HV857 EL Lamp Driver Circuits for Low Audible Noise or High Brightness Applications

This Application Note is used to describe the patented method to reduce the audible noise generated by the EL (Electroluminescent) lamp used in mobile phone applications.

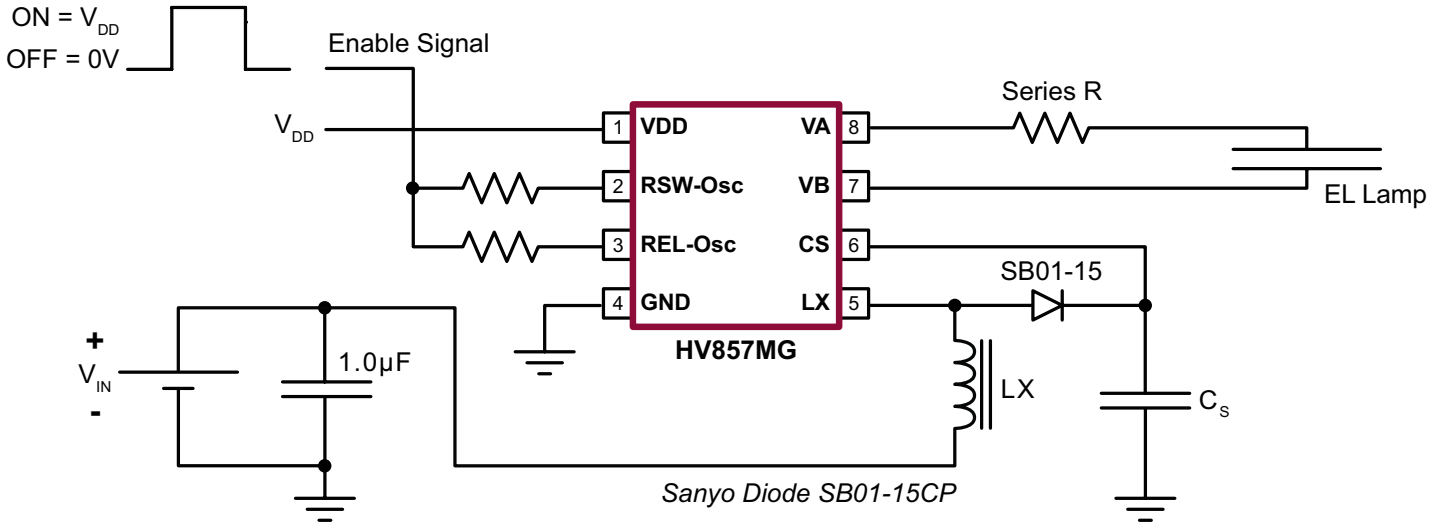
This Application Note also provides example circuits as a guideline for applications with different lamp sizes, input voltages, and brightness requirements.

For additional assistance in designing EL driver circuits, please refer to Application Notes AN-H33 (effect of external components on performance of Supertex EL drivers), Lamp Driver Circuits.

When constructing and testing one of the driver circuits listed below, keep in mind that results may differ from those given due to lamp characteristics and component tolerance.

When making component changes for circuit optimization, always remove the supply voltages first. After making adjustments, bring up the supply voltage slowly starting from the minimum required device input voltage while monitoring input current. A sharp rise in current usually indicates a saturated inductor. Use a higher current rated inductor, a higher value inductor, or increase conversion frequency by lowering $R_{SW\text{-}Osc}$ value.

Figure 1: Typical Application Circuit



Mobile Phone Circuit for Audible Noise Reduction:

The following table provides EL lamp audible noise and brightness for circuits which were designed based on typical EL lamp sizes for mobile phone applications. See Figure 1 and Table 3.

