Claim Chart A2

Infringement of claims 1, 3, 4, 5, 21, 22, 23, 24, 28, 31, and 35 of U.S. Patent No. 9,939,140 (the ’140 patent)

The accused products include, but are not limited to, GE current's following series: Dual Mode Glass Tube - Type A + Type B, which include at least following model numbers: LED13ABT8/G4/830, LED13ABT8/G4/835, LED13ABT8/G4/840, LED13ABT8/G4/850, and substantially similar equivalents thereof. On information and belief, GE current's LED13ABT8/G4/840 is representative of the manner in which the above-identified products infringe the asserted claims of the ’140 Patent.

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product
1[pre] An installation detection circuit configured in a light-emitting diode (LED) tube lamp configured to receive an external driving signal,	The GE LED13ABT8/G4/840, also referred to herein as the "GE LED tube lamp," is a light emitting diode (LED) tube lamp. The GE Lighting "Spec sheet" (see Figure 1) indicates that this product, and those in the same product series, are "Type A+B Dual Mode LED Tubes" as well as "T8 Glass 4' LED Tube". The "T8" portion of the product model number indicates that the lamp is a 1" tube lamp. The "T" indicates it is a tubular lamp while the "8" indicates it has a 1" diameter (the 8 corresponds to the tube diameter in counts of 1/8th inches)

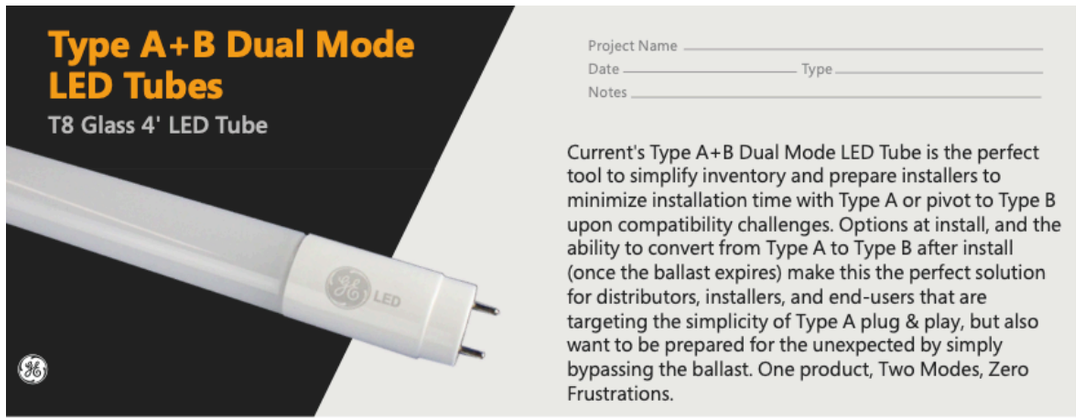
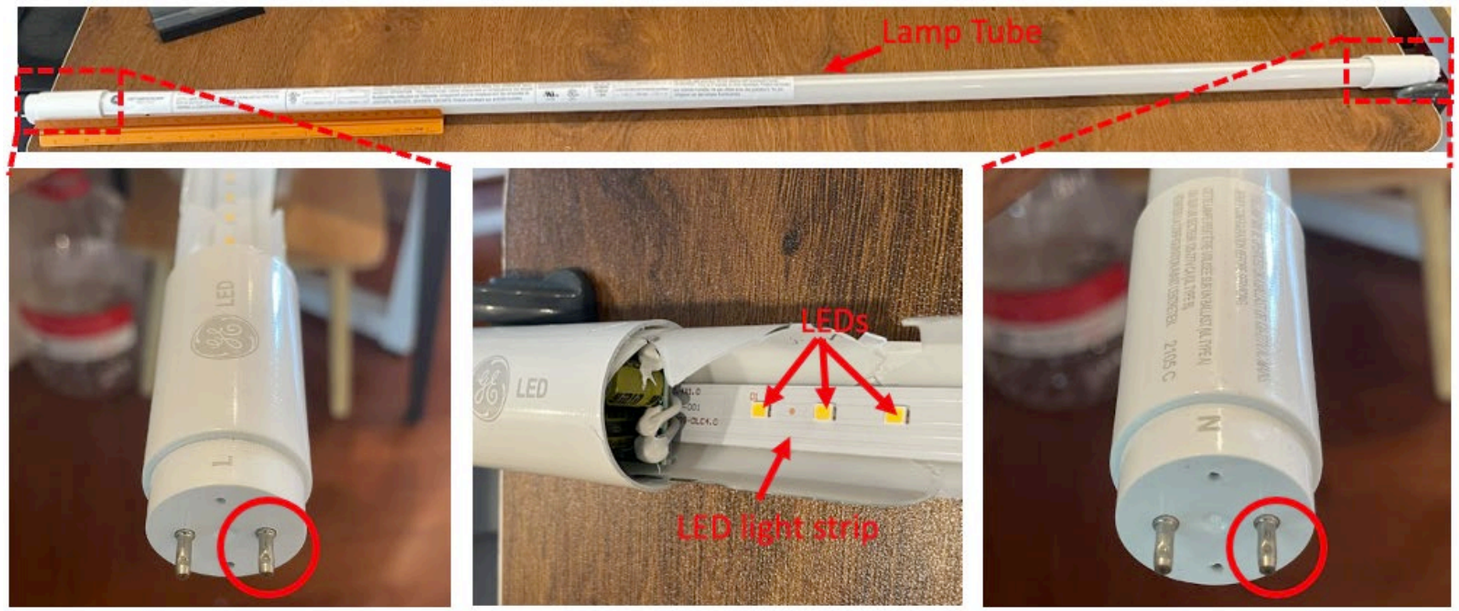


Figure 1. Spec sheet for GE Type A+B Dual Mode LED Tubes.

Figure 2 includes several photos of the exterior of the accused GE LED tube lamp product. The top image shows the entire LED tube lamp while the bottom left and right photos show the two ends of the tube with external connection terminals. The bottom middle photo of the shows a portion of the lamp tube wherein the tube has been broken open to expose the LEDs disposed on a strip contained within the tube.

Claim 1	**GE LED Tube LED13ABT8/G4/840 – Representative Product**
	The external connection terminals visible on the end caps in the bottom left and bottom right photographs of Figure 2, are configured for receiving an external driving signal. Each end cap has a pair of pins. For each pair of end cap pins, only one is electrically coupled to the lamp tube. The two terminals circled in red in the bottom left and bottom right of Figure 2 are the two terminals used for connecting the power line in a lamp socket and receiving an external driving signal, while the other pins are not attached. As indicated on the lamp labelling shown in Figure 3, the GE LED tube lamp may be used with AC line voltage 120-277 V as the external driving signal, with or without a ballast. Thus, the GE product is a light-emitting diode (LED) tube lamp configured to receive an external driving signal.  Figure 2.Photos of the GE LED tube lamp showing central portion comprised of lamp tube (top), two end caps with electrical contacts for receiving an external driving signal (bottom right and bottom left), and central portion of the lamp wherein the tube has been broken to expose the LEDs disposed on a strip contained within the tube.

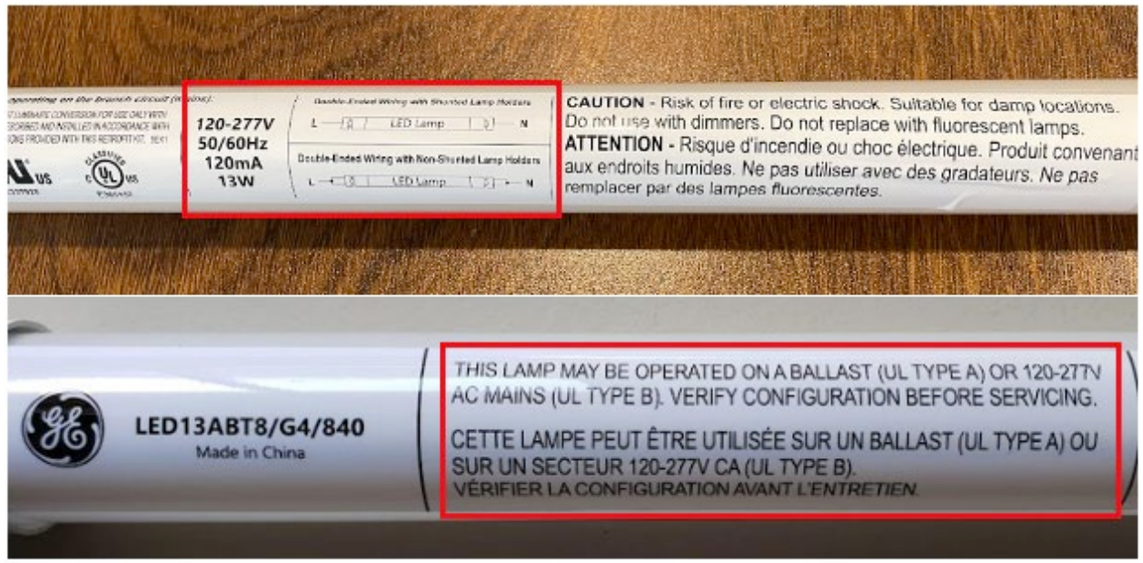


Figure 3. Information printed on GE LED tube lamp indicates it is to be used with an external driving signal corresponding to common AC line voltage (UL Type B) or a ballast (UL Type A).

A power supply module disposed in an end cap of the GE LED tube lamp is shown in Figure 4. Said module contains both a main PCB as well as a smaller daughter board, labeled as CHP6072-MV1.O, and identified here as the claimed installation detection circuit.

The equivalent circuit schematic of the GE power supply module shown in Figure 5 was generated based on the teardown and analysis of the product exhibited in this claim chart. The portion of the schematic corresponding to the installation detection circuit (circuit board CHP6072-MV1.O) is outlined in red.

Therefore, the installation detection module disposed on the power supply module contained in the GE light-emitting diode (LED) tube lamp is configured to receive an external driving signal, and thus, for at least the reasons stated above, the GE LED tube lamp satisfies the preamble of claim 1 of the ’140 Patent.

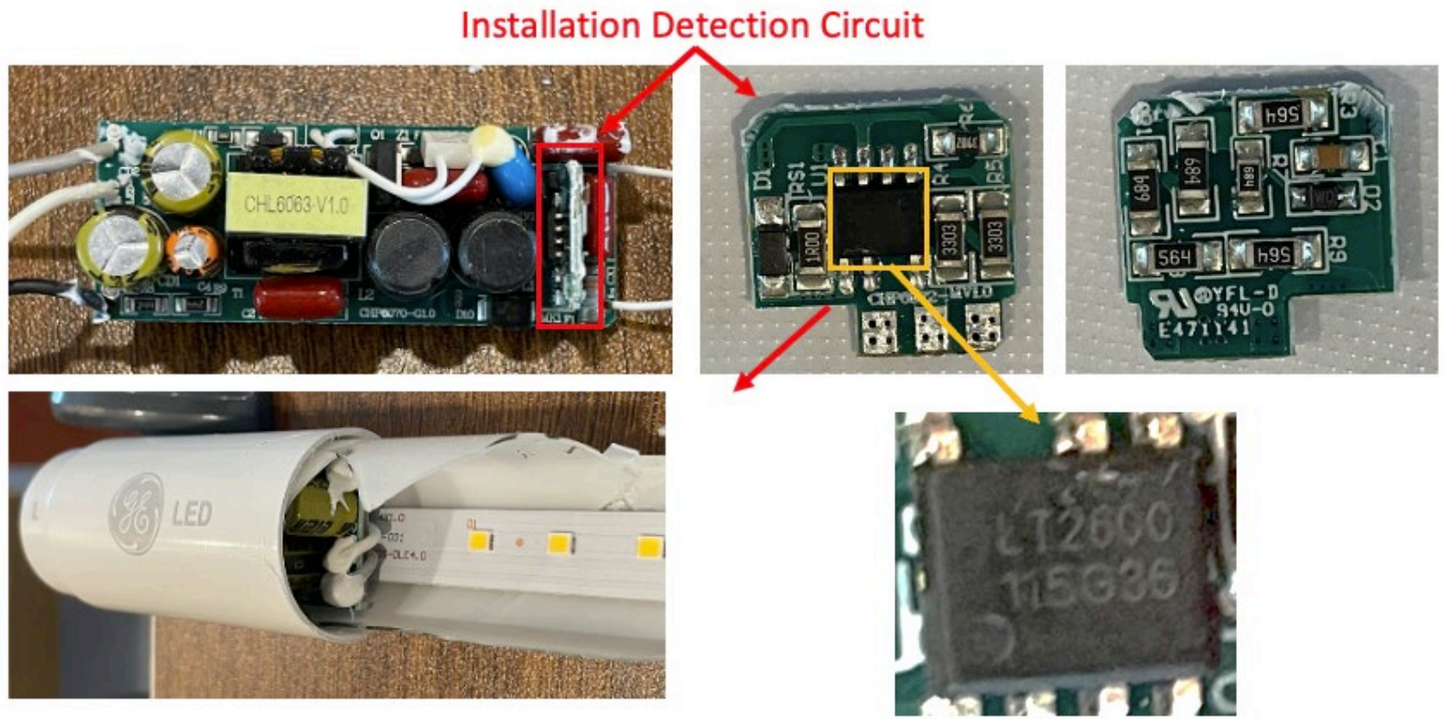
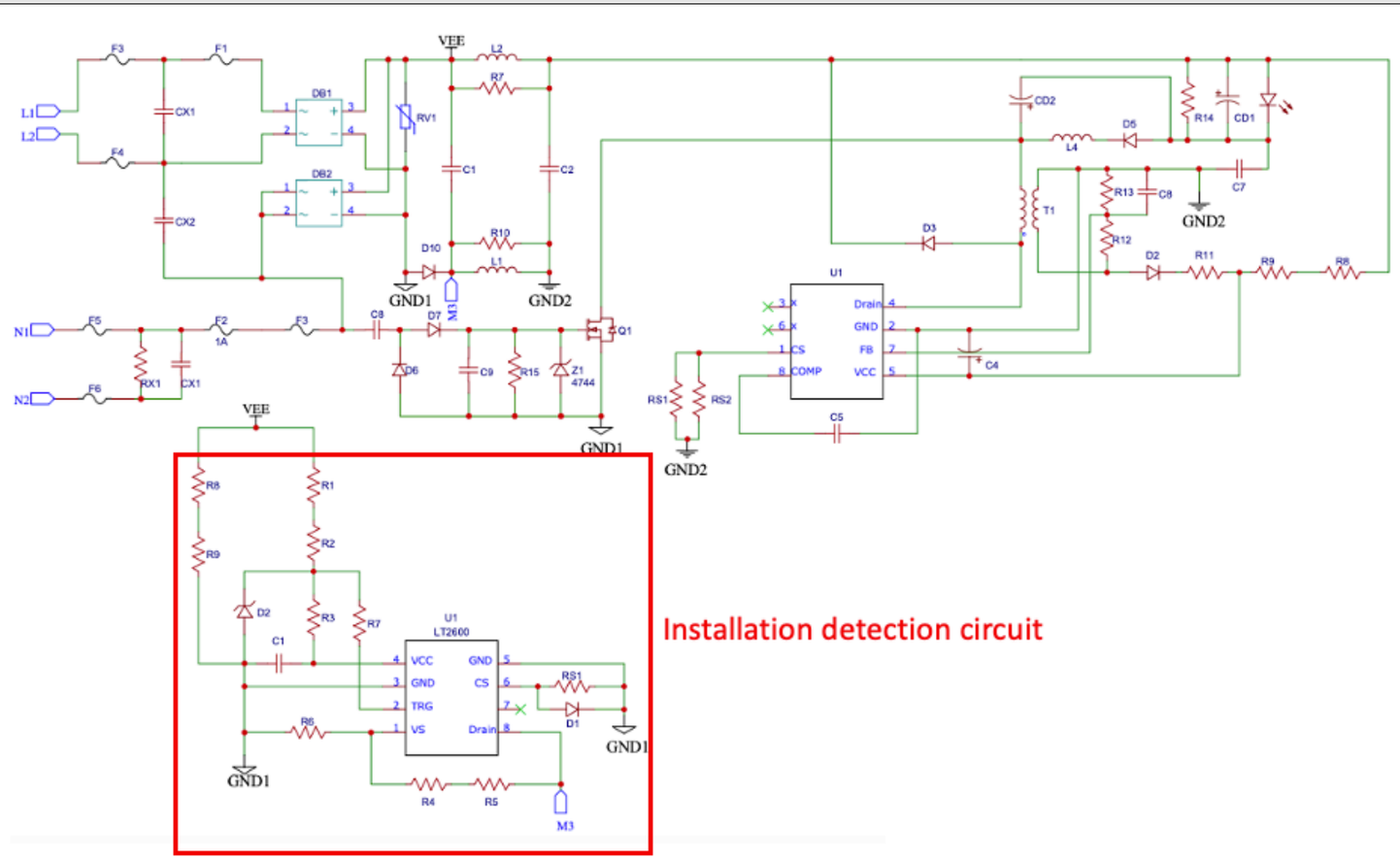


Figure 4. (Top left) Power supply module comprised of main circuit board and daughter board, outlined in red and identified as the claimed installation detection circuit. (Bottom left) Photo illustrates how the GE power supply module is disposed inside of an end cap of the lamp tube. (Top right) Photos of the first and second sides of the daughter board, labeled CHP6072-MV1.O, comprising the claimed installation detection circuit. (Bottom right) Integrated circuit on the GE daughter board.

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product
	 Figure 5. Equivalent circuit schematic of the main PCB and daughter board in the GE LED tube lamp. The installation detection circuit is represented by the daughter board, and the corresponding schematic is outlined in red.
1[a] the installation detection circuit comprising: a pulse generating circuit configured to output one or more pulse signals;	The GE LED13ABT8/G4/840 LED tube lamp contains an installation detection circuit, as discussed above with respect to the preamble of claim 1, which includes a pulse generating circuit configured to output one or more pulse signals. For example, a pulse generating circuit is formed by a control signal generator on the CHP6072-MV1.O daughter board, which is integrated in the 8-pin integrated circuit package identified as a LT2600. Figure 6 shows an X-ray image of the LT2600 as well as an optical microscope image of the decapped package illustrating that the LT2600 contains 2 chips, labeled here as CP1 and CP2.

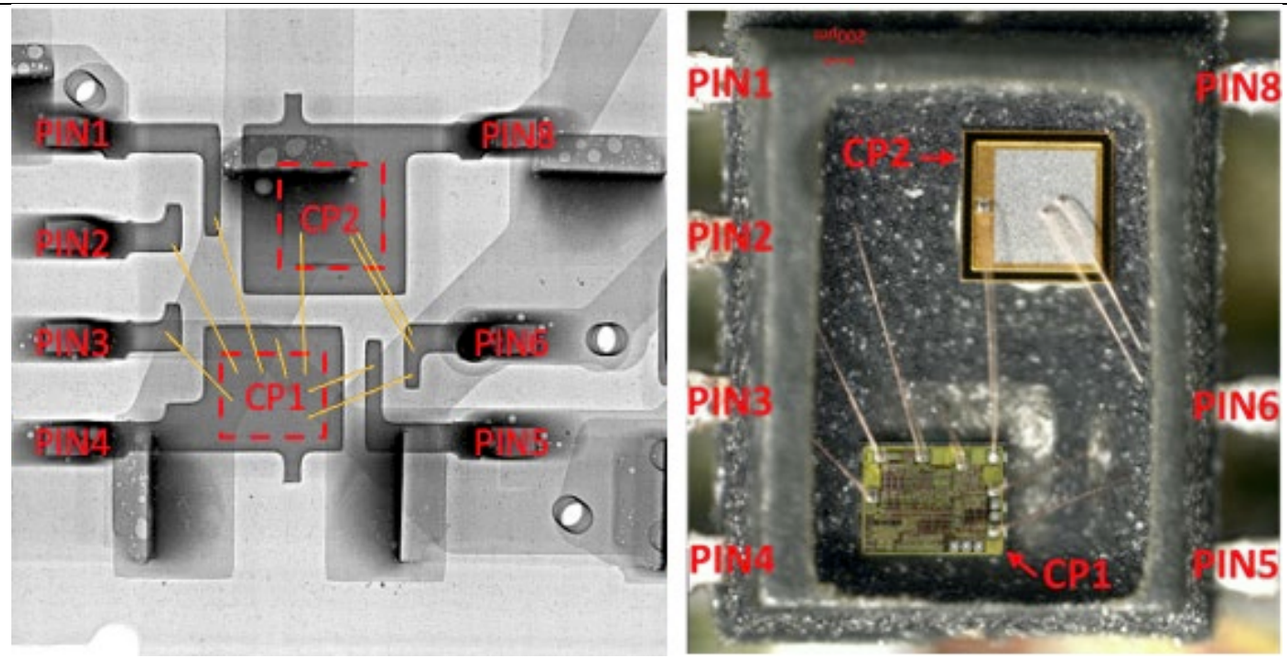


Figure 6. (Left) X-ray image of the LT2600 IC on the CHP6072-MV1.O daughter board showing two chips, labeled as CP1 and CP2. Wire bonds between chips and the package pin outs are highlighted in yellow for visibility. (Right) Optical micrograph of decapped LT2600 on the daughter board.

An optical micrograph of chip CP1 in the LT2600, with the bonding wires removed, is shown on the left side of Figure 7. The right side of Figure 7 shows an optical micrograph of chip CP1 after de-layering the metallic and insulating layers to reveal the underlying silicon structures (e.g. n- and p-doped well structures). The results of following analysis with respect to the LT2600 IC are consistent with the findings provided in the "BA12003_LT2600_CA_Report_v1.pdf" teardown report, which was conducted independently by a third-party company (f Corp). After comparing the layout and the de-layer circuit arrangement, it was found that there are no materially difference between LT2600 and LT2600G, which was found in different tube products of GE, with respect to the asserted claims.[1]

[1] Due to their similarity, some images are shared across charts A1 and A2.

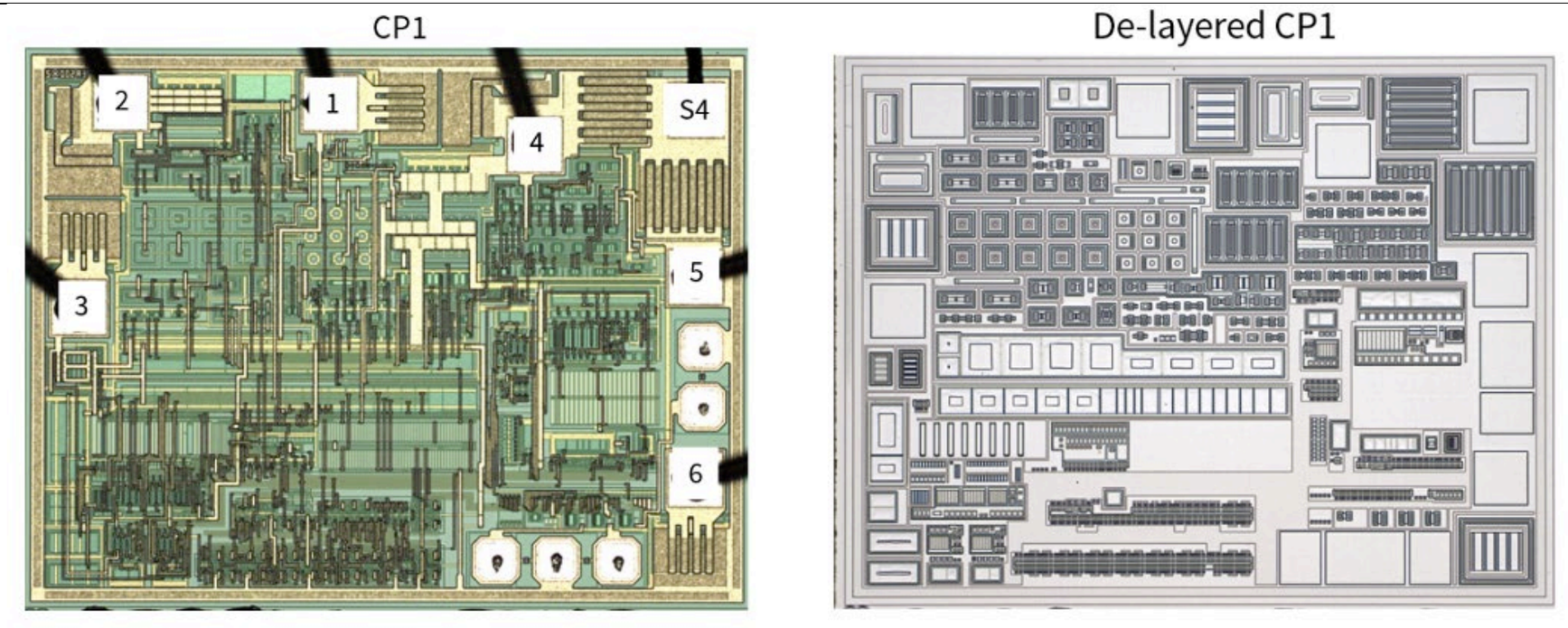


Figure 7. (Left) Optical micrograph of CP1 with wire bonds removed. (Right) Optical micrograph of CP1 after de-layering process to remove metallic traces and insulating layers.

High-resolution optical microscopy provides information relating to physical structures within the integrated circuit, including their organization and functionality. Semiconductor fabrication of integrated circuits frequently utilizes structures of device components with characteristic features. Figure 8 highlights several structures on the CP1 die with functionality that may be ascertained from their characteristic form. For example, the matched bipolar junction transistor array (outlined in red) is a typical feature of self-biased current reference. The resistor ladder along with the decoupling capacitors, (together outlined in blue) are features of a voltage generator used for the multiple voltage reference signals required for the IC’s operation.

