



Maxim > Design Support > Technical Documents > Reference Designs > Automotive > APP 4363
Maxim > Design Support > Technical Documents > Reference Designs > Power-Supply Circuits > APP 4363

Keywords: vacuum fluorescent display, fly back converter, flyback

REFERENCE DESIGN 4363 INCLUDES: ✓Tested Circuit ✓Schematic ✓BOM ✓Description ✓Test Data

Vacuum Fluorescent Display (VFD) Reference Design for Automotive Applications

Mar 26, 2009

Abstract: This article describes a vacuum fluorescent display (VFD) and some ideal applications for the technology. The reference design then shows how to use a MAX15005 power-supply controller in a flyback topology to obtain multiple output voltages for a vacuum fluorescent display.

Introduction

This reference design shows a solution for obtaining the drive voltage required for a vacuum fluorescent display (VFD) power supply in automotive applications. The design includes the complete schematic, and presents the bill of materials (BOM), load/line regulation measurements, and test results.

VFD Basics

A vacuum fluorescent display (VFD) is a type of display used commonly on consumer-electronics equipment such as video cassette recorders, car radios, and microwave ovens. Unlike liquid crystal displays (LCDs), a VFD emits a very bright light with clear contrast and can easily support display elements of various colors. The technology is related to both the cathode ray tube and the nixie tube. Unlike LCDs, however, most VFDs continue to function normally in subzero temperatures, making them ideal for outdoor devices in cold climates.

The VFD is composed of three basic electrodes—the cathode filaments, anodes (phosphor), and grids—under a high-vacuum condition in a glass envelope. The cathode consists of fine tungsten wires, coated by alkaline earth metal oxides which emit electrons. The grids are a thin metal mesh, which controls and diffuses electrons emitted from the cathode. The anodes are conductive electrodes on which the phosphor is printed to indicate characters, icons, or symbols. Electrons emitted from the cathode are accelerated with positive potential applied to both grid and anode; upon collision with the anode the electrons excite the phosphor to emit light. The desired illuminated patterns can be achieved by controlling the positive or negative potentials on each grid and anode. The anode and grid require a DC-regulated voltage to avoid flickering of the display. For driving large VFDs, the cathode requires AC drive to prevent luminance slant, i.e., the difference in brightness from one side of the display to the other. A frequency range of 20kHz to 200kHz is recommended to avoid audible noise and flicker.

Design Specifications and Setup

This reference design features the [MAX15005](#) power-supply controller optimized for automotive and VFD applications. The application circuit is designed to meet the following specifications:

- V_{IN} : 9V to 16V continuous, 5.5V to 40V transient
- V_{ANODE} : 77V_{DC} ±10% at 18mA (typ), 58mA (max)

- V_{GRID} : 55V_{DC} ±10% at 14mA (typ), 41mA (max)
- $V_{FILAMENT}$: 3.1V_{AC} ±10% at 350mA (typ), 385mA (max)
- Output ripple: 77V: 1V_{P-P}; 55V: 0.5V_{P-P}
- Line regulation, V_{IN} = 9V to 16V:
 V_{ANODE} = ±3%
 V_{GRID} = ±3%
 $V_{FILAMENT}$ = ±5%
- Load regulation: (see **Line/Load Regulation Data** section below)
- Switching frequency: 22kHz
- Temperature: -40°C to 125°C

The schematic for the above specifications is shown in **Figure 1**. In this design MAX15005B is used in the flyback configuration for obtaining three output voltages.