Table 1

Circuit	Lamp Size / Series R (in^2 / kΩ)	Audible Noise (dBA)	Lamp Brightness		Supply Voltage		LX Supply Current (mA)	Lamp Frequency (Hz)
			(ft-lm)	(cd/m^2)	V_{DD} (V)	V_{IN} (V)		
1	2.6 / 0	35.1	8.09	27.70	3.0	3.0	20.6	250
	2.6 / 25	32.0	6.93	23.70			23.3	
	2.6 / 50	29.2	5.00	17.10			23.5	
	2.6 / 75	26.7	3.83	13.10			22.6	
	2.6 / 100	23.3	2.80	9.56			21.3	
2	1.7 / 0	32.0	6.90	23.59	3.0	3.0	13.4	250
	1.7 / 25	28.3	6.35	21.73			15.5	
	1.7 / 50	26.0	5.72	19.55			16.6	
	1.7 / 75	24.4	4.85	16.60			16.9	
	1.7 / 95	22.9	4.20	14.35			16.5	
	1.7 / 120	21.0	3.42	11.69			15.6	

How to Minimize EL Lamp Audible Noise:

The EL lamp, when lit, generates an audible noise. This is due to EL lamp construction which creates a major problem for applications where the EL lamp can be close to the ear such as cellular phones. The noisiest waveform is a square wave and the quietest waveform has been assumed to be a sine wave.

After extensive research, Supertex has developed a waveform that is quieter than a sine wave. The waveform takes the shape of approximately 2RC time constants for rising and 2RC time constants for falling, where the C is the capacitance of the lamp and R is the external resistor used in series with one side of thelamp. This waveform has been proven to generate less noise than a sine wave.

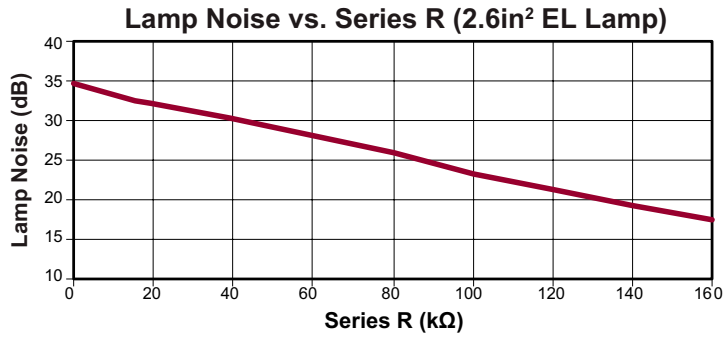
The audible noise from the EL lamp can be set at a desired level based on the series resistor value used with the lamp. We have chosen two commonly used lamp sizes for the mobile phones to demonstrate the effect of series resistor on the audible noise generated by the EL lamp. It is important to note that use of this resistor will reduce the voltage across the lamp. Reduction of voltage across the lamp will also has another effect on the overall performance of the Supertex EL drivers, age compensation (patented). This addresses a very important issue. EL lamp life is an important design concern to mobile phone manufacturers.

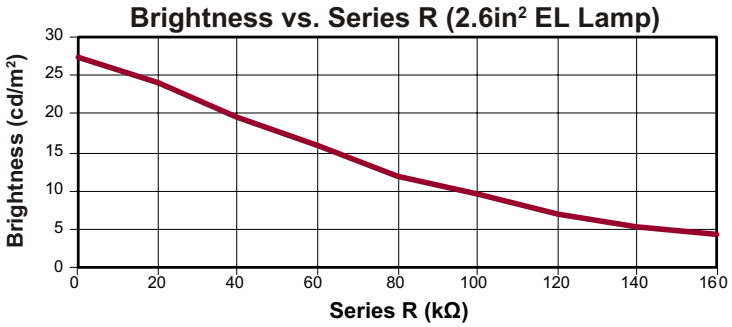
As an EL lamp ages, its brightness is reduced and its capacitance is diminished. By using the RC model to reduce the audible noise generated by an EL lamp, the voltage across the lamp will increase as its capacitance diminishes. Hence the increase in voltage will compensate for the reduction of the brightness. As a result, it will extend an EL lamp's half-life (half the original brightness).

Effect of Series Resistor on EL Lamp Audible Noise and Brightness:

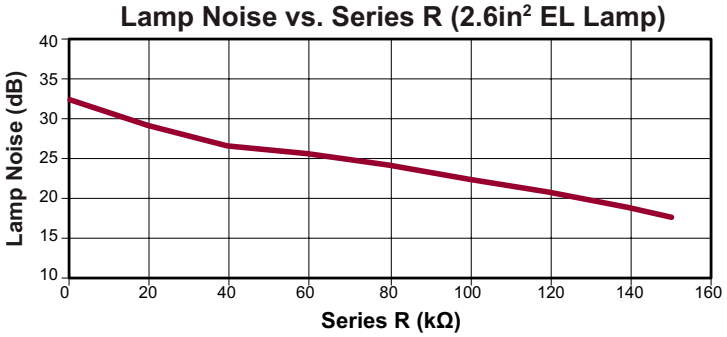
Increasing the value of the series resistor with the lamp will reduce the audible noise of an EL lamp as well as its brightness. This is due to the fact that the output voltage across the lamp will be reduced and the output waveform will have rounder edges.

