

Claim Chart B2

Infringement of claims 1, 2, 3, 5, 10, 11, 12, 16, 17, 18, 23, 25, 26, 27, 28, 29, and 32 of U.S. Patent No. 9,841,174 (the '174 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 '174 Patent.

Claim 1	GE LED Tube LED13ABT8/G4/830 – Representative Product																								
1[pre] A light-emitting diode (LED) tube lamp, comprising:	The GE LED13ABT8/G4/830, 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). Type A+B Dual Mode LED Tubes T8 Glass 4' LED Tube  Project Name _____ Date _____ Type _____ Notes _____ Current's Type A+B Dual Mode LED Tube is the perfect tool to simplify inventory and prepare installers to minimize installation time with Type A or pivot to Type B upon compatibility challenges. Options at install, and the ability to convert from Type A to Type B after install (once the ballast expires) make this the perfect solution for distributors, installers, and end-users that are targeting the simplicity of Type A plug & play, but also want to be prepared for the unexpected by simply bypassing the ballast. One product, Two Modes, Zero Frustrations. PERFORMANCE HIGHLIGHTS: <table><tr><td>Light Output Range:</td><td>1850-1950 Lumens</td></tr><tr><td>CRI:</td><td>80</td></tr><tr><td>CCT:</td><td>3000K, 3500K, 4000K & 5000K</td></tr><tr><td>Input Voltage:</td><td>120-277V</td></tr><tr><td>Efficiency:</td><td>Up to 150 LPW</td></tr><tr><td>Wattage:</td><td>13W</td></tr><tr><td>Life:</td><td>50,000 hours L70</td></tr><tr><td>Temperature Rating:</td><td>-20°C to +45°C</td></tr><tr><td>Rating:</td><td>Damp</td></tr><tr><td>Fixtures:</td><td>Open or Enclosed</td></tr><tr><td>Ballast Compatibility Guide:</td><td>gecurrent.com/LEDTUBES-ballast-compatibility</td></tr><tr><td>Certification:</td><td>DLC Listed</td></tr></table> FEATURES: • Savings up front and in the future with Type A Plug & Play and future ballast bypass • Simplifies stocking & Install with Type A and Type B modes • Provides options at install and after to rewire once ballast reaches end of life, maximizing life of lamp • Type A Plug & Play-No wiring • Type B Double Ended-works on shunted or unshunted sockets • Safety First-built in protection for installers and end-users	Light Output Range:	1850-1950 Lumens	CRI:	80	CCT:	3000K, 3500K, 4000K & 5000K	Input Voltage:	120-277V	Efficiency:	Up to 150 LPW	Wattage:	13W	Life:	50,000 hours L70	Temperature Rating:	-20°C to +45°C	Rating:	Damp	Fixtures:	Open or Enclosed	Ballast Compatibility Guide:	gecurrent.com/LEDTUBES-ballast-compatibility	Certification:	DLC Listed
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Figure 1. Spec sheet for GE Type A+B Dual Mode LED Tubes LED13ABT8/G4/830.

Claim 1	GE LED Tube LED13ABT8/G4/830 – Representative Product
1[a] a lamp tube; two end caps, each having an external connection terminal, and each coupled to a respective end of the lamp tube, wherein the external connection terminals are configured to receive an external driving signal;	The GE LED13ABT8/G4/830 is a light emitting diode (LED) tube lamp comprising a lamp tube as well as two end caps, each having an external connection terminal, and each coupled to a respective end of the lamp tube, wherein the external connection terminals are configured to receive an external driving signal. For example, the photographs in Figure 2 illustrate that the GE LED13ABT8/G4/830 comprises a lamp tube. 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 left and right photos show the two opposing ends of a GE LED13ABT8/G4/830 LED tube lamp. Each end includes an end cap 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. 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. Figure 2. Photos of the GE LED13ABT8/G4/830 LED tube lamp showing a central portion comprising a lamp tube (Top), and two end caps, each having an external connection terminal, and each coupled to a respective end of the lamp tube (bottom left and right). 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.

Claim 1	GE LED Tube LED13ABT8/G4/830 – Representative Product 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). Thus, as detailed above, the GE LED13ABT8/G4/830 light-emitting diode (LED) tube lamp comprises a lamp tube with two end caps affixed to the respective opposing ends of the lamp tube, wherein each end cap includes an external connection terminal configured to receive an external driving signal. Therefore, the GE LED13ABT8/G4/830 satisfies claim element 1[a] of the '174 Patent.
1[b] a rectifying circuit, coupled to the external connection terminals, for rectifying the external driving signal to produce a rectified signal;	The GE LED13ABT8/G4/830 includes a rectifying circuit, coupled to the external connection terminals, for rectifying the external driving signal to produce a rectified signal. For example, the GE LED13ABT8/G4/830 can be operated in either Type A or Double-Ended Type B mode, as explained above. The equivalent circuit diagram of the GE LED13ABT8/G4/830 power supply module shown in Figure 4 was generated based on the teardown and analysis of the product exhibited in this claim chart. The power supply module includes shock protection integrated circuit LT2600.