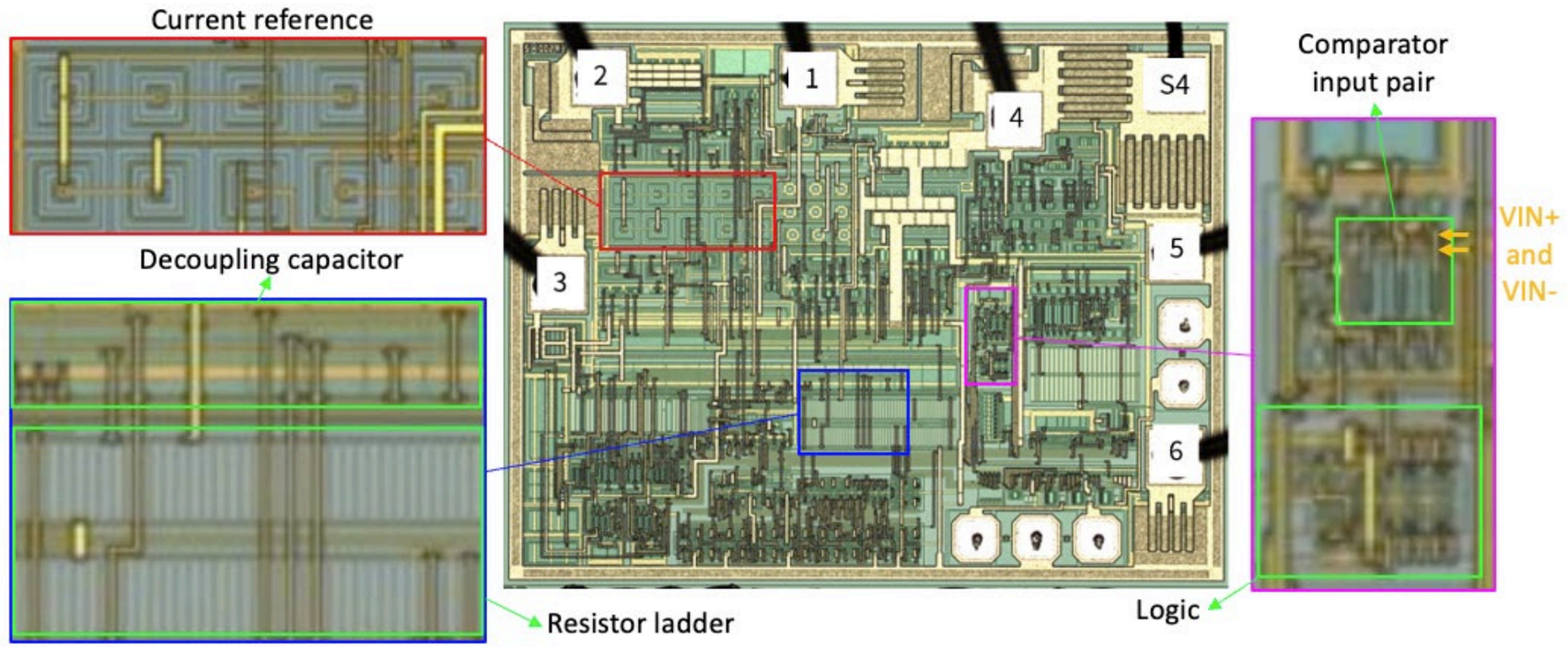


Figure 8. Integrated circuit components are identified on the CP1 die.

High-resolution optical imaging was also used to determine electrical pathway of signals from input and output terminals of the IC. This is possible in part because the metallic traces along which the signals propagate are visible through the thin insulating layers. For example, Figure 9 shows that the signal input on PIN1 of the LT2600 IC follows the trace highlighted in red to the area of CP1 identified as the control signal generator. The control signal generator takes several input signals, including multiple voltage references, and outputs signal S5.

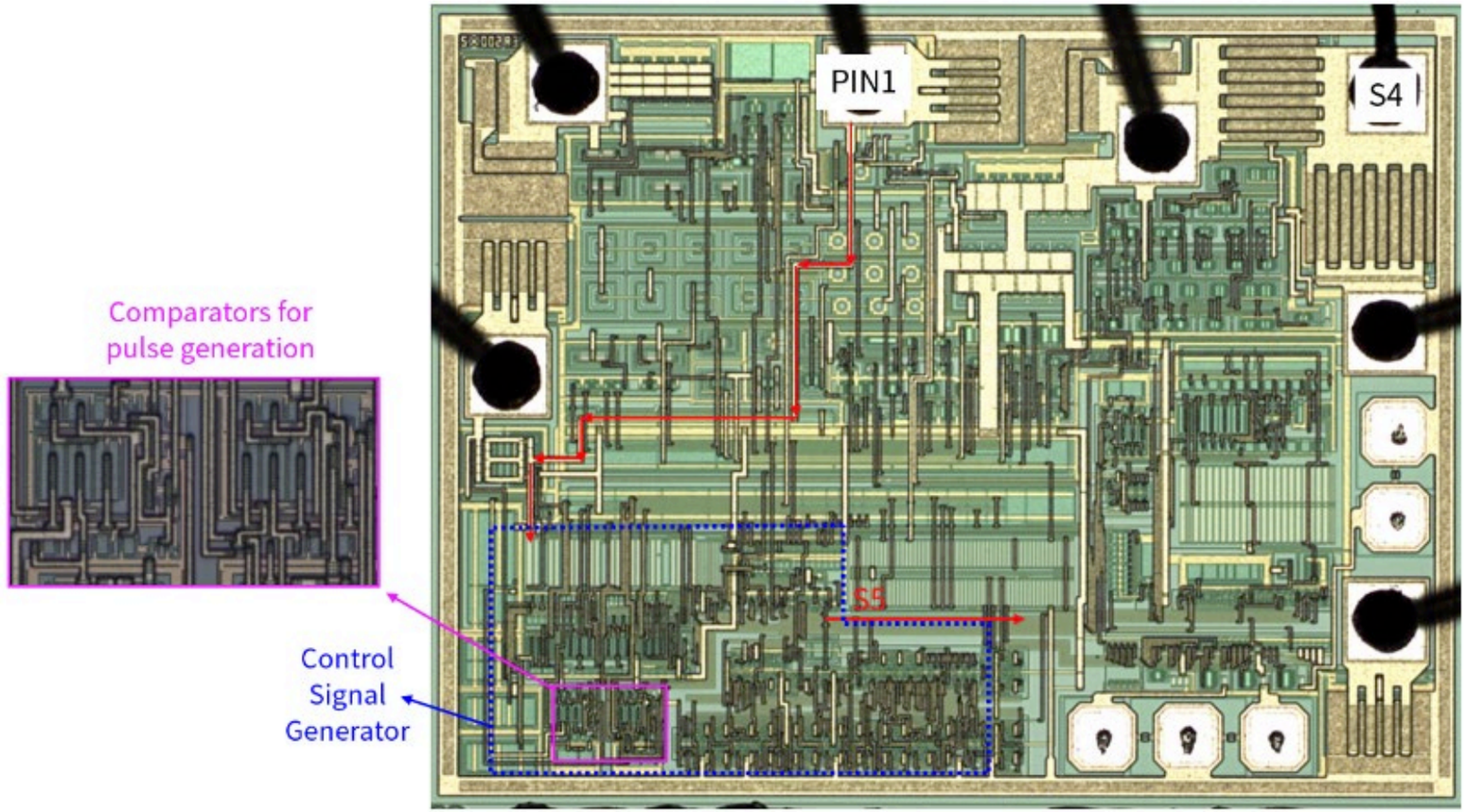


Figure 9. Signal traces from PIN1 serves as input for the pulse generator, which outputs signal S5.

Figure 10 shows that comparator 1 receives inputs from signals that follow the traces highlighted in red. The red-highlighted signal originating at PIN6 is passed through an operational transconductance amplifier (OTA) before making its way to comparator 1 where it is compared to reference voltage V_{REF1} to generate signal S9.

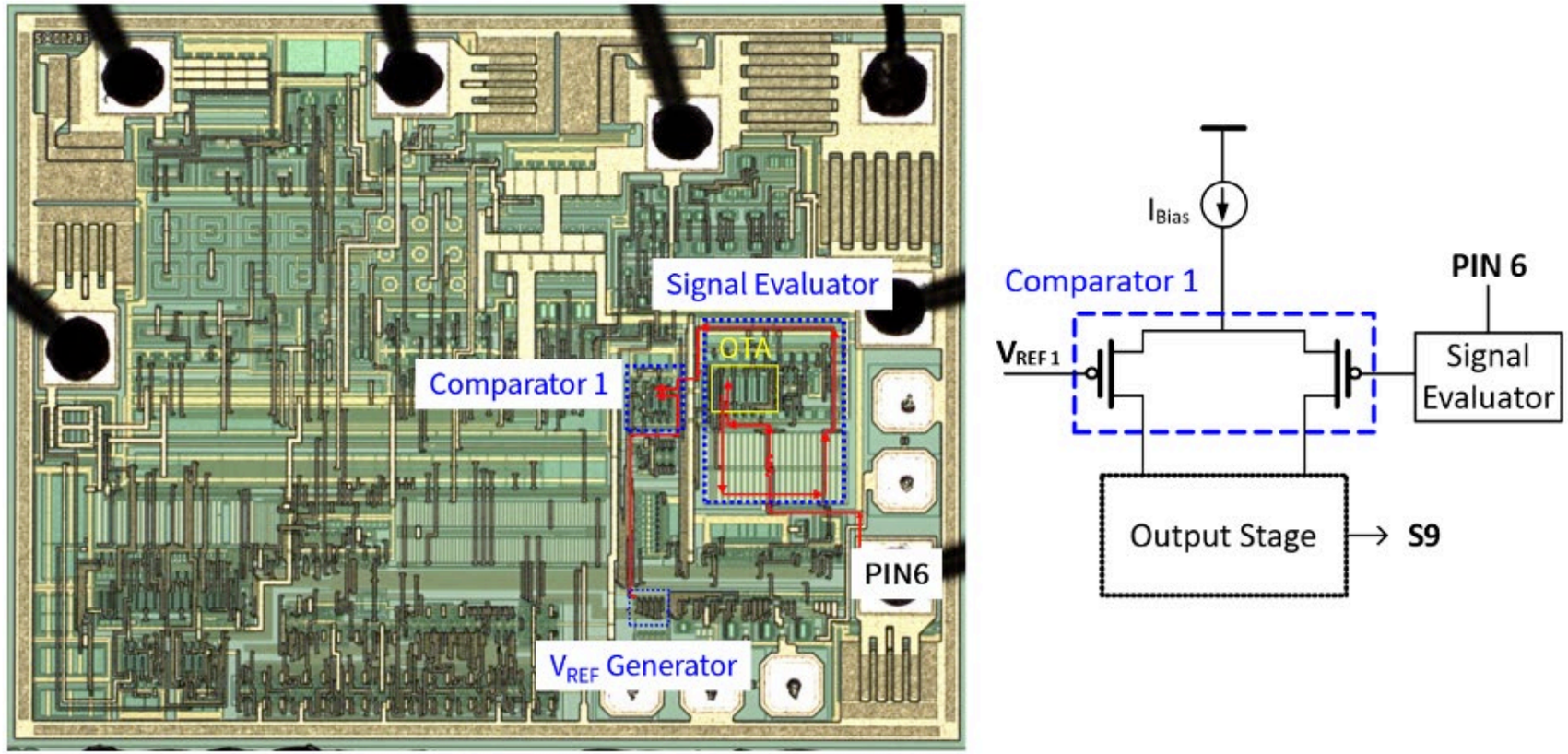


Figure 10. Signal traces from the output of the signal evaluator circuit and a voltage reference, V_{REF1}, provide a pair of input signals to comparator 1, which outputs signal S9.

In Figure 11, the S5 signal (orange trace) and S9 signal (magenta trace) serve as inputs for the logic blocks where they are processed and combined to generate a digital signal that is utilized as an input for the S4 driver.

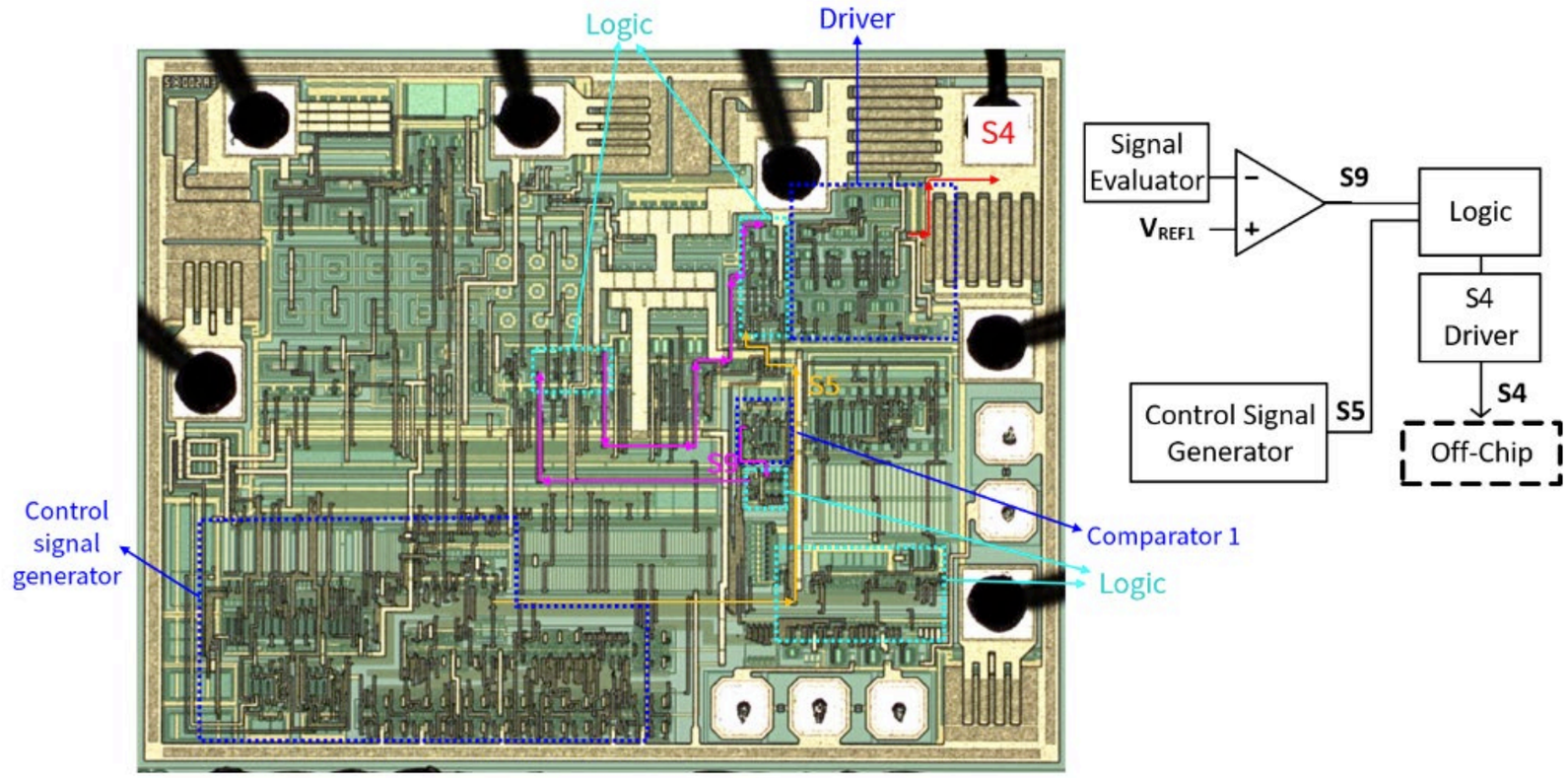


Figure 11. Signal traces from comparator 1 and the pulse generator provide S9 and S5, respectively, as input signals for the digital logic circuitry, which outputs a signal to the S4 driver.

The S4 driver receives an input in the form of a digital signal, via the logic circuitry, provided along the trace identified in Figure 11, and acts as a buffer circuit. An analog output signal is then generated with sufficient current gain to drive or control the FET connected to S4. Figure 12 exhibits close up views of S4 driver and logic circuitry corresponding to the digital input stage, comprised of a level-shifter that operates to transfer (i.e., increase) the voltage range of the oscillating signal, along with an analog output stage, and large pull-up and pull-down transistors. A deadtime generator is also implemented to create a short gap in time between the actions of the pull-up and pull-down transistors to prevent the occurrence of a short circuit at the rising/falling edge of a pulse.

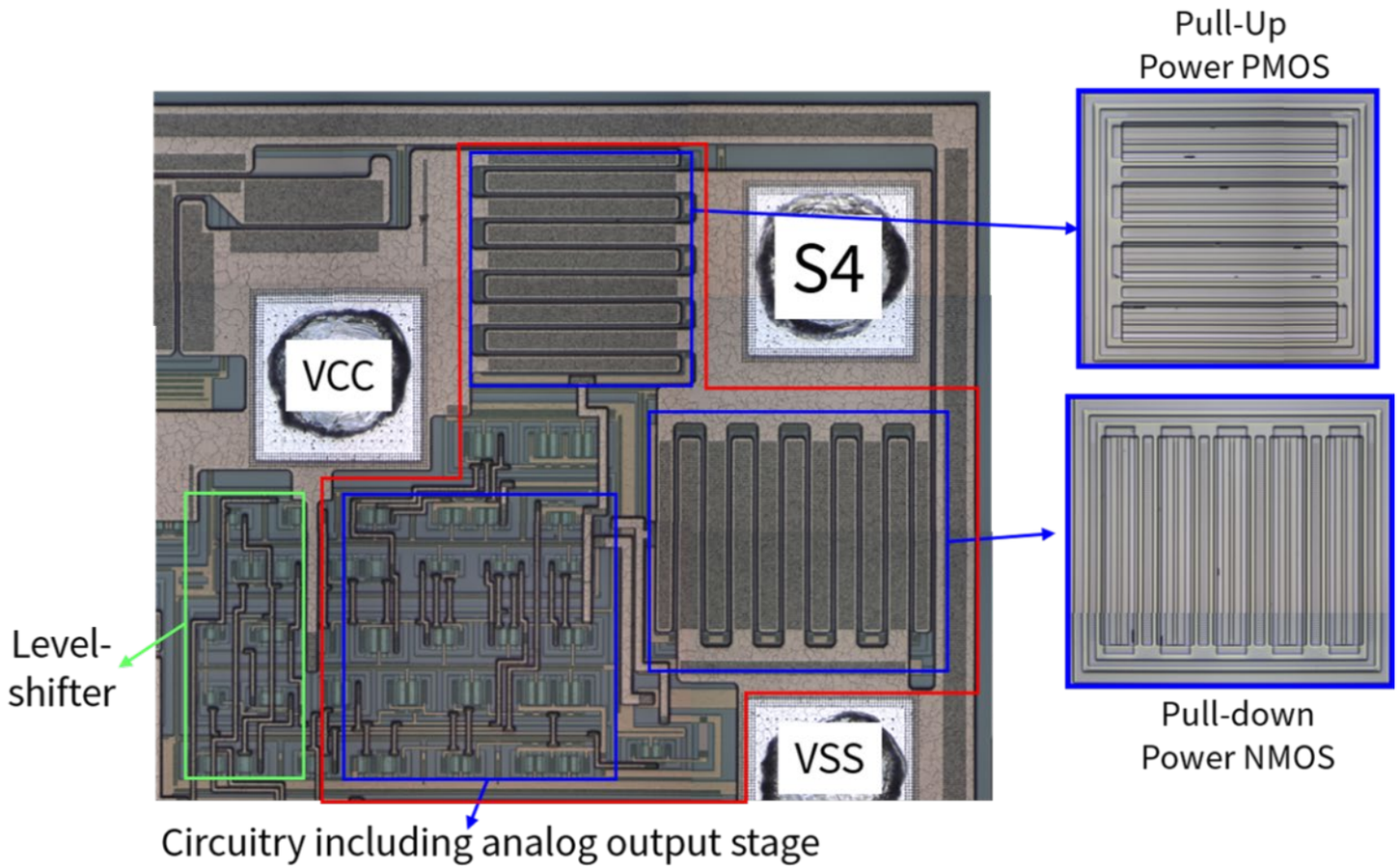


Figure 12. The S4 driver consists of sub-component including a digital input stage, deadtime generator, analog output stage, and large pull-up and pull-down transistors near the S4 pad.

The diagram in Figure 13 provides a simplified system schematic overview of the installation detection circuit based on the above analysis in the context of the GE LED13ABT8/G4/840 tube lamp. The red and green dotted boxes indicate the components contained on chips CP1 and CP2, respectively. Components in this diagram outside of these boxes correspond to peripheral circuits on the PCB. The resistors are simplified representations of one or more circuit components in combination. Noted that the ground terminal labeled GND(PIN5) in the simplified system schematic refers to terminal GND1 in the equivalent circuit schematic in Figure 5.

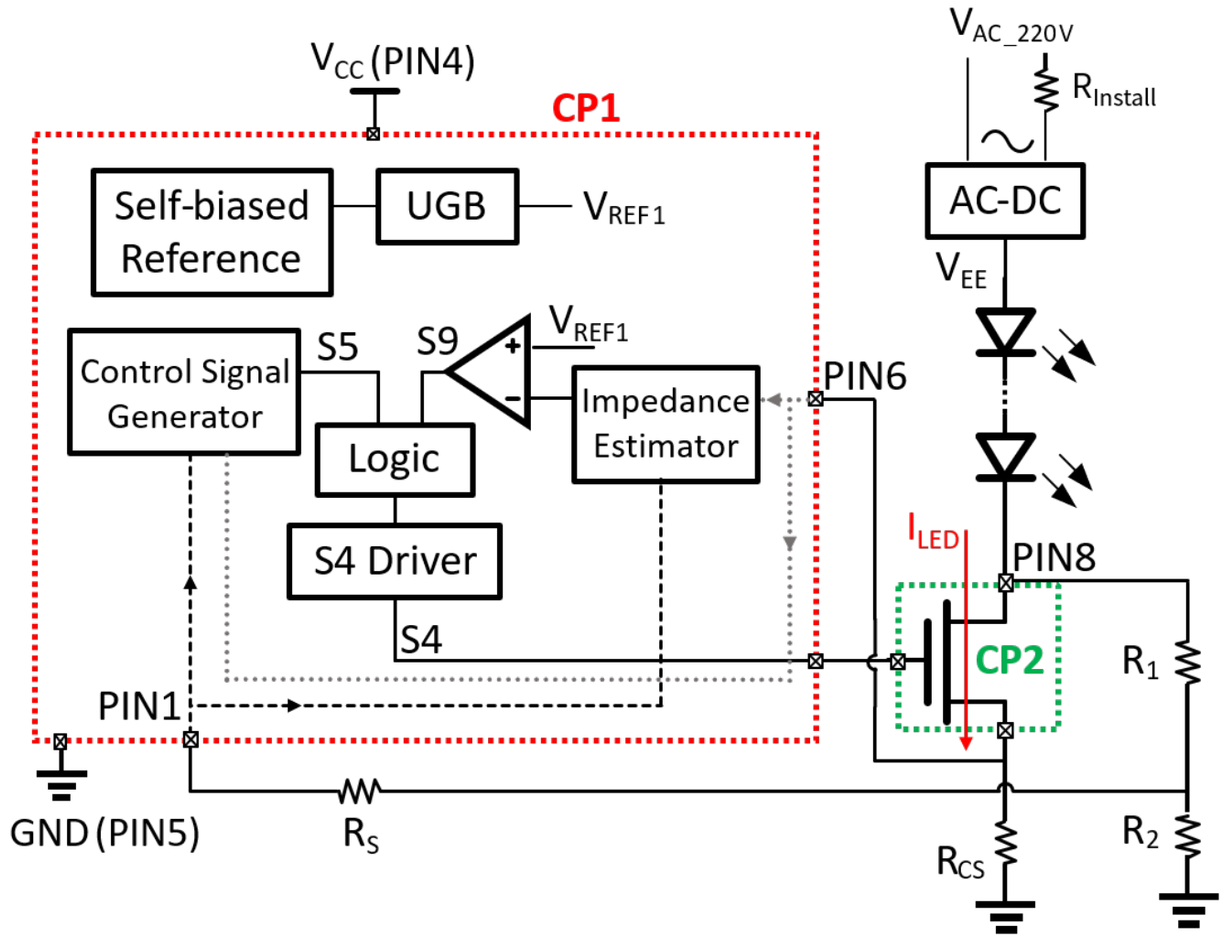


Figure 13. Simplified schematic showing system overview of the installation detection circuit. Comparator 1 follows the impedance estimator, which includes the signal evaluator shown in Figure 10. The output of comparator 1 and the output of the control signal generator are both used as inputs for the subsequent logic circuitry.

The installation detection circuit in the GE LED tube lamp includes a control signal generator, corresponding to circuitry contained on the CP1 die (Figure 14), which includes inputs from both the VS signal at PIN1 and the CS signal at PIN6, and constitutes a pulse generating circuit, as outlined by the dashed red box in Figure 14.

