GreenPoint™
From ON Semiconductor

160 W CRT-TV Power Supply Documentation Package

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1 Overview

This reference document describes a built-and-tested, GreenPoint™ solution for a CRT TV power supply.

The reference design circuit consists of one single-sided 163 mm x 80 mm printed circuit board designed to fit into a CRT TV.

An overview of the entire circuit is provided by Figure 1. As shown in that figure, ON Semiconductor devices are available for every block of the CRT TV power supply; and by judicious choice of design tradeoffs, optimum performance is achieved at minimum cost.

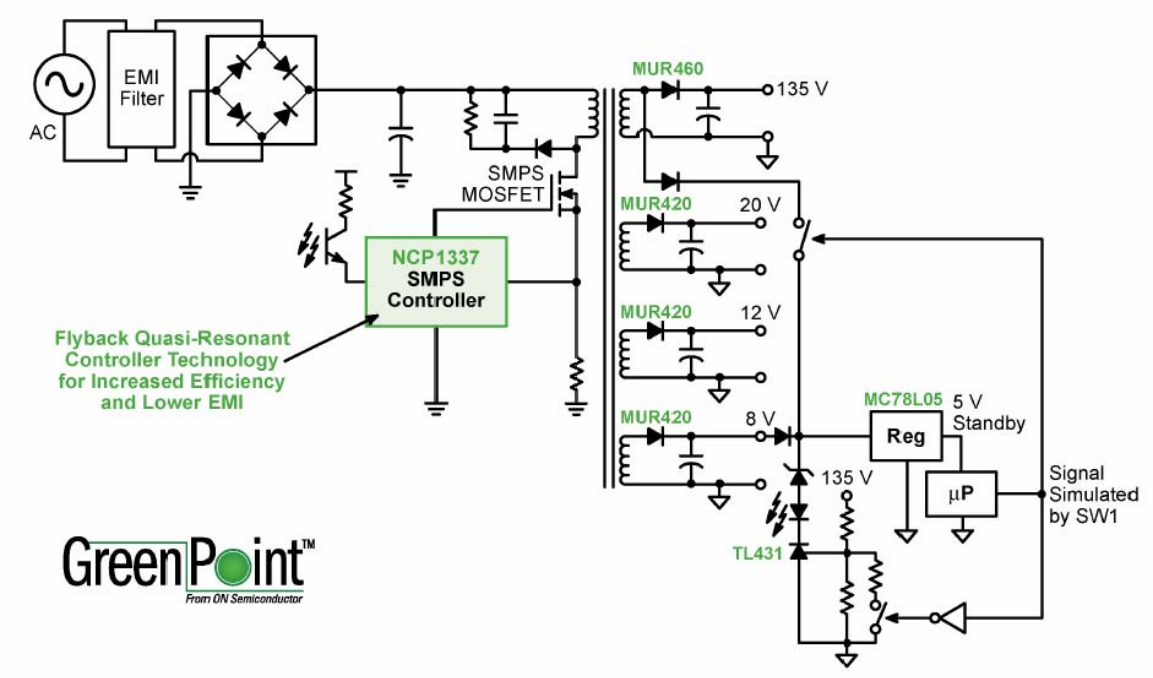


Figure 1

2 Introduction

Energy efficiency has become one of the most important policy areas. The energy consumption of consumer electronics equipment, while in standby mode, is huge. Recent studies and in situ measurement campaigns have indicated that in the average EU household between 5% and 10% of its total yearly electricity consumption is due to the stand-by mode of consumer electronics equipment and other devices, and this is due to increase in the next decade. TV sets are obviously one of the biggest contributors. According to EPA, the bill Americans pay to supply their TVs and VCRs when they are switched off is $1 billion each year.

In 1997, the European Commission concluded a negotiated agreement with individual consumer electronics manufacturers and the EU trade association EACEM, to reduce the stand-by losses of TVs and VCRs. In the year 2003 a new agreement for TVs and DVDs was concluded.

Since then many initiatives have been taken around the word. Even if these requirements are not yet standards, most of the manufacturers have already applied these rules in their designs.

