CHARACTERIZATION AND RELIABILITY REPORT

ACT29

REV 1 JUNE 2004

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A. CHARACTERIZATION SUMMARY

A.1. PARAMETRIC CHARACTERIZATION

Table A.1.1. Statistical Parametric Characterization at 25°C (Lot AP10A_SP1A, 20 units)

PARAMETER	UNIT	AVERAGE	STANDARD DEVIATION (SIGMA, δ)	AVG - 6δ	AVG + 6δ	PROD LIMIT MIN	PROD LIMIT MAX	PROD YIELD
SW Breakdown Voltage	V	23.5	0.59	20.0	27.0	18	30	> 6δ
FB/VDD Start Voltage	V	4.99	0.038	4.77	5.22	4.76	5.24	> 6δ
SW Start Voltage	V	7.51	0.069	7.10	7.92	6.5	8.5	> 6δ
FB/VDD Under-voltage Threshold	V	3.35	0.026	3.19	3.51	3.18	3.52	> 6δ
FB/VDD Clamp Voltage	V	5.45	0.048	5.16	5.74	5.16	5.74	> 6δ
Supply Current	mA	0.66	0.019	0.546	0.774	0.46	0.9	> 6δ
Switching Frequency – ACT29	kHz	63.2	2.23	49.8	76.6	52	83	6δ
Switching Frequency – ACT29L						47	88	> 6δ
Switching Frequency – ACT28	kHz	128.6	5.66	94.6	162.56	97	168	5δ
Switching Frequency – ACT28L						87	178	6δ
Maximum Duty Cycle	%	75	1.27	67.4	82.6	67.5	82.5	6δ
Current Limit – ACT28/ACT29	mA	383.9 (1)	16.62	284.2	483.6	330	500	5δ
Current Limit – ACT28L/ACT29L						300	530	6δ
SW Switch Off Current	μA	11.2	0.41	8.7	13.7	6	25	> 6δ

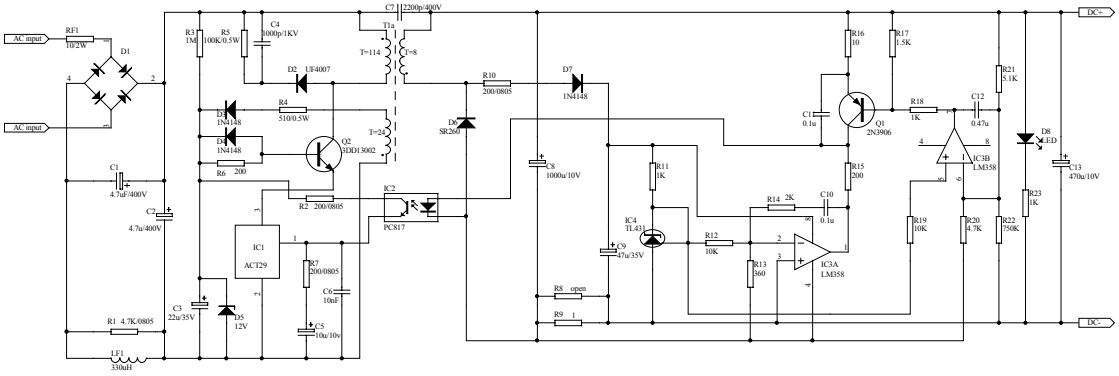
Notes: (1) Typical current limit is 9% higher on production lots after engineering lot AP10A_SP1A. This is static current limit measurement. Dynamic current limit is about 25mA higher that this value.

Table A.1.2. Parametric Temperature Variation (Lot AP10AZSP1A, 1 unit)

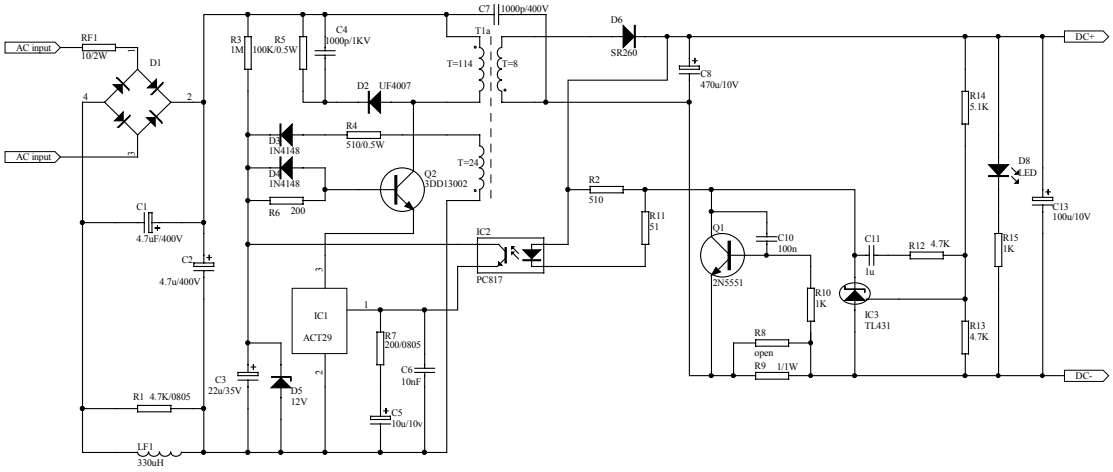
PARAMETER	- 40°C	25°C	85°C	UNIT
SW Breakdown Voltage	22.6	23.0	23.1	V
FB/VDD Start Voltage	4.76	4.97	4.97	V
SW Start Voltage	7.45	7.44	7.46	V
FB/VDD Under-voltage Threshold	3.34	3.33	3.33	V
FB/VDD Clamp Voltage	5.43	5.43	5.46	V
Supply Current	0.66	0.66	0.62	mA
Switching Frequency – ACT29	68.5	62.8	61.8	kHz
Switching Frequency – ACT28	128.9	128.3	116.7	kHz
Maximum Duty Cycle	74.0	73.8	74.1	%
Minimum Duty Cycle	3.5	3.4	4.4	%
Current Limit	419	401	392	mA
SW Switch Off Current	14	11	8	μA

A.2. TEST CIRCUITS

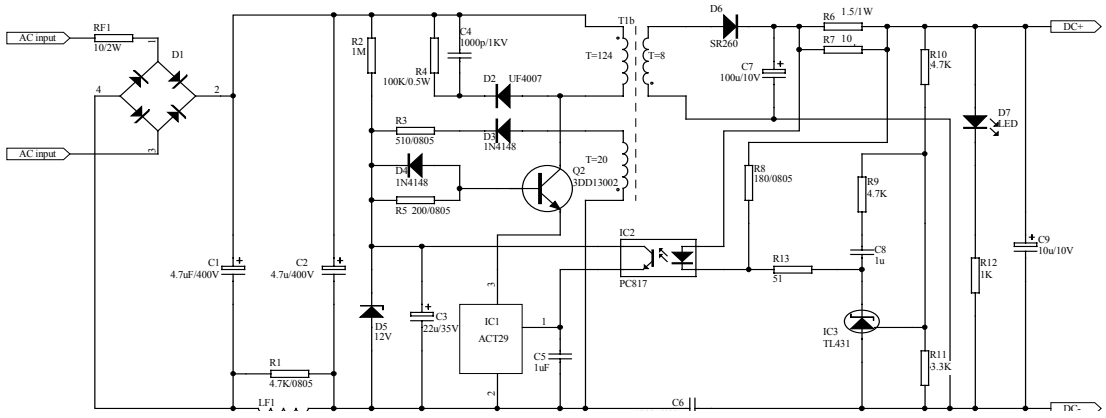
In-circuit performance characterization was done on several circuit configurations below.