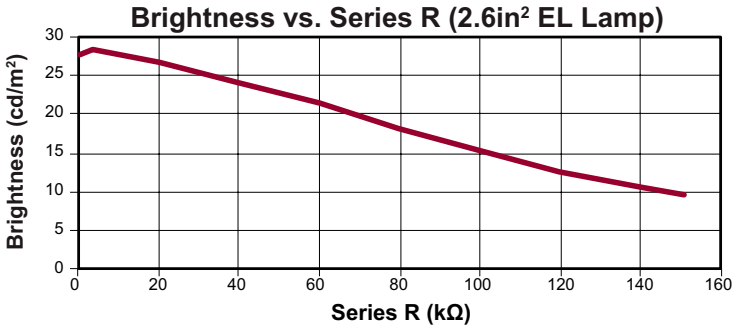
Circuit 1





Circuit 2



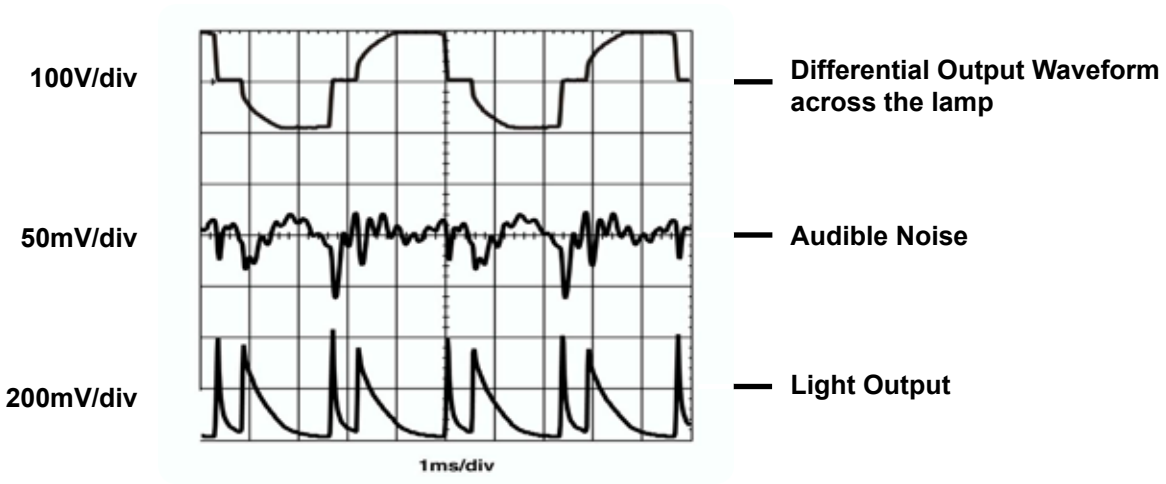


Typical HV857 Output Waveform Before and After Noise Reduction:

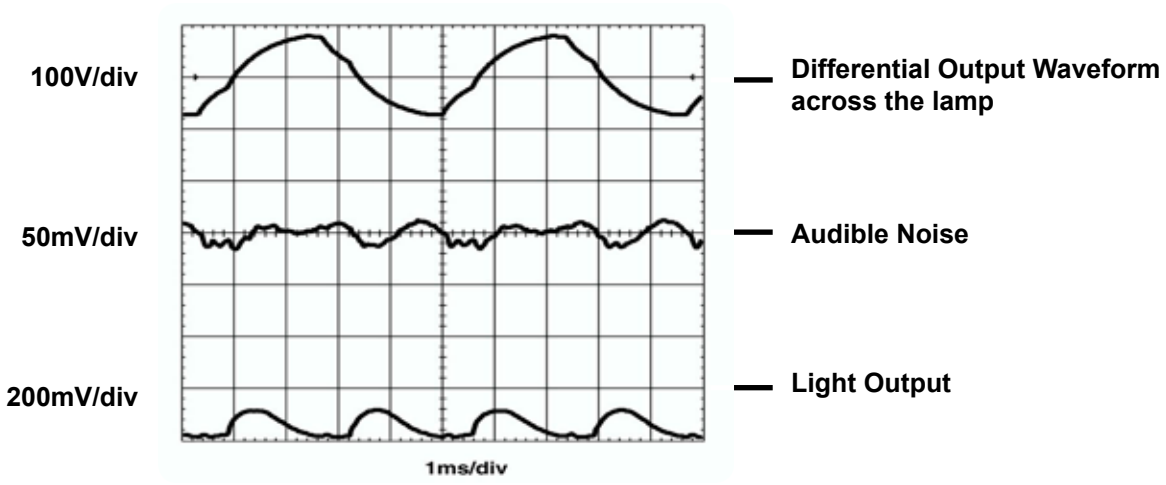
The following are actual scope pictures, which show the differential output waveform across the lamp, audible noise, and lamp light output for circuits 1 and 2.

