EL DRIVER

FEATURES

- **Optimized for 2-4 square-inch Panels**
- **Low Supply Current**
- **Minimum External Components**
- **Laser-trimmed Internal Oscillator**
- **Adjustable Output Voltage**
- **Miniature Package (SOT-23L-6)**
- **Panel Voltage Slew Rates Controlled for Life Enhancement**

APPLICATIONS

- **Battery Powered Systems**
- **Cellular Telephones**
- **Pagers**
- **LCD Modules**
- **Wrist Watches**
- **Consumer Electronics**

DESCRIPTION

The TK6592x Electroluminescent (EL) Lamp Driver has been optimized for battery controlled systems where power consumption and size are primary concerns. The miniature device size (SOT-23L-6), together with the miniature Toko EL coils (D32FU, D31FU), further helps system designers reduce the space required to drive the small EL panels.

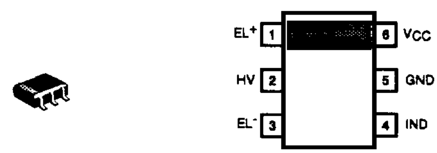
The proprietary architecture of the TK6592x provides a constant output power to the lamp, independent of variations in the battery voltage. This architecture allows the output voltage to remain relatively constant as battery voltages decay, without the need for directly sensing the high voltage output of the EL driver.

The oscillator circuits for the boost converter and lamp driver are both internally generated in the TK6592x, without the need for external components. The clock frequency of the boost converter is laser-trimmed to ensure good initial accuracy that is relatively insensitive to variations in temperature and supply voltage. The clock frequency of the lamp driver tracks the frequency of the boost converter by a constant scaling factor.

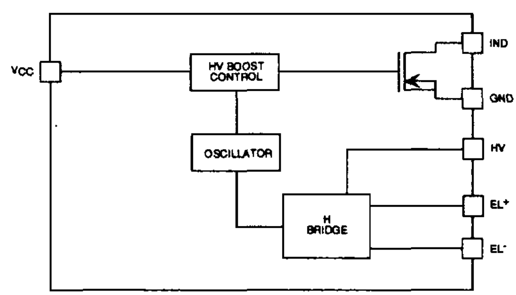
Furthermore, the drive architecture of the TK6592x has been designed to limit peak drive current delivered to the lamp. This approach limits the slew rate of the voltage across the lamp and has the potential to improve lamp life and decrease RF interference.

The TK6592x is available in a miniature, 6-pin SOT-23L-6 surface mount package.

TK6592x



BLOCK DIAGRAM



ORDERING INFORMATION

TK6592x□

Lamp Frequency Code

LAMP FREQUENCY CODE

TK65920	175 Hz	TK65925	300 Hz
TK65921	200 Hz	TK65926	325 Hz
TK65922	225 Hz	TK65927	350 Hz
TK65923	250 Hz	TK65928	375 Hz
TK65924	275 Hz	TK65929	400 Hz

TAPE/REEL CODE
TL: Tape Left

ABSOLUTE MAXIMUM RATINGS

V_{CC} Pin .... 6 V
All Pins Except V_{CC} and GND .... V_{CLAMP}
Power Dissipation (Note 1) .... 400 mW
Storage Temperature Range .... -55 to +150 °C
Operating Temperature Range .... -30 to +80 °C
Junction Temperature .... 150 °C

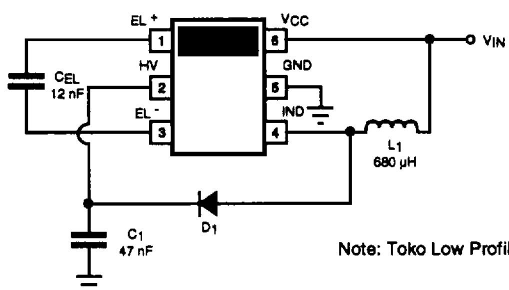
TK6592x ELECTRICAL CHARACTERISTICS

V_{IN} = 3.6 V, T_A = T_j = 25 °C, unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
V_{CC}	Input Supply Range		2.7		6	V
I_{CC}	Quiescent Current			100		µA
I_{PEAK}	Peak Current Threshold			52		mA
F_{LAMP}	Lamp Frequency		See Table 1			Hz
F_{BOOST}	Boost Frequency		See Table 2			kHz
V_{HV}	Boost High Voltage Output				90	V
V_{CLAMP}	Boost Clamp Voltage			105		V
C_{BOOST}	Maximum Duty Cycle			90		%
V_{OUT}	Converter Output Voltage	(Note 3)	65	70	75	V
I_{CONV}	Converter Supply Current	(Notes 2, 3)	See Table 3			mA

Note 1: Power dissipation is 400 mW when mounted as recommended (200 mW in Free Air). Derate at 1.6 mW/°C for operation above 25 °C.
Note 2: Converter supply current is dependent upon the DC resistance of inductor L_1. Lower DC resistances will result in lower supply currents.
Note 3: When using test circuit below.