Hereinafter the list of the most important initiatives:

Region / Country	Program name	Requirements for Televisions	Demoboard compliance
China	CECP	3 W	Yes
Korea	Energy Saving	3 W	Yes
European Union	EU Eco-Label	1 W 9 W with a STB	Yes
European Union	EU Code of Conduct	3 W with a STB	Yes
Europe	GEEA	1 W	Yes
US	Energy Star	1 W to 15 W New revision on going	Yes
US	1 Watt Executive Order	1 W	Yes

This reference document describes a solution for a CRT TV power supply based on the NCP1337 that allows compliance with the most stringent requirements, using a single power supply.

3 CRT-TV Power Supply Requirements

Most of the CRT Power supplies are designed to cope with universal mains: 90 Vac to 265 Vac, 47-63 Hz.

In any CRT, the tube needs to be supplied by a high voltage rail, generally between 110 and 140 V.

The microcontroller and the memory use 3.3 V and 5 V that derive from an intermediate 8 V.

Audio ICs are often supplied from 12 V and 20 V.

Tuner can be supplied from 12 V or a 5 V.

4 Limitations of existing solutions

4.1 Achieve 1 W with 1 PSU

The classical technique consisting of disabling the secondary loads while keeping the power supply running can no longer be used. In fact, even in a disabled mode the loads are generally presenting some hundred milliwatts of leakage. This is the case in TV sets. A solution to cancel this leakage consists of totally disconnecting the loads, but it is expensive and can lead to some issues when the fault conditions tests are performed.

Another technique consists of completely disabling the main power supply during the stand-by mode, and of installing a micropower side-power supply to keep ready to work the wake-up block. This is also not a preferred solution for obvious cost reasons.

4.2 Audible noise

One of the issues faced by the classical solutions is audible noise. Since a TV sets can be placed in a very quite environment (e.g.: bed room, living room) any whistling noise would be dramatic.

Classical burst mode operation can easily generate some noise. Solving this noise issue made the power supply design more difficult and may interfere with the wish of achieving very low standby power consumption.

5 Overcoming limitations with NCP1337

5.1 Quasi resonant operation

Valley switching converters, also known as quasi resonant (QR) converters, allow designing flyback Switch Mode Power Supplies (SMPS) with reduced Electromagnetic Interference (EMI) signatures and improved efficiency compared to a classical fixed frequency flyback approach. Thanks to the low level of generated noise, valley switching SMPS converters are therefore very well suited to applications dealing with RF and video signals, such as TVs.

The NCP1337 is a powerful valley switching controller, which eases the design of an EMI−friendly TV power supply with only a few surrounding components.

Valley-switching operation is ensured whatever the operating conditions are, due to the internal soxyless circuitry. As a result, there are virtually no primary switch turn-on losses, and no secondary diode recovery losses, and EMI and video noise perturbations are reduced. The converter also stays a first-order system and accordingly eases the feedback loop design.

5.2 Secondary reconfiguration

We choose to use a secondary reconfiguration that, by re-routing the high voltage winding to the low voltage output, reduces the voltage of all the unused outputs.

In fact, the energy stored in the high voltage winding is used to refuel the low voltage output capacitor, and regulation is now made on this low voltage output. As the windings are imposing currents (not voltages), connecting a high voltage winding to a low voltage output is completely safe. But as the regulation loop now forces the high voltage winding to deliver a low voltage, then all the other windings are also delivering lower voltages than in normal conditions (in the same ratio). The sum of the consumptions on all the windings is drastically reduced due to this division of all the output voltages.

5.3 Standby mode

Under low load conditions, NCP1337 enters a soft ripple mode: when the CS setpoint becomes lower than 20% of the maximum peak current, output pulses are stopped; then switching is started again when FB loop forces a setpoint higher than 25%. As this occurs at low peak current, with soft-skip activated, and as the TOFF is clamped, noise-free operation is guaranteed, even with a cheap transformer.

6 Specifications

Input Voltage: Universal input 90 Vac to 265 Vac, 47-63 Hz

Outputs:
+135 V, 1 A max (135 W) regulated
+20 V, 800 mA max (16 W)
+12 V, 500 mA max (6 W)
+8 V, 500 mA max (4 W)
Standby output :
+5 V, 100 mA derived from +8 V through a regulator

Protections Short-circuit, over-power, over-voltage and brown-out

Standby Power below 1 W

7 Reference Design Performance Summary

7.1 Efficiency

- At 230 Vac, 148 W IN for 135 W OUT 91%
- At 110 Vac, 154 W IN for 135 W OUT 87%

7.2 Standby Power

Noise-free operation is achieved during standby mode.