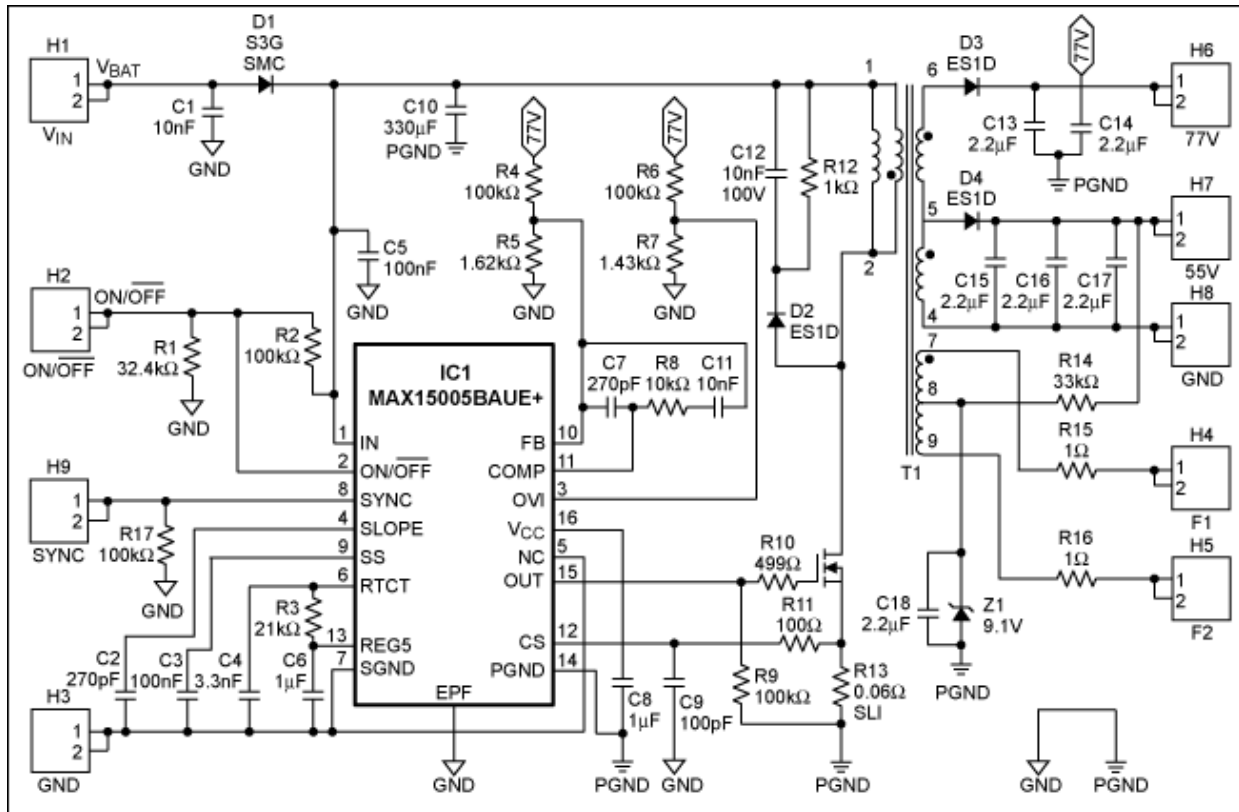


Figure 1. Schematic of the MAX15005B flyback converter for $F_{SW} = 22\text{kHz}$.

The bill of materials (BOM) for this reference design is given in **Table 1**.