TEST CIRCUIT



Note: Toko Low Profile D52FU Series: 875FU-681 M

TK6592x ELECTRICAL CHARACTERISTICS

V_{IN} = 3.6 V, T_A = T_j = 25 °C, unless otherwise specified.

TABLE 1: LAMP FREQUENCY

TOKO PART NO.	MIN.	TYP.	MAX.
TK65920	157 Hz	175 Hz	193 Hz
TK65921	180 Hz	200 Hz	220 Hz
TK65922	202 Hz	225 Hz	248 Hz
TK65923	225 Hz	250 Hz	275 Hz
TK65924	247 Hz	275 Hz	303 Hz
TK65925	270 Hz	300 Hz	330 Hz
TK65926	292 Hz	325 Hz	358 Hz
TK65927	315 Hz	350 Hz	385 Hz
TK65928	337 Hz	375 Hz	413 Hz
TK65929	360 Hz	400 Hz	440 Hz

TABLE 2: OSCILLATOR FREQUENCY

TOKO PART NO.	MIN.	TYP.	MAX.
TK65920	20.1 kHz	22.4 kHz	24.7 kHz
TK65921	23.0 kHz	25.6 kHz	28.2 kHz
TK65922	25.9 kHz	28.8 kHz	31.7 kHz
TK65923	28.8 kHz	32.0 kHz	35.2 kHz
TK65924	31.6 kHz	35.2 kHz	38.8 kHz
TK65925	34.5 kHz	38.4 kHz	42.3 kHz
TK65926	37.4 kHz	41.6 kHz	45.8 kHz
TK65927	40.3 kHz	44.8 kHz	49.3 kHz
TK65928	43.2 kHz	48.0 kHz	52.8 kHz
TK65929	46.1 kHz	51.2 kHz	56.3 kHz

TABLE 3: CONVERTER SUPPLY CURRENT

TOKO PART NO.	MIN.	TYP.	MAX.
TK65920	-	7.8 mA	TBD
TK65921	-	9.0 mA	TBD
TK65922	-	10.1 mA	TBD
TK65923	-	11.2 mA	TBD
TK65924	-	12.3 mA	TBD
TK65925	-	13.4 mA	TBD
TK65926	-	14.5 mA	TBD
TK65927	-	15.6 mA	TBD
TK65928	-	16.8 mA	TBD
TK65929	-	17.9 mA	TBD

THEORY OF OPERATION

An Electroluminescent (EL) Lamp is a strip of plastic, coated with a phosphorous material that emits light when a high voltage AC signal is applied to the terminals of the device. EL panels have the ability to light the entire panel uniformly. Because of this, they are gradually becoming more popular and widespread than LEDs. The amount of light emitted from an EL Lamp is typically proportional to the magnitude of the voltage applied to the lamp. Furthermore, the color of the light emitted by an EL Lamp is somewhat dependent upon the frequency of the applied drive signal. For most applications, a peak-to-peak voltage of 100 to 170 V, with a drive frequency of 175 to 400 Hz, provides optimal trade-off between lamp intensity and power consumption.

The capacitance of the EL Panel is typically proportional to the size of the lamp (a 1 square inch EL Panel typically exhibits approximately 5 nF of capacitance load). The TK6592x series of devices has been optimized to drive EL panels, which are approximately 2-4 square inches in size.

The Boost section of the TK6592x consists of a controller for stepping up a relatively low voltage (2.7 to 6 V) to a much higher voltage (50 to 90 V) needed to drive the EL Lamp. The boost section of the TK6592x uses a proprietary architecture which provides a relatively constant output power, independent of the input supply, without the need for sensing the high voltage output of the boost converter. By controlling the peak current through the switching element of the boost converter, the boost section provides a constant output power independent of the input supply.

The H-Bridge section of the TK6592x switches the high voltage output of the boost converter to the two terminals of the EL Lamp. By alternately switching the terminals of the lamp between the high voltage supply and ground, the peak-to-peak voltage developed across the lamp is effectively twice the high voltage generated by boost converter. Furthermore, the TK6592x limits the magnitude of the drive currents through the H-Bridge switches in order to minimize the edge rates developed across the EL Lamp. This approach protects the EL Panel from large current spikes and reduces the likelihood of high frequency noise components being injected into neighboring circuitry.