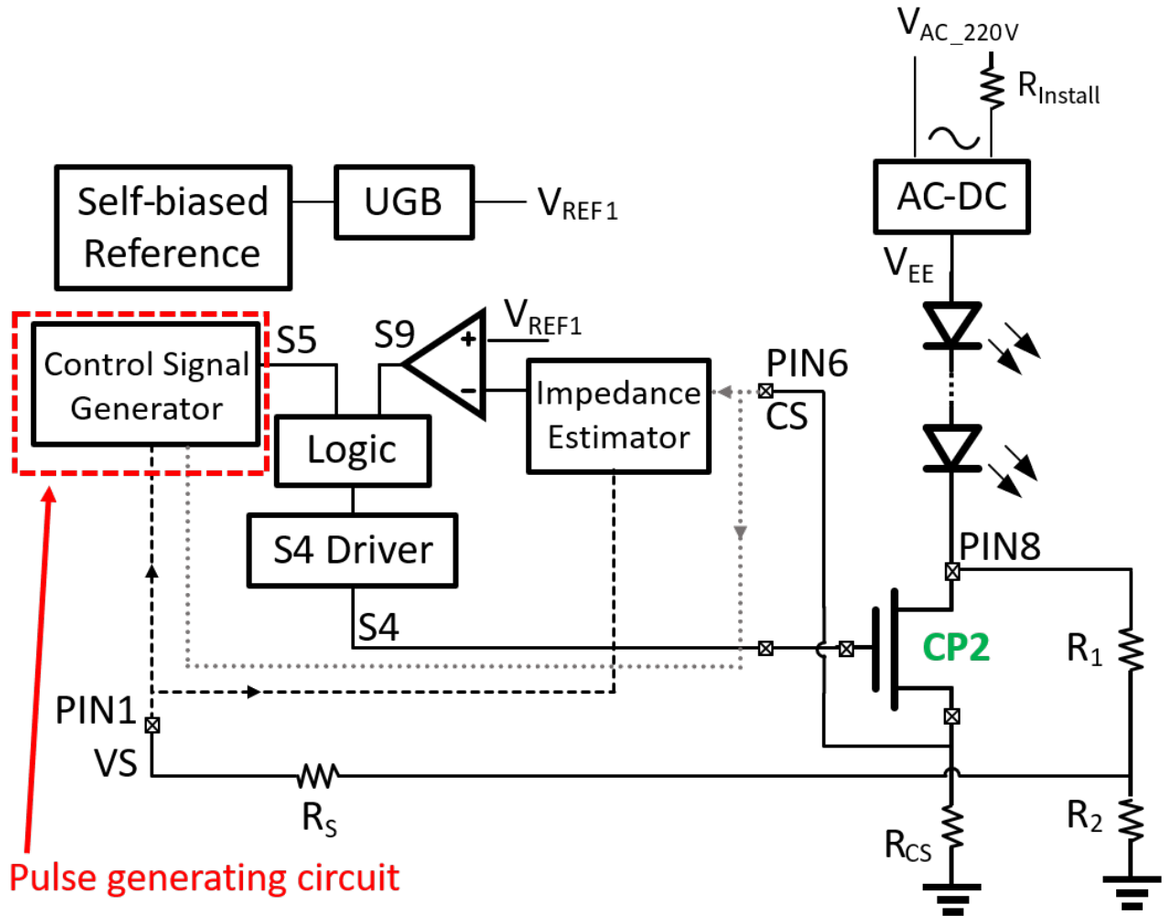
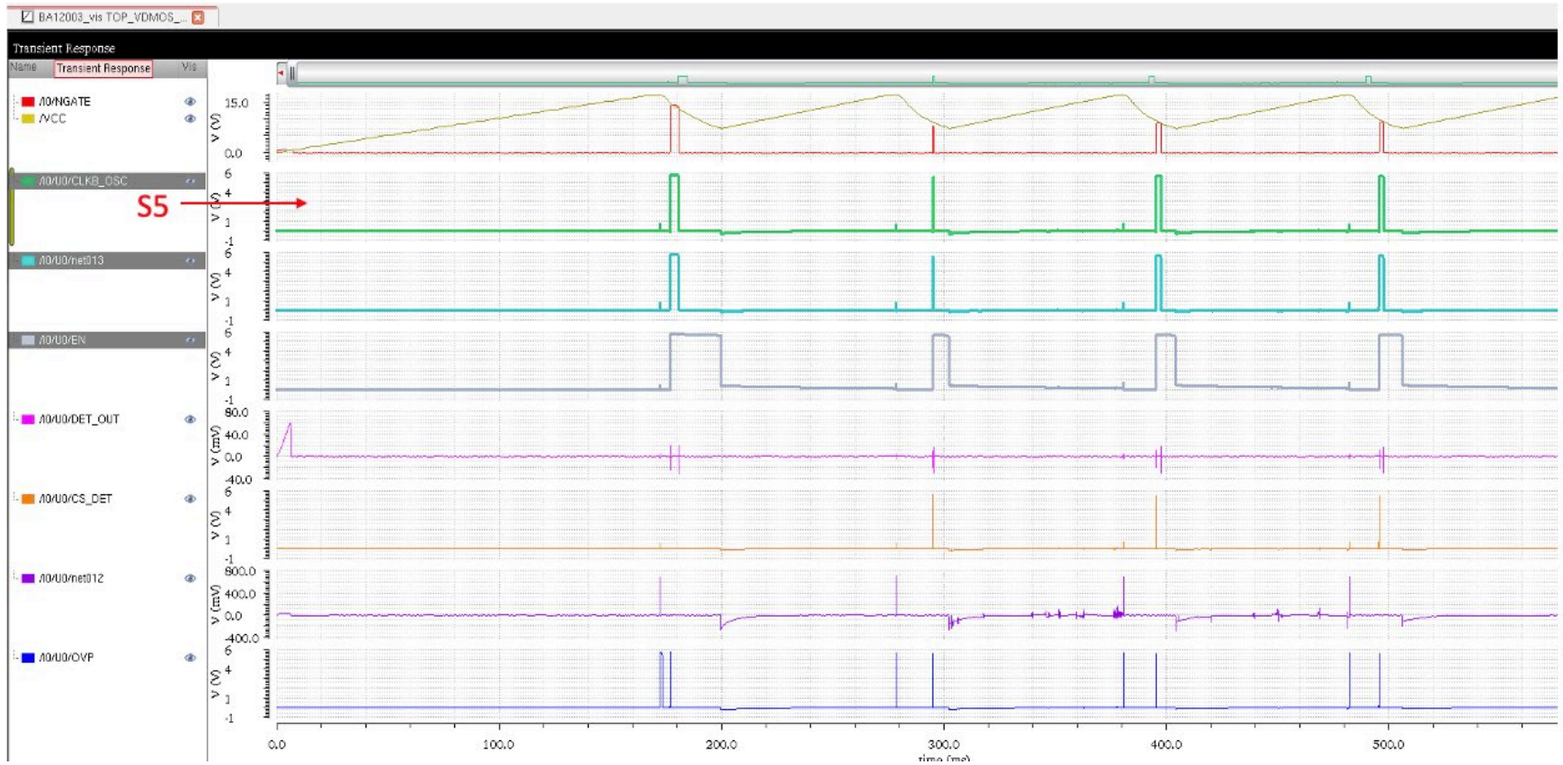


Figure 14. The pulse generating circuit is outline by the dashed red line and consists of circuitry contained on the CP1 die inside the LT2600.

The simulation result of signal S5 shown in Figure 15 further evident signal S5 outputted from control signal generator includes one or more pulse signals. The simulation was conducted based on the "BA12003_LT2600_CA_Report_v1.pdf" teardown report and the relevant raw data of the teardown analysis.

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product
	 Figure 15. Simulation result of S5 based on the teardown analysis Therefore, the pulse generating circuit is configured to output signal S5, corresponding to what is labeled as the signal waveform in Figure 15. Hence, for at least the reasons described above, the installation detection circuit of the GE LED tube lamp includes a pulse generating circuit configured to output one or more pulse signals, and thus the GE LED tube lamp satisfies claim element 1[a] of the ’140 Patent.
1[b] wherein the installation detection circuit is configured to detect during at least one of the one or more pulse signals whether the LED tube lamp is properly installed on a lamp socket, based on detecting a signal generated from the external driving signal; and	The installation detection circuit in the GE LED13ABT8/G4/840 LED tube lamp is configured to detect whether or not the LED tube lamp is properly installed on the lamp socket during one or more of the pulse signals described above with respect to claim element 1[b]. The GE tube lamp does this based on detecting a signal generated from the external driving signal. For instance, the installation detection circuit in the GE LED tube lamp detects a signal on PIN6, as shown in Figure 16 during the one or more pulse signals of S5.

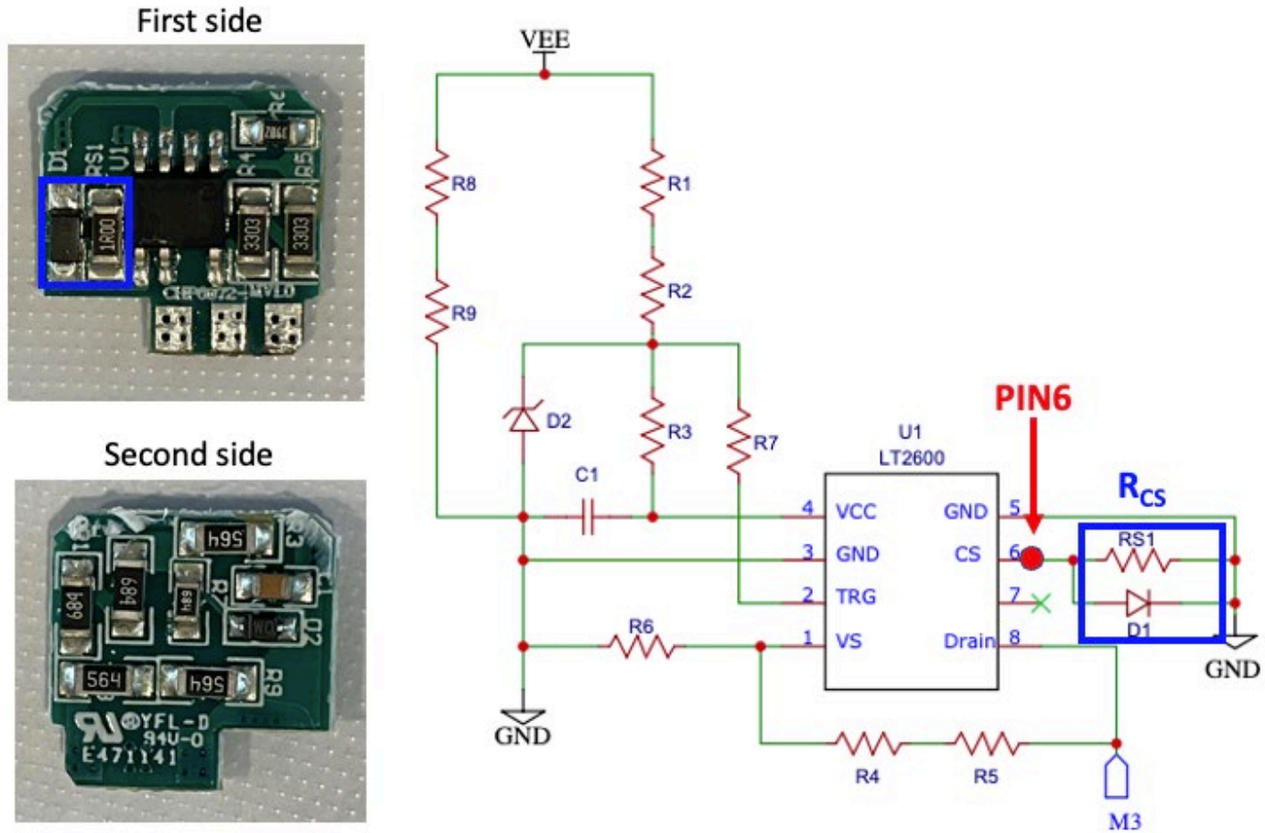


Figure 16. The installation detection circuit detects the voltage on PIN6 as current passes through resistor RS1 and diode D1 (together referred to as R_{CS}) to determine whether the LED tube lamp is properly installed on the lamp socket. The components comprising R_{CS} are outlined in blue on the photograph of the daughter board (Left) and on the equivalent circuit diagram (Right).

With respect to Figure 17, the CS signal on PIN6 is used to detect proper installation of the LED tube lamp on the lamp socket, in accord with current flow through resistor R_{CS}. An external driving signal supplies power to the external lamp terminals, through the tube lamp's power supply module, and through the LED module. If the tube lamp is improperly installed, there will be a non-negligible series resistance ($R_{install}$) in the power supply path to the LED module. In this scenario, the current labeled in Figure 17 as I_{LED} will be small. As I_{LED} flows through R_{CS}, a voltage is generated at PIN6. A high voltage on PIN6 corresponds to a high I_{LED}, and a low voltage on PIN5 corresponds to a low I_{LED}. A test setup for leakage-current and shock-current measurement (also called "relamping-test") defined in UL can be used for evaluating the leakage current when the tube lamp is improperly installed. Said non-negligible series resistance ($R_{install}$) is represented by a 500 Ω resistor in the test setup.

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product

Hence, a detection signal is based on the signal on PIN6 and indicates whether the LED tube lamp is properly installed on a lamp socket. Furthermore, because the voltage on PIN6 is generated by the current through the LED module that originates from the external driving signal, the detection signal is therefore generated from the external driving signal, as required by this claim element.

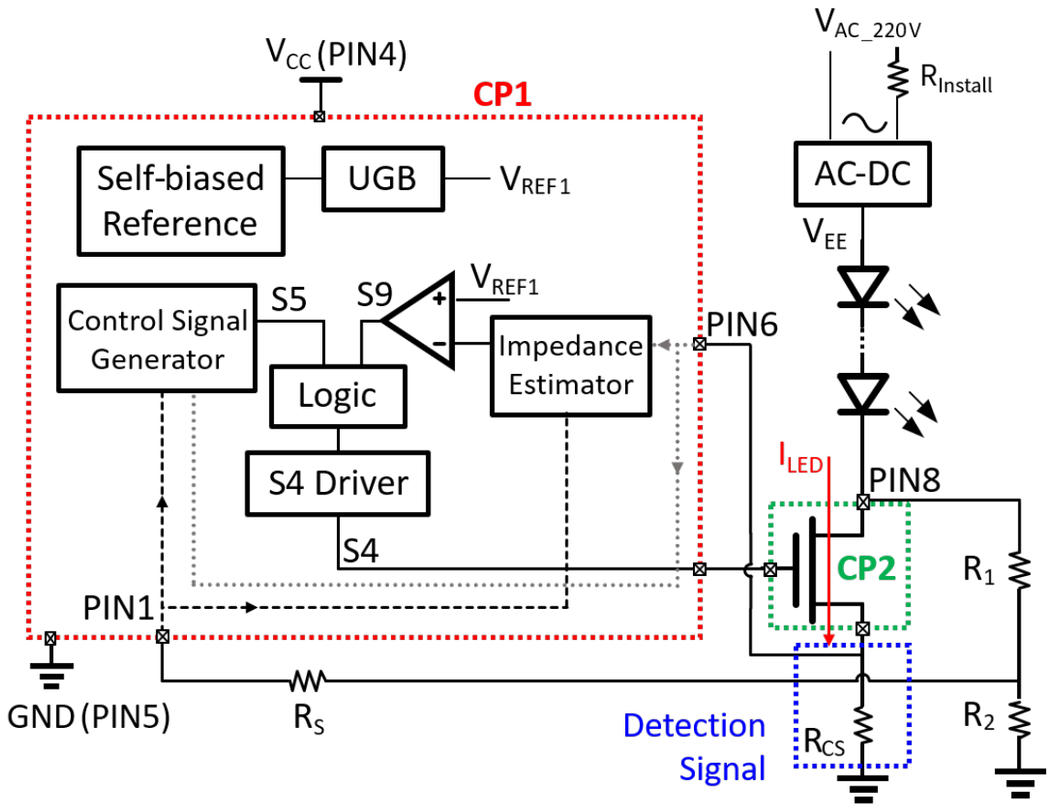
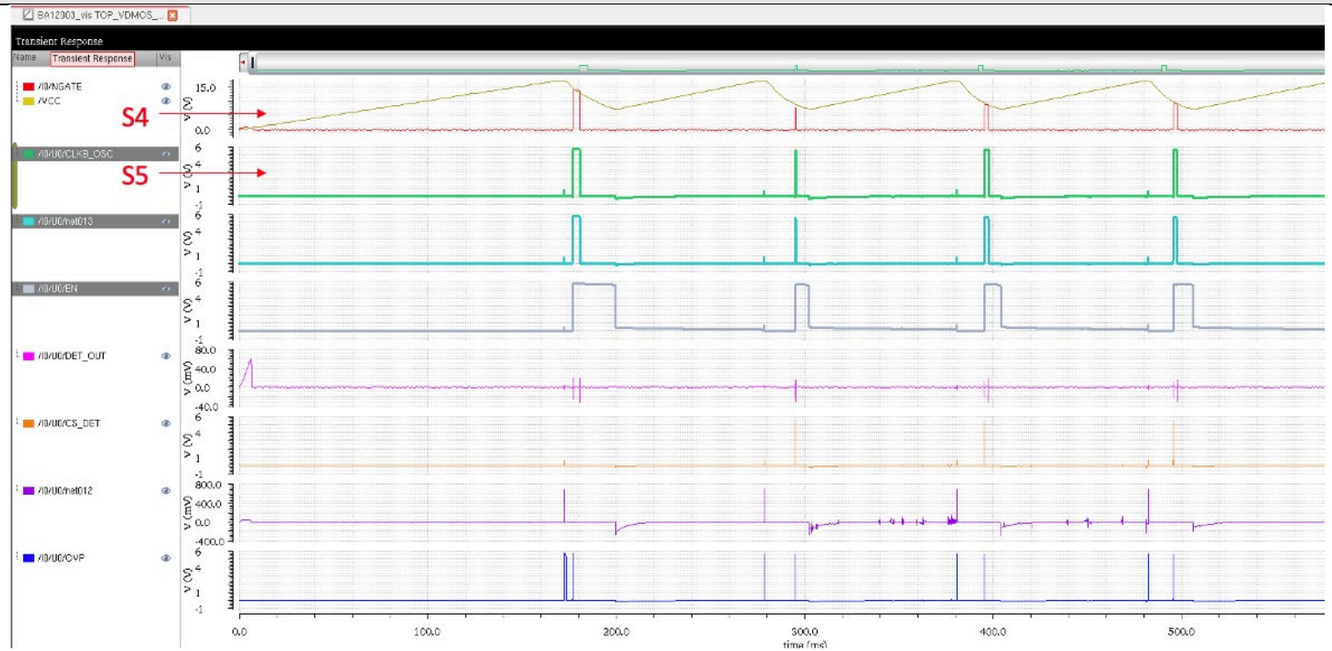
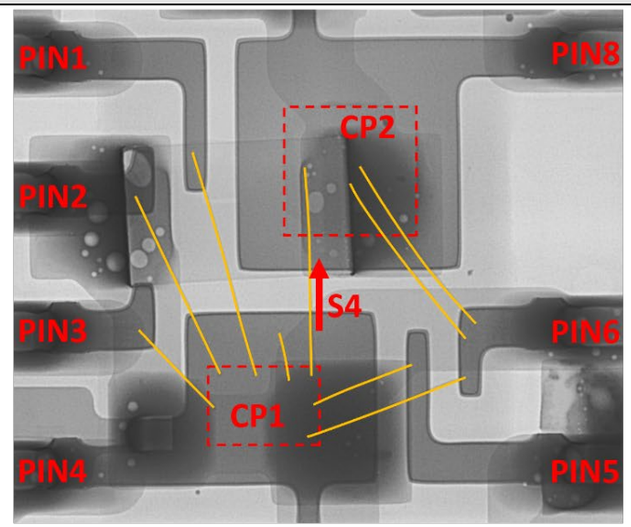
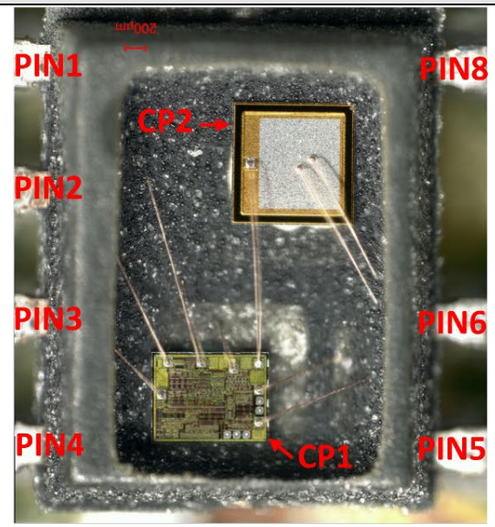
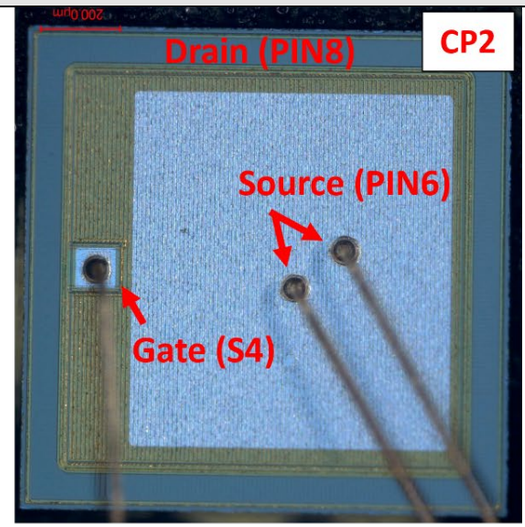


Figure 17. The installation detection circuit detects the signal on PIN6 as current passes through R_{CS}.

Moreover, the gate terminal on the MOSFET in CP2 is driven by S4. During a re-lamping period, S4 will follow the waveform of S5, and thus the gate terminal on the MOSFET in CP2 will periodically open and close the channel in sync with the pulse signal S5. Said operation can be proved by the simulation result shown in Figure 18. On the other hand, the gate terminal on CP2 must be activated in order to permit current conduction through the MOSFET channel. Thus, I_{LED} can only be sensed by the corresponding voltage at PIN6 when the gate on CP2 is high. Thus, the detecting signal is only active while S5 is high. Therefore, the installation detection circuit is configured to detect whether the LED tube lamp is properly installed in a lamp socket during the one or more pulse signals.

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product
	 Figure 18. Simulation result of S4 and S5 when a 500 Ω resistor is connected (re-lamping test / improper installation). Hence, the installation detection circuit of the GE LED tube lamp is configured to detect whether the LED tube lamp is properly installed on a lamp socket, and it is configured to perform this detection during the one or more pulse signals, and further, the detection is based on a signal generated from the external driving signal. Thus, for at least the reasons described above, the GE LED tube lamp satisfies claim element 1[b] of the ’140 Patent.
1[c] a switch circuit coupled to the pulse generating circuit, wherein the one or more pulse signals control turning on and off of the switch circuit;	The GE LED13ABT8/G4/840 LED tube lamp satisfies claim element 1[c] of the ’140 Patent because it contains an installation detection circuit that includes a switch circuit coupled to the pulse generating circuit described above with respect to claim element 1[a], and further, the pulse signals from the pulse generating circuit control the on and off states of the switch circuit. In particular, the 8-pin LT2600 packages contains 2 chips, one of which is an N-type MOSFET, labeled as CP2 in Figure 19, which represents the claimed switch circuit.

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product
	 LT2600 (X-ray)  LT2600 (Optical)  LT2600 (Optical-CP2) Figure 19. (Left) X-ray image of LT2600 on the GE CHP6072-MV1.O daughter board showing two chips, labeled as CP1 and CP2. Wire bonds between chips and the package pin outs are highlighted in yellow for visibility. (Middle) Optical micrograph of decapped LT2600. (Right) Optical micrograph of the CP2 switch circuit. When the channel between the source and drain terminals of CP2 is open, current may flow through the channel, and the MOSFET switch is said to be in an “on” state; and when the channel between the source and drain terminals of CP2 is closed, current may not flow through the channel, and the MOSFET switch is said to be in an “off” state. The on and off state of the MOSFET is dependent upon the voltage on the gate terminal, which is determined by the signal S4. The switch circuit and the pulse generating circuit are coupled via S4. During a re-lamping test, for example, when a resistor is placed in series with the LED lamp while the leakage current on the tube lamp is measured, S4 follows S5, and thus the on and off state of the switch circuit is controlled by the pulse signals from the pulse generating circuit. Therefore, the GE LED tube lamp contains an installation circuit that includes a switch circuit coupled to the pulse generating circuit, wherein the on and off state of the switch is controlled by the pulse signals, and therefore the GE LED tube lamp satisfies claim element 1[c] of the '140 Patent.
1[d] wherein the installation detection circuit is further configured to: when it is detected during one of the one or more pulse signals that the LED tube lamp is not properly installed on the lamp socket, control the switch circuit to remain in an off	The GE LED13ABT8/G4/840 LED tube lamp satisfies claim element 1[d] of the ’140 Patent for at least the following reasons. The GE LED tube lamp contains an installation detection circuit comprising a switch circuit and a pulse generating circuit, and can detect a signal, as described above with respect to claim element 1[a] – 1[c]. When the GE LED tube lamp detects that the lamp is not properly installed on the lamp socket, the switch circuit remains in an off state, preventing current conduction and causing an open circuit in the LED tube lamp’s power loop. The VS signal on PIN1 is measured just prior to generating the ON side of the pulse signal S5, and thus just prior to S4 going high to close the switch circuit, while the CS signal on PIN6, corresponding to the switch current, is measured just after the switch is closed. The detected CS signal is combined with the VS signal to estimate an impedance value of the LED loop circuit. When S4 is high, the output signal of the impedance estimator is compared to a reference value at comparator 1 in and

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product
state to cause a power loop of the LED tube lamp to be open; and	Figure 13. The output of comparator 1 is signal S9. The simulation result of S9 is shown in Figure 20, when the lamp is not properly installed on the lamp socket, the detected CS signal combined with the VS signal will lead to an impedance that exceeds a threshold value, and then S9 will take on one of its two possible states. For the sake of discussion, this may be a logical low value state. When S9 is low, S4 will continue to follow the waveform of S5 and CP2 will remain in an off state during low periods of the S5 pulse.