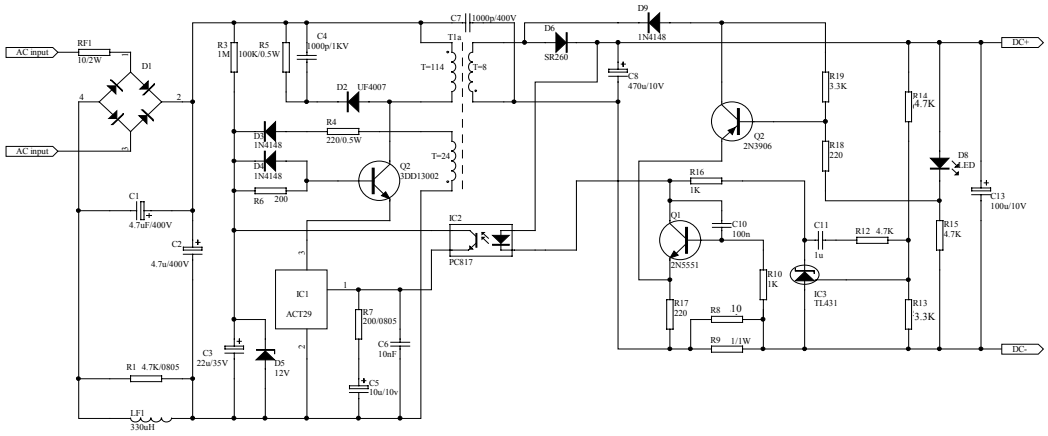
Circuit A1 – Circuit Using ‘431 and ‘358



Circuit A2 – Circuit with ‘431 and VBE Current Limit



Circuit A3 – Circuit with Minimum Component Count and Constant Current to Short Circuit



Circuit A4 – Circuit with Current Limit Fold-back at Short Circuit

A.3. EFFICIENCY

The following curves show efficiency tests for different circuit configurations. Note that efficient depends greatly on the value of the current limit shunt resistor and is also higher for higher output voltage.

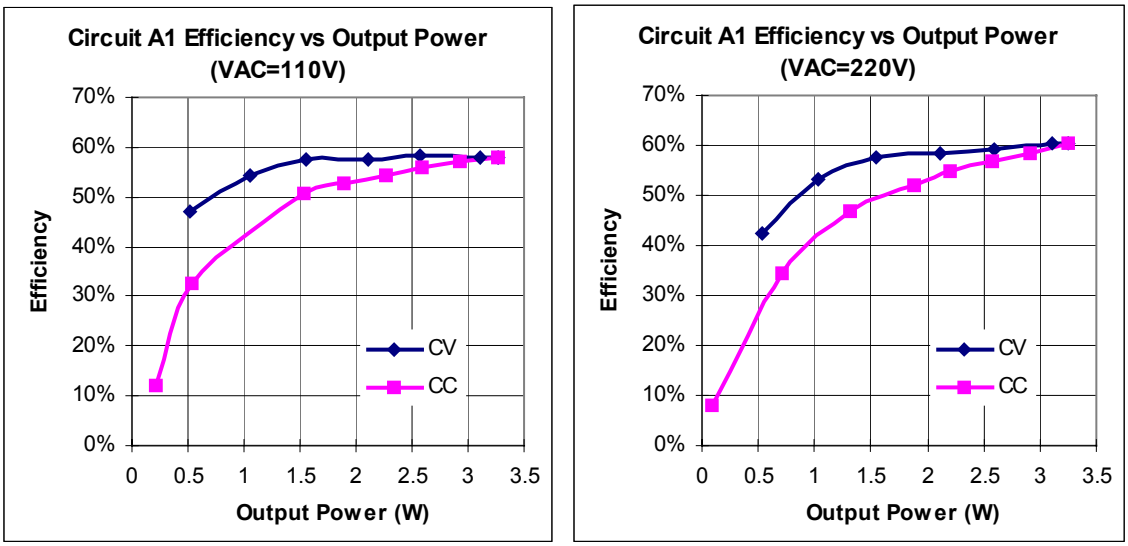


Figure A.3.1 Circuit A1 Efficiency vs. Output Power at 110V and 220V

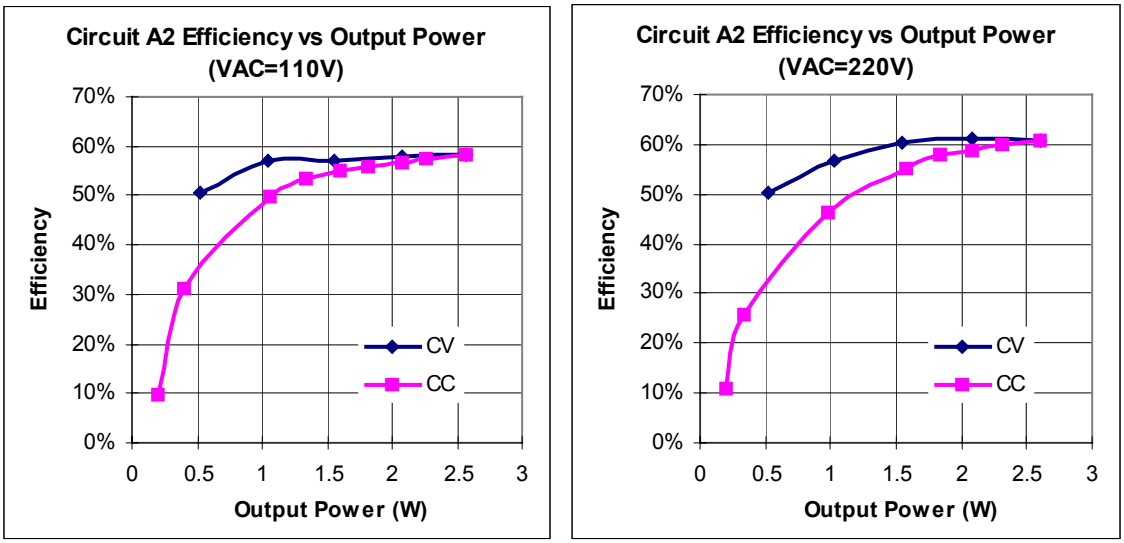


Figure A.3.2. Circuit A2 Efficiency vs. Output Power at 110V and 220V

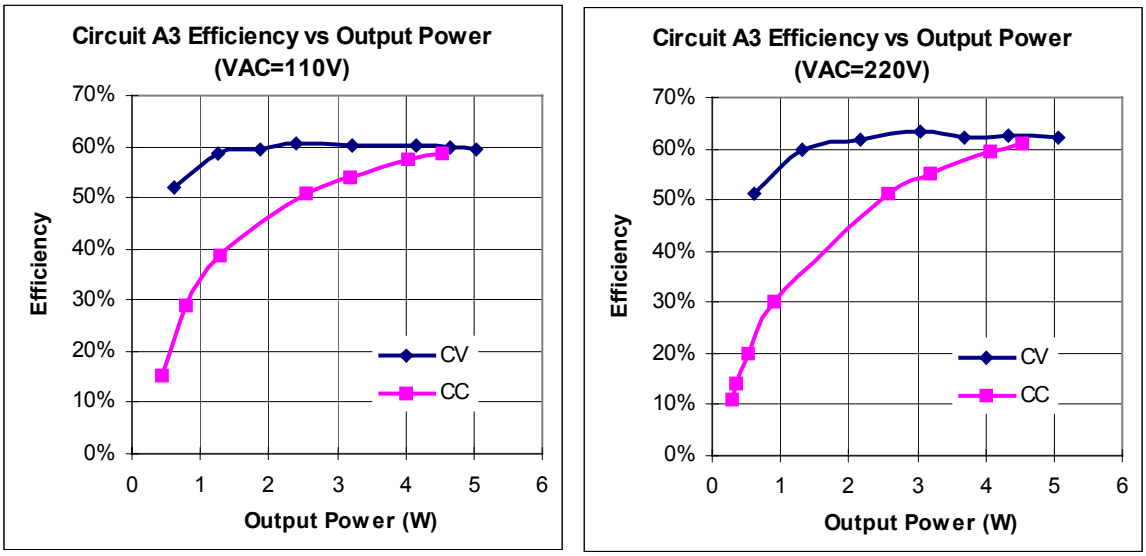


Figure A.3.3. Circuit A3 Efficiency vs. Output Power at 110V and 220V (No LED)