The Oscillator section of the TK6592x generates a fixed frequency clock source for the previously described Boost and H-Bridge sections, without the need for external components. The high frequency output of the oscillator is used for driving the boost controller. A lower frequency clock is generated by dividing the high frequency clock by 128; this lower frequency clock corresponds to the drive frequency of the EL Lamp. The laser-trimmed oscillators are relatively insensitive to variations in temperature and supply voltage. Therefore, they provide good control of the lamp color emitted by the panel.

The circuit below illustrates a typical application where the TK6592x is driving a 2-square-inch EL Lamp with a capacitance of approximately 12 nF.

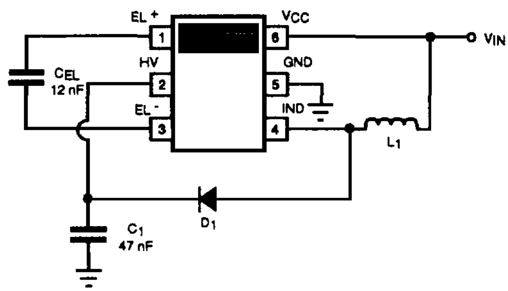


FIGURE 1: TYPICAL APPLICATION

By keeping the ratio of the boost frequency and the H-Bridge frequency constant, the peak-to-peak output voltage from the TK6592x becomes primarily dependent upon the capacitance of the EL Lamp, the peak current threshold of the boost converter, and the value of the inductive element used in the boost converter. For the TK6592x, the peak current threshold is laser-trimmed to 52 mA. The capacitive load of the EL Lamp is a function of panel size and is typically fixed. Therefore, the high voltage output of the boost converter can be set to a desired voltage by selecting the appropriate value of the inductive element used in the boost converter.

I_{PEAK} = Boost Peak Current Threshold (52 mA)

C_{EL} = Capacitance of EL Lamp

L = Inductance Value

$$V_{HV} = (I_{PEAK} / 2) \times \sqrt{(L / C_{EL}) \times 128}$$

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THEORY OF OPERATION (CONT.)

With properly selected components, the TK6592x will nominally support peak output voltages to 90 V (180 V pk-pk). Should the EL Panel become disconnected from the driver outputs, the removal of the load can cause the output voltage to increase beyond 90 V. To protect against this fault condition, a clamp circuit exists on the high voltage output which nominally limits the output voltage to a typical value of 105 V.

PIN DESCRIPTIONS

SUPPLY PIN (V_{CC})

This pin is the positive input supply for the TK6592x. Good design practices dictate capacitive decoupling to the ground pin.

GROUND PIN (GND)

The pin provides the ground connection for the IC.

IND PIN

This pin is periodically pulled to ground by a power transistor acting as an internal switch to the TK6592x. Externally, this pin is typically connected to an inductor and a rectifying diode. By modulating the switching action of the internal switch, the TK6592x can boost the relatively low voltage of the battery to the high voltage required to drive the EL Lamp.

HV PIN

This pin is connected to the filter capacitor and the cathode of the rectifying diode in order to generate a high voltage supply. This high voltage supply is switched to the terminals of the EL Lamp through the H-Bridge.

EL^+ PIN

This pin is connected to one side of the EL Panel.

EL^- PIN

This pin is connected to the other side of the EL Panel.

DESIGN CONSIDERATIONS

INDUCTOR VALUE SELECTION

Designing an EL Driver utilizing the TK6592x is a very simple task. The primary component affecting the behavior of the converter is the inductor. Essentially, the entire design task primarily consists of selecting the proper inductor value and type given the operating conditions of the EL Panel (e.g., lamp capacitance, frequency, output voltage, supply range). The following tables and charts are intended to simplify the selection of the inductor.

Given the capacitance of the EL Lamp, and the peak output voltage requirements, the following table can be utilized to select the value of the inductive component.

TABLE 4: PEAK OUTPUT VOLTAGE VS. INDUCTOR VALUE AND LAMP CAPACITANCE

INDUCTOR VALUE	9.0 nF LAMP	12.0 nF LAMP	15.0 nF LAMP	18.0 nF LAMP	21.0 nF LAMP	24.0 nF LAMP	27.0 nF LAMP
180 µH	42 V	36 V	32 V	29 V	27 V	25 V	24 V
220 µH	46 V	40 V	36 V	33 V	30 V	28 V	27 V
330 µH	56 V	49 V	44 V	40 V	37 V	34 V	33 V
390 µH	61 V	53 V	47 V	43 V	40 V	37 V	35 V
470 µH	67 V	58 V	52 V	48 V	44 V	41 V	39 V
560 µH	73 V	64 V	57 V	52 V	48 V	45 V	42 V
680 µH	81 V	70 V	63 V	57 V	53 V	50 V	47 V
820 µH	89 V	77 V	69 V	63 V	58 V	54 V	51 V
1000 µH		85 V	76 V	69 V	64 V	60 V	57 V
1200 µH			83 V	76 V	70 V	66 V	62 V
1500 µH				85 V	79 V	74 V	69 V
1800 µH					86 V	81 V	76 V
2200 µH						89 V	84 V