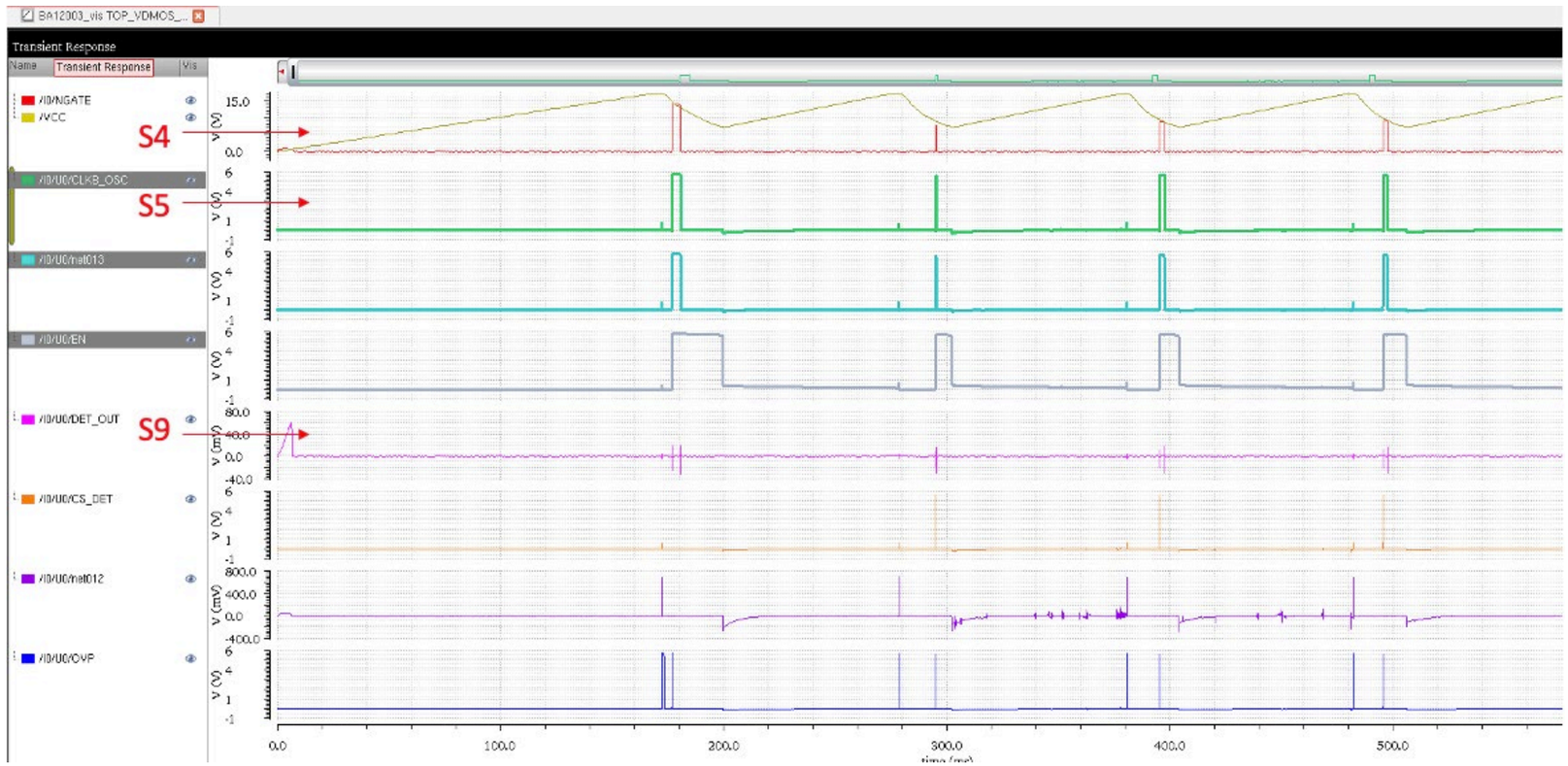
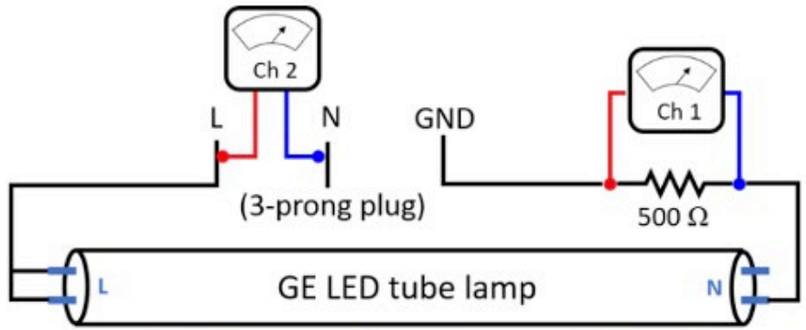


Figure 20. Simulation result of S9 when a 500 Ω resistor is connected (re-lamping test / improper installation). The switch circuit will remain in an off (non-conducting) state when the lamp is not installed properly, except for brief periods of a high signal on control pulse S4 during which the circuit checks again whether the LED tube lamp is properly. The detection of whether the LED is properly installed is determined by estimating the impedance based on a sampling of PIN6 and PIN1. When the impedance is sufficiently high such that the voltage at comparator 1 is below a threshold $V_{IMP\ REF}$ value, the off state of the switch circuit persists.

To further probe this circuit behavior, leakage current of the GE LED tube lamp was tested in accord with the UL 1993 standard. As shown in the measurement setup in Figure 21, power is supplied through external connection terminal at each end of the lamp. A 277 VAC line voltage is input to the end marked "L." On the opposite end of the tube, a non-inductive 500 Ω resistor was connected in series between the one pin that is connected to the internal circuitry and the ground wire. The 500

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product
	Ω resistor represents the resistive equivalent of a human body providing an electrical pathway to ground. Thus, it also is representative of a lamp tube that is not properly installed.



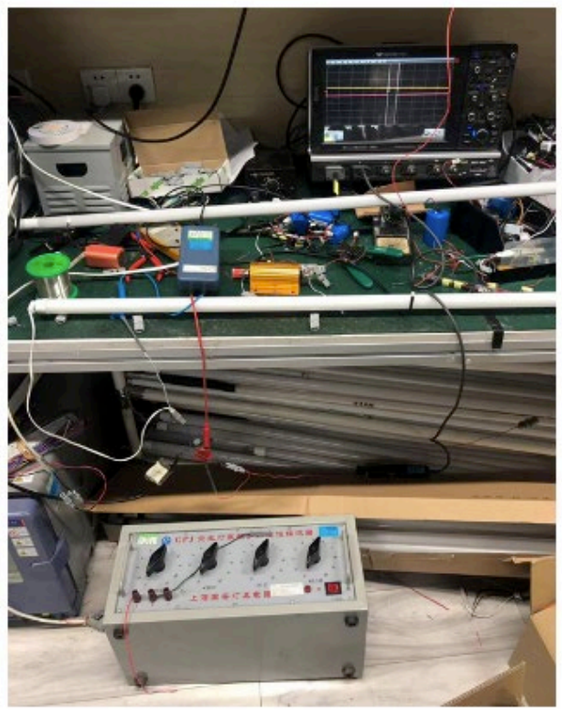
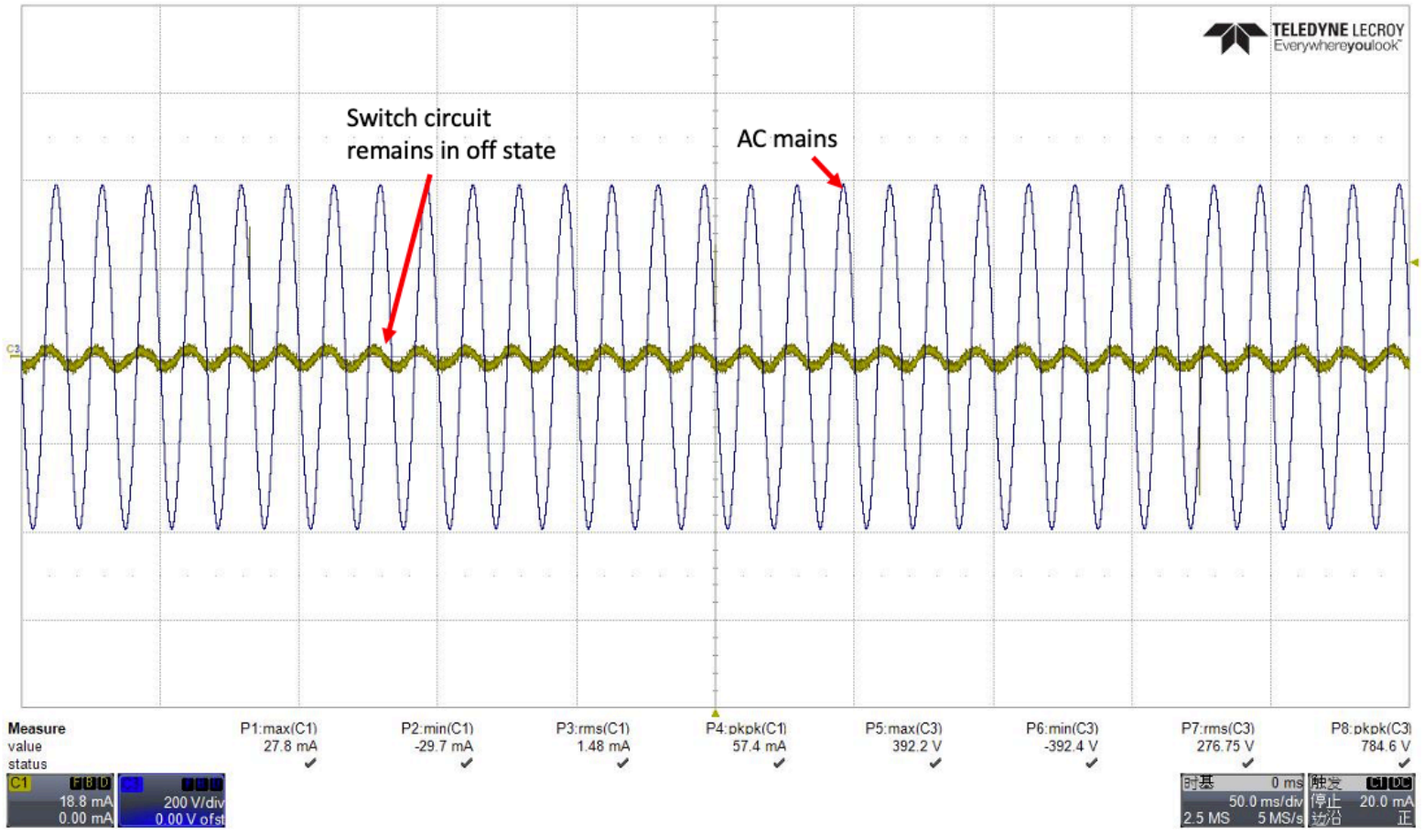
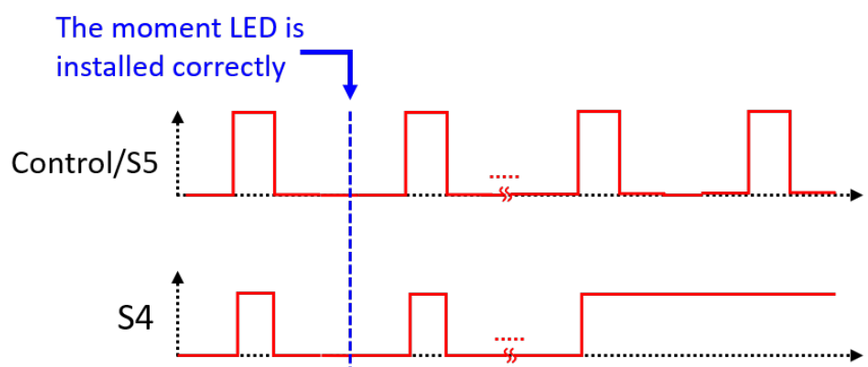


Figure 21. (Top) Schematic of measurement setup for re-lamping test, in accord with UL 1993, to ascertain whether switch circuit will turn on or remain off when the LED lamp tube is detected to be improperly installed. (Bottom) Photographs of measurement setup with GE LED tube lamp.

Figure 22 shows the results of the measurement. The indigo trace is a measurement of the external driving signal, and the olive-green trace is a measure of the leakage current, corresponding to the voltage measured across the non-inductive 500 Ω resistor that was connected in series with the GE lamp. The data in this figure

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product
	demonstrates that when power was applied, the RMS current is approximately 1.48 mA. Thus, the leakage current remains negligible because the switch circuit remains in the off state, and the loop current will similarly remain negligible.  Figure 22. Leakage current measured during re-lamping test. The indigo trace is a measurement of the external driving signal, and the olive-green trace is a measure of the leakage current, corresponding to the voltage measured across the non-inductive 500 Ω resistor was connected in series with the GE lamp and ground. The leakage current, as well as the loop current, remains negligible because the switch circuit remains in the off state. Therefore, for at least the reasons described above, the GE LED tube lamp satisfies claim element 1[d] of the ’140 Patent.
[e] when it is detected during one of the one or more pulse signals that the LED tube lamp is properly	The GE LED13ABT8/G4/840 LED tube lamp satisfies claim element 1[e] of the ’140 Patent for at least the following reasons.

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product
installed on the lamp socket, control the switch circuit to remain in a conducting state to cause the power loop of the LED tube lamp to maintain a conducting state,	The GE LED tube lamp contains an installation detection circuit comprising a pulse generating circuit, detection determining circuit, and switch circuit, as described above with respect to claim element 1[a] – 1[c]. When the GE LED tube lamp detects that the lamp is properly installed on the lamp socket, the control switch remains in an on state, permitting current conduction and maintaining a conducting channel in the LED tube lamp's power loop. Regardless of whether the tube lamp is initially in a proper or an improper installation configuration, brief pulse signals will be generated as described above with respect to claim element 1[d]. During such a pulse signal, S5 will be high and S4 will also be high. A high S4 will cause the switch circuit to permit current to flow through CP2 thereby allowing for the installation detection procedure to be performed. That is, the VS signal on PIN1 will be measured just prior to generating the ON side of the pulse signal S5, and thus just prior to S4 going high to close the switch circuit, while the CS signal on PIN6, corresponding to the switch current, will be measured just after the switch is closed. The detected CS signal will be combined with the VS signal to estimate an impedance value of the LED loop circuit. When S4 is high, and thus before the current has decayed causing the ZCD comparator to trigger, the output signal of the impedance estimator is compared to a reference value at comparator 1 in and Figure 13. The output of comparator 1 is signal S9. When the lamp is properly installed on the lamp socket, the detected CS signal combined with the VS signal will lead to an impedance that is less than a threshold value, and then S9 will take on the other of its two possible states (i.e., opposite to the state when the impedance exceeds the threshold value). For the sake of discussion, following the example from claim element 1[d], when the impedance is below the threshold value, S9 will increase to a logical high value state. When S9 is high, S4 will latch to a high signal value. This will in turn lead to a high voltage on the gate terminal of CP2, forcing the switch circuit to remain in a conducting on state wherein current may flow through the source-drain channel of the MOSFET. The correspondence between S5 and S4 when the lamp configuration transitions between an incorrect and a correct installation is shown in the timing diagram in Figure 23.  Figure 23. Timing diagram showing the signals at various nodes as the LED tube lamp transitions from a configuration in which it is not properly installed in a lamp socket to a configuration in which it is properly installed in a lamp socket. To further illustrate the claimed functionality, the measurement setup shown in Figure 24 was used to demonstrate the circuit behavior when the GE tube lamp is properly installed. For example, when the GE LED tube lamp is properly connected to a lamp socket and an appropriate external driving signal is provided, the switch circuit will remain in a conducting state, and loop current will flow continuously. In particular, the setup shown in Figure 24 was used to enable measurements of loop current through the LED module by probing the voltage drop across a 1.1 Ω shunt resistor in both an improper installation, when the mechanical switch in the top right of the schematic is open sending current through the 500 Ω resistor, and a proper installation, when the mechanical switch is closed.

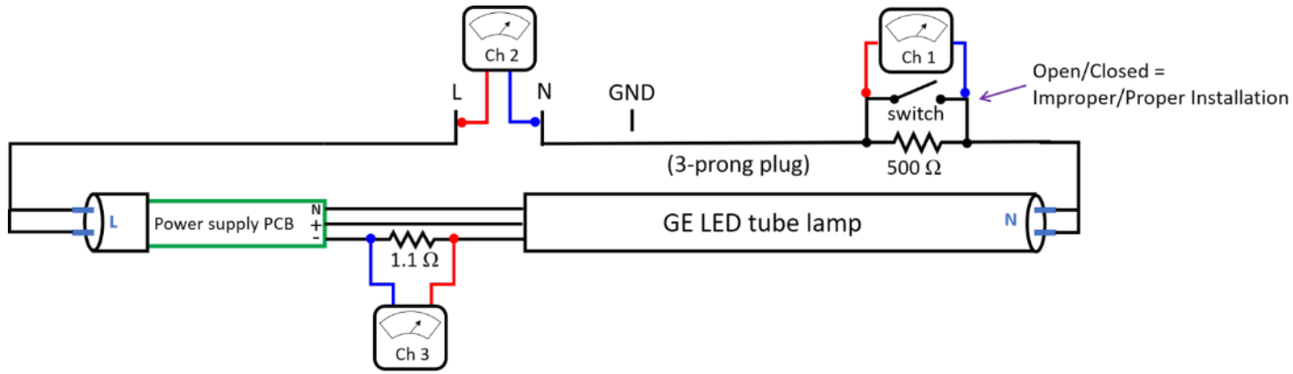
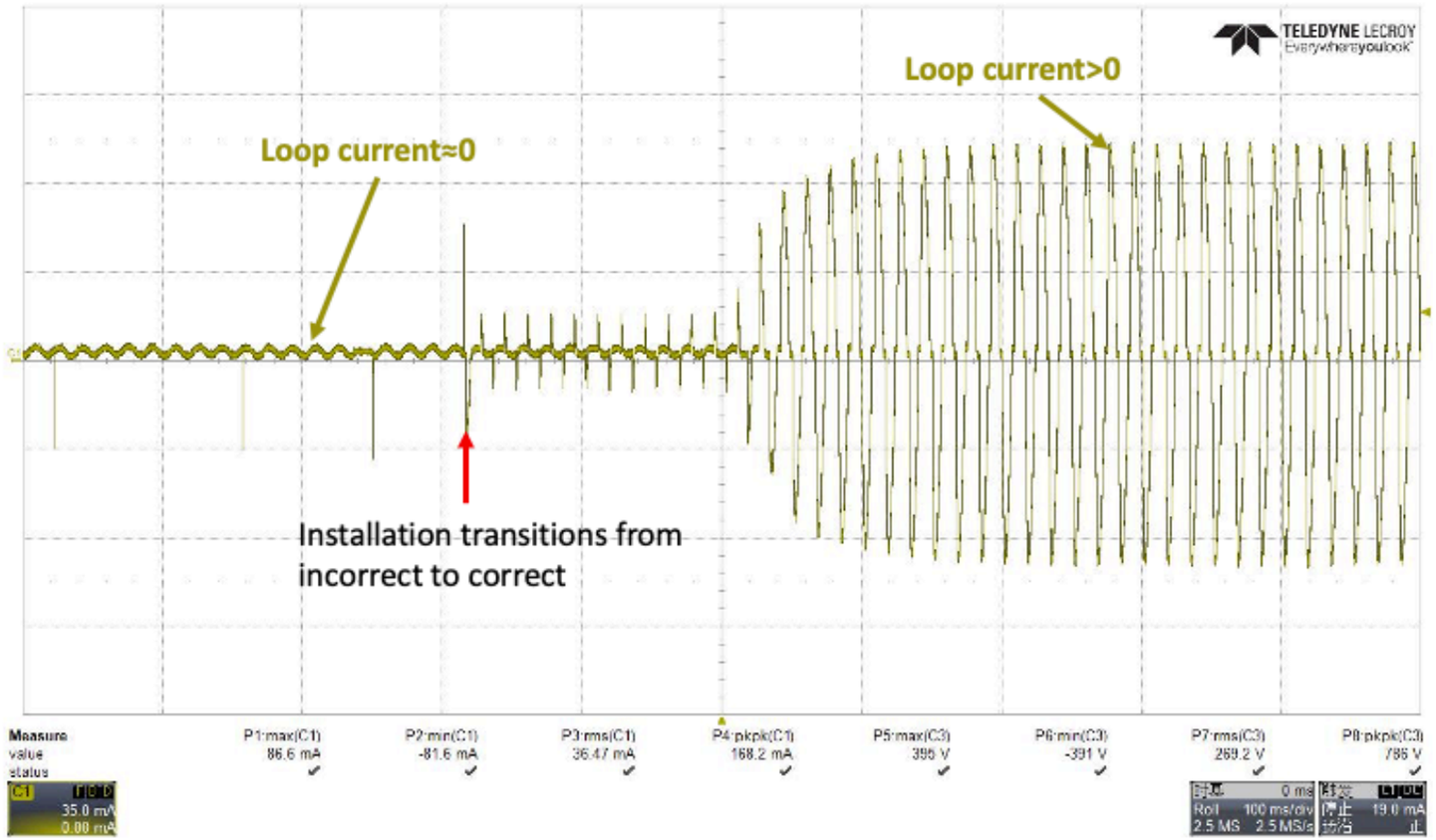
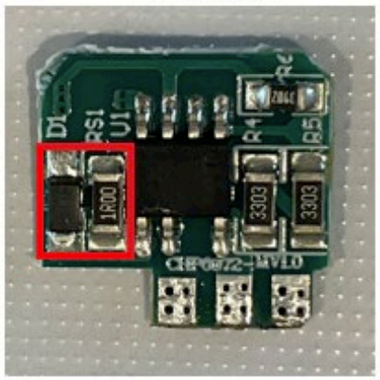
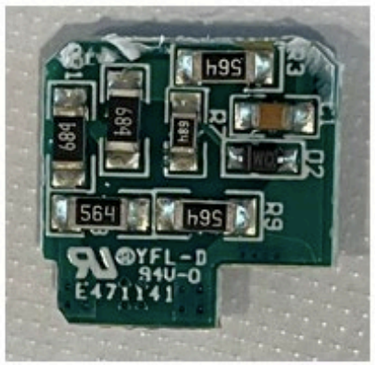
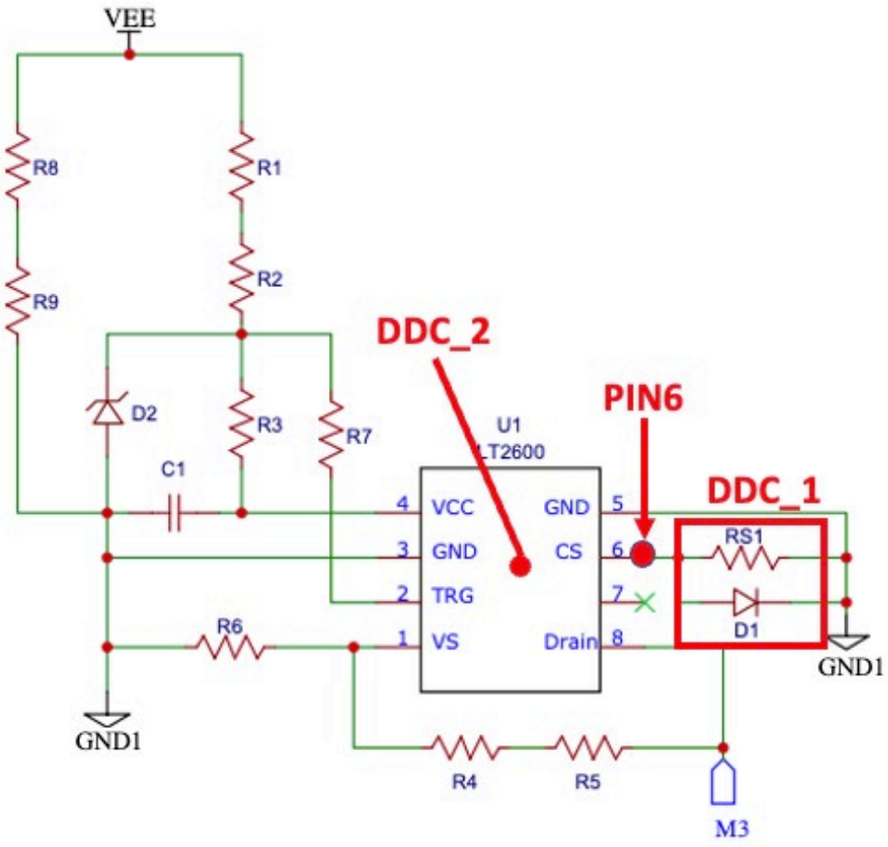


Figure 24. Schematic of measurement setup. Channel 3 measures voltage across a 1.1 Ω shunt resistor, which is proportional to loop current. Thus, loop current can be measured when the lamp in not properly installed (i.e., when the mechanical switch is open and the current must flow through the 500 Ω resistor), and when the lamp is properly installed (i.e., when the mechanical switch is close and the current may flow through the short circuit around the 500 Ω resistor).

Figure 25 shows the results of the measurement. The olive-green trace is the loop current passing through the 500 Ω resistor and clearly shows when the mechanical switch is flipped to change the installation configuration. The data in this figure demonstrates that when power is applied and the lamp is in a proper installation configuration (i.e. mechanical switch is closed), the loop current rises to a non-negligible value as the switch circuit remains in a conducting "on" state. This same data demonstrates that when power is applied and the lamp is in an improper installation configuration (i.e. mechanical switch is open), the loop current remains near zero as the switch circuit remains in a non-conducting "off" state.

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product
	 Figure 25. Measurement data as lamp transition between improper installation to proper installation. When an external driving signal is applied and it is detected during one or more pulse signals that the GE LED tube lamp is properly installed on a lamp socket, the switch circuit latches to a conducting state, allowing the loop current to flow. Therefore, for at least the reasons described above, the GE LED tube lamp satisfies claim element 1[e] of the ’140 Patent.
1[f] wherein the signal generated from the external driving signal is a sampling signal on the power loop, the installation detection circuit further comprises a detection	The GE LED13ABT8/G4/840 LED tube lamp satisfies claim element 1[f] of the ’140 Patent for at least the following reasons. As described above with respect to claim element 1[a], the GE LED tube lamp contains an installation detection circuit, which includes a pulse generating circuit and is configured to detect whether the LED tube lamp is properly installed on a lamp socket based on a signal generated from the external driving signal, and further, the detection process is performed during the pulses from the pulse generating circuit.