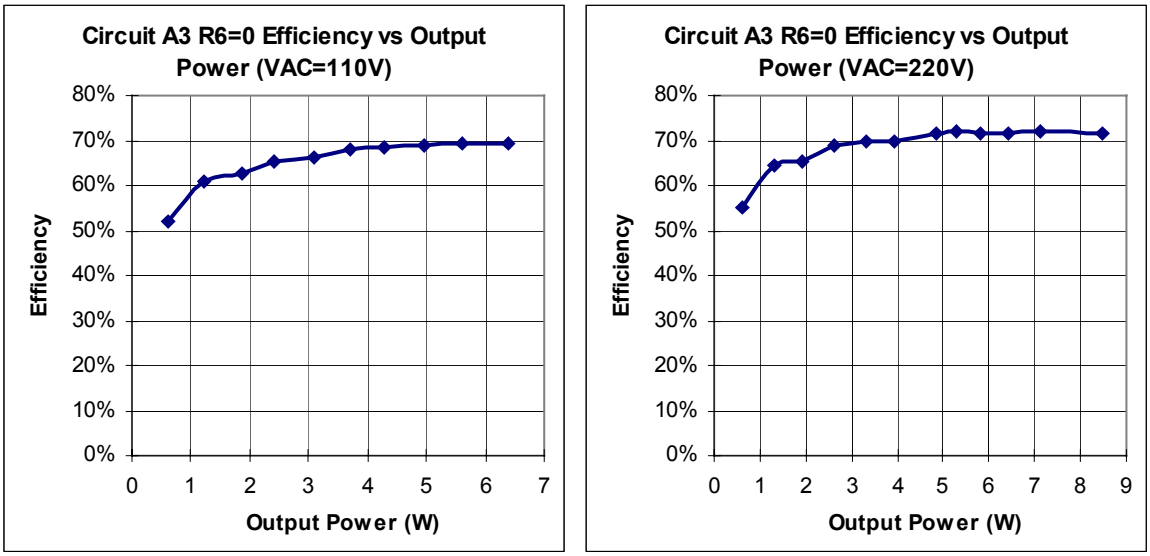


Figure A.3.4. Circuit A3 (with R6=0) Efficiency vs. Output Power at 110V and 220V.

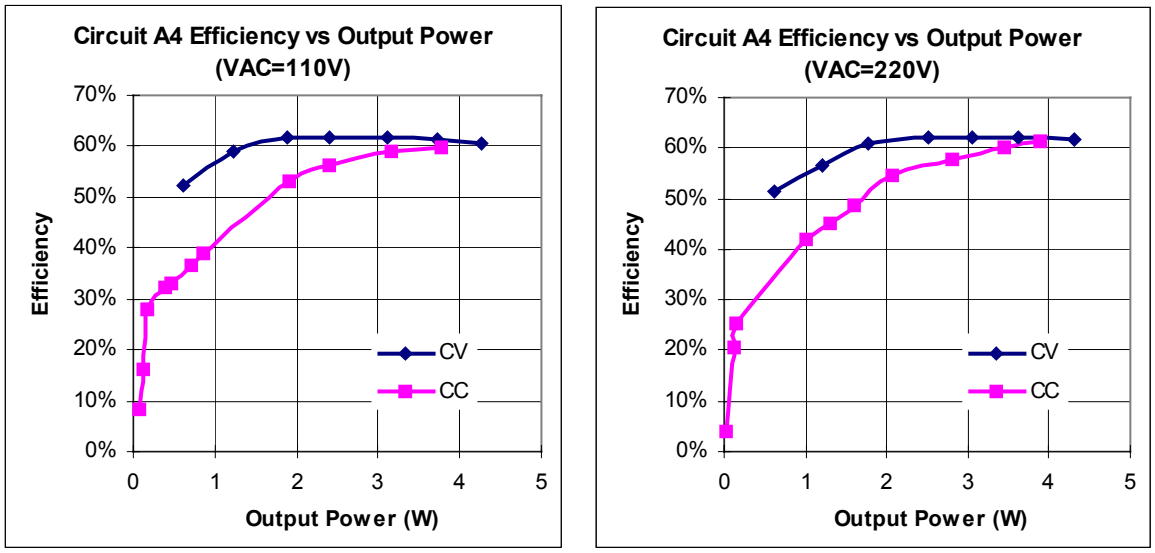


Figure A.3.5. Circuit A4 Efficiency vs. Output Power at 110V and 220V

A.4. OUTPUT VOLTAGE VS. OUTPUT CURRENT

The V-I curves for different circuit configurations are shown below. Circuit A4 can be used when foldback current limit is required. Circuit A3, which has minimum component count, can be used when straight current limit down to short circuit is required.