All outputs are low (135 V output is 12.7 V), except 5 V standby output which is maintained. I_{OUT} consumption is taken on 5 V standby output. Controller is powered thanks to the Dynamic Self-Supply (DSS).

I_{OUT} / V_{IN}	0	10	20	30	40
230 Vac	390 mW	600 mW	780 mW	980 mW	1.18 W
110 Vac	230 mW	460 mW	700 mW	860 mW	975 mW

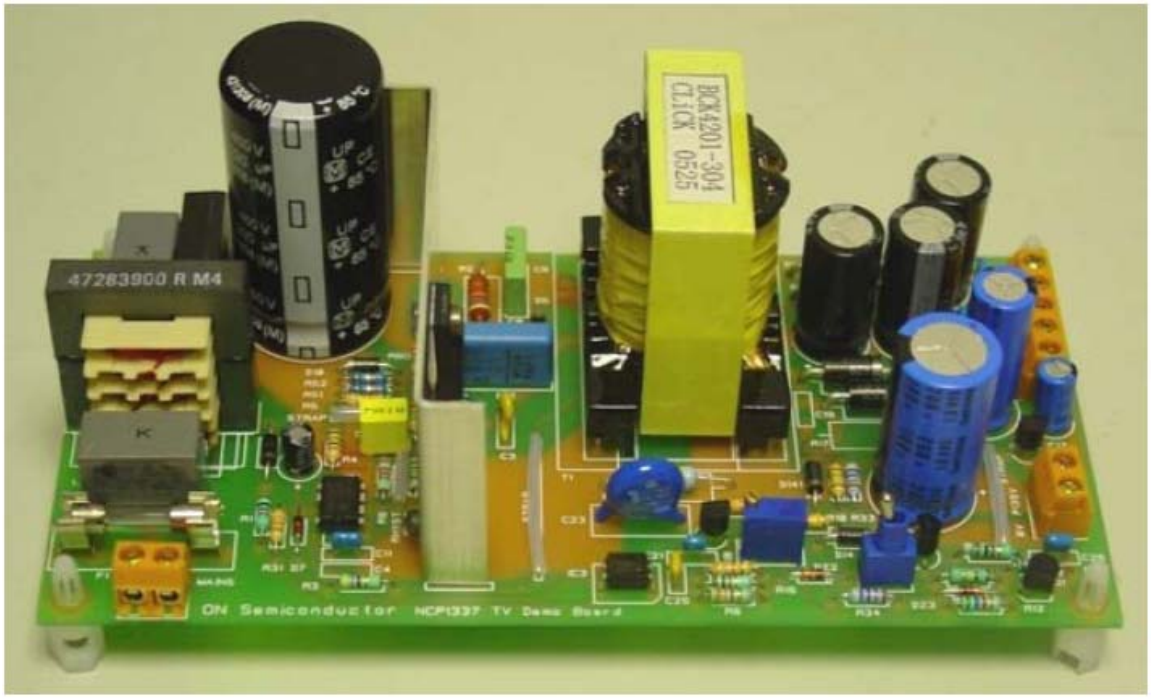
All outputs are low (135 V output is 12.7 V), except 5 V standby output which is maintained. I_{OUT} consumption is taken on 5 V standby output. Controller is powered thanks to a forward-coupled auxiliary winding.

I_{OUT} / V_{IN}	0	10	20	30	40
230 Vac	340 mW	470 mW	580 mW	730 mW	900 mW
110 Vac	140 mW	350 mW	540 mW	700 mW	820 mW