Table 1. Bill of Materials for VFD Reference Design

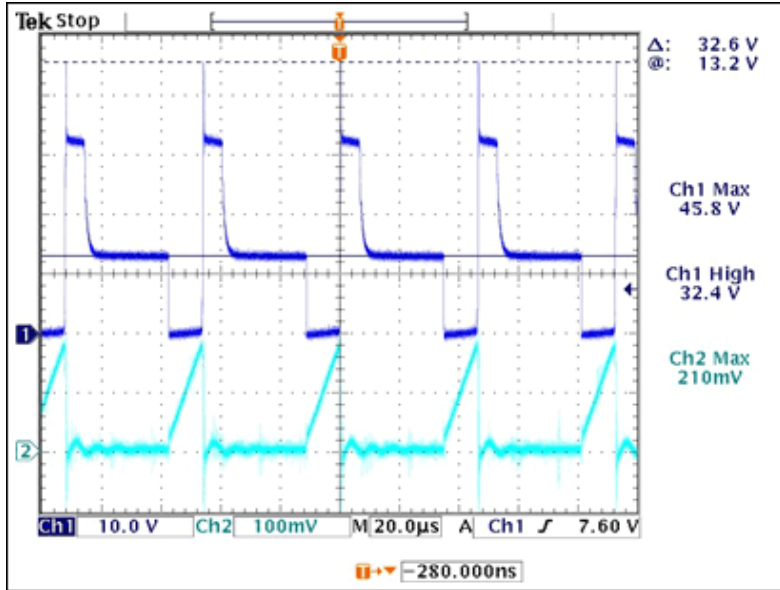
Designator	Value	Description	Part Number	Footprint	Manufacturer	Quantity
C1, C11, C12	10nF, 100V	Capacitor	C2012X7R2A103K	0805	TDK®	3
C2, C7	270pF, 100V	Capacitor	GRM188R72A271KA01D	0805	Murata®	2
C3, C5	100nF, 100V	Capacitor	C2012X7R2A104K	0805	TDK	2
					AVX®	

C4	3.3nF, 25V	Capacitor	08053A332FAT2A	0805	Corporation	1
C6, C8	1μF, 50V	Capacitor	C3216X7R1H105K	1206	TDK	2
C9	100pF, 100V	Capacitor	GRM2165C2A101JA01D	0805	Murata	1
C10	330μF, 35V	Capacitor	–	SMD	TDK	1
C13, C14, C15, C16, C17, C18	2.2μF, 100V	Capacitor	GRM32ER72A225KA35L	1210	Murata	6
D1	3A, 400V	Diode	S3G	SMC	Vishay®	1
D2, D3, D4	1A, 200V	Diode	ES1D	SMA	Vishay	3
Q1	11A, 55V	n-FET	BUK92150-55A	–	NXP®	1
R1	32.4kΩ	Resistor	SMD, 5%, 0.125W	0805	KOA	1
R2, R9, R17	100kΩ	Resistor	SMD, 5%, 0.125W	0805	KOA	3
R3	21kΩ	Resistor	SMD, 1%, 0.125W	0805	KOA	1
R4, R6	100kΩ	Resistor	SMD, 1%, 0.250W	1206	KOA	2
R5	1.62kΩ	Resistor	SMD, 1%, 0.125W	0805	KOA	1
R7	1.43kΩ	Resistor	SMD, 1%, 0.125W	0805	KOA	1
R8	10kΩ	Resistor	SMD, 5%, 0.125W	0805	KOA	1
R10	499Ω	Resistor	SMD, 1%, 0.125W	0805	KOA	1
R11	100Ω	Resistor	SMD, 5%, 0.125W	0805	KOA	1
R12	1kΩ	Resistor	SMD, 1%, 0.333W	1210	KOA	1
R13	0.06Ω	Resistor	SMD, 1%, SL1	SL1	KOA	1
R14	33kΩ	Resistor	SMD, 5%, 0.125W	0805	KOA	1
R15, R16	1.0Ω	Resistor	SMD, 1%, 0.250W	1206	KOA	2
T1	54μH	Transformer	DCT20EFD-UxxSOA5	SMD	TDK	1
Z1	9.1V	Zener diode	1SMB5924BT	SMB	Vishay	1
IC1	MAX15005B	Boost controller	MAX15005BAUE+	16TSSOP	MAXIM®	1