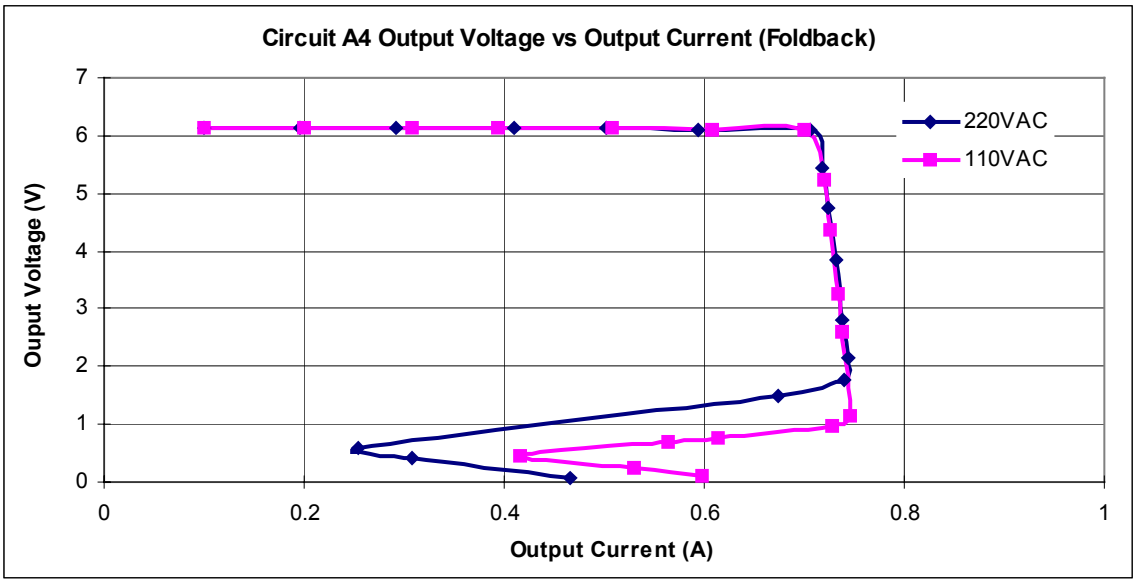


Figure A.4.1. Circuit A4 Output Voltage vs. Output Current

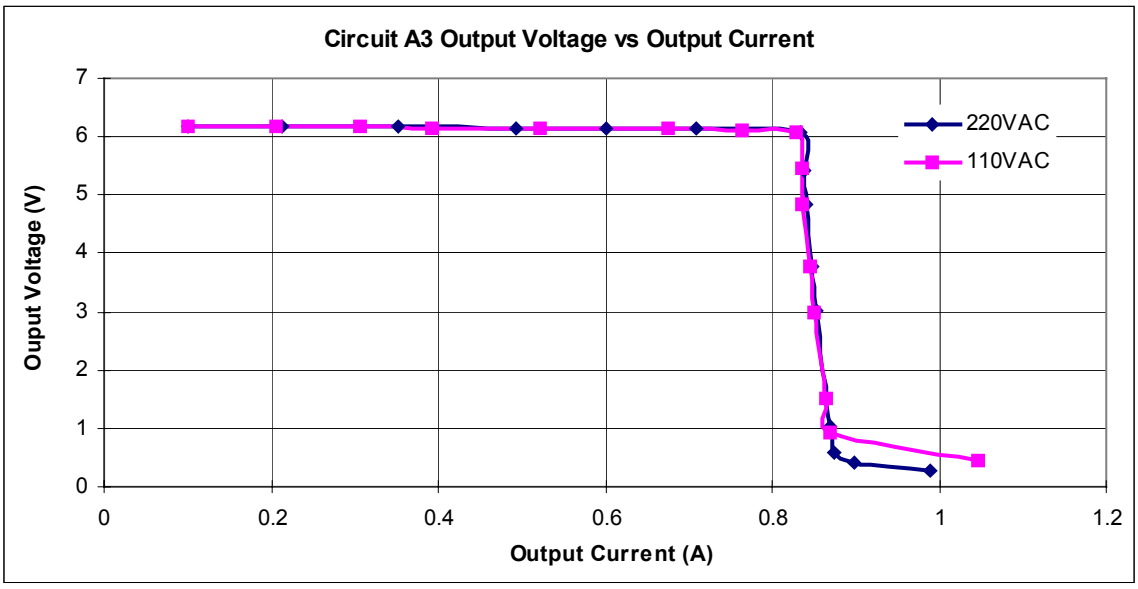


Figure A.4.2. Circuit A3 Output Voltage vs. Output Current (6.1V/0.85A)

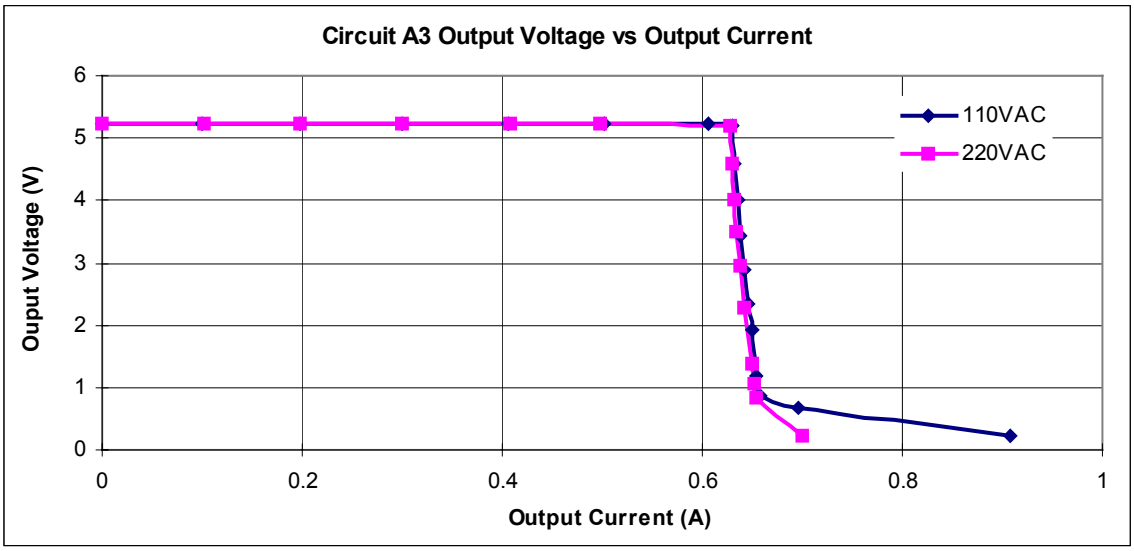


Figure A.4.3. Circuit A3 Output Voltage vs. Output Current (5.2V/0.65A)

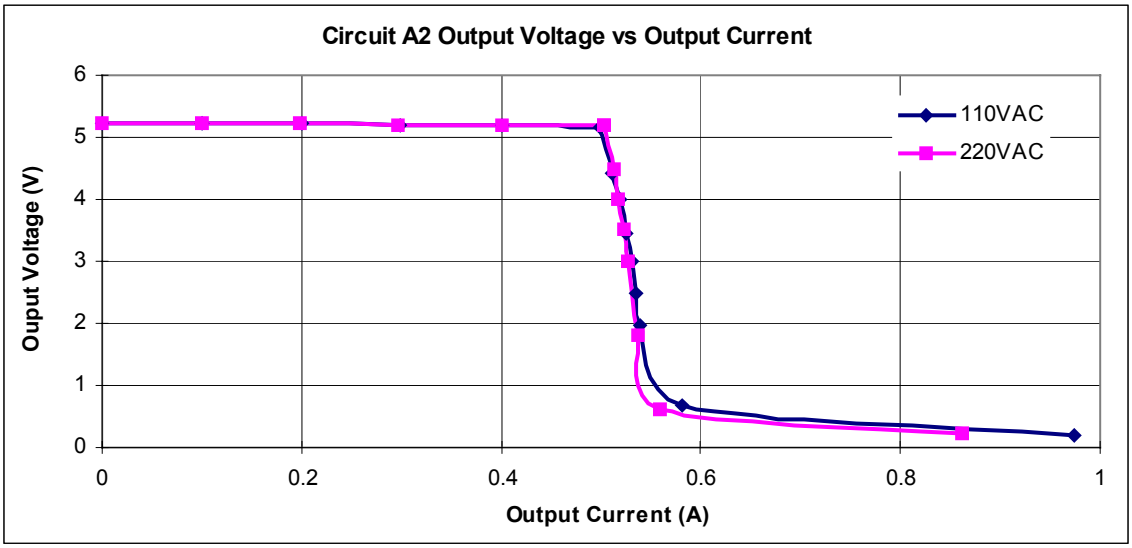


Figure A.4.3. Circuit A2 Output Voltage vs. Output Current

A.5. MAXIMUM OUTPUT POWER

The maximum output power of the ACT29 and ACT28 using Circuit A2 are as follow. Current limit section is disabled by shorting R8 resistor.

