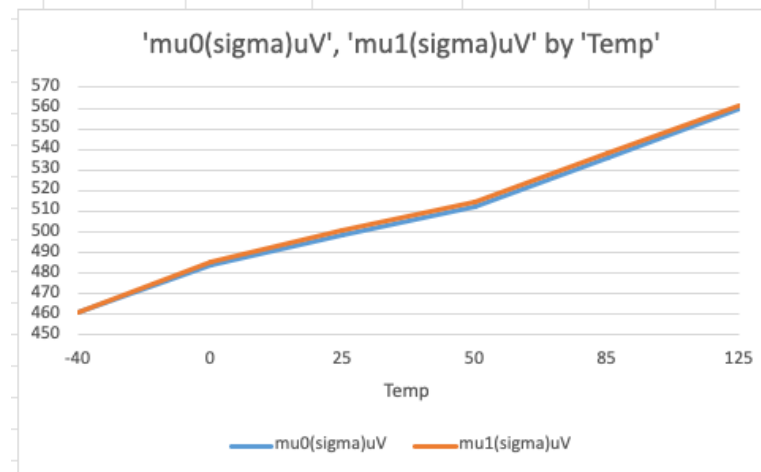
Before caliberation

Temp	TP	FP	FN	TN
-40	92.8093645	7.19063545	0.66889632	99.3311037
0	92.4749164	7.52508361	2.84280936	97.1571906
25	88.9632107	11.0367893	4.18060201	95.819398
50	84.6153846	15.3846154	5.18394649	94.8160535
85	73.5785953	26.4214047	6.85618729	93.1438127
125	62.8762542	37.1237458	8.02675585	91.9732441

Accuracy with Temperature
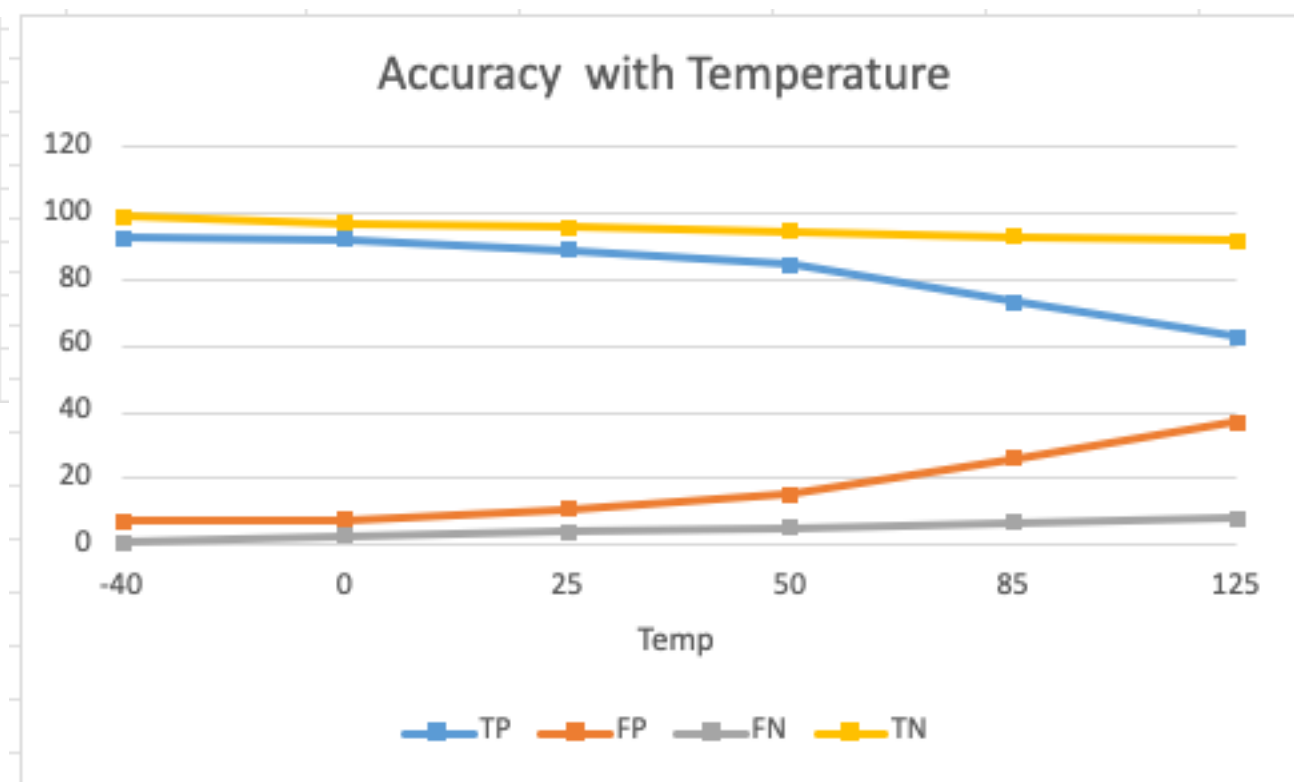
Through with different techniques