Circuit 1

Series R = 0Ω

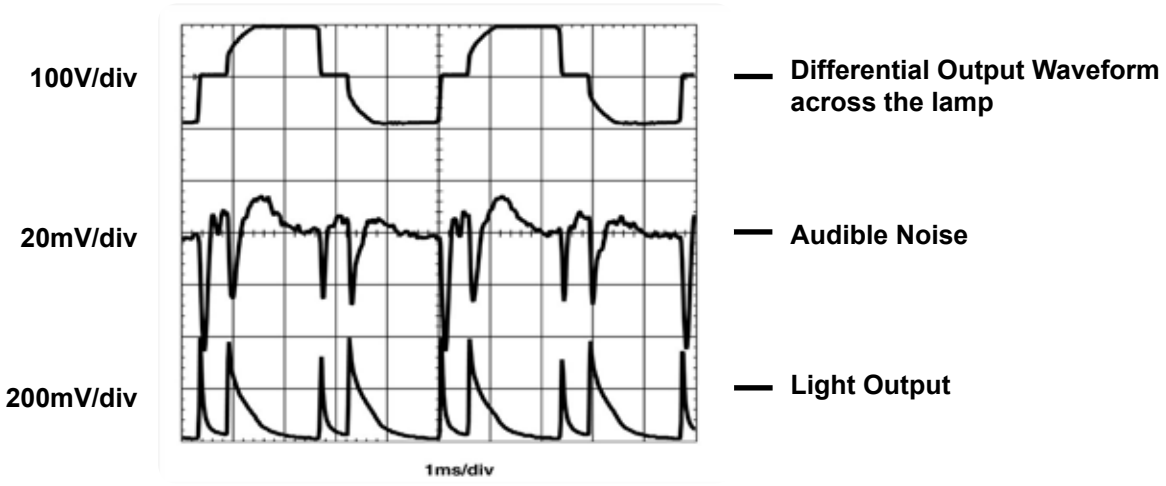


Series R = 65kΩ

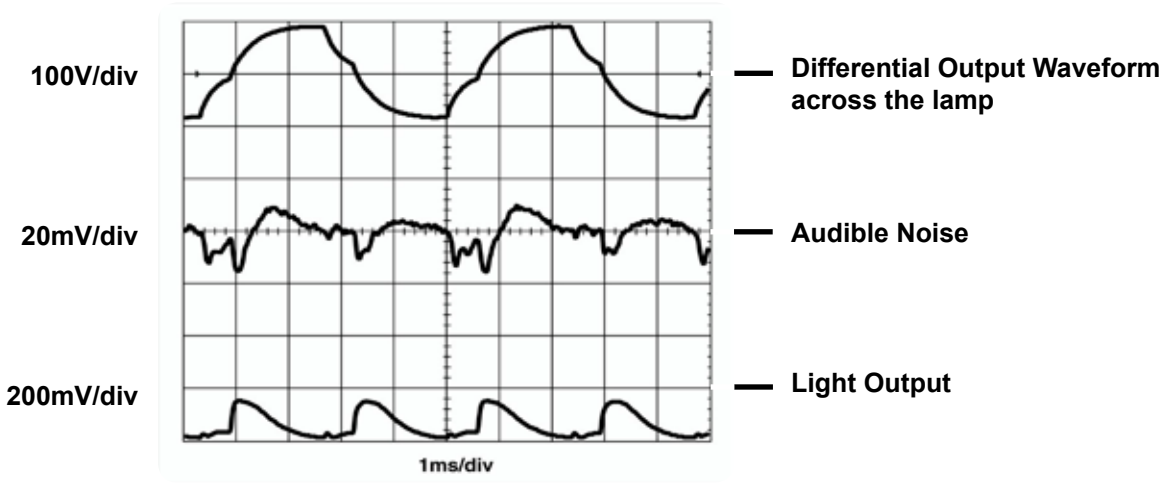


Circuit 2

Series R = 0Ω

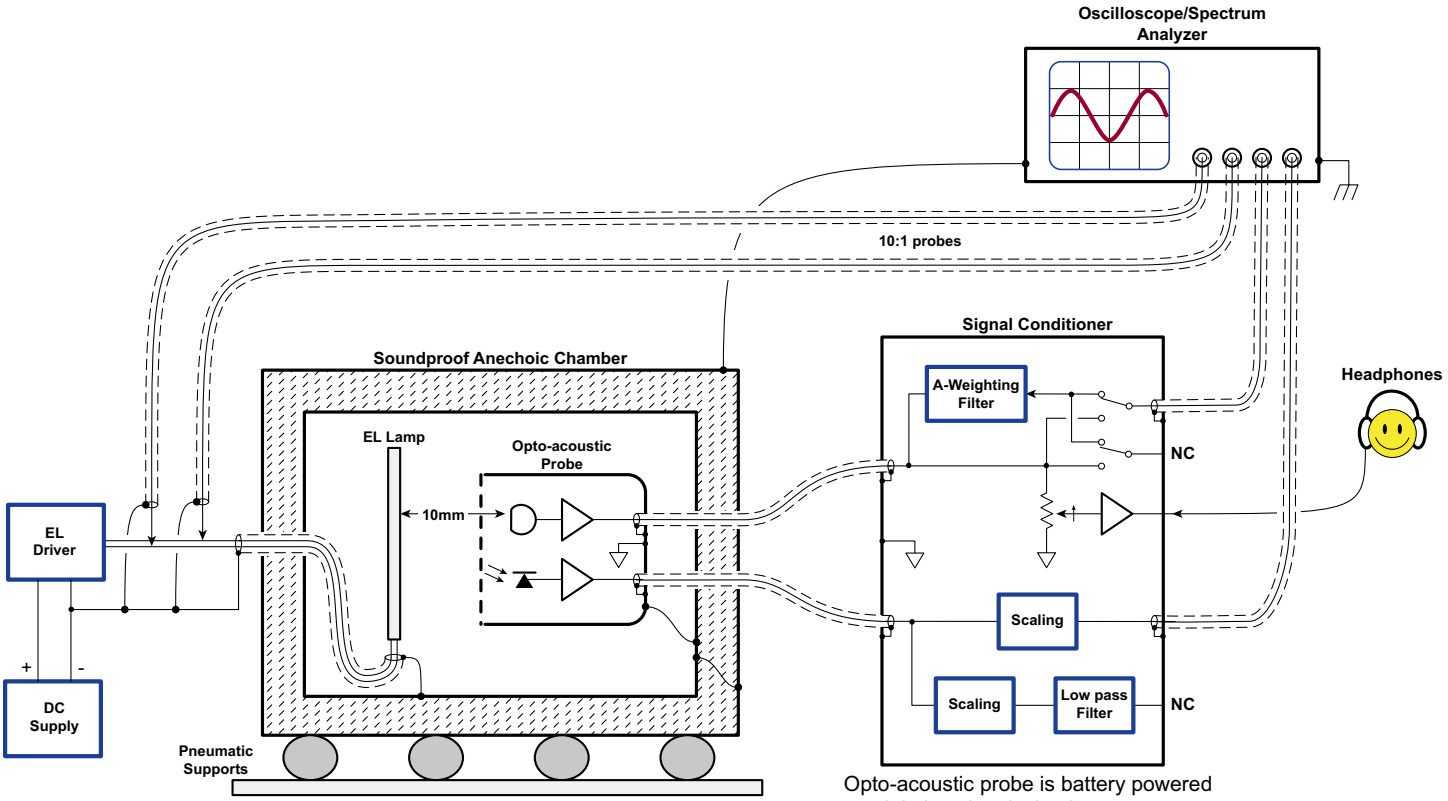


Series R = 55kΩ



Audible Noise Measurement Setup:

The following setup was used to collect EL lamp audible noise data. An Oscilloscope/Spectrum analyzer was used to observe the differential output waveform, audible noise level (in mV), and light output (in mV) of the EL lamp. The EL lamp is placed in the anechoic chamber and a condenser microphone is placed 10mm away from the surface of the EL lamp.