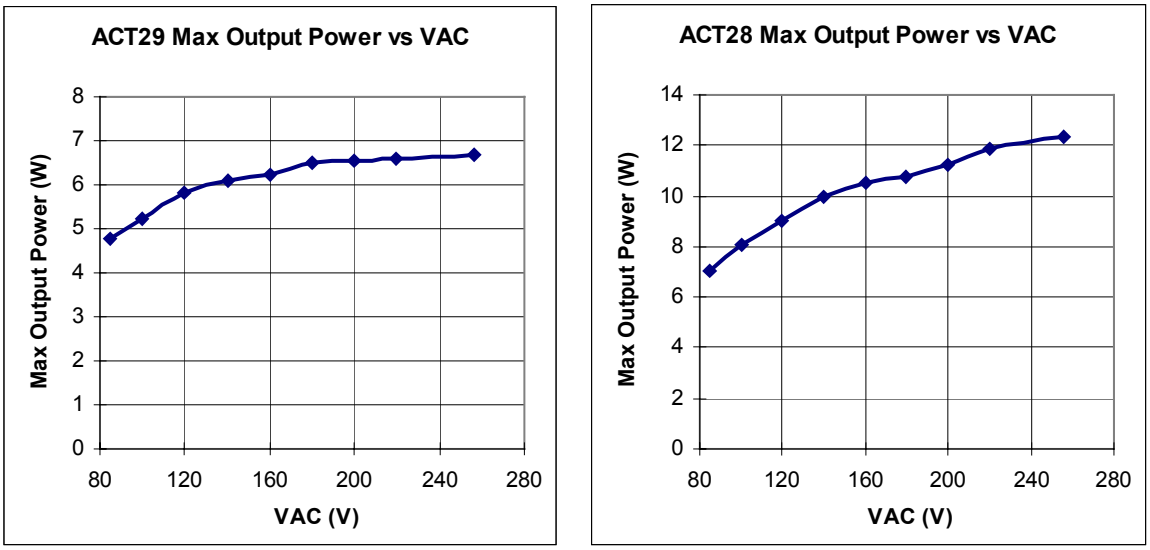


Figure A.5.1. Maximum Output Power vs. AC Input Voltage

A.6. STANDBY POWER

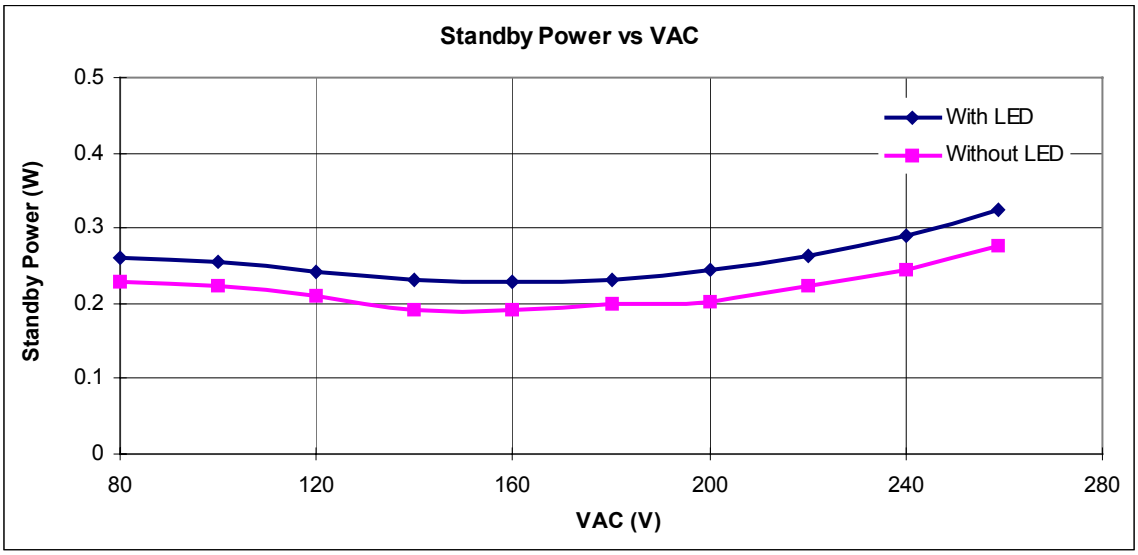


Figure A.6.1. Standby Power vs. AC Input Voltage (Circuit A3)

A.7. COMPONENTS TEMPERATURE

Table A.7.1. Open Air Temperatures of Key Components (Circuit A3)

OUTPUT CURRENT	INPUT VOLTAGE (VAC)	ACT29 TEMPERATURE	13002 TEMPERATURE	TRANSFORMER TEMPERATURE	SHUNT RESISTOR TEMPERATURE
FULL LOAD 5.208V / 600mA	255	52℃	53℃	61℃	95℃
	220	53℃	54℃	58℃	95℃
	110	60℃	70℃	55℃	90℃
	85	65℃	78℃	52℃	92℃
SHORT CIRCUIT	255	37℃	37℃	37℃	92℃
	220	35℃	38℃	38℃	93℃
	110	33℃	32℃	40℃	94℃
	85	35℃	32℃	40℃	103℃

A.8. EXTREME CONDITIONS STRESS TESTS

Table A.8.1. Extreme Conditions Stress Tests (Circuits A2 and A3)

CONDITIONS	REPETITIONS OR DURATION	RESULT
Short circuit pulsing short/open at different intervals, VAC=85V to 255V	300 times	PASS
No Load Input AC toggling on/off at different intervals, VAC=85V to 255V	300 times	PASS
Full Load Input AC toggling on/off at different intervals, VAC=85V to 255V	300 times	PASS
Short Circuit Input AC toggling on/off at different intervals, VAC=85V to 255V	300 times	PASS
Short Circuit Withstanding, VAC=85V to 255V	>3 hours	PASS
Temperature Cycling 85oC to –40oC, VAC=85V to 255V	20 times	PASS

A.9. SWITCHING WAVEFORMS – NO LOAD (CIRCUIT A3)

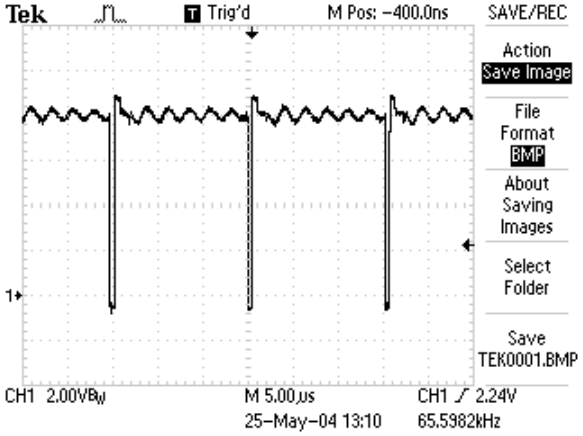


Figure A.9.1 SW Pin Voltage at 110VAC, No Load

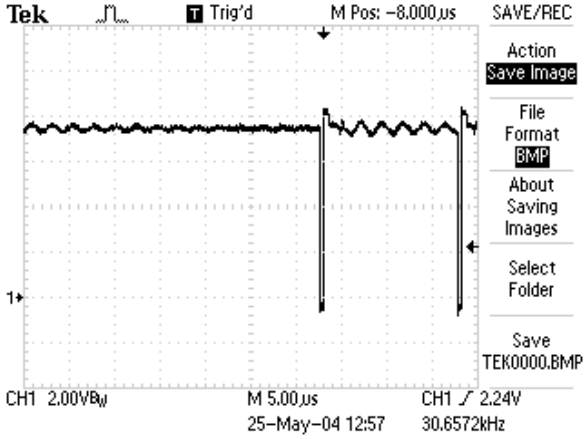


Figure A.9.2 SW Pin Voltage at 220VAC, No Load

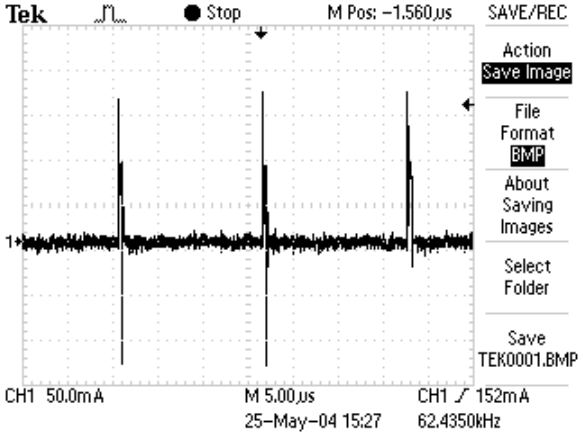


Figure A.9.3 SW Pin Current at 110VAC, No Load

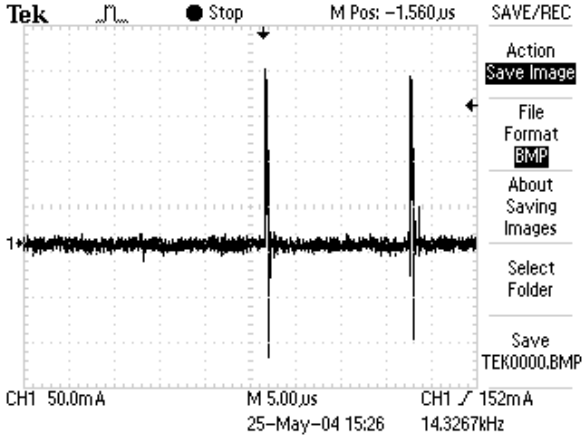


Figure A.9.4 SW Pin Current at 220VAC, No Load

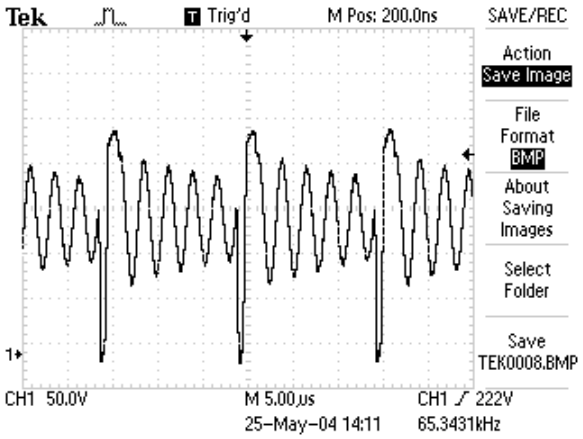


Figure A.9.5 High Voltage NPN Collector Voltage at 110VAC, No Load

A.10. SWITCHING WAVEFORMS – LIGHT LOAD (CIRCUIT A3)