Waveform Measurements

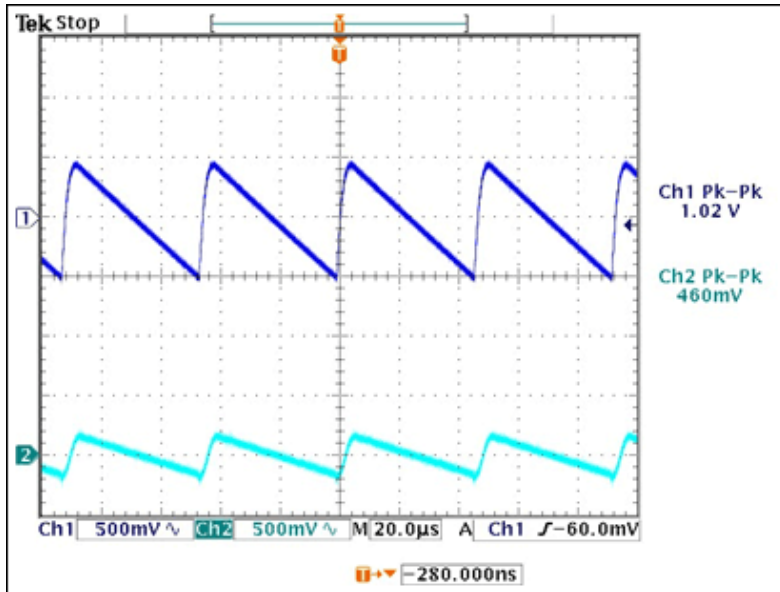
The following test results were generated from the board built for evaluating the circuit.

Test conditions: $V_{IN} = 14V$; $R_{ANODE} = 3.3k\Omega$; $R_{GRID} = 3.3k\Omega$; $R_{FILAMENT} = 8\Omega$.



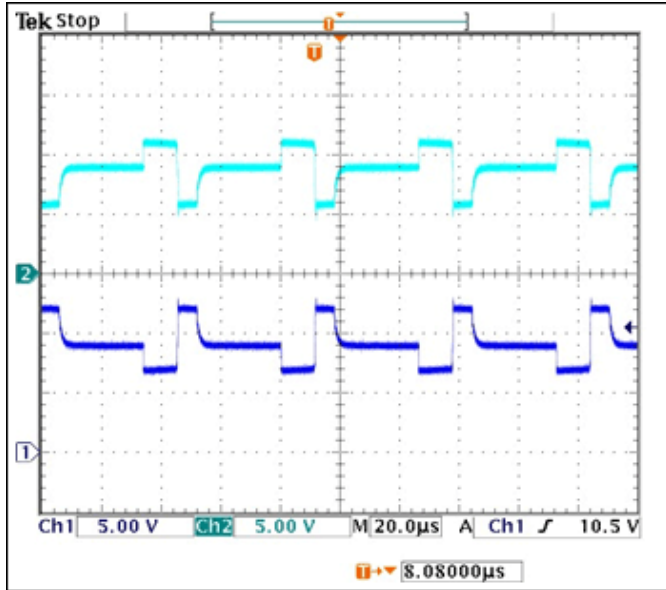
Ch1: MOSFET Q1 drain voltage (V_{DRAIN}); Ch2: current-sense voltage across R13 (V_{ISENSE}).

Test conditions: $V_{IN} = 14V$; $R_{ANODE} = 3.3k\Omega$; $R_{GRID} = 3.3k\Omega$; $R_{FILAMENT} = 8\Omega$.



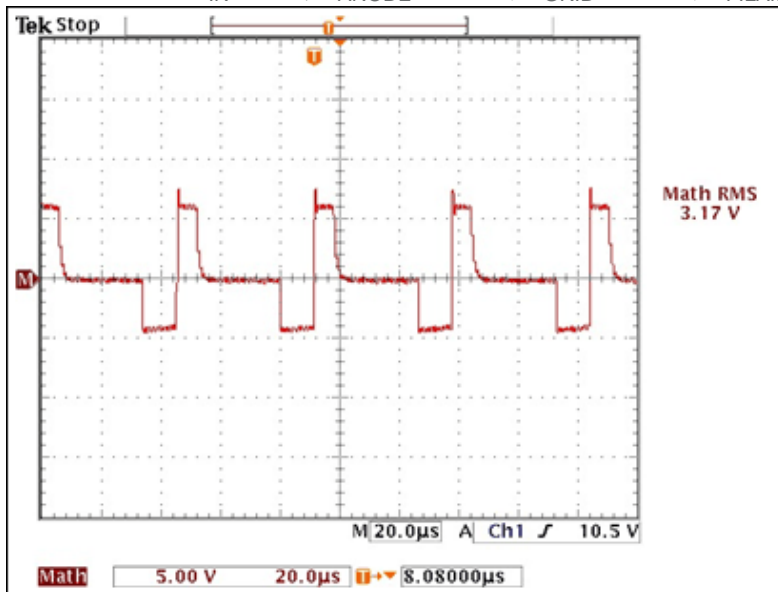
Ch1: anode output voltage ripple; Ch2: grid output voltage ripple.