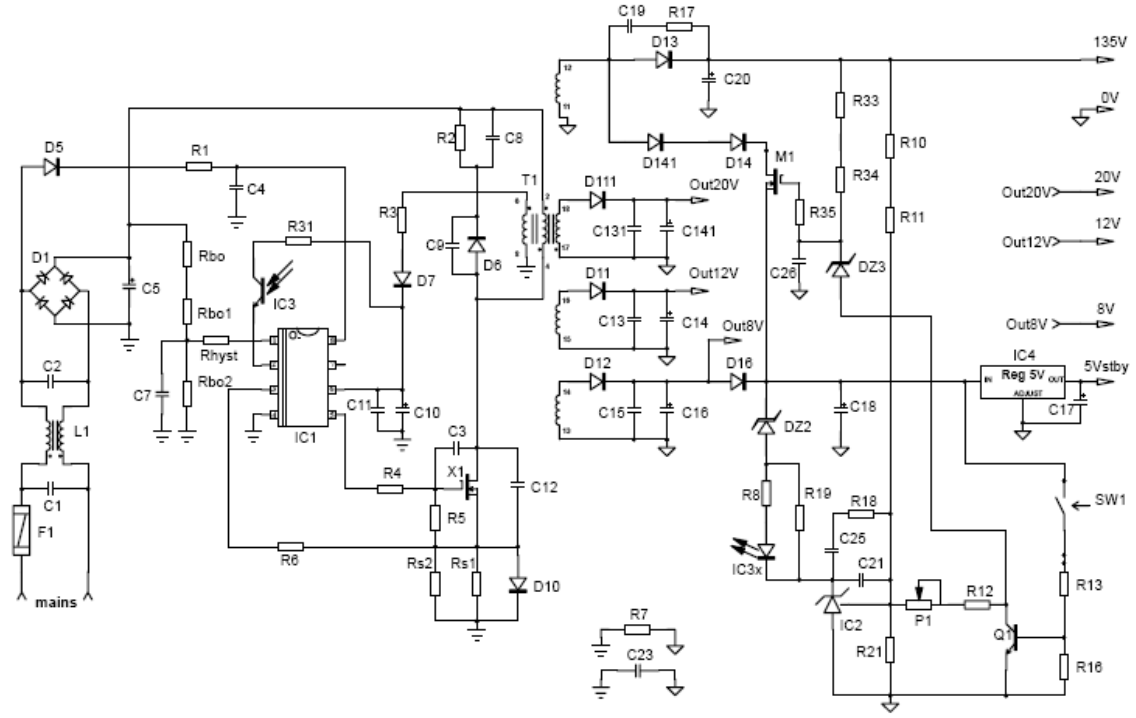
All outputs are at their nominal values. I_{OUT} consumption is taken on 5 V standby output. Controller is powered thanks to the auxiliary winding.

I_{OUT} / V_{IN}	0	10	20	30	40
230 Vac	260 mW	380 mW	620 mW	740 mW	880 mW
110 Vac	180 mW	280 mW	400 mW	540 mW	690 mW