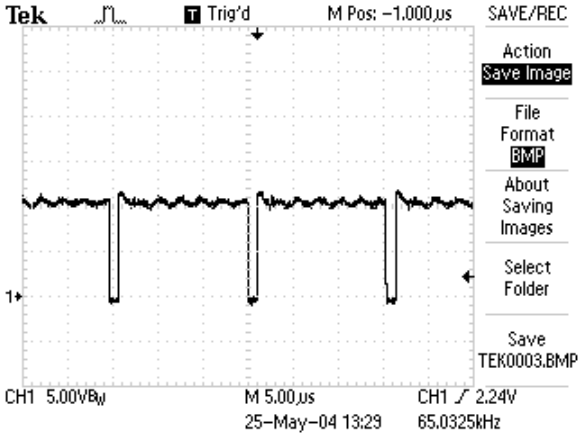


Figure A.10.1 SW Pin Voltage at 110VAC, 50mA Load

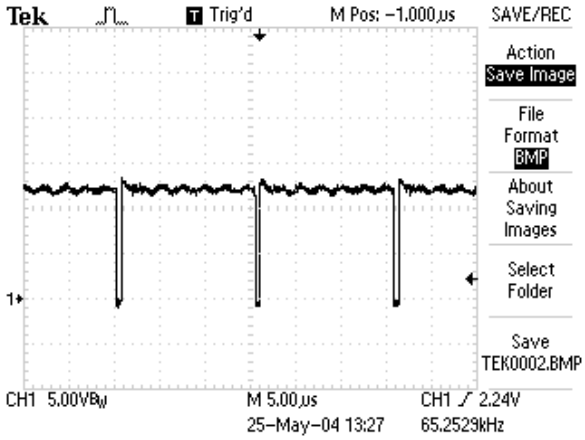


Figure A.10.2 SW Pin Voltage at 220VAC, 50mA Load

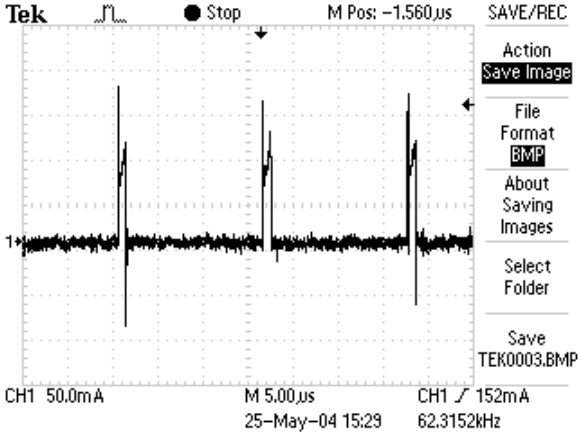


Figure A.10.3 SW Pin Current at 110VAC, 50mA Load

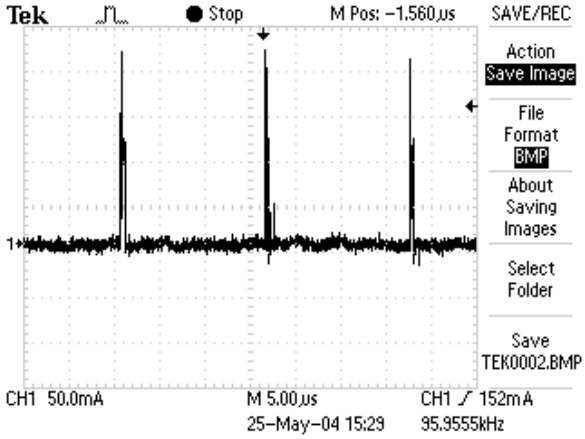


Figure A.10.4 SW Pin Current at 220VAC, 50mA Load

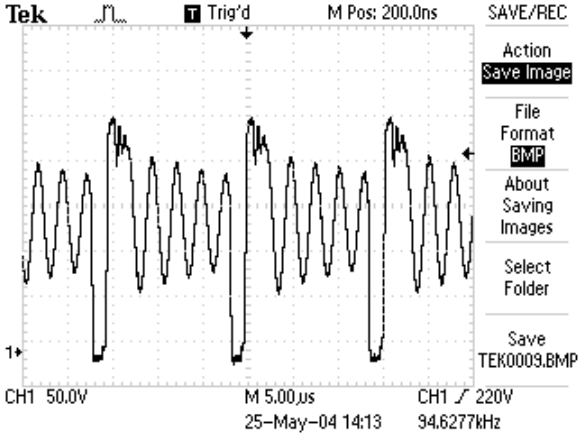


Figure A.10.5 High Voltage NPN Collector Voltage at 110VAC, 50mA Load

A.11. SWITCHING WAVEFORMS – FULL LOAD (CIRCUIT A3)