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product
determining circuit configured to detect the sampling signal for determining whether the LED tube lamp is properly installed on the lamp socket, and the power loop includes the switch circuit and the detection determining circuit, and	The detection determining circuit in the GE LED tube lamp is comprised of a first circuit disposed on the GE daughter board, labeled in Figure 26 as DDC_1, and a second circuit integrated into the LT2600 package, and referred to as DDC_2. If the tube lamp is not properly installed in the lamp socket then the impedance of the LED power loop will be high, attributable to a current through the LED module that is small relative to the applied voltage. As current I_{LED} passes through the switch circuit and then flows through R_{CS}, which is comprised of resistor RS1 and diode D1 on the daughter board, a voltage is generated at PIN6 (i.e. the CS signal). This CS signal corresponds to the claimed sampling signal, and is used for determining whether the LED tube lamp is properly installed on the lamp socket. First side  Second side   Figure 26. The detection determining circuit is comprised of DDC_1 on the GE daughter board, outlined in red on the PCB (bottom left) and on the equivalent circuit schematic (right), and DDC_2 comprised of circuitry within the LT2600 package, labeled on the schematic as U1.

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product

The diagram in Figure 27 also illustrates that the detection determining circuit is comprised of two sub-circuits: DDC_1 and DDC_2. DDC_1 is disposed on the PCB of the GE daughter board as described above. DDC_2 is disposed on chip CP1 in the LT2600 and comprised of both the impedance estimator circuit, which includes the Signal Evaluator circuit in Figure 10, together with comparator 1, also shown in Figure 10. The CS signal at PIN6 (sampled just after the switch circuit is closed during the "on" portion of an S5 pulse) is input into the impedance estimator circuitry and combined with the VS signal from PIN1 (measured just prior to the switch circuit being closed) to calculate an estimated value of the impedance of the lamp circuit. The impedance estimator outputs a voltage proportional to the calculated estimated impedance, which is compared with reference voltage V_{REF1} at comparator 1. The output of comparator 1 is signal S9, which indicates whether the lamp is determined to be properly installed, corresponding to a logical high S9 value, or improperly installed, corresponding to a logical low S9 value.

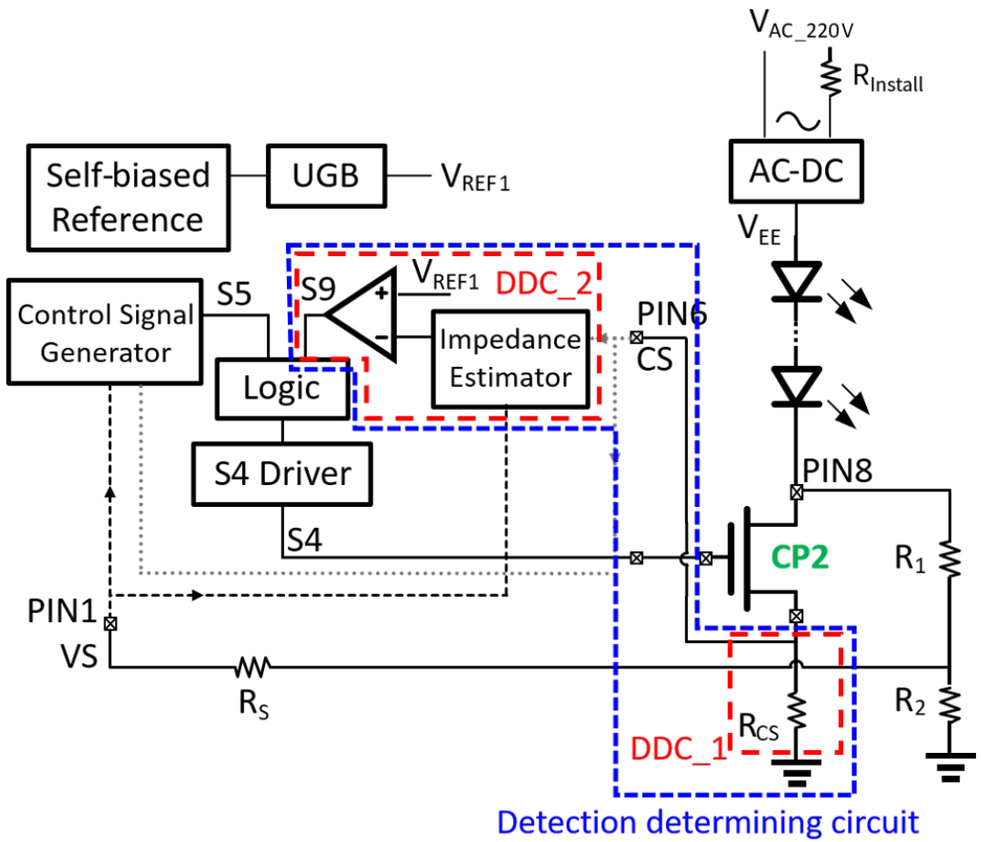


Figure 27. The detection determining circuit in the GE LED tube lamp (outlined in dashed blue line) is comprised of a circuit, DDC_1, represented by components disposed on the daughter board of the power supply module, and a circuit, DDC_2, represented by circuitry disposed in the LT2600 IC.

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product
	Furthermore, since a driving current of the LED tube lamp passes switch circuit CP2 and resistor RS1 and diode D1 of circuit DDC_1, the power loop of the LED tube lamp includes switch circuit CP2 and the detection determining circuit. Therefore, for at least the reasons described above, the installation detection circuit in the GE tube lamp includes a detection determining circuit configured to detect the sampling signal, generated from the external driving signal, for determining whether the LED lamp is properly installed, wherein the power loop includes both the detection determining circuit and the switch circuit. Thus, the GE tube lamp satisfies claim element 1[f] of the ’140 Patent.
1[g] wherein the pulse generating circuit is configured to output one or more pulse signals independent of whether the detection determining circuit detects the sampling signal.	The GE LED13ABT8/G4/840 LED tube lamp satisfies claim element 1[g] of the ’140 Patent because the pulse generating circuit is configured to output one or more pulse signals independent of whether the detection determining circuit detects the sampling signal. As described above with respect to claim element 1[a], the pulse generating circuit in the GE LED tube lamp is comprised of the control signal generator circuit disposed on die CP1 in the LT2600 IC package. The S5 pulse signal transitions on (high). Meanwhile, the detection determining circuit uses the sampling signal as an input for the impedance estimator, the output of which serves as an input for comparator 1 to produce the detection determining signal S9. However, the signal S9 is based on an input from the impedance estimator, but the signal S5 is not. Thus, in the event that the impedance estimator does not detect the sampling signal, this will have no impact on the S5 signal. Additionally, as shown by the timing diagrams in Figure 23, the control signal generator will output pulses S5 whether the lamp is properly or improperly installed in the lamp socket. Hence, the pulse generating circuit is configured to output one or more pulse signals independent of whether the detection determining circuit detects the sampling signal. Yet further, based on the simplified schematic of the installation detection circuit as shown in Figure 28, the only reference for triggering the control signal generator to generate pulses S5 is the voltage VS on PIN1. VS will be generated once the external driving signal V_{AC_220V} applies, and VS can trigger the control signal generator to generate pulses S5 in either proper installation or improper installation states. That is, the control signal generator will generate and output one or more pulse signals solely based on VS and independent of whether the detection determining circuit detects the sampling signal.

Claim 1	GE LED Tube LED13ABT8/G4/840 – Representative Product

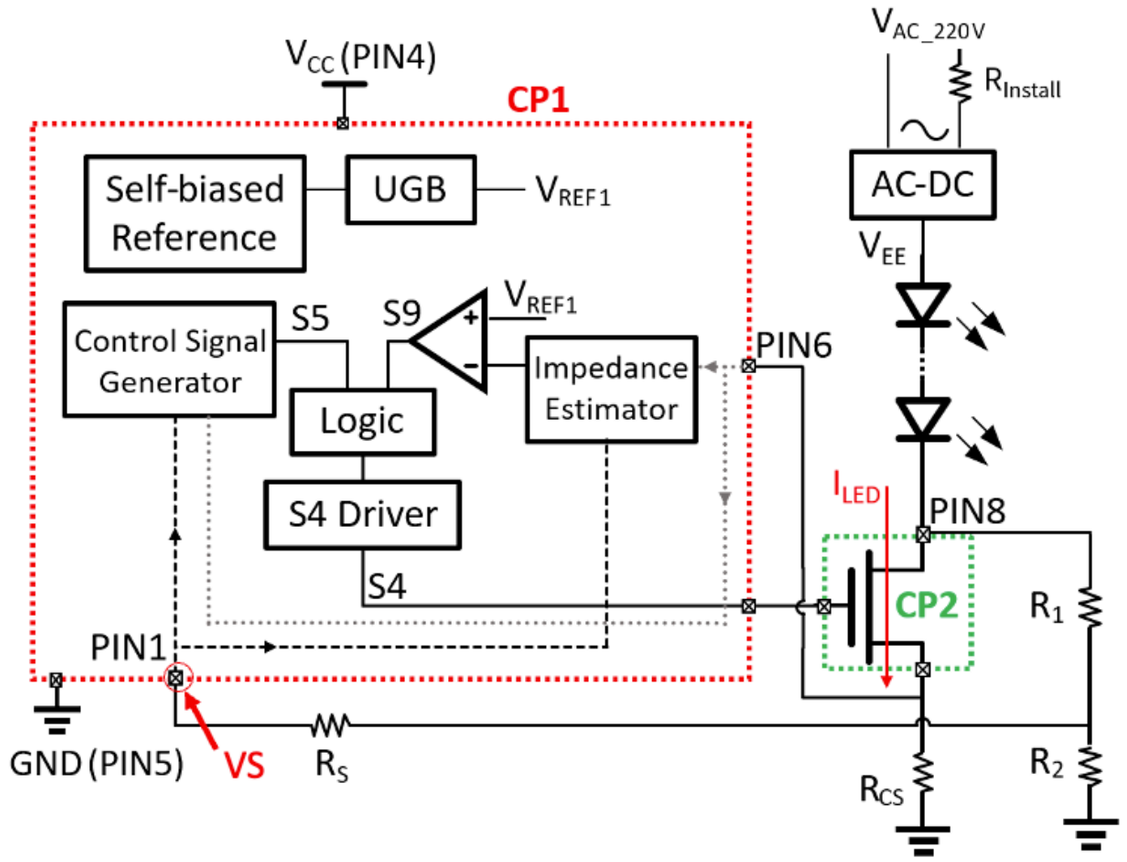
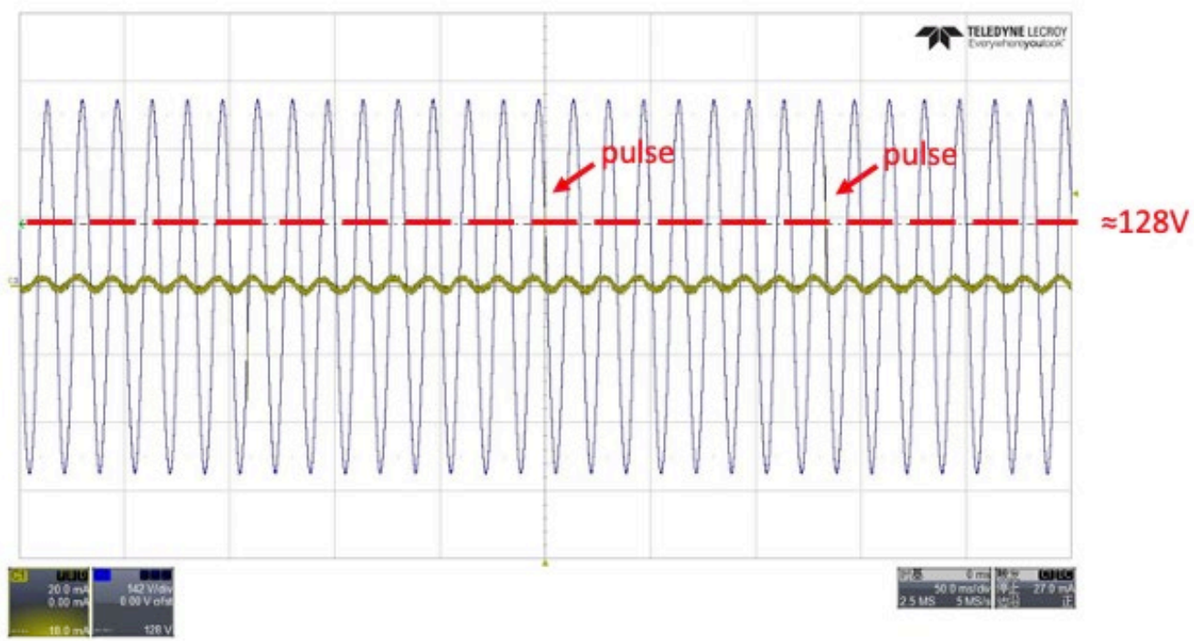


Figure 28. The only reference for triggering control signal generator to generate pulses S5 is voltage VS on PIN1, which will be generated no matter whether the detection determining circuit detects the sampling signal.

Therefore, the GE tube lamp satisfies claim element 1[g] of the ’140 Patent because the pulse generating circuit in the installation detection circuit is configured to output one or more pulse signals independent of whether the detection determining circuit detects the sampling signal.

Thus, for at least the reasons the GE LED tube lamp satisfies each and every element of claim 1, and therefore the GE LED tube lamp infringes claim 1 of the ’140 Patent.

Claim 3	GE LED Tube LED13ABT8/G4/840 – Representative Product
3[a] The installation detection circuit according to claim 1, wherein when the detection determining circuit determines that the sampling signal is greater than or equal to a predefined signal, it is detected that the LED tube lamp is properly installed on the lamp socket; and	The GE LED13ABT8/G4/840 LED tube lamp satisfies claim element 3[a] of the ’140 Patent because the LED tube lamp is detected to be properly installed on the lamp socket when the detection determining determines that the sampling signal is greater than or equal to a predefined signal. For example, with respect to Figure 27, the impedance estimator, as discussed above in claim 1[f], outputs a voltage proportional to the calculated estimated impedance, which is compared with reference voltage V_{REF1} at comparator 1. Therefore, a logical high S9 value, indicating the lamp is properly installed, outputs when the estimated value of the impedance is smaller than a specific value to make its output voltage is smaller than reference voltage V_{REF}. Furthermore, the impedance estimator calculates the estimated impedance based on the voltage VS at PIN1 and the CS signal at PIN6. From the measurement result during re-lamping test shown in Figure 29, it can be found that the LT2600 triggers the detection always at a fixed voltage level (around 128V). Therefore, the voltage VS at PIN1 for calculating the estimated impedance is a constant, which is around 128V, and CS signal at PIN6 is the voltage proportional to the current generated at around 128V. According to Ohm's law (V=IR), the estimated impedance (R) is inverse proportional to the CS signal (I) when the voltage VS (V) is a constant. Hence, "the estimated value of the impedance is smaller than a specific value" can be considered the same as "the CS signal is greater than or equal to a predefined signal". In other words, the impedance estimator will generate a voltage smaller than reference voltage V_{REF1} when the CS signal is greater than or equal to a predefined signal to enable the comparator 1 to output signal S9 with a logic high value to indicate the proper installation of the tube lamp is detected.  Figure 29. Measurement result demonstrated the installation detection circuit triggers the detection and calculates the estimated impedance at a fixed voltage level (around 128V) during re-lamping test.

Claim 3	GE LED Tube LED13ABT8/G4/840 – Representative Product
	Therefore, the GE LED tube lamp contains an installation detection circuit that generates signal S9 indicating the LED tube lamp is properly installed on the lamp socket when the detection determining circuit determines that the CS signal is greater than or equal to a predefined signal which makes the output voltage of the impedance estimator smaller than reference voltage V_{REF}, and therefore the GE LED tube lamp satisfies claim element 3[a] of the '140 Patent.
3[b] when the detection determining circuit determines that the sampling signal is smaller than a predefined signal, it is detected that the LED tube lamp is not properly installed on the lamp socket.	The GE LED13ABT8/G4/840 LED tube lamp satisfies claim 3[b] of the ’140 Patent because the LED tube lamp is detected to be not properly installed on the lamp socket when the detection determining circuit determines that the sampling signal is smaller than a predefined signal. The impedance estimator, as discussed above in claim element 1[f], outputs a voltage proportional to the calculated estimated impedance, which is compared with reference voltage V_{REF1} at comparator 1. Therefore, a logical low S9 value, indicating the lamp is not properly installed, outputs when the estimated value of the impedance is greater than or equal to a specific value to make its output voltage is greater than or equal to reference voltage V_{REF}. As discussed above in claim element 3[a], since the voltage VS at PIN1 for calculating the estimated impedance is always around 128V and can be referred to a constant when LT2600 triggers the detection, "the estimated value of the impedance is greater than or equal to a specific value" and "the CS signal is smaller than a predefined signal" is synonymous. In other words, the impedance estimator will generate a voltage greater than or equal to reference voltage V_{REF1} when the CS signal is smaller than a predefined signal to enable the comparator 1 to output signal S9 with a logic low value to indicate the improper installation of the tube lamp is detected. Therefore, the GE LED tube lamp contains an installation detection circuit that generates signal S9 indicating the LED tube lamp is not properly installed on the lamp socket when the detection determining circuit determines that the CS signal is smaller than a predefined signal which makes the output voltage of the impedance estimator greater than or equal to reference voltage V_{REF}, Hence, for at least the reasons stated above, the GE LED tube lamp satisfies all elements of claim 1, and further satisfies all additional limitation added to claim 2 by claim 3, and therefore infringes claim 3 of the '140 patent.

Claim 4	GE LED Tube LED13ABT8/G4/840 – Representative Product
4[pre]. An installation detection circuit configured in a light emitting diode (LED) tube lamp configured to receive an external driving signal,	See Claim 1[pre].
4[a] the installation detection circuit comprising: a pulse generating circuit configured to output one or more pulse signals;	See Claim 1[a].
4[b] wherein the installation detection circuit is configured to detect during at least one of the one or more pulse signals whether the LED tube lamp is properly installed on a lamp socket, based on detecting a signal generated from the external driving signal; and	See Claim 1[b].
4[c] a switch circuit coupled to the pulse generating circuit, wherein the one or more pulse signals control turning on and off of the switch circuit;	See Claim 1[c].
4[d] wherein the installation detection circuit is further configured to: when it is detected during one of the one or more pulse signals that the LED tube lamp is not properly installed on the lamp socket, control the switch circuit to remain in an off state to cause a power loop of the LED tube lamp to be open; and	See Claim 1[d].

Claim 4	GE LED Tube LED13ABT8/G4/840 – Representative Product
4[e] when it is detected during one of the one or more pulse signals that the LED tube lamp is properly installed on the lamp socket, control the switch circuit to remain in a conducting state to cause the power loop of the LED tube lamp to maintain a conducting state, and	See Claim 1[e].
4[f] wherein the signal generated from the external driving signal is a sampling signal on the power loop, the installation detection circuit further comprises a detection determining circuit configured to detect the sampling signal for determining whether the LED tube lamp is properly installed on the lamp socket, and the power loop includes the switch circuit and the detection determining circuit; and	See Claim 1[f].
4[g] wherein the installation detection circuit further includes a detection result latching circuit coupled to the switch circuit, wherein the detection result latching circuit is configured to receive the one or more pulse signals to control turning on and off of the switch circuit based on a detection result signal from the detection determining circuit.	The installation detection circuit in the GE LED13ABT8/G4/840 LED tube lamp includes a detection result latching circuit that is coupled to the switch circuit and configured to receive one or more pulses to control turning on and off of the switch circuit based on a detection result signal from the detection determining circuit. The detection result latching circuit is comprised of multiple blocks on the CP1 die (outlined in cyan), representing logic components (outlined in green) and the S4 driver (outlined in blue), all of which is highlighted in Figure 30. These components are also outlined together by the dashed blue line in the simplified system overview diagram in Figure 31.

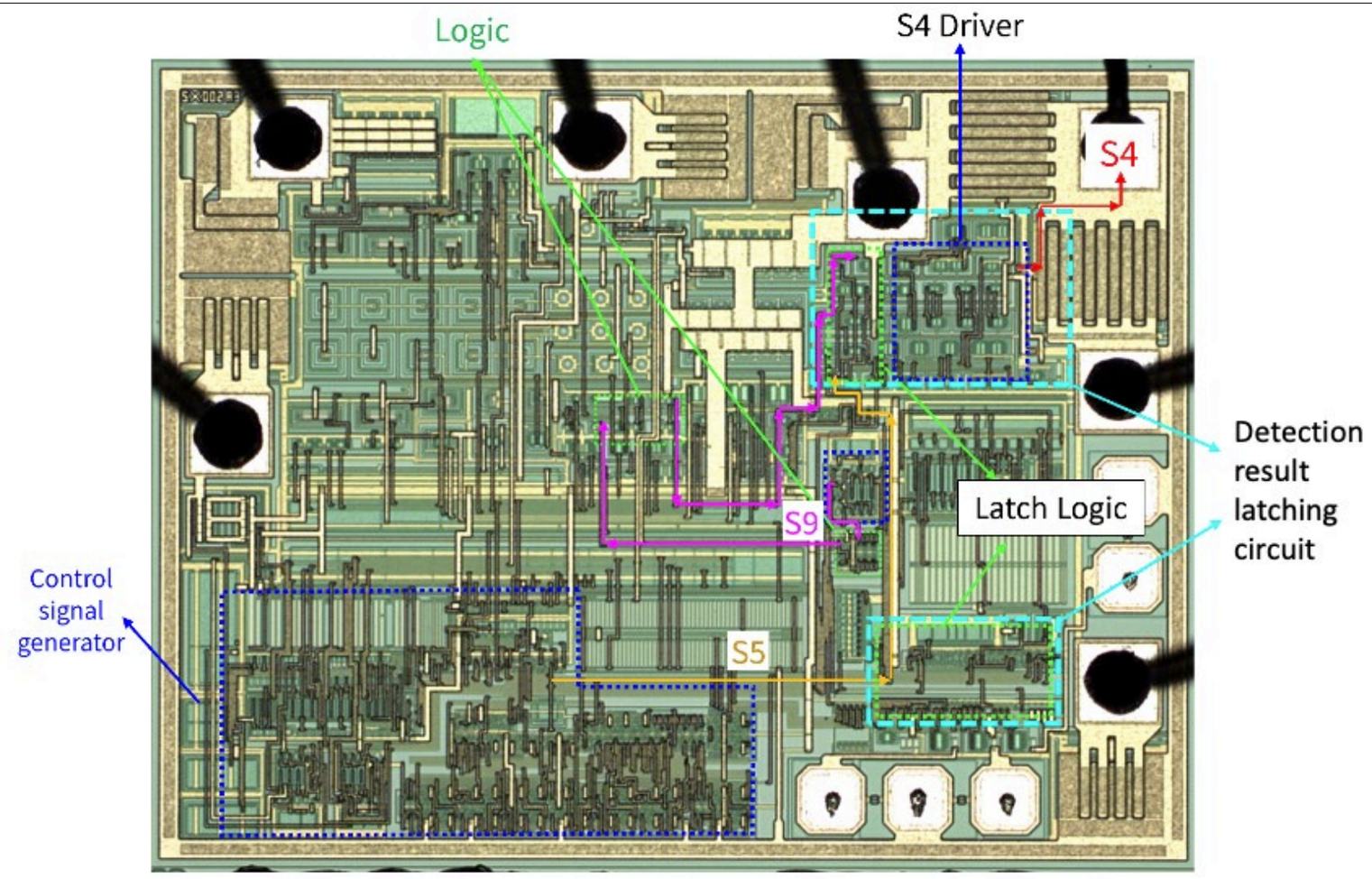


Figure 30. Logic blocks (e.g., digital logic) and the S4 driver together form the detection result latching circuit, outlined by the upper and lower dashed cyan boxes.

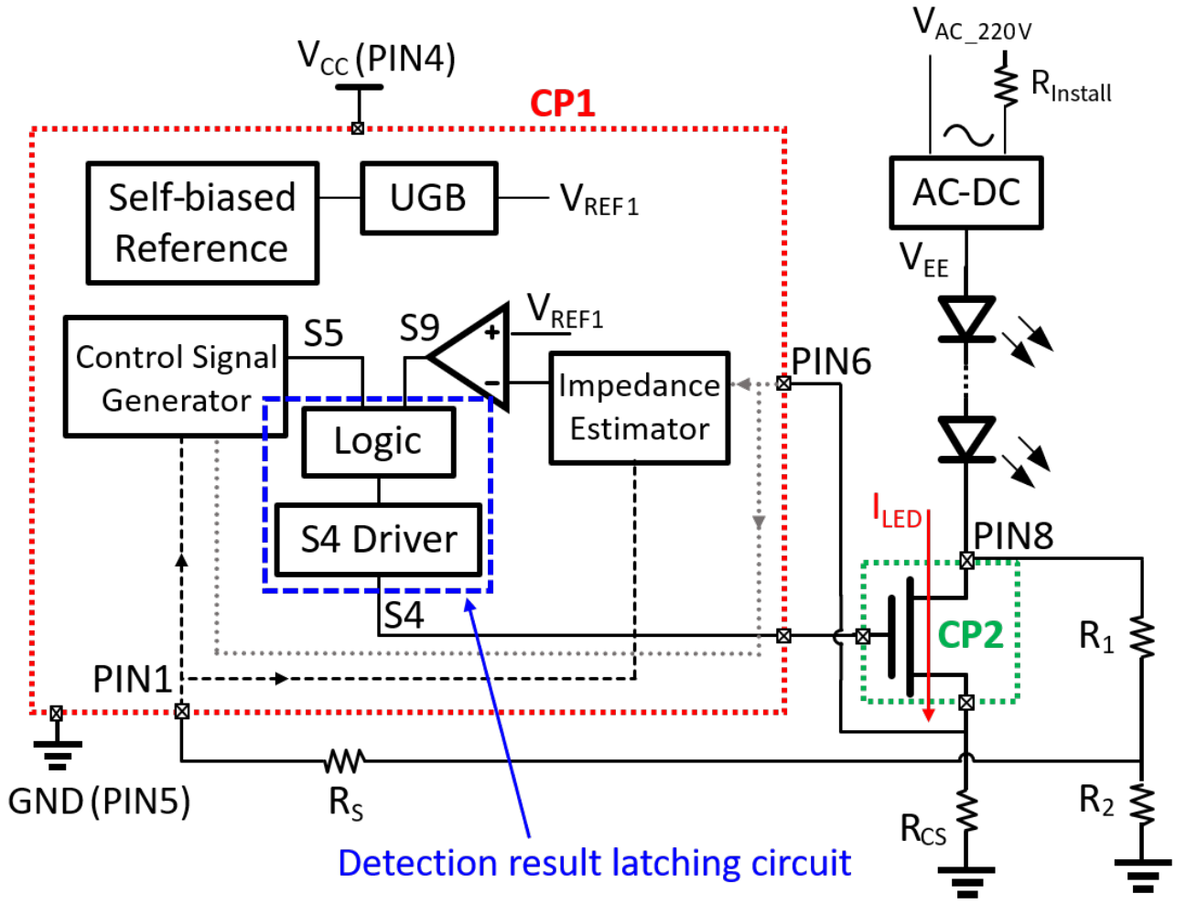


Figure 31. The digital logic and S4 driver, both outlined in dashed blue, together form the detection result latching circuit.