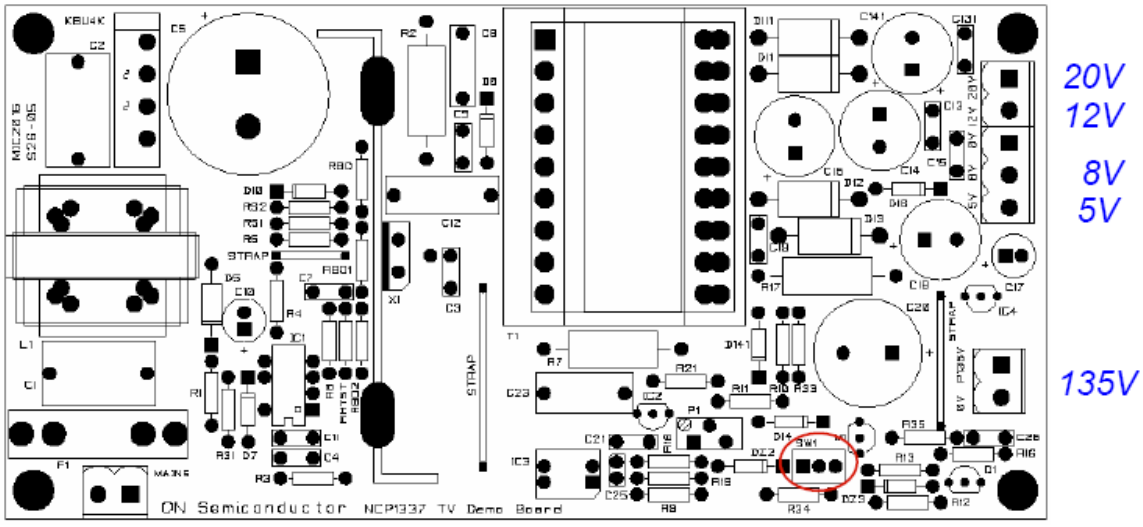
8 Board Picture



9 Schematic



10 Board Layout



11 BOM

Designator	Part Number	Supplier	Description	Value	Tolerance	Package
IC1	NCP1337PG	ON Semiconductor	Enhanced Current−Mode Controller	NA	NA	PDIP-7
IC2	TL431CLP	ON Semiconductor	Programmable Precision Reference	2.5 - 36 V, 1-100 mA	2.2%	TO-92
IC3	SFH615A	Vishay	Optocoupler, High Reliability	5300 VRMS	NA	DIP-4
IC4	MC78L05ACP	ON Semiconductor	Positive Voltage Regulator	5 V, 100 mA	5%	TO-92
X1	IRFIB6N60A	IR	HEXFET Power MOSFET	600 V, 5.5 A	NA	TO-220
M1	BS108G	ON Semiconductor	Small Signal MOSFET	200 V, 250 mA		TO-92
Q1	BC547C	ON Semiconductor	NPN Transistor	NA	NA	TO-92
T1	SRW42/15EC−X21V017	TDK	Transformer	NA	NA	NA
	BCK4201−304	CLICK				
L1	47283900 RM4	OREGA	Comon mode choke	NA	NA	NA
F1	218002	Littelfuse	Fuse	250 V, 2 A	NA	5 x 20 (mm)
D1	KBU4K	Vishay	Bridge Rectifier	800 V, 4 A	NA	KBU
D5, D10, D14, D16, D141	1N4007	ON Semiconductor	Standard Rectifier	1000 V, 1 A	NA	Axial
D6	1N4937	ON Semiconductor	Fast-Recovery Rectifier	600 V, 1 A	NA	Axial
D7	MMSD4148T1	ON Semiconductor	Small Signal Switch Diode	100 V, 200 mA	NA	SOD-123
D11, D12, D111	MUR420	ON Semiconductor	Ultrafast Rectifier	200 V, 4 A	NA	Axial
D13	MUR460	ON Semiconductor	Ultrafast Rectifier	600 V, 4 A	NA	Axial
DZ2	1N5335B	ON Semiconductor	5 W Zener Diode	3.9 V, 320 mA	NA	Axial
DZ3	1N5341B	ON Semiconductor	5 W Zener Diode	6.2 V, 200 mA	NA	Axial
R1, R35	CCF551K00FK	Vishay	Metal Film resistor R0204	1 kΩ, 0.5 W	1%	Axial
R2	PR02000204702J	Vishay	Metal Film resistor 2W (PR2)	47 kΩ, 2 W	5%	Axial
Rbo	CCF552M74FK	Vishay	Metal Film resistor	2.7 MΩ, 0.5 W	1%	Axial
Rbo1	CCF551M21FK	Vishay	Metal Film resistor	1.2 MΩ, 0.5 W	1%	Axial
Rbo2	CCF5515K0FK	Vishay	Metal Film resistor	15 kΩ, 0.5 W	1%	Axial
Rhyst	-	-	Not Mounted	-	-	-
R3	CCF5547R5FK	Vishay	Metal Film resistor	47 Ω, 0.5 W	1%	Axial
R4	CCF5515R0FK	Vishay	Metal Film resistor	15 Ω, 0.5 W	1%	Axial
R5, R21	CCF5533K2FK	Vishay	Metal Film resistor	33 kΩ, 0.5 W	1%	Axial
Rs1, Rs2	LVR03R1500FS70	Vishay	Low value resistor	0.15 Ω	1%	Axial
R6	CCF552K21FK	Vishay	Metal Film resistor	2.2 kΩ, 0.5 W	1%	Axial
R7	VR370000106JA1	Vishay	High Ohmic, High Voltage Resistor	10 MΩ, 0.5 W	5%	Axial
R8	CCF60332RFK	Vishay	Metal Film resistor	330 Ω, 0.75 W	1%	Axial
R10	CCF60150KFK	Vishay	Metal Film resistor	150 kΩ	1%	Axial
R11	CCF55121KFK	Vishay	Metal Film resistor	120 kΩ, 0.5 W	1%	Axial
R12	CCF555K62FK	Vishay	Metal Film resistor	5.6 kΩ, 0.5 W	1%	Axial
R13, R16	CCF55100KFK	Vishay	Metal Film resistor	100 kΩ, 0.5 W	1%	Axial
R17	-	-	Not Mounted	-	-	-
R18, R31	CCF5518K2FK	Vishay	Metal Film resistor	18 kΩ, 0.5 W	1%	Axial
R19	CCF551K50FK	Vishay	Metal Film resistor	1.5 kΩ, 0.5 W	1%	Axial
R33,R34	CCF5547K5FK	Vishay	Metal Film resistor	47 kΩ, 0.5 W	1%	Axial
P1	T93YB102K	Vishay	3/8" Square Multi-Turn Cermet Trimmer	1 kΩ, 0.5 W	10%	NA
C1,C2	R73PI 2330DQ0-J	Arcotoronics	X2 Polypropylene Capacitor	0.033 uF, 300 Vac	5%	Box
C3	5AS100JABCG	AVX	Ceramic Disc Capacitor	10 pF, 2 kV	5%	Disc
C4	-	-	Not Mounted	-	-	-
C5	ESMM451VSN221MQ40S	Nippon Chemicon	Electrolytic Capacitor	220 uF, 450 V	20%	Radial
C7	R82DC4100DQ6-J	Arcotronics	Polyester Capacitor	1 uF, 63 V	5%	Box
C8	R60PF2100DQ6-M	Arcotronics	Polyester Capacitor	10 nF, 630 V	20%	Box
C9	-	-	Not Mounted	-	-	-
C10	ECEA1EN330U	Panasonic	Electrolytic Capacitor	33 uF, 25 V	20%	Radial
C11, C13, C15, C25, C131	TGP10	Vishay	Ceramic Capacitor	100 nF, 100 V	20%	Disc
C12	5SS331KABAA	AVX	Ceramic Capacitor	330 pF, 2 kV	10%	Disc
C14,C16, C141	ECA1VM102	Panasonic	Electrolytic Capacitor	1000 uF, 35 V	20%	Radial
C17	ECA1EM101	Panasonic	Electrolytic Capacitor	100 uF, 25 V	20%	Radial
C18	ECA1CM102	Panasonic	Electrolytic Capacitor	1000 uF, 16 V	20%	Radial
C20	ECA2DM101	Panasonic	Electrolytic Capacitor	100 uF, 200 V	20%	Radial
C21	TSD10	AVX	Ceramic Capacitor	1 nF, 100 V	10%	Axial
C23	WKP222	Vishay	Y1 Ceramic Capacitor	2.2 nF, 500 Vac	20%	Disc
C26	C430C474M5U5CA7200	Kemet	Ceramic Capacitor	470 nF, 50 V	20%	Axial
H1	1718029	Phoenix Contact	PCB Connector	NA	NA	NA
H2	1890963	Phoenix Contact	PCB Connector	NA	NA	NA
H3	1890976	Phoenix Contact	PCB Connector	NA	NA	NA