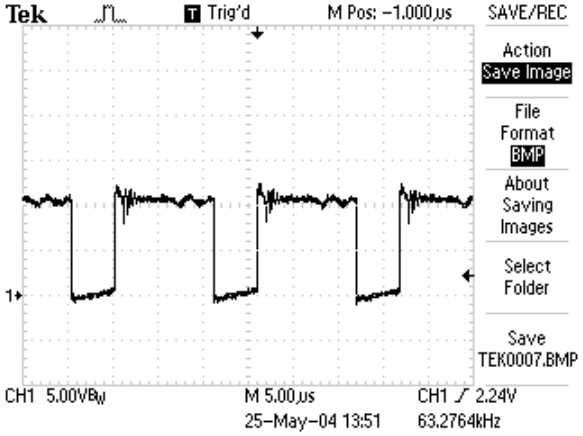


Figure A.11.1 SW Pin Voltage at 110VAC, 600mA Load

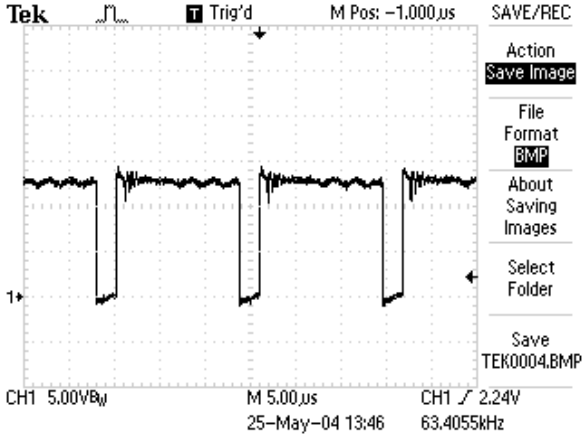


Figure A.11.2 SW Pin Voltage at 220VAC, 600mA Load

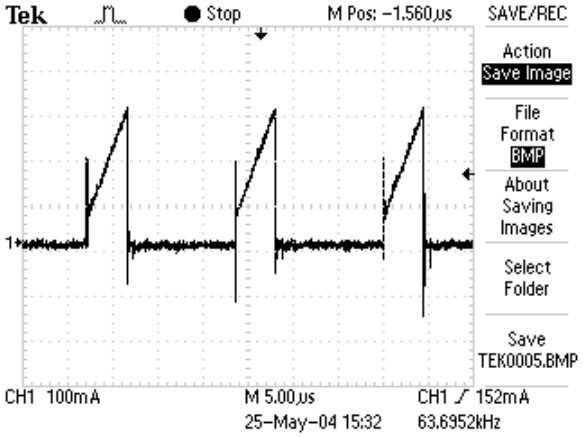


Figure A.11.3 SW Pin Current at 110VAC, 600mA Load

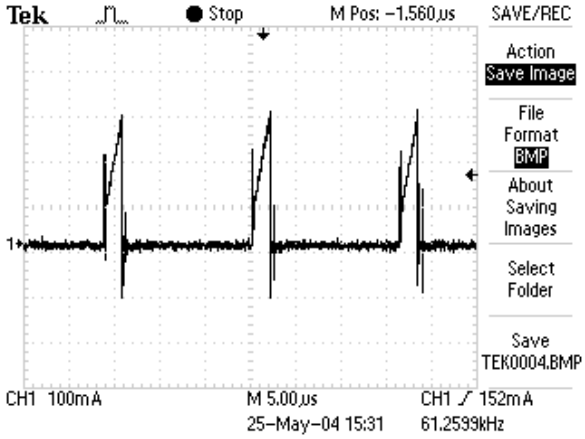


Figure A.11.4 SW Pin Current at 220VAC, 600mA Load

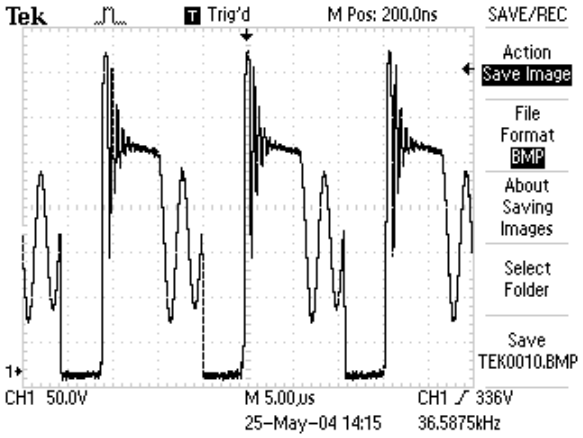


Figure A.11.5 High Voltage NPN Collector Voltage at 110VAC, 600mA Load

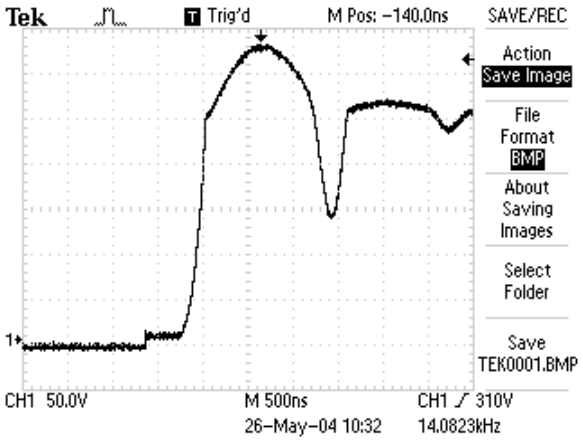


Figure A.11.7 High Voltage NPN Collector Rise Time at 110VAC, 600mA Load

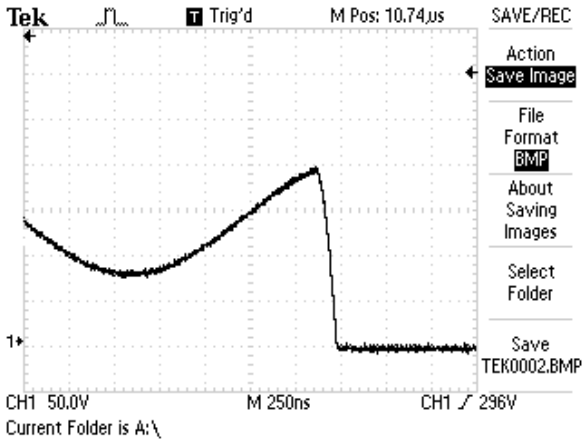


Figure A.11.8 High Voltage NPN Collector Fall Time at 110VAC, 600mA Load

A.12. SWITCHING WAVEFORMS – SHORT CIRCUIT (CIRCUIT A3)

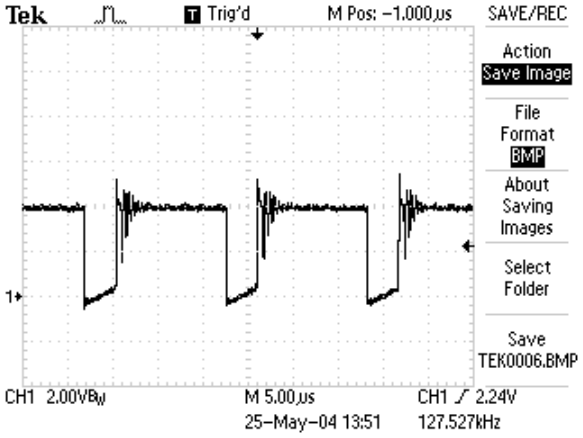


Figure A.12.1 SW Pin Voltage at 110VAC, Short Circuit

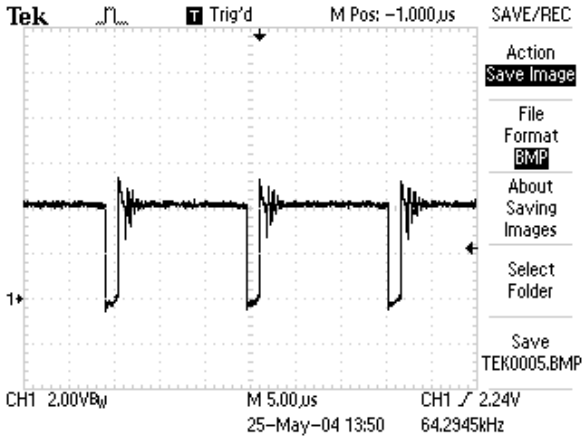


Figure A.12.2 SW Pin Voltage at 220VAC, Short Circuit

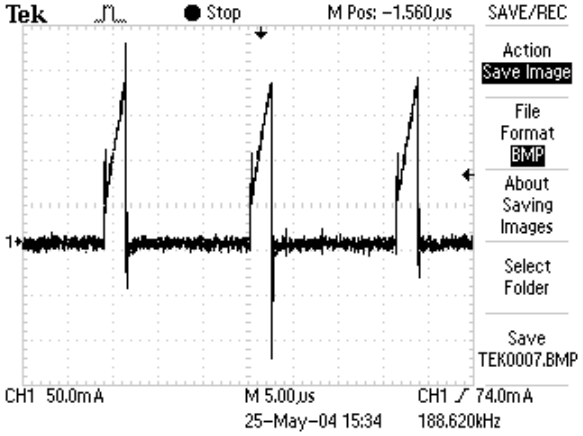


Figure A.12.3 SW Pin Current at 110VAC, Short Circuit

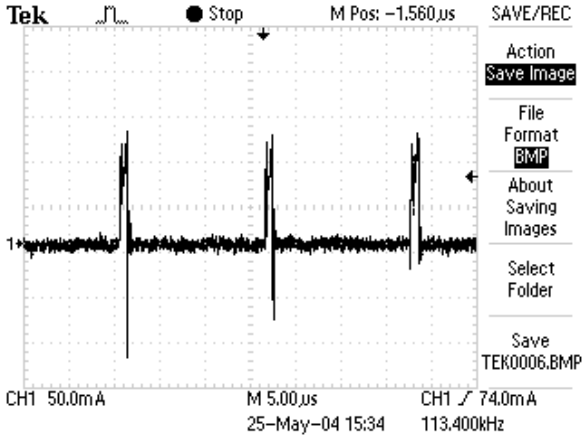


Figure A.12.4 SW Pin Current at 220VAC, Short Circuit

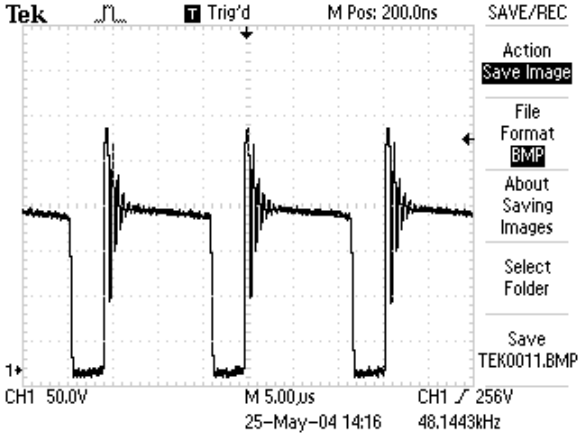


Figure A.12.5 High Voltage NPN Collector Voltage at 110VAC, Short Circuit

A.13. STARTUP WAVEFORMS (CIRCUIT A3)