Test conditions: $V_{IN} = 14V$; $R_{ANODE} = 3.3k\Omega$; $R_{GRID} = 3.3k\Omega$; $R_{FILAMENT} = 8\Omega$.



Ch1: filament positive node voltage (V_{F1}); Ch2: filament negative node voltage (V_{F2}).

Test conditions: $V_{IN} = 14V$; $R_{ANODE} = 3.3k\Omega$; $R_{GRID} = 3.3k\Omega$; $R_{FILAMENT} = 8\Omega$.



M: effective filament voltage ($V_{F1} - V_{F2}$).

Line/Load Regulation Data

The following line/load regulation data was taken from the test board over the input voltage range and load.

V_{IN}	I77 (mA)	I55 (mA)	V77 (V_{DC})	V55 (V_{DC})	VF (V_{RMS})
9.0	7.7	5.5	77.0	55.2	2.41
	7.7	16.7	77.0	55.0	2.64
	7.7	44.0	77.0	54.8	3.03

23.0	5.5	77.0	55.4	2.82	
23.0	16.7	77.0	55.2	2.97	
23.0	44.0	77.0	55.0	3.24	
61.6	5.5	77.0	55.8	3.35	
61.6	16.7	77.0	55.6	3.43	
61.6	44.0	77.0	55.4	3.62	
14.0	7.7	5.5	77.0	55.2	2.52
	7.7	16.7	77.0	55.0	2.75
	7.7	44.0	77.0	54.8	3.14
	23.0	5.5	77.0	55.4	2.80
	23.0	16.7	77.0	55.2	3.08
	23.0	44.0	77.0	55.0	3.36
	61.6	5.5	77.0	55.8	3.50
	61.6	16.7	77.0	55.7	3.59
	61.6	44.0	77.0	55.4	3.79
16.0	7.7	5.5	77.0	55.2	2.63
	7.7	16.7	77.0	55.0	2.86
	7.7	44.0	77.0	54.8	3.25
	23.0	5.5	77.0	55.4	3.04
	23.0	16.7	77.0	55.2	3.20
	23.0	44.0	77.0	55.0	3.49
	61.6	5.5	77.0	54.8	3.25
	61.6	16.7	77.0	55.0	3.49
	61.6	44.0	77.0	55.4	3.92

Conclusion

This application note presents a power-supply reference design for driving a typical vacuum fluorescent display in an automotive application. The design was built to the specifications presented here. The design was then tested. The circuit schematic, BOM, and typical waveforms have been presented.

AVX is a registered trademark of AVX Corporation.

Maxim is a registered trademark of Maxim Integrated Products, Inc.

NXP is a registered trademark of NXP B.V.

TDK is a registered service mark and registered trademark of TDK Corporation.

Vishay is a registered trademark of Vishay Intertechnology, Inc.

More Information

For Technical Support: <http://www.maximintegrated.com/support>

For Samples: <http://www.maximintegrated.com/samples>

Other Questions and Comments: <http://www.maximintegrated.com/contact>

Application Note 4363: <http://www.maximintegrated.com/an4363>

REFERENCE DESIGN 4363, AN4363, AN 4363, APP4363, Appnote4363, Appnote 4363

Copyright © by Maxim Integrated Products

Additional Legal Notices: <http://www.maximintegrated.com/legal>