Opto-acoustic probe is battery powered to minimize electrical noise.

Drawing not to scale

Circuit Selector Guide for Non Audible Noise Sensitive Applications:

(Handheld products, PDAs, GPS, 2-way pagers, MP3)

No series resistor is used for the following circuits (R = 0Ω). Also see Figure 1 and Table 3.

Table 2

Circuit	Lamp Size (in^2)	Lamp Brightness		Supply Voltage		LX Supply Current (mA)	Output Voltage (V_{P-P})	Lamp Frequency (Hz)
		(ft-lm)	(cd/m^2)	V_{DD} (V)	V_{IN} (V)			
3	1.3	9.38	32.10	3.3	3.3	12.9	180	357
4	1.7	4.44	15.20	3.0	3.2	7.4	182	160
		4.48	15.31		4.2	5.7	186	
5	1.7	12.0	41.60	3.0	3.2	23.7	168	475
		13.2	45.30		4.2	20.9	178	
6	0.93	7.74	26.51	3.0	3.0	8.3	175	250
7	3.1	7.84	26.87	5.0	5.0	17.9	184	250
8	4.0	7.50	25.70	3.0	3.0	25.8	160	250
9	5.2	4.77	16.34	3.3	3.3	21.2	168	160

Note:

Lamp brightness and current draw can vary by type and manufacturer.

External Components Used for Circuits 1 to 9:

The following table provides the value for external components used in Figure 1. The manufacturer and part number for the inductor is also provided. If other value inductors are used, the circuit will need to be reoptimized.

Table 3

Circuit	LX Inductor		R_{SW-osc} (KΩ)	R_{EL-osc} (Ω)	C_S Capacitor	
	Value (µH)	MuRata Part #			Value (nF)	Type
1	220	LQH32CN221K21	560	2.0	3.3	NPO
2	220	LQH32CN221K21	560	2.0	3.3	NPO
3	220	LQH32CN221K21	560	1.5	3.3	NPO
4	220	LQH32CN221K21	330	3.3	3.3	NPO
5	220	LQH32CN221K21	560	1.0	3.3	NPO
6	220	LQH32CN221K21	560	2.0	3.3	NPO
7	220	LQH32CN221K21	560	2.0	3.3	NPO
8	220	LQH43MN221K01	560	2.0	3.3	NPO
9	220	LQH43MN221K01	560	3.3	3.3	NPO

LX Inductor Selection:

Different inductor values and/or from different manufacturers can be used in place of what is shown. However, the circuit willneed to be reoptimized by changing the R_{SW-Osc} value. Smaller R_{SW-Osc} value needs to be used for inductors with lower series resistance. Lower amount of current will be drawn when using larger value inductors. But, for the same R_{SW-Osc} value, a lower amount of energy will be transferred due to the higher series resistance of a larger value inductor. Hence, when larger value inductors with higher series resistance are used, the R_{SW-Osc} value needs to be increased. It is very important to make a note of the saturation current of the inductor. If the saturation current of the inductor is lower than what the circuit/application requires, the inductor and/or IC will be damaged.

C_S Capacitor Selection:

Different C_S capacitor types and value can be used in place of what is shown in circuits 1 to 9. However, the use of a different C_S capacitor type will generate audible noise due to the piezo-electric effect of materials used for their structure (such as X7R and 5YU capacitors).

A different value capacitor can be used. A larger value C_S capacitor (10nF) is recommended to be used for larger EL lamps and/or larger input voltage range. A smaller value C_S capacitor can be used as long as the over all efficiency of the circuit is not decreased. When using a smaller value C_S capacitor, the circuit will need to be reoptimized by using a smaller R_{SW-Osc} value.

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