The detection result latching circuit receives the outputs of comparator 1 and the pulse generator as input signals. The output of the pulse generator, S5, is the one or more pulse signals produced by the claimed pulse generating circuit. The output of comparator 1, S9, is the result of the detection determining circuit. The output of the detection result latching circuit is signal S4, which couples directly to the gate terminal of the switch circuit on CP2.

With respect to Figure 30, the one or more pulses enter the lower box of the detection result latching circuit, which includes one or more signals that feedback to the control signal generator, as discussed further in relation to Claim 5. The one or more pulse signals are further propagated to the upper box of the detection result latching circuit. The digital logic component of the LT2600 contains circuitry, including an S-R latch, that may be applied to the detection result determination signal, S9, the result of which is combined with the one or more pulse signals at a logical OR gate.[2] The result of the logic component in the top block of the latching circuit is

Claim 4	GE LED Tube LED13ABT8/G4/840 – Representative Product

provided as an input for the S4 driver, which takes the digital input and outputs an analog driving signal that will operate to open or close the gate on the switch circuit.

The behavior of the latching circuit was ascertained by the circuit tracing analysis used to understand its functionality. An image of the CP1 die section subject to this analysis is shown on the left side of Figure 32 with the individual transistor gates labeled with m_1 through m_9. Together these constitute a level-shifter with enable function that operates to change the voltage offset of the input signal without adding delay (or equivalently, without adding a phase shift to the input signal).

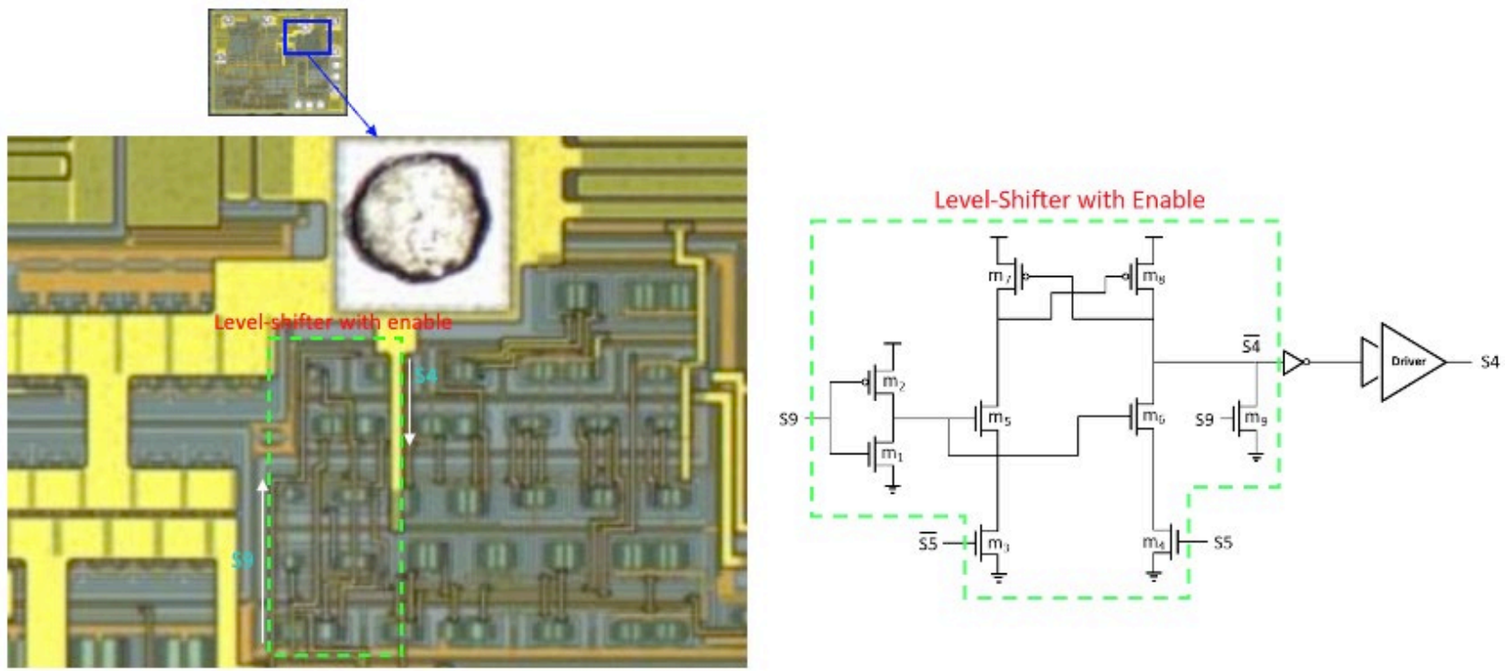


Figure 32. Circuit tracing of a portion of the logic circuitry in the detection result latching circuit shows it to comprise a level-shifter. An image of the CP1 die with the transistor gates labeled is shown on the left and the equivalent circuit diagram is shown on the right.

The output of this level shifter feeds into a deadtime generator and the S4 driver. The deadtime generator functions to avoid the occurrence of a short circuit at the edge of a pulse by creating a small gap in time between the action of the large pull-up and pull-down transistors near the S4 pad. Further components of the S4 driver act as a buffer circuit and generates an analog output signal with current gain to drive the FET connected to S4.

When the CS signal voltage on PIN6 is low, such that when combined with the VS signal in the impedance estimator, the power loop is determined to have an impedance, scaled to the voltage, higher than V_{REF1}, then S9 will be low (0) and S4 will follow S5. As noted in claim elements 1[d] and 1[e], S9 has two possible states,

[2] BA12003_LT2600_CA_Report_v1.pdf

<table>
<tr><th>Claim 4</th><th>GE LED Tube LED13ABT8/G4/840 – Representative Product</th></tr>
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and for the sake of discussion, here an impedance exceeding a threshold is chosen to indicate a logical low state. In this scenario S4 will remain low along with control signal S5 until S5 pulses to a high state in order to allow the installation detection circuit to detect a sampling signal, at which time S4 will also rise to a high state. When the CS signal voltage on PIN6 is high, such that when combined with the VS signal in the impedance estimator, the power loop is determined to have an impedance, scaled to the voltage, lower than V_{REF1}, S9 will be high (1) and S4 will latch to a high value regardless of whether S5 is low or high. The corresponding truth table exhibits the logical input and output states of the detection result latching circuit.
<table>
<tr><th>Input: S5</th><th>Input: S9</th><th>Output: S4</th></tr>
<tr><td>Low/0</td><td>Low/0</td><td>Low/0</td></tr>
<tr><td>High/1</td><td>Low/0</td><td>High/1</td></tr>
<tr><td>Low/0</td><td>High/1</td><td>High/1</td></tr>
<tr><td>High/1</td><td>High/1</td><td>High/1</td></tr>
</table>
Table 1. Truth table of possible inputs and outputs for the detection result latching circuit show that it operates upon the inputs as a logical OR gate.

In effect, the signal state of S4 is dominated by the calculation of impedance stemming from a comparison between R_{CS} and $R_{Install} + R_{LED}$, where R_{LED} is the resistance of the LED strip (see Figure 31). When the lamp is installed correctly, $R_{Install}$ is low, the LED current (loop current) will be high and the estimated impedance will relatively low. Conversely, if the lamp is not installed correctly $R_{Install}$ will be high, the LED current will be low, and the estimated impedance will be relatively high. Thus, the impedance will change in accord with the installation status of the LED tube lamp in the lamp socket.

Therefore, the detection result latching circuit is configured to receive the one or more pulse signals from the pulse generating circuit. The detection result latching circuit is also coupled to the switch circuit. Additionally, the pulse signals together with the result of the detection result signal from the detection determining circuit control the turning on and off of the switch circuit. Thus, for at least the reasons described above, the GE LED tube lamp satisfies claim element 4[g].

Because the GE LED tube lamp satisfies each and every element of claim 4, the GE LED tube lamp infringes claim 4 of the ’140 Patent.
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Claim 5	GE LED Tube LED13ABT8/G4/840 – Representative Product
5. The installation detection circuit according to claim **4**, wherein the pulse generating circuit is coupled to an output of the detection result latching circuit to control the time of the one or more pulse signals.	The GE LED13ABT8/G4/840 LED tube lamp satisfies claim 5 of the ’140 Patent, for at least the reasons described below, because it includes an installation detection circuit, as described above with respect to claim 4, wherein the pulse generating circuit is coupled to an output of the detection result latching circuit to control the time of the one or more pulse signals. The one or more pulse signals, S5, generated by the pulse generating circuit of the GE LED tube lamp first pass into the lower of the two logic blocks in the detection result latching circuit shown in Figure 33. A modified version of the pulse signal is created after it passes through multiple inverters (labeled as CLKB_OSC in Figure 34). This modified pulse signal then passes through several circuit components (including comparators, logic gates, transistors, and a Schmitt Trigger). More than one signal is generated as an output from these components, one of which serves as a reset signal for an enable control module in the control signal generator, which corresponds to the pulse generating circuit (outlined in blue in Figure 33). This is identified in the "BA12003_LT2600_CA_Report_v1.pdf" teardown report of the LT2600 as signal OVP_DLY_EN, highlighted by the magenta line in Figure 33, and functions to help stabilize S5. That is, an output signal produced in the detection result latching circuit couples back to the pulse generating circuit to control the time of the one or more pulse signals. For instance, OVP_DLY_EN is used to generate a signal (SET’) which is subsequently used as a shared input for frequency dividers within the pulse generating circuit. Figure 34 shows the pathway of the trace that carries signal OVP_DLY_EN in greater detail. Therefore, the GE LED tube lamp satisfies all elements of claim 4, and further satisfies all additional limitations added to claim 4 by claim 5, and therefore infringes claim 4 of the ’140 Patent.

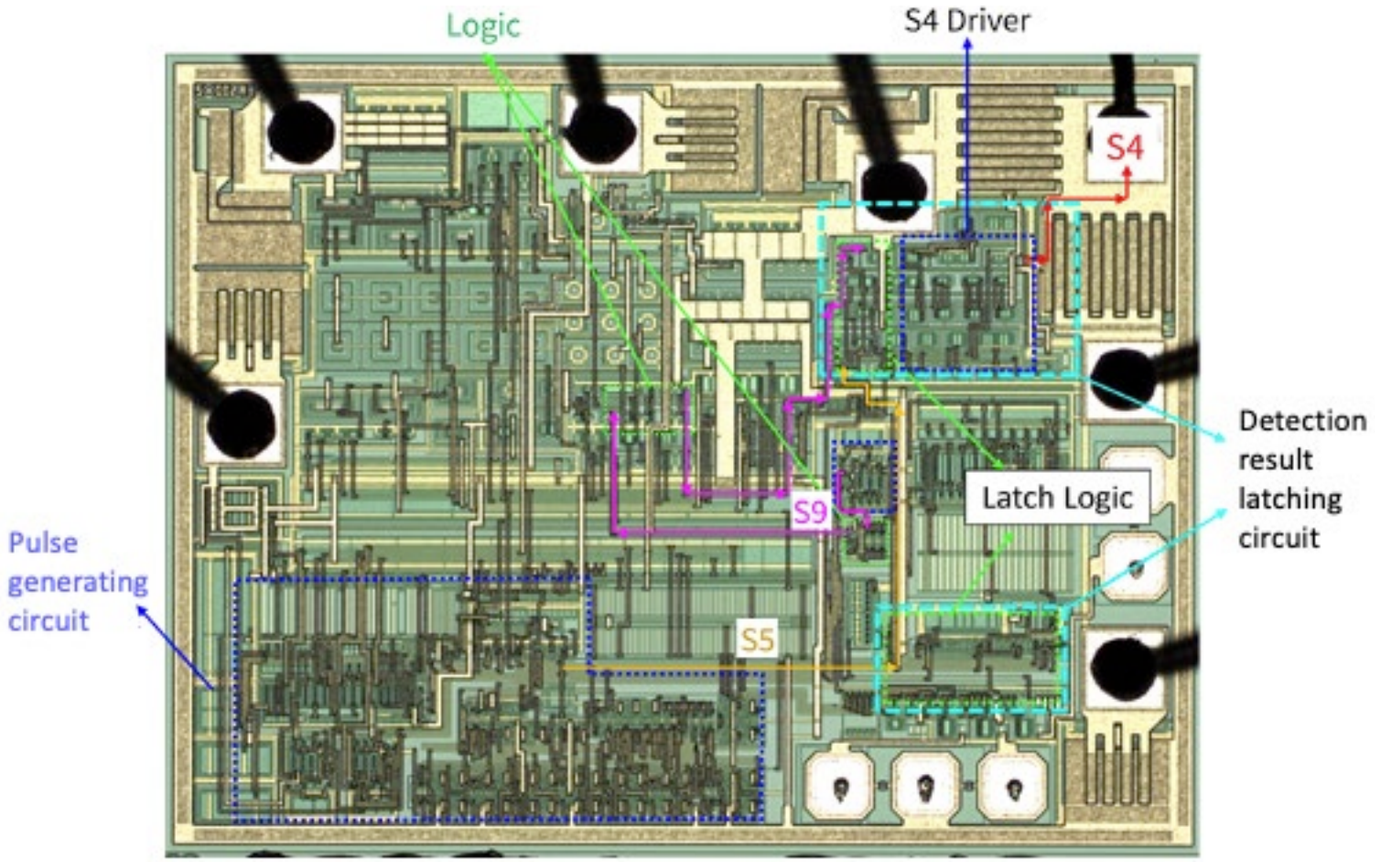


Figure 33. The signal OVP_DEL_EN is generated within the detection result latching circuit and is coupled between the pulse generating circuit and an output of the detection result latching circuit. The trace this signal follows is highlighted by the magenta arrow. The region outlined by the dashed red line is shown in greater detail in Figure 34.

Claim 5	GE LED Tube LED13ABT8/G4/840 – Representative Product

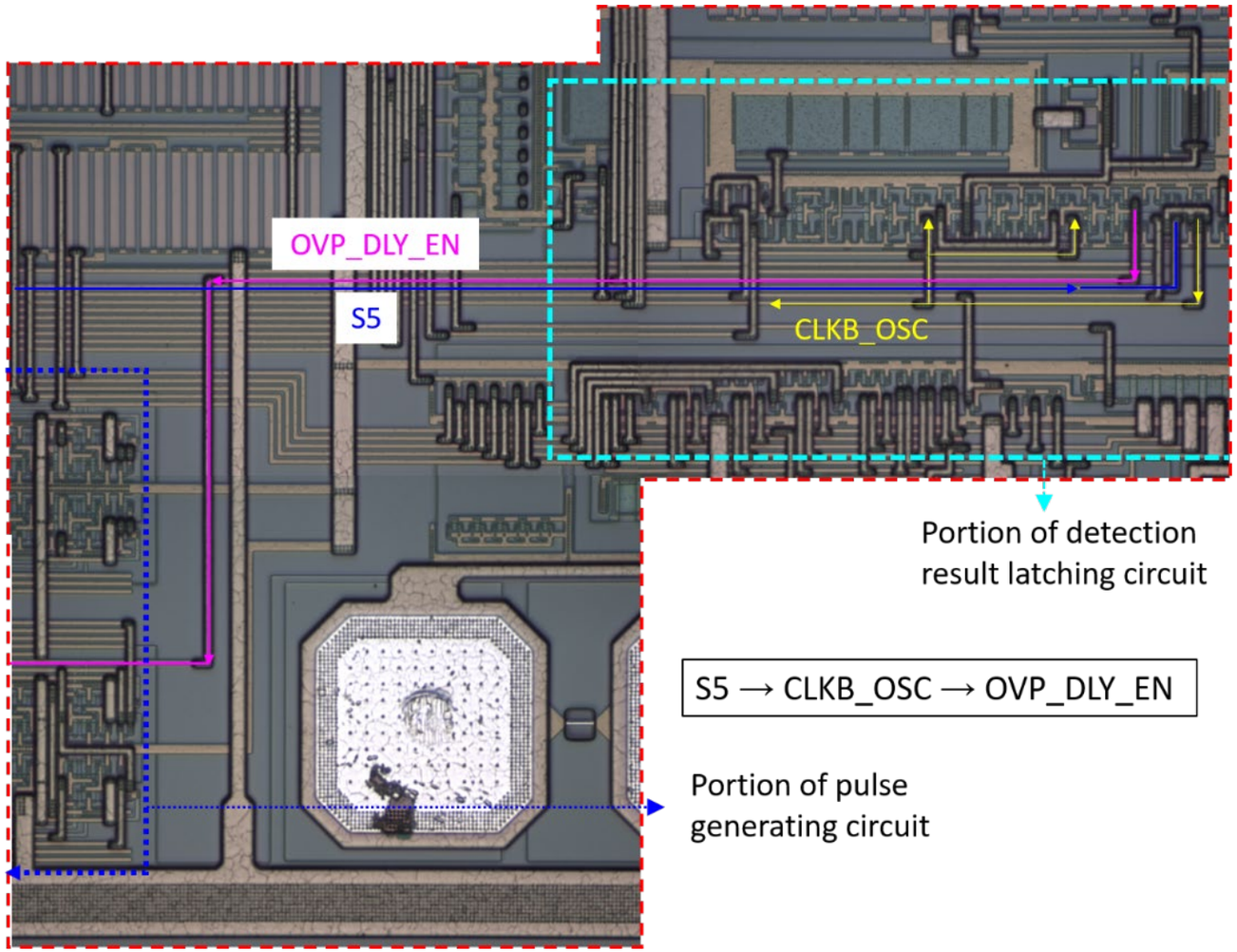


Figure 34. High resolution image of a region of the CP1 die in the LT2600 on the power supply module of the GE LED tube lamp. Signal S5 (blue), from the pulse generating circuit, is used to generate signal CLKB_OSC (yellow). OVP_DEL_EN is generated from CLKB_OSC, and is subsequently output from the detection result latching circuit (cyan) back to the pulse generating circuit. The pathway of OVP_DEL_EN highlighted by the magenta arrow.

Claim 21	GE LED Tube LED13ABT8/G4/840 – Representative Product
21[pre] An installation detection circuit configured in a light-emitting diode (LED) tube lamp, the installation detection circuit comprising:	See Claim 1[pre].
21[a] means for generating one or more pulse signals;	See Claim 1[a]. The control signal generator identified as a pulse generating circuit implements means for generating one or more pulse signals in this claim element. The control signal generator on LT2600 generates pulses S5 based on the voltage VS on PIN1. Therefore, the GE LED tube lamp satisfies the claim element 21[a] of the ’140 Patent.
21[b] means for detecting during one or more pulse signals whether the LED tube lamp is properly installed on a lamp socket; and	See Claim 1[b].
21[c] a switch circuit coupled to the means for generating one or more pulse signals, wherein the one or more pulse signals control turning on and off of the switch circuit;	See Claim 1[c].
21[d] wherein the installation detection circuit is further configured to: when it is detected during one of the one or more pulse signals that the LED tube lamp is not properly installed on the lamp socket, control the switch circuit to remain in an off state to cause a power loop of the LED tube lamp to be open; and	See Claim 1[d].
21[e] when it is detected during one of the one or more pulse signals that the LED tube lamp is properly installed on the lamp socket, control	See Claim 1[e].

Claim 21	GE LED Tube LED13ABT8/G4/840 – Representative Product
the switch circuit to remain in a conducting state to cause the power loop of the LED tube lamp to maintain a conducting state,	
21[f] wherein the means for detecting is configured to detect a sampling signal on the power loop for determining whether the LED tube lamp is properly installed on the lamp socket, and the power loop includes the switch circuit and the means for detecting, and	See Claim 1[f]. The circuits DDC_1 and DDC2 identified as a detection determining circuit implements means for detecting configured to detect a sampling signal on the power loop for determining whether the LED tube lamp is properly installed on the lamp socket, and the power loop includes the switch circuit and the means for detecting.
21[g] wherein the LED tube lamp is configured to receive an external driving signal and comprises a rectifying circuit for rectifying the external driving signal and a filtering circuit coupled to the rectifying circuit, wherein the installation detection circuit is coupled between the rectifying circuit and the filtering circuit.	The GE LED13ABT8/G4/840 LED tube lamp satisfies claim 21[g] of the ’140 Patent because the GE tube lamp is configured to receive an external driving signal and comprises a rectifying circuit for rectifying the external driving signal and a filtering circuit coupled to the rectifying circuit, wherein the installation detection circuit is coupled between the rectifying circuit and the filtering circuit. For example, in Figure 35, components DB1 and DB2 outlined in red form a rectifying circuit as claimed (marked with “6”), in which rectifying circuit 6 rectifies the external driving signal received an external driving signal from pins and produces a rectified signal S2. Components C1, C2, L1, L2, R7, and R10 outlined in blue form a filtering circuit (marked with “7”), in which filtering circuit 7 is coupled to rectifying circuit 6 via a connection node of capacitor C1, inductor L2, and resistor R7, and is capable of filtering rectified signal to produce filtered signal S3. LT2600 which refers to the installation detection circuit is coupled between rectifying circuit 6 and filtering circuit 7 through terminals M3 and GND1 as depicted in Figure 36.