12 Appendix

References:

- Draft Commission Communication on Policy Instruments to Reduce Stand-by Losses of Consumer Electronic Equipment (19 February 1999)
  - http://energyefficiency.jrc.cec.eu.int/pdf/consumer_electronics_communication.pdf
- European Information & Communications Technology Industry Association
  - http://www.eicta.org/
- http://standby.lbl.gov/ACEEE/StandbyPaper.pdf

CECP (China):

- http://www.cecp.org.cn/englishhtml/index.asp

Energy Saving (Korea)

- http://weng.kemco.or.kr/efficiency/english/main.html#

Top Runner (Japan):

- http://www.eccj.or.jp/top_runner/index.html

EU Eco-label (Europe):

- http://europa.eu.int/comm/environment/ecolabel/index_en.htm
- http://europa.eu.int/comm/environment/ecolabel/product/pg_television_en.htm

EU Code of Conduct (Europe):

- http://energyefficiency.jrc.cec.eu.int/html/standby_initiative.htm

GEEA (Europe):

- http://www.efficient-appliances.org/
- http://www.efficient-appliances.org/Criteria.htm

Energy Star:

- http://www.energystar.gov/
- http://www.energystar.gov/index.cfm?c=product_specs.pt_product_specs

1 Watt Executive Order:

- http://oahu.lbl.gov/
- http://oahu.lbl.gov/level_summary.html

Additional collateral from ON Semiconductor

- AND8246/D, A 160 W CRT TV Power Supply Using NCP1337
- NCP1337

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