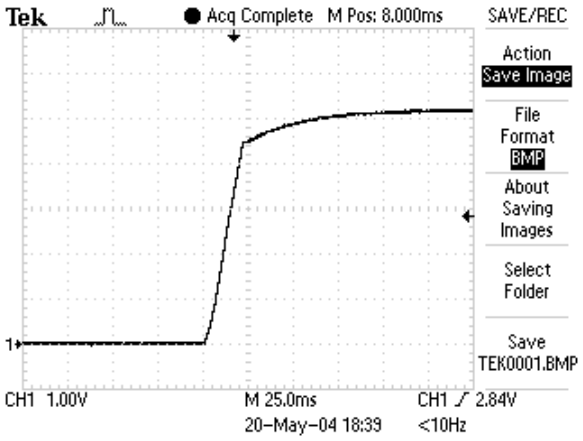


Figure A.13.1 Output Voltage Startup at 110VAC, Full Load

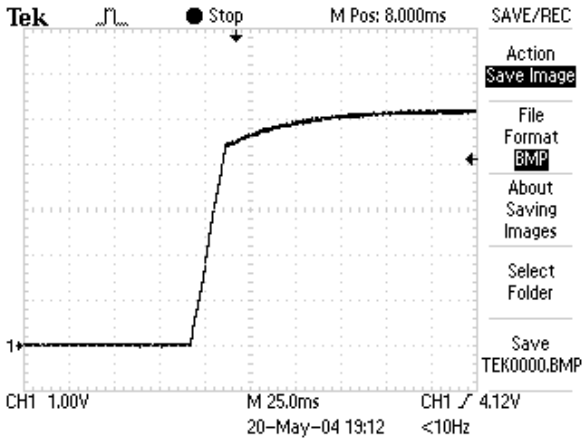


Figure A.13.2 Output Voltage Startup at 220VAC, Full Load

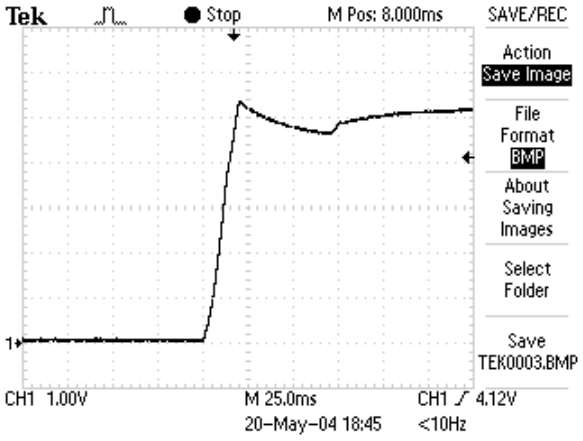


Figure A.13.3 Output Voltage Startup at 110VAC, No Load

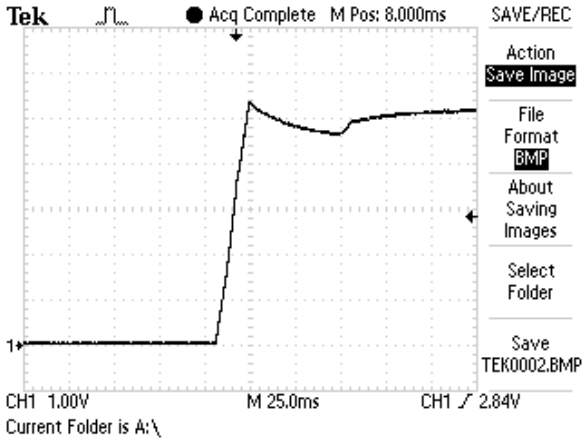


Figure A.13.4 Output Voltage Startup at 220VAC, No Load

A.14. EMI TESTS

TO BE DETERMINED

B. RELIABILITY SUMMARY

B.1. ESD & LATCHUP TESTS

Table B.1.1. ESD Tests History

LOT	DATE	CONDITION	SAMPLE SIZE	FAILURES
AP10AZSP1A		2kV	3	0

Table B.1.2. Latchup Tests History

LOT	DATE	CONDITION	SAMPLE SIZE	FAILURES
AP10AZSP1A		150mA	3	0

B.2. OPERATING LIFE TESTS

Operating Life Tests of Active Semiconductors ICs are done at an elevated temperature equivalent to at least 1000 hours at 135°C. The operating voltage, current, and other conditions of the ICs under test are such that they closely match their actual applications. The acceleration factor used for burn-in is calculated using the following Arrhenius equation:

$$AF = \text{Acceleration Factor} = \exp\left[(E_A / k_B) \bullet (1 / T_{NORMAL} - 1 / T_{BURN\text{-}IN})\right]$$

where k_B = Boltzmann Factor = 8.62×10^{-5} eV/K and the Activation Energy E_A is conservatively modeled at 0.8eV. From this equation, we can calculate that the AF at 135°C is 4430 if the ICs normally operate at 25°C. The burn-in stress for each device is equivalent to at least 500 years at 25°C.

Table B.2.1's before and after burn-in data shows that there are no changes in parametric values during and after Operating Life Tests of lot AP10AZSP1A. Table B.2.2 lists results of Operating Life Tests to-date.

Table B.2.1. Before and After Burn-In Parameters Comparison (Lot AP10AZSP1A, 10 units)

PARAMETER	BEFORE BURN-IN		AFTER 135°C @ 100HRS		AFTER ADDITIONAL 150°C @ 600HRS		CHANGE	UNIT
	AVERAGE	SIGMA	AVERAGE	SIGMA	AVERAGE	SIGMA		
SW Breakdown Voltage	23.5	0.71	23.4	0.36	23.7	0.44	0.9%	V
SW Start Voltage	7.54	0.075	7.54	0.075	7.52	0.059	-0.3%	V
FB/VDD Under-voltage Threshold	3.35	0.031	3.35	0.030	3.35	0.031	0%	V
FB/VDD Clamp Voltage	5.46	0.060	5.46	0.060	5.46	0.062	0%	V
Supply Current	0.673	0.023	0.687	0.025	0.679	0.022	0.9%	mA
Switching Frequency	63.7	2.62	63.6	3.34	63.0	3.04	-1.1%	kHz
SW Switch Off Current	11.4	0.52	11.7	0.67	11.3	0.67	-0.9%	μA

Table B.2.2. Operating Life Tests History

LOT	DATE	CONDITION	EQUIV. CONDITION	SAMPLE SIZE	FAILURES
AP10AZSP1A GROUP 1	2004/04/08	135°C @ 100 hours	135°C @ 100 hours	10	0
	2004/05/08	150°C @ 600 hours	135°C @ 1320 hours	10	0
AP10AZSP1A GROUP 2		150°C @ 100 hours	135°C @ 220 hours	10	
CUMMULATIVE MTTF (MEAN TIME TO FAILURE)		$> 5.8 \times 10^7$ device-hours			