Claim 21	GE LED Tube LED13ABT8/G4/840 – Representative Product

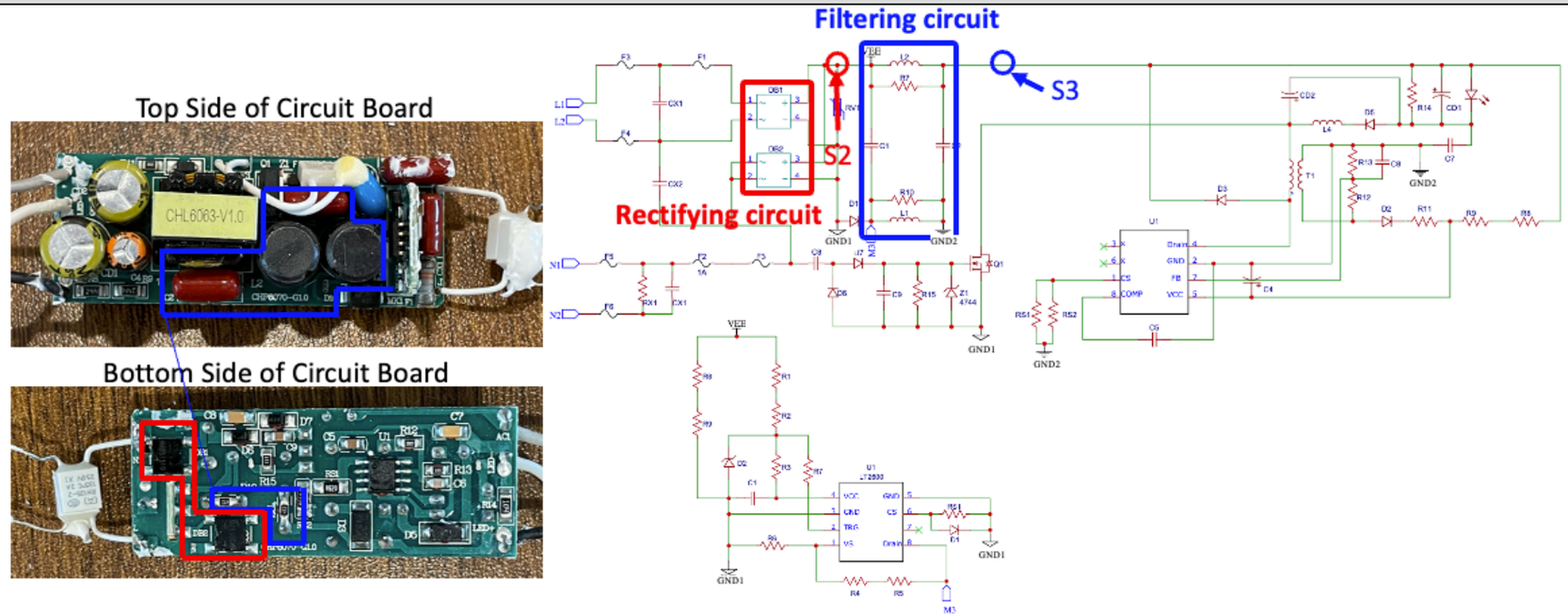


Figure 35. The GE tube lamp comprises a rectifying circuit, outlined in red, and a filtering circuit, outlined in blue on the PCB (left) and on the equivalent circuit diagram (right)

Claim 21	GE LED Tube LED13ABT8/G4/840 – Representative Product

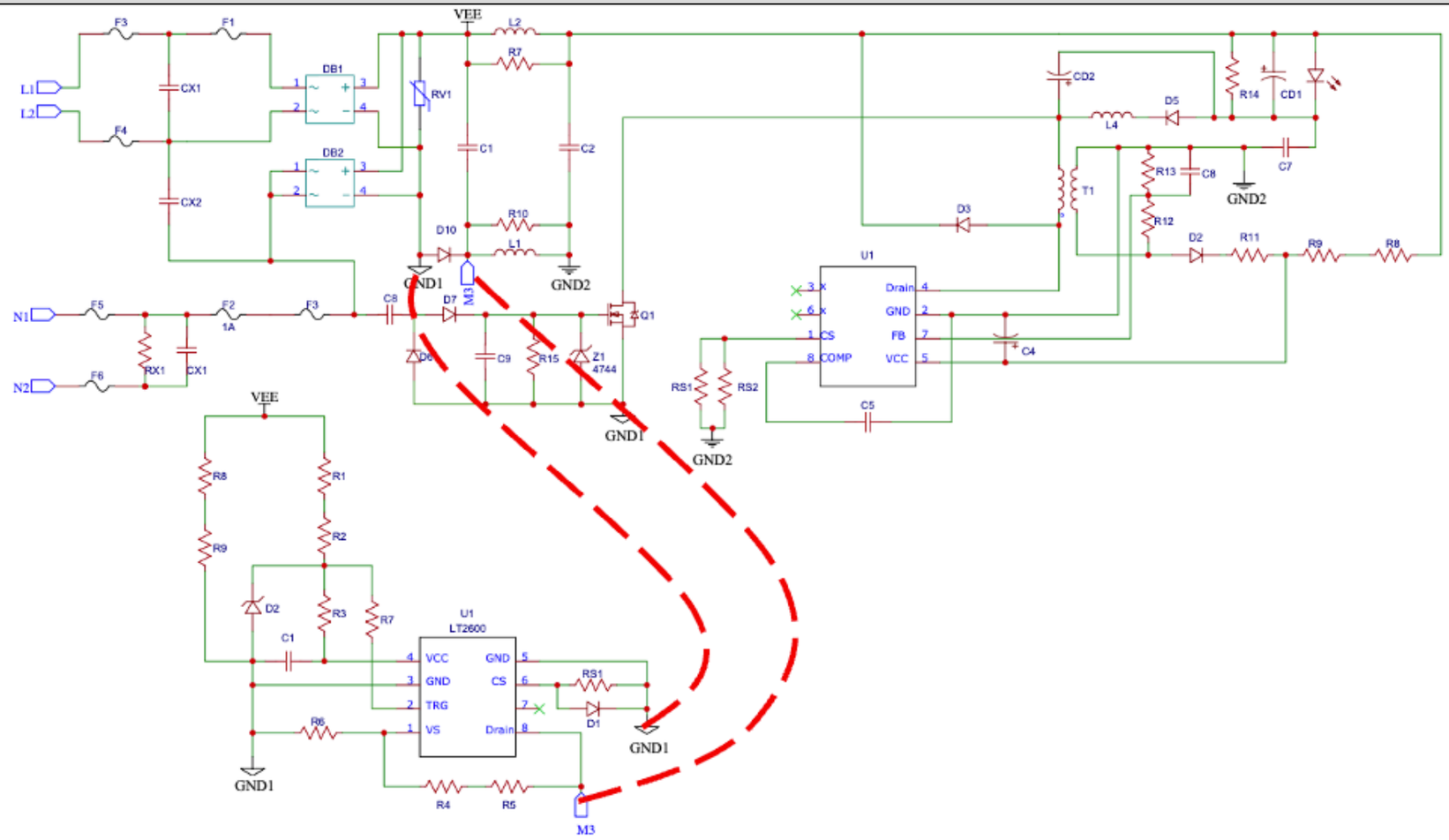
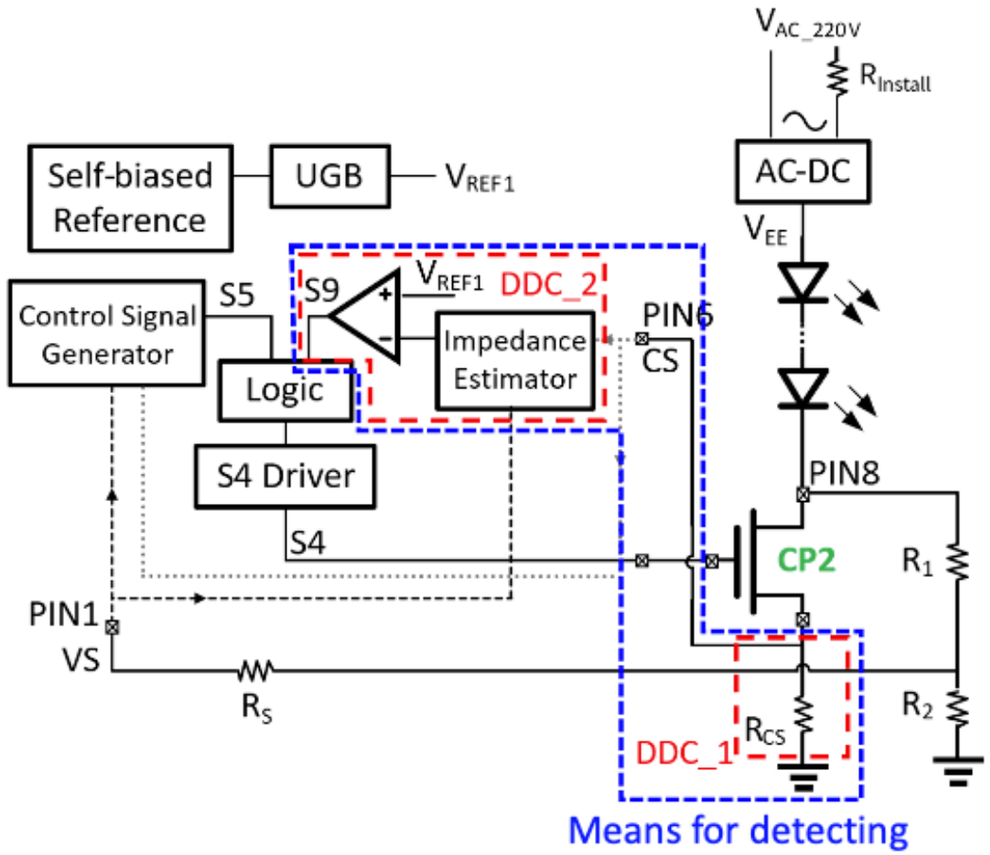
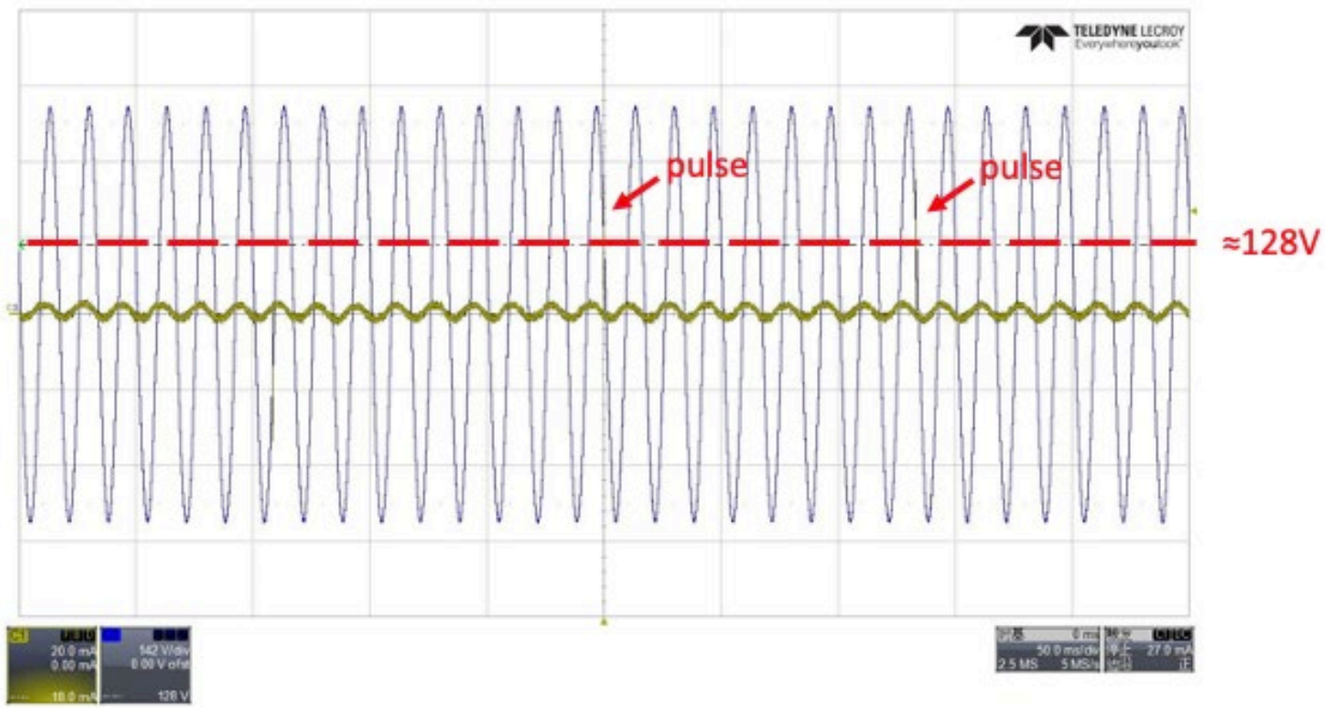


Figure 36. The connection correlation of LT2600 shows it is coupled between the rectifying circuit and the filtering circuit through GND terminal (PIN5) and BUS-terminal (PIN8).

Therefore, the GE LED tube lamp satisfies all elements of claim 21, and therefore infringes claim 21 of the ’140 Patent.

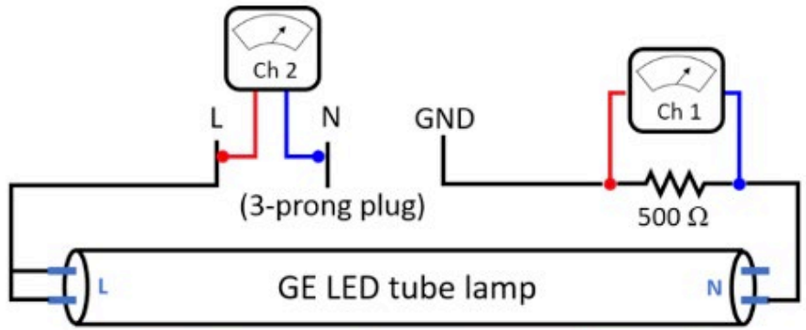
Claim 22	GE LED Tube LED13ABT8/G4/840 – Representative Product
22[a] The installation detection circuit according to claim 21, wherein the means for detecting determines that the sampling signal is greater than or equal to a predefined signal, it is detected that the LED tube is properly installed on the lamp socket; and	The GE LED13ABT8/G4/840 LED tube lamp satisfies claim element 22[a] of the ’140 Patent because the means for detecting, as discussed above with respect to claim 21, determines that the sampling signal is greater than or equal to a predefined signal, it is detected that the LED tube is properly installed on the lamp socket. For example, in Figure 37, the impedance estimator, as discussed above in claim element 1[f], outputs a voltage proportional to the calculated estimated impedance, which is compared with reference voltage V_{REF1} at comparator 1. Therefore, a logical high S9 value, indicating the lamp is properly installed, outputs when the estimated value of the impedance is smaller than a specific value to make its output voltage is smaller than reference voltage V_{REF}.  Figure 37. The means for detecting in the GE tube lamp (outlined in dashed blue line) is comprised of a circuit, DDC_1, represented by components disposed on the daughter board of the power supply module, and a circuit, DDC_2, represented by circuitry disposed in the LT2600 IC.

Claim 22	GE LED Tube LED13ABT8/G4/840 – Representative Product
	Furthermore, the impedance estimator calculates the estimated impedance based on the voltage VS at PIN1 and the CS signal at PIN6. From the measurement result during re-lamping test shown in Figure 38, it can be found that the LT2600 triggers the detection always at a fixed voltage level (around 128V). Therefore, the voltage VS at PIN1 for calculating the estimated impedance is a constant, which is around 128V, and CS signal at PIN6 is the voltage proportional to the current generated at around 128V. According to Ohm's law (V=IR), the estimated impedance (R) is inverse proportional to the CS signal (I) when the voltage VS (V) is a constant. Hence, "the estimated value of the impedance is smaller than a specific value" can be considered the same as "the CS signal is greater than or equal to a predefined signal". In other words, the impedance estimator will generate a voltage smaller than reference voltage V_{REF1} when the CS signal is greater than or equal to a predefined signal to enable the comparator 1 to output signal S9 with a logic high value to indicate the proper installation of the tube lamp is detected.  Figure 38. Measurement result demonstrated the installation detection circuit triggers the detection and calculates the estimated impedance at a fixed voltage level (around 128V) during re-lamping test. Therefore, the GE LED tube lamp contains an installation circuit that includes means for detecting determines that the sampling signal is greater than or equal to a predefined signal, it is detected that the LED tube is properly installed on the lamp socket, and therefore the GE LED tube lamp satisfies claim element 22[a] of the '140 Patent.

Claim 22	GE LED Tube LED13ABT8/G4/840 – Representative Product
22[b] when the means for detecting determines that the sampling signal is smaller than a predefined signal, it is detected that the LED tube lamp is not properly installed on the lamp socket.	The GE LED13ABT8/G4/840 LED tube lamp satisfies claim element 22[b] of the ’140 Patent because the means for detecting further determines that the sampling signal is smaller than a predefined signal, it is detected that the LED tube lamp is not properly installed on the lamp socket. The impedance estimator, as discussed above in claim element 1[f], outputs a voltage proportional to the calculated estimated impedance, which is compared with reference voltage V_{REF1} at comparator 1. Therefore, a logical low S9 value, indicating the lamp is not properly installed, outputs when the estimated value of the impedance is greater than or equal to a specific value to make its output voltage is greater than or equal to reference voltage V_{REF}. As discussed above in Claim element 22[a], since the voltage VS at PIN1 for calculating the estimated impedance is always around 128V and can be referred to a constant when LT2600 triggers the detection, "the estimated value of the impedance is greater than or equal to a specific value" and "the CS signal is smaller than a predefined signal" is synonymous. In other words, the impedance estimator will generate a voltage greater than or equal to reference voltage V_{REF1} when the CS signal is smaller than a predefined signal to enable the comparator 1 to output signal S9 with a logic low value to indicate the improper installation of the tube lamp is detected. Hence, for at least the reasons stated above, the GE LED tube lamp satisfies all elements of claim 21, and further satisfies all additional limitation added to claim 21 by claim 22, and therefore infringes claim 22 of the '140 patent.

Claim 23	**GE LED Tube LED13ABT8/G4/840 – Representative Product**
23. The installation detection circuit according to claim 21, further comprising a detection result latching circuit coupled to the switch circuit, wherein the detection result latching circuit is configured to receive the one or more pulse signals to control turning on and off of the switch circuit based on a detection result signal from the means for detecting.	See Claim 4[g]. Because the GE LED tube lamp satisfies each and every element of claims 21 and 23, the GE LED tube lamp infringes claim 23 of the ’140 Patent.

Claim 24	**GE LED Tube LED13ABT8/G4/840 – Representative Product**
24[pre] A detection method adopted by a light-emitting device (LED) tube lamp for preventing a user from electric shock when the LED tube lamp is being installed on a lamp socket,	The GE LED13ABT8/G4/840 LED tube lamp employs a detection method adopted by the light-emitting device (LED) tube lamp for preventing a user from electric shock when the LED tube lamp is being installed on a lamp socket. The GE LED tube lamp does not emit light when a leakage current is measured, as in the re-lamping tests described below, which means the risk of electric shock is detected and there must be a detection method adopted by the GE LED tube lamp for protecting a user from electric shock when the LED tube is being installed on a lamp socket. Re-lamping tests in accord with UL 1993 involve the use of 500 Ω non-inductive resistor placed in series with the current through the lamp, between the second end of the tube and ground. The measurement setup is shown schematically and in photograph in Figure 39. The 500 Ω resistor represents the equivalent series resistance of a human in contact with the lamp, providing an electrical path to ground before the lamp is properly installed on the lamp socket. The measurements results of this test are shown in Figure 40. The lamp does not light up during this re-lamping test despite the application of an external driving signal and a closed loop path for current to flow, and therefore a detection method must be implemented by the tube lamp for preventing a user from receiving an electric shock while the lamp is being installed in the lamp socket.



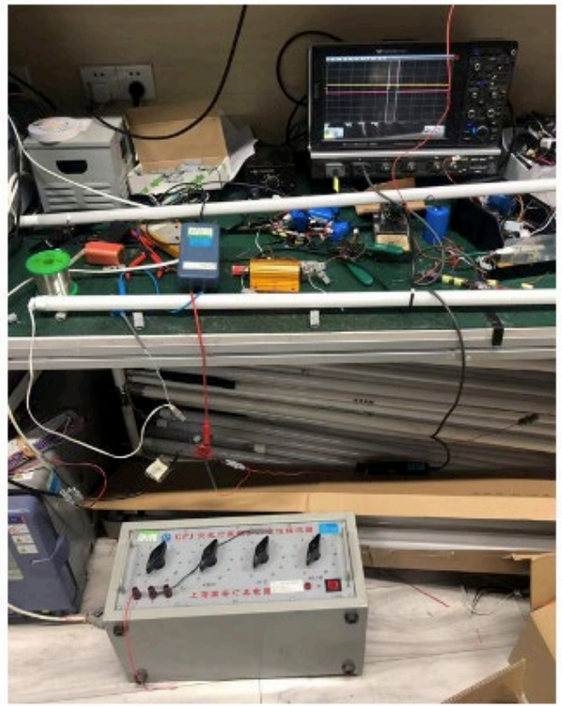


Figure 39. (Top) Schematic of measurement setup for re-lamping test, in accord with UL 1993, to ascertain whether switch circuit will turn on or remain off when the LED lamp tube is detected to be improperly installed. (Bottom) Photographs of measurement setup with GE LED tube lamp.

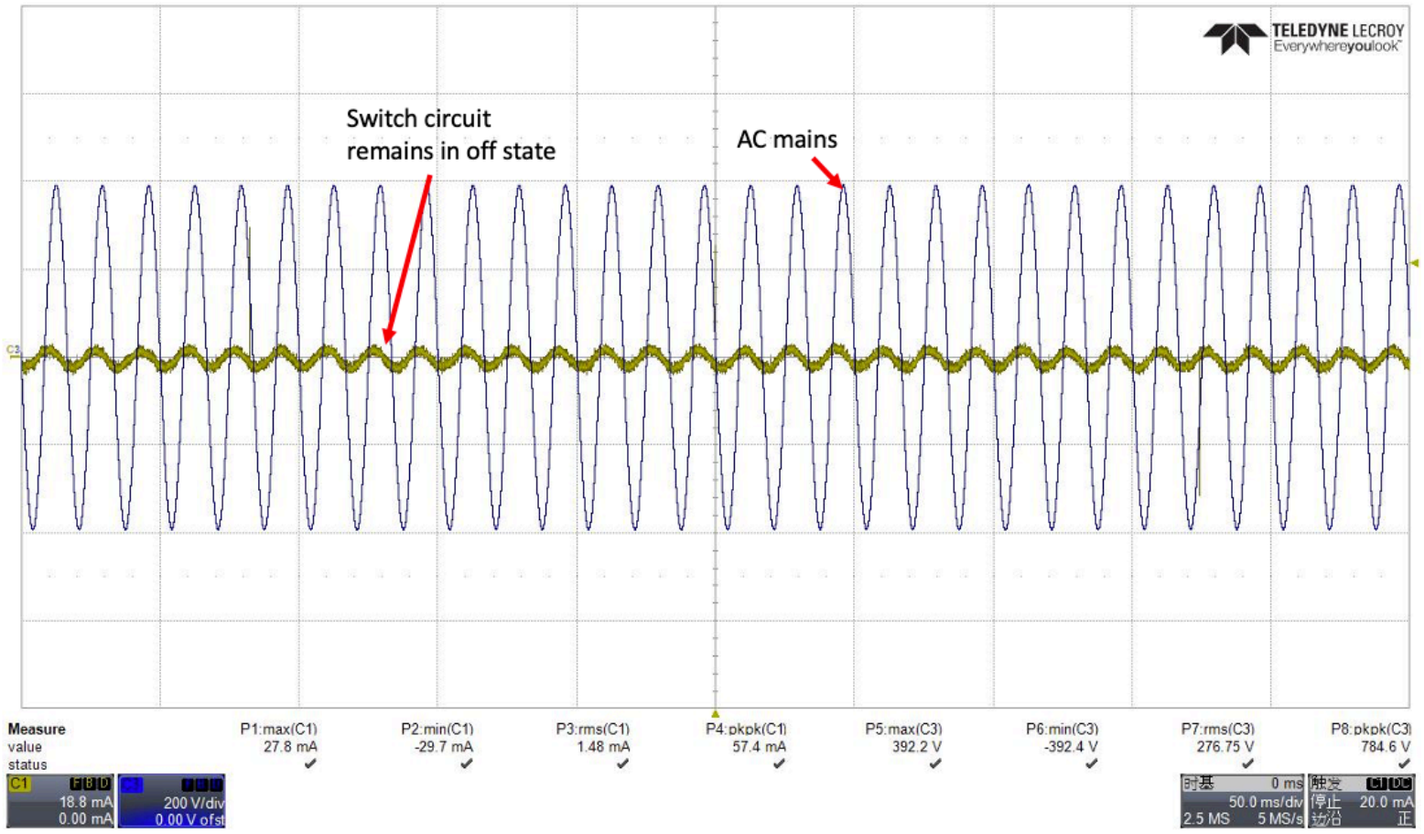
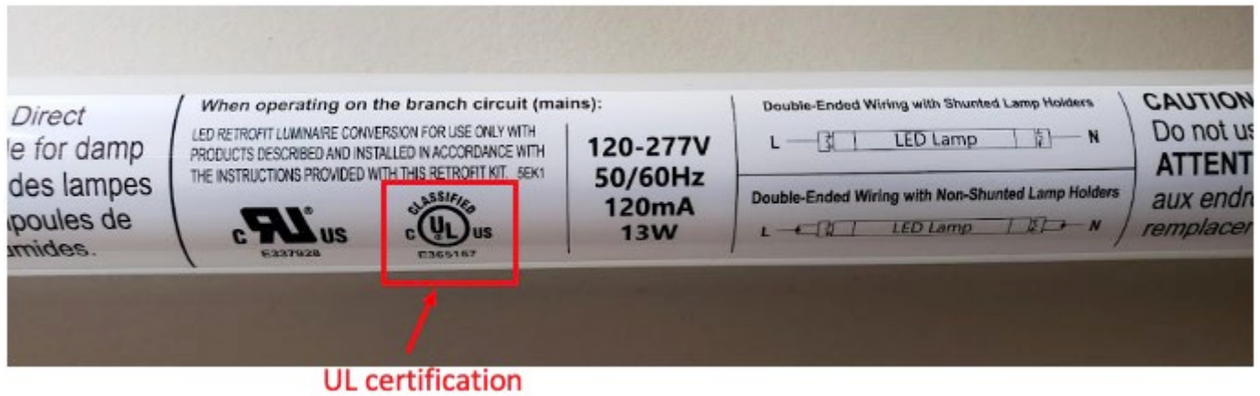
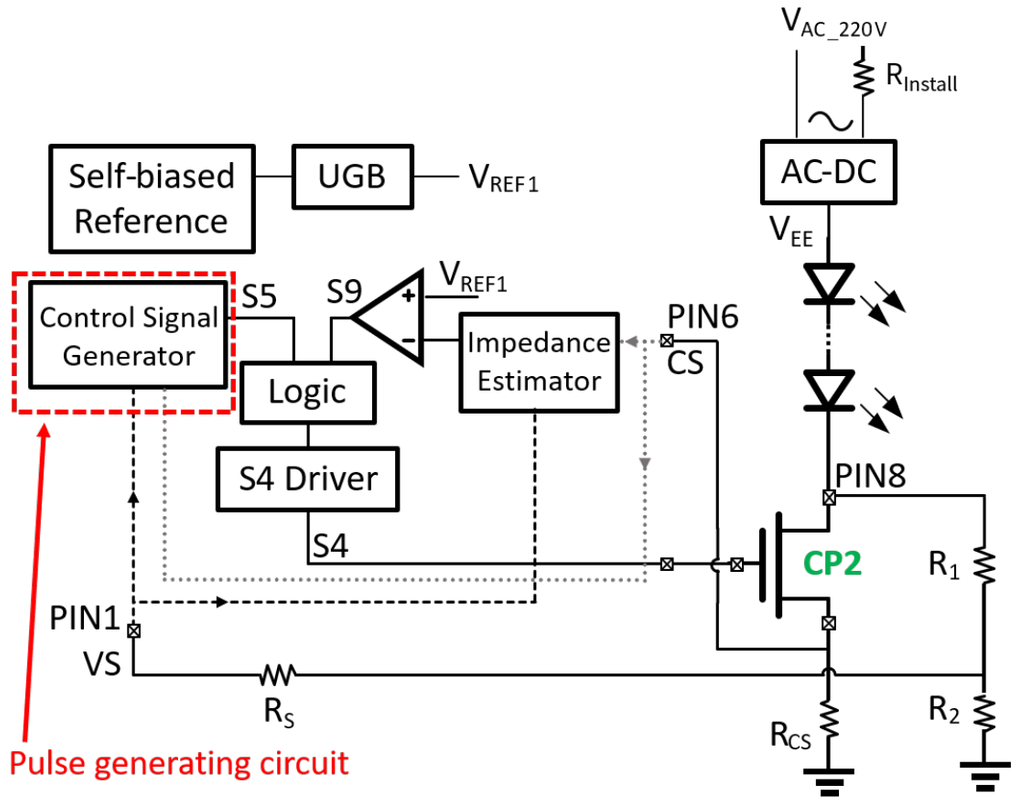


Figure 40. Leakage current measured during re-lamping test. The indigo trace is a measurement of the external driving signal, and the olive-green trace is a measure of the leakage current, corresponding to the voltage measured across the non-inductive 500 Ω resistor connected in series with the GE lamp and ground. The leakage current remains negligible (~1.2 mA) because the switch circuit remains in the off state, and the loop current will likewise remain negligible.