As an example as to how the above table is to be used, assume that we have a 2-square-inch panel (12 nF capacitance) and we would like the peak-to-peak voltage across the lamp to be 140 V. The peak voltage on either terminal would be 70 V (140 V / 2). *Referring to the table above, we can see that using a 680 µH coil the peak voltage developed across* a 12 nF Lamp would be approximately 70 V. In this particular example, the inductive component should have a value of 680 µH.

INDUCTOR TYPE SELECTION

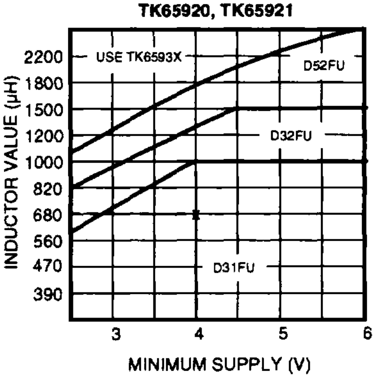
After the value of the inductor has been selected, an appropriate coil type needs to be selected taking into account such factors as DC resistance and current capability. The following charts can be utilized for selecting the proper family of Toko Coils. Furthermore, the following charts will also indicate if the TK6592x is the appropriate driver given the frequency and input supply requirements. If the TK6592x does not have sufficient drive capability given the input supply and frequency requirements, the following charts will suggest the TK6593x family of EL Drivers which have higher drive capabilities. To utilize the following charts in selecting an appropriate coil, perform the following steps:

DESIGN CONSIDERATIONS (CONT.)

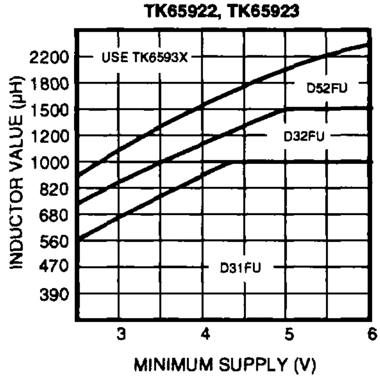
1) From the following charts, select the chart that matches the part number of the Toko EL Driver that will be used in the application. The part number of the Toko EL Driver will be dependant upon the desired frequency of the EL panel (e.g., TK65921 - 200Hz).
2) Determine input supply voltage range (e.g., 4 to 6 V). The x-axis of the following charts represent the minimum expected supply voltage. Below this minimum supply voltage the EL Driver output may begin to droop. On the appropriate chart, draw a vertical line upward from the minimum supply voltage represented on the x-axis (e.g., 4V).
3) Draw a horizontal line passing through the chosen inductor value on the y-axis (e.g., 680 µH).
4) The vertical and horizontal lines drawn in steps 2 and 3 respectively will intersect at a point. This point will lie in one of four regions of the chart (e.g., D31FU). These four regions suggest which family of Toko Coils to use.

Of the three coil families suggested in these charts, the D31FU has the smallest physical size but also has higher DC resistance. The D52FU series of coils has the largest physical size and the lowest DC resistance. The D52FU or the D32FU can be used as a reasonable substitute for the D31FU. Similarly, the D52FU can be used as a replacement for the D32FU. Substituting a coil with lower DC resistance will generally result in a system that will consume less power supply current.

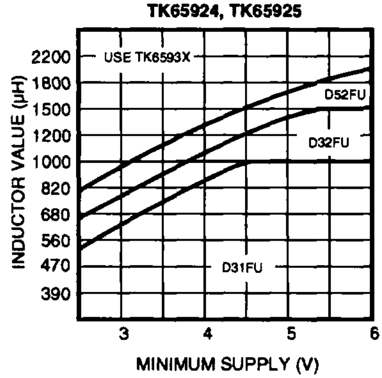
TK65920, TK65921



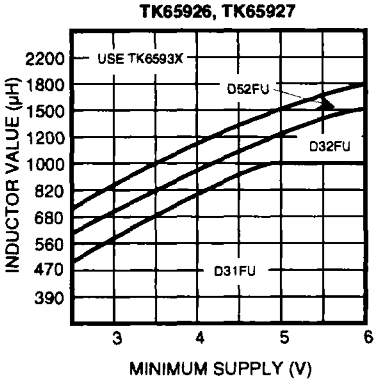
TK65922, TK65923



TK65924, TK65925



TK65926, TK65927



TK65928, TK65929