Rsns	Throughput			
	DDNR	No DDNR	MV	MV-Always
100	185	202	174	40
150	168	202	150	40
200	142	202	126	40
250	147	202	134	40
300	136	202	114	40
350	114	202	94	40
400	112	202	91	40
450	105	202	93	40
500	106	202	92	40
550	114	202	96	40
600	137	202	118	40
650	144	202	122	40
700	151	202	130	40
750	165	202	150	40
800	187	202	178	40
900	193	202	186	40

Throughput
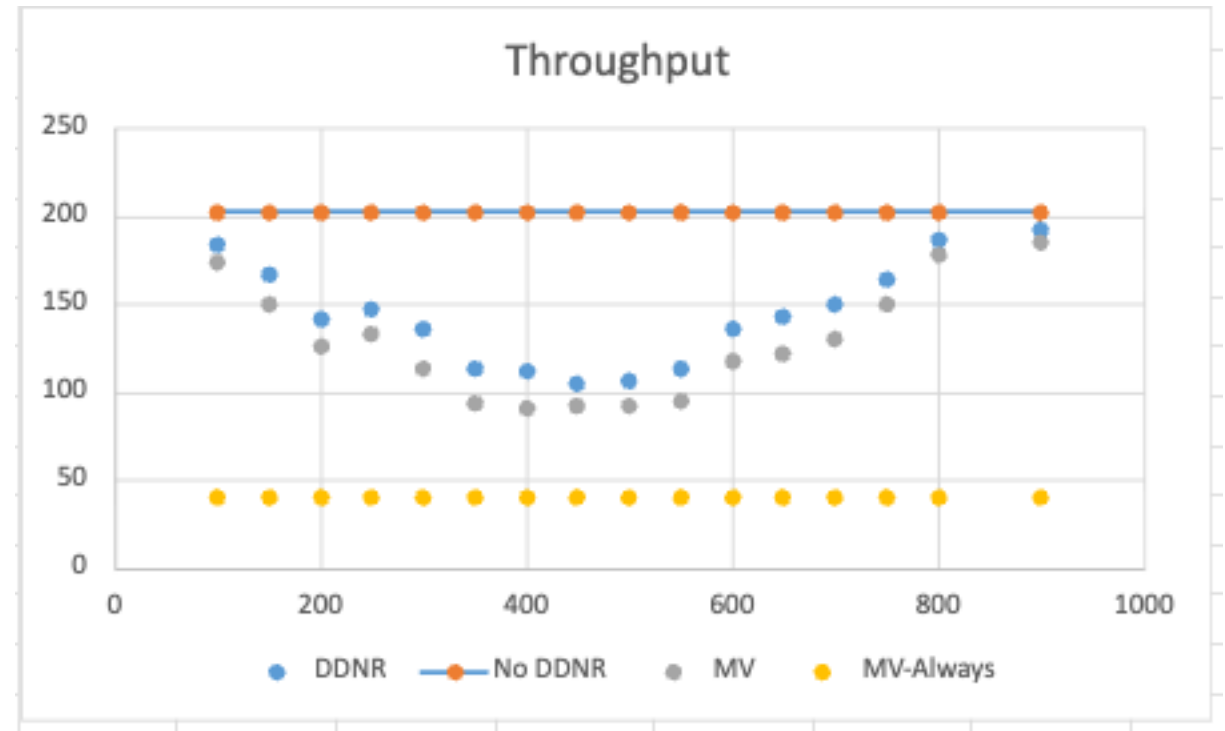
Detection Time

Rsns	Average Detection Time			
	DDNR	No DDNR	MV	MV-Alway
100	1.091892	1	1.16092	5.05
150	1.202381	1	1.346667	5.05
200	1.422535	1	1.603175	5.05
250	1.37415	1	1.507463	5.05
300	1.485294	1	1.77193	5.05
350	1.77193	1	2.148936	5.05
400	1.803571	1	2.21978	5.05
450	1.92381	1	2.172043	5.05
500	1.90566	1	2.195652	5.05
550	1.77193	1	2.104167	5.05
600	1.474453	1	1.711864	5.05
650	1.402778	1	1.655738	5.05
700	1.337748	1	1.553846	5.05
750	1.224242	1	1.346667	5.05
800	1.080214	1	1.134831	5.05
900	1.046632	1	1.086022	5.05
Min	1.046632	5.233161		
Max	1.92381	9.619048		
Rscamin	1.474453	7.372263		

Normalized Detection Time

Detection Rate

Rsns	No DDNR	MV	DDNR
100	1.98%	1.72%	1.62%
150	4.95%	2.67%	2.38%
200	9.41%	5.56%	3.52%
250	16.34%	11.19%	12.24%
300	22.28%	16.67%	17.65%
350	31.19%	24.47%	25.44%
400	43.07%	43.96%	43.75%
450	53.47%	54.84%	55.24%
500	63.37%	65.22%	68.87%
550	74.75%	84.38%	82.46%
600	82.67%	89.83%	89.05%
650	87.62%	95.90%	93.75%
700	93.07%	97.69%	98.01%
750	96.53%	98.67%	98.79%
800	97.52%	98.88%	98.93%
900	99.50%	100.00%	100.00%

P-SCA detection Positive Rate vs Rsns

Thank you!