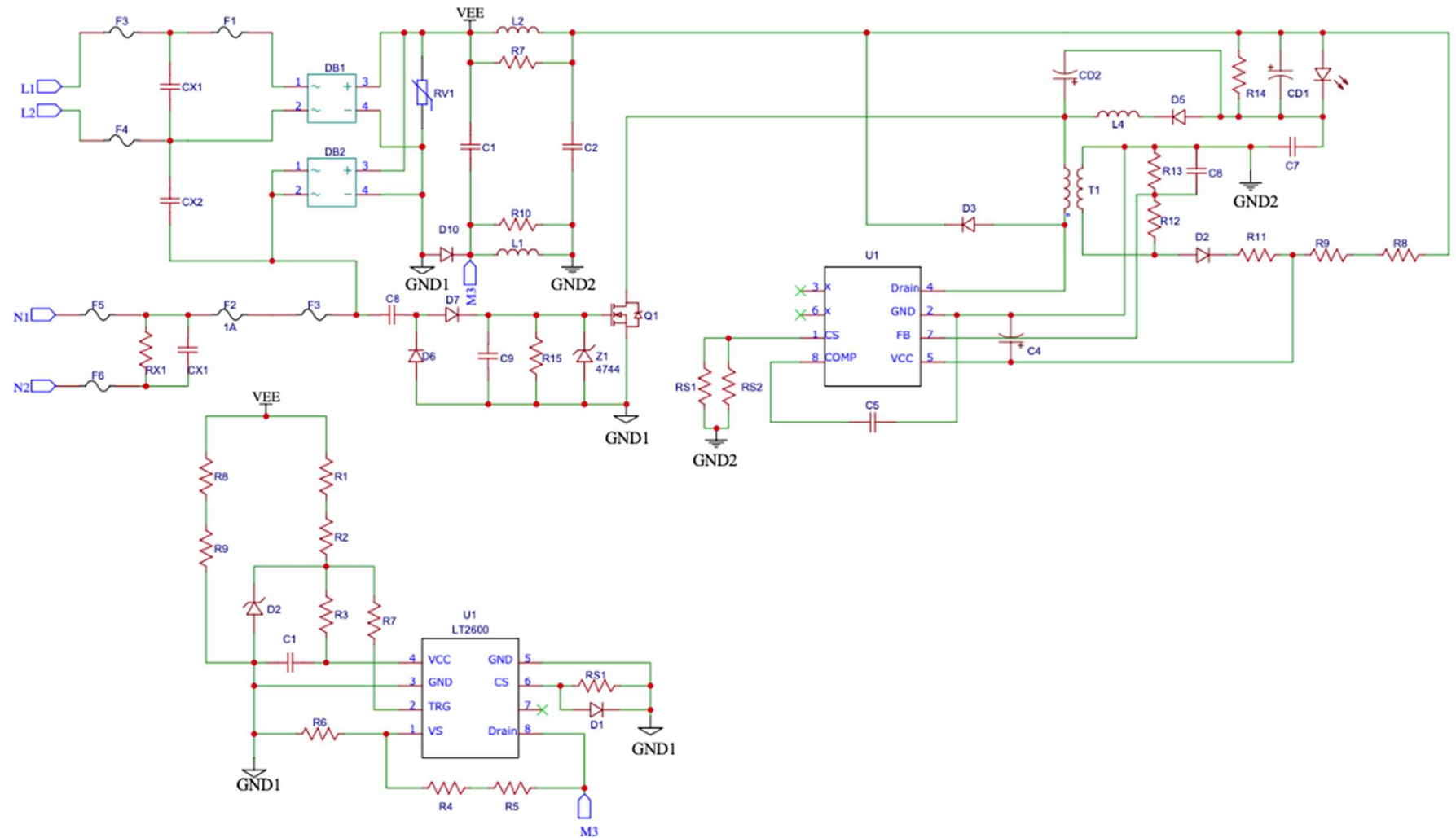
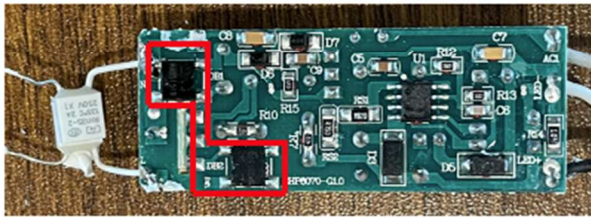