The UL certification label on the GE lamp (as shown in Figure 41) indicates that the installation detection circuit enables the capability of passing a leakage current test providing electric shock protection for a user when touching or installing the GE LED tube lamp in a lamp socket. Therefore, the installation detection circuit is configured such that when the GE is properly connected to a lamp socket, the installation detection circuit conducts current or allows or causes the LED module to be driven by the rectified input signal; and when the GE is not properly connected to a lamp socket, the installation detection circuit prevents the LED module from being driven by the rectified signal.

Claim 24	GE LED Tube LED13ABT8/G4/840 – Representative Product
	 Figure 41. Photo of text printed on first end of GE LED tube lamp showing that the product has passed UL certification. Therefore, the GE LED tube lamp satisfies the preamble of claim 24 of the ’140 Patent.
24[a] the detection method comprising: when at least one end of the LED tube lamp is installed on the lamp socket, generating one or more pulse signals by a pulse generating circuit, wherein the pulse generating circuit is configured in the LED tube lamp;	The GE LED13ABT8/G4/840 LED tube lamp contains LT2600 IC employing the step of when at least one end of the LED tube lamp is installed on the lamp socket, generating one or more pulse signals by a pulse generating circuit, wherein the pulse generating circuit is configured in the LED tube lamp. For example, a control signal generator shown in Figure 42 is a pulse generating circuit configured to generate one or more pulse signals S5, which is configured to turn on switch circuit CP2 for a short period to detect whether both end of the LED tube lamp is properly installed on the lamp socket. That is, when at least one end of the LED tube lamp is connected to the power source in the lamp socket, the control signal generator generates pulse signal S5 regardless whether the other end is properly installed. The full process for deriving the operation of the control signal generator based on the teardown analysis has been stated in claim 1[a].

Claim 24	GE LED Tube LED13ABT8/G4/840 – Representative Product
	 Figure 42. The pulse generating circuit is outline by the dashed red line and consists of circuitry contained on the CP1 die inside the LT2600. Therefore, for at least the reasons described above, the operation of the control signal generator configured in the GE LED tube lamp satisfies claim element 24[a].
24[b] detecting a sampling signal on a power loop of the LED tube lamp by a detection determining circuit, to detect during the one or more pulse signals whether the other end of the LED tube lamp is properly installed on the lamp socket;	The GE LED13ABT8/G4/840 LED tube lamp contains LT2600 IC employing the step of detecting a sampling signal on a power loop of the LED tube lamp by a detection determining circuit, to detect during the one or more pulse signals whether the other end of the LED tube lamp is properly installed on the lamp socket. For example, circuits DDC_1 and DDC_2 shown in Figure 43 is a detection determining circuit configured to detect CS signal at PIN6 and voltage VS at PIN1 during switch circuit CP2 being turned on by control signal S4/ pulse signal S5. Circuit DDC_2 outputs signal S9 to indicate the detection result of whether the other end of the LED tube lamp is properly installed on the lamp socket. When the lamp is not properly installed on the lamp socket, the detected CS signal combined with the VS signal will lead to an impedance that exceeds a threshold value, and then S9 will take on one of its two possible states, which may be a logical low value state. When the lamp is properly installed on the lamp socket, the detected CS signal combined with the VS signal will lead to an impedance that is less than a threshold value, and

Claim 24	GE LED Tube LED13ABT8/G4/840 – Representative Product

then S9 will take on the other of its two possible states, which may be a logical high value state. The full process for deriving the operation of circuits DDC_1 and DDC_2 based on the teardown analysis has been stated in claim 1[b] and 1[f].

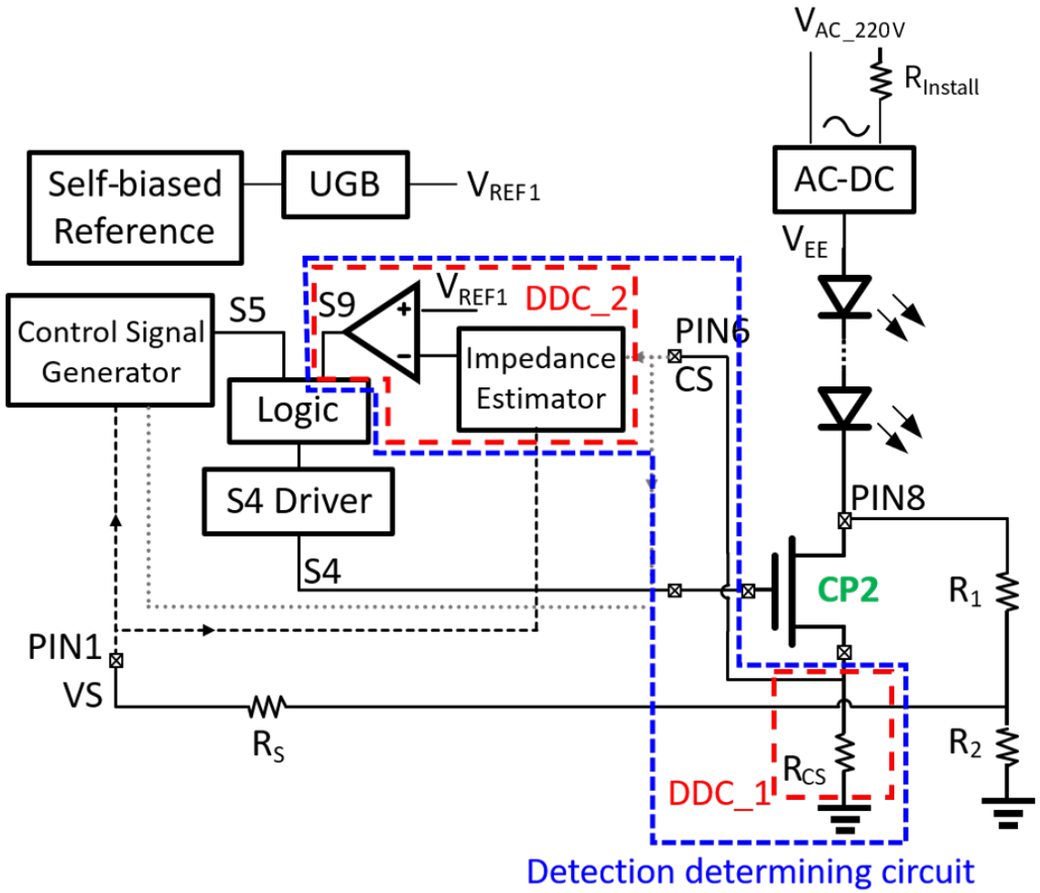
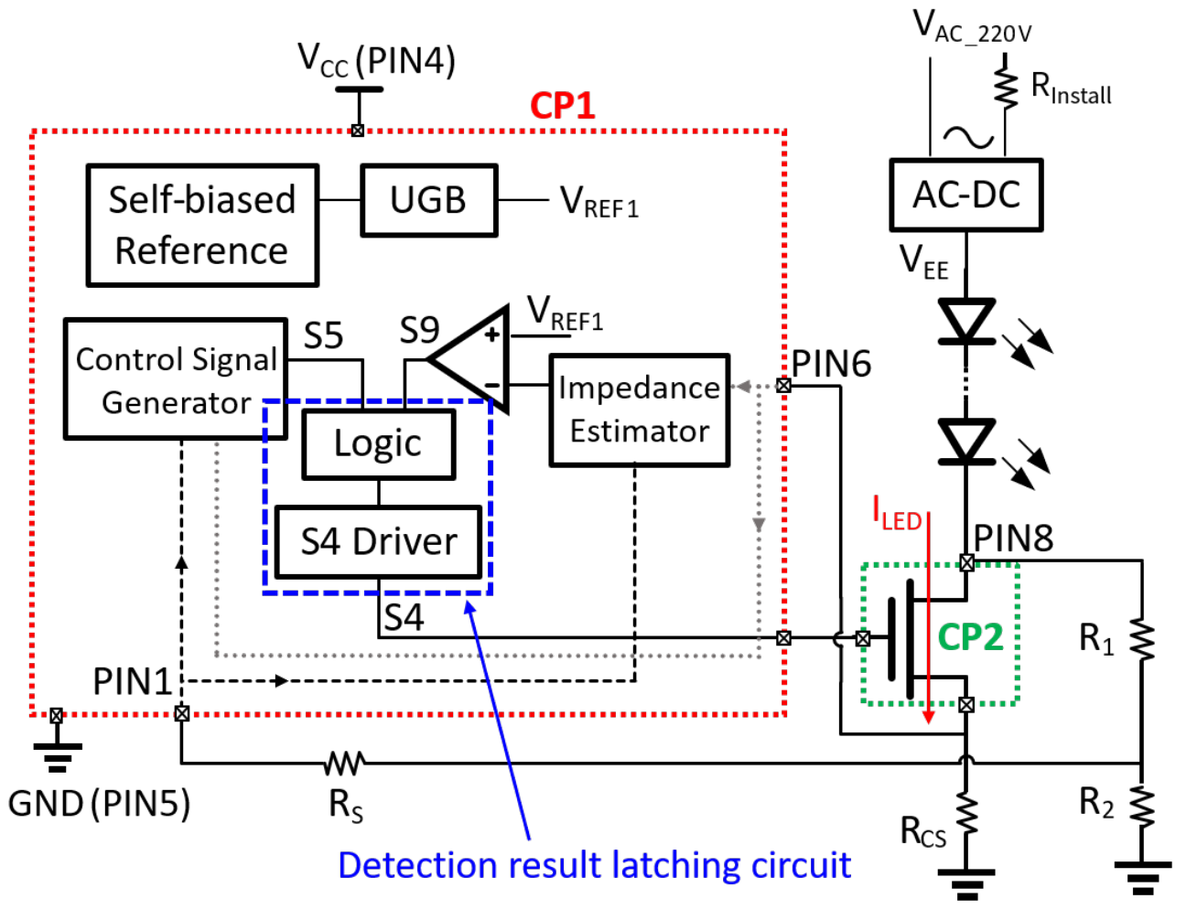


Figure 43. The detection determining circuit in the GE LED tube lamp (outlined in dashed blue line) is comprised of a circuit, DDC_1, represented by components disposed on the daughter board of the power supply module, and a circuit, DDC_2, represented by circuitry disposed in the LT2600 IC.

Therefore, for at least the reasons described above, the operation of the detection determining circuit comprised of circuits DDC_1 and DDC_2 configured in the GE LED tube lamp satisfies claim element 24[b].

Claim 24	GE LED Tube LED13ABT8/G4/840 – Representative Product
24[c] receiving the one or more pulse signals through a detection result latching circuit by a switch circuit, wherein the switch circuit is on the power loop; and	The GE LED13ABT8/G4/840 LED tube lamp contains LT2600 IC employing the step of receiving the one or more pulse signals through a detection result latching circuit by a switch circuit, wherein the switch circuit is on the power loop. For example, the digital logic and S4 driver, both outlined in dashed blue, together form a detection result latching circuit as shown in Figure 44. Switch circuit CP2 receives signal S4 output from the detection result latching circuit which is generated based on the signal S5 and S9. Before the proper installation is detected, signal S9 is low (0) and signal S4 follows pulse signal S5 (see Table 1). Therefore, switch circuit CP2 can be considered as to receive pulse signal S5 through the detection result latching circuit. The full process for deriving the operation of the digital logic and S4 driver based on the teardown analysis has been stated in claim 1[f] and 4[g].  Figure 44. Switch circuit CP2 receives S5 through the detection result latching circuit comprised of the digital logic and S4 driver, both outlined in dashed blue.

Claim 24	GE LED Tube LED13ABT8/G4/840 – Representative Product
	Therefore, for at least the reasons described above, the operation of the detection result latching circuit comprised of the digital logic and S4 driver and switch circuit CP2 configured in the GE LED tube lamp satisfies claim element 24[c].
24[d] comparing the sampling signal with a predefined signal, wherein during the one or more pulse signals	The GE LED13ABT8/G4/840 LED tube lamp contains LT2600 IC employing the step of comparing the sampling signal with a predefined signal. For example, as discussed above in claim 1[f] and 3, comparator 1 compares the output voltage of the impedance estimator with reference voltage V_{REF1}, in which the output voltage is proportional to the estimated impedance calculated based on voltage VS at PIN1 and CS signal at PIN6. Since voltage VS is a constant when the control signal generator triggers pulse signal S5, the operation of comparing the output voltage of the impedance estimator with reference voltage V_{REF1} can be considered as comparing the CS signal at PIN6 with a predefined signal. In addition, since the CS signal can be detected only when switch circuit CP2 is turned on by pulse signal during detection, the comparison proceeds during the one or more pulse signals. Therefore, for at least the reasons described above, the operation of the detection determining circuit configured in the GE LED tube lamp satisfies claim element 24[d].
24[e] when the sampling signal is smaller than the predefined signal, the detection method further comprises: controlling the switch circuit to remain in an off state to cause the power loop of the LED tube lamp to be open.	The GE LED13ABT8/G4/840 LED tube lamp contains LT2600 IC employing the step of controlling the switch circuit to remain in an off state to cause the power loop of the LED tube lamp to be open when the sampling signal is smaller than the predefined signal. For example, as discussed above in claim 1[f] and 3, when the sampling signal is smaller than the predefined signal, S9 is low, and S4 will continue to follow the waveform of S5 and CP2 will remain in an off state during low periods of the S5 pulse. Therefore, the operation of the detection result latching circuit and switch circuit CP2 configured in the GE LED tube lamp satisfies claim element 24[e]. Hence, for at least the reason stated above, the GE LED tube lamp satisfies all elements of claim 24, and therefore infringes claim 24 of the '140 patent.

Claim 28	**GE LED Tube LED13ABT8/G4/840 – Representative Product**
28. The detection method according to claim **24**, wherein a period of each of the one or more pulse signals is between 10 microseconds and 1 millisecond.	The GE LED13ABT8/G4/840 LED tube lamp satisfies claim 24 and the additional limitations added to claim 24 by claim 28 because the period of each of the one or more pulse signals generated by the detection method of claim 24 is between 10 microseconds and 1 millisecond. Timing of the one or more pulse signals generated during the detection method of claim 24 can be measured by probing the signal S4, either directly or through its impact on signals elsewhere in the circuitry. As described above with respect to claim 1[a], 1[d], 4[a], 4[d], 24[a], and 24[d], signal S4 is synchronized with the one or more pulse signals S5 generated while the lamp is not properly installed, for instance during a re-lamping test. One or ordinary skill would understand that the period of the one or more pulses is a measure of the duration of the pulse's logical high state, and thus equates to the width of the one or more pulses. To assess the period of each of the one or more pulse signals, the measurement setup shown at the top of Figure 45 was used, which includes a 500 Ω non-inductive resistor in series with the second end of the lamp and the neutral terminal of the 3-prong power supply plug. The inclusion of the 500 Ω resistor leads to an effective line resistance that is sufficiently large such that the installation detection circuit determines the lamp is not properly installed in the lamp socket, and the pulse generating circuit within the LT2600 produces one or more pulse signals, S5, which in turn generates signal S4, to periodically open the switch circuit through which loop current may briefly pass during logical high periods of the pulse, as described above with respect to claim 1. The loop current passing through the 500 Ω resistor is synchronized with S4 and the one or more pulse signals, S5, and was found to have a pulse width measured to be approximately 50 microseconds, as shown on the bottom of Figure 45. This width is between 10 microseconds and 1 millisecond.

Claim 28	GE LED Tube LED13ABT8/G4/840 – Representative Product

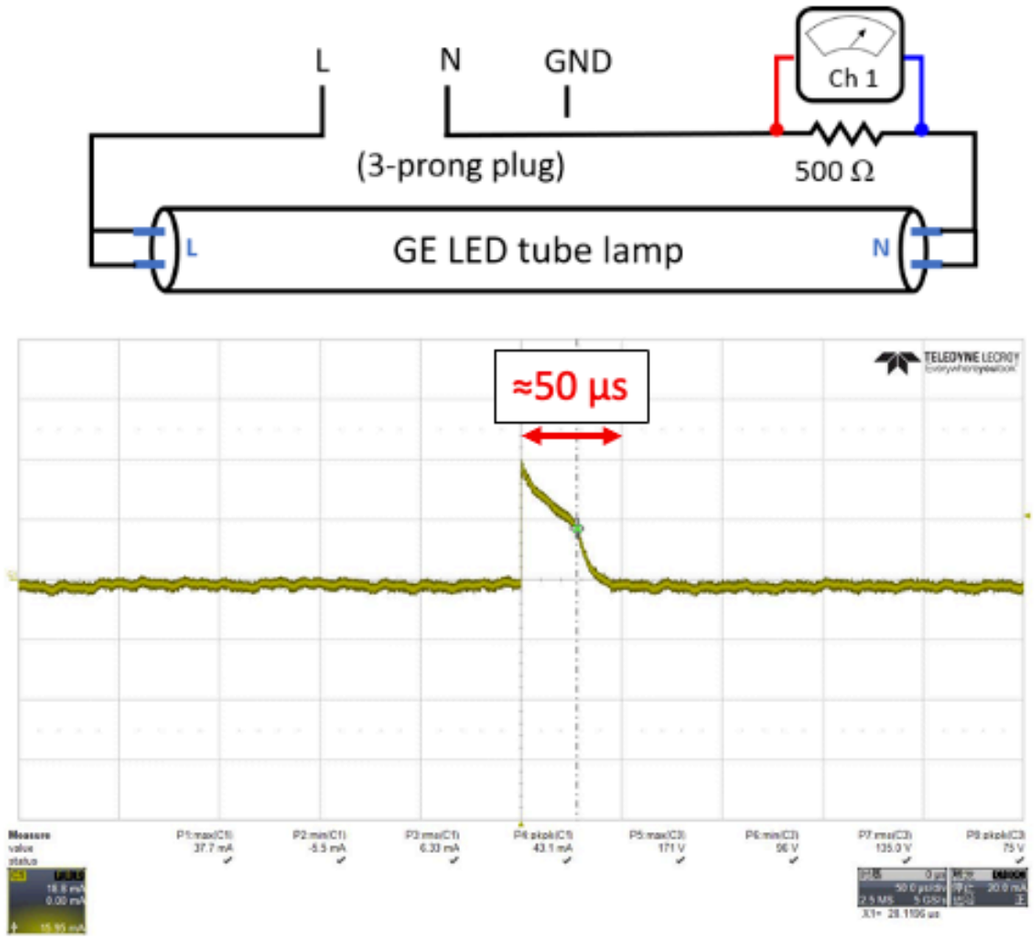


Figure 45. (Top) Schematic of measurement configuration used to assess the period of pulse signals generated in accord with the detection method of claim 24. (Bottom) The signal on channel 1 (orange) is synchronized with signal S4 and the output of the pulse generating circuit, S5, and is measured to have a period (width) of approximately 50 microseconds.

Therefore, for at least the reasons described above, the GE LED tube lamp satisfies each and every limitation of claim 24 of the ’140 Patent, as well as the additional limitations added to claim 24 by claim 28, and thus the GE LED tube lamp satisfies claim 28 of the ’140 Patent.

Claim 31	**GE LED Tube LED13ABT8/G4/840 – Representative Product**
31. The installation detection circuit according to claim **1**, further comprising a detection result latching circuit coupled to the switch circuit, wherein the detection result latching circuit is configured to receive the one or more pulse signals to control turning on and off of the switch circuit based on a detection result signal from the detection determining circuit.	See claim elements 1[a] through 1[f], claim 3, and claim element 4[g]. Also see Claim 23. The detection result latching circuit receives control signal S5 as an input. S5 is the one or more pulse signals from the pulse generating circuit. Input S5 can control the turning on and off of the switch circuit based on the result of a detection determining signal, S9, because the detection result latching circuit is coupled to the gate terminal of the switch circuit, CP2. Thus the GE LED tube lamp satisfies all elements of claim 1, and further satisfies all additional limitation added to claim 1 by claim 31, and therefore infringes claim 31 of the ’140 Patent.

Claim 35	**GE LED Tube LED13ABT8/G4/840 – Representative Product**
35. The installation detection circuit according to claim 1, wherein a period of each of the one or more pulse signals is between 1 microsecond and 1 millisecond.	The GE LED13ABT8/G4/840 LED tube lamp satisfies claim 24 and the additional limitations added to claim 24 by claim 28 because the period of each of the one or more pulse signals generated by the detection method of claim 24 is between 10 microseconds and 1 millisecond. Timing of the one or more pulse signals generated during the detection method of claim 24 can be measured by probing the signal S4, either directly or through its impact on signals elsewhere in the circuitry. As described above with respect to claim 1[a], 1[d], 4[a], 4[d], 24[a], and 24[d], signal S4 is synchronized with the one or more pulse signals S5 generated while the lamp is not properly installed, for instance during a re-lamping test. One or ordinary skill would understand that the period of the one or more pulses is a measure of the duration of the pulse’s logical high state, and thus equates to the width of the one or more pulses. To assess the period of each of the one or more pulse signals, the measurement setup shown at the top of Figure 46 was used, which includes a 500 Ω non-inductive resistor in series with the second end of the lamp and the neutral terminal of the 3-prong power supply plug. The inclusion of the 500 Ω resistor leads to an effective line resistance that is sufficiently large such that the installation detection circuit determines the lamp is not properly installed in the lamp socket, and the pulse generating circuit within the LT2600 produces one or more pulse signals, S5, which in turn generates signal S4, to periodically open the switch circuit through which loop current may briefly pass during logical high periods of the pulse, as described above with respect to claim 1. The loop current passing through the 500 Ω resistor is synchronized with S4 and the one or more pulse signals, S5, and was found to have a pulse width measured to be approximately 50 microseconds, as shown on the bottom of Figure 46. This width is between 10 microseconds and 1 millisecond.

Claim 35	GE LED Tube LED13ABT8/G4/840 – Representative Product

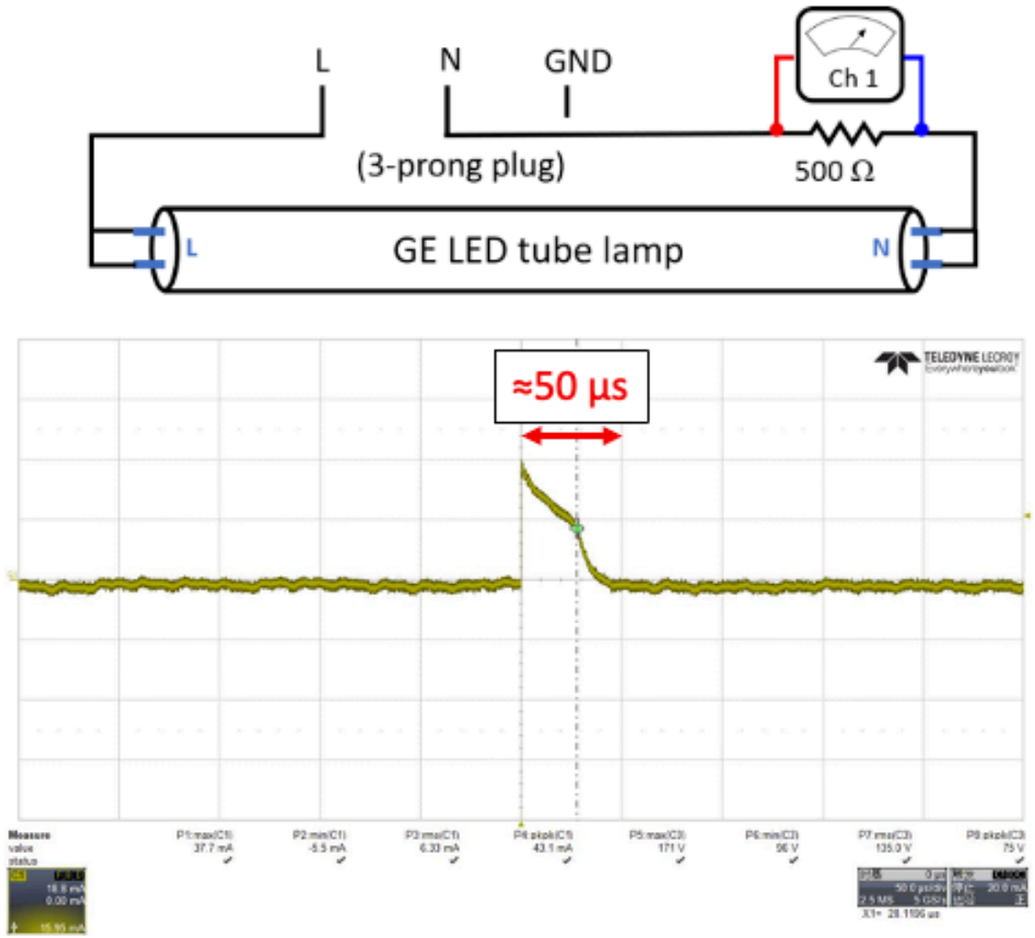


Figure 46. (Top) Schematic of measurement configuration used to assess the period of pulse signals generated in accord with the detection method of claim 24. (Bottom) The signal on channel 1 (orange) is synchronized with signal S4 and the output of the pulse generating circuit, S5, and is measured to have a period (width) of approximately 50 microseconds.

For at least the reason stated above, the GE LED tube lamp satisfies all elements of claim 1, and further satisfies all additional limitation added to claim 1 by claim 35, and therefore infringes claim 35.

Annotations to the figures in this chart are preliminary and illustrative only, and are not final or intended to limit Plaintiffs’ identification of claim elements in the accused products. Plaintiff may change, expand, modify or narrow its identification of claim elements in the accused products as it develops further facts as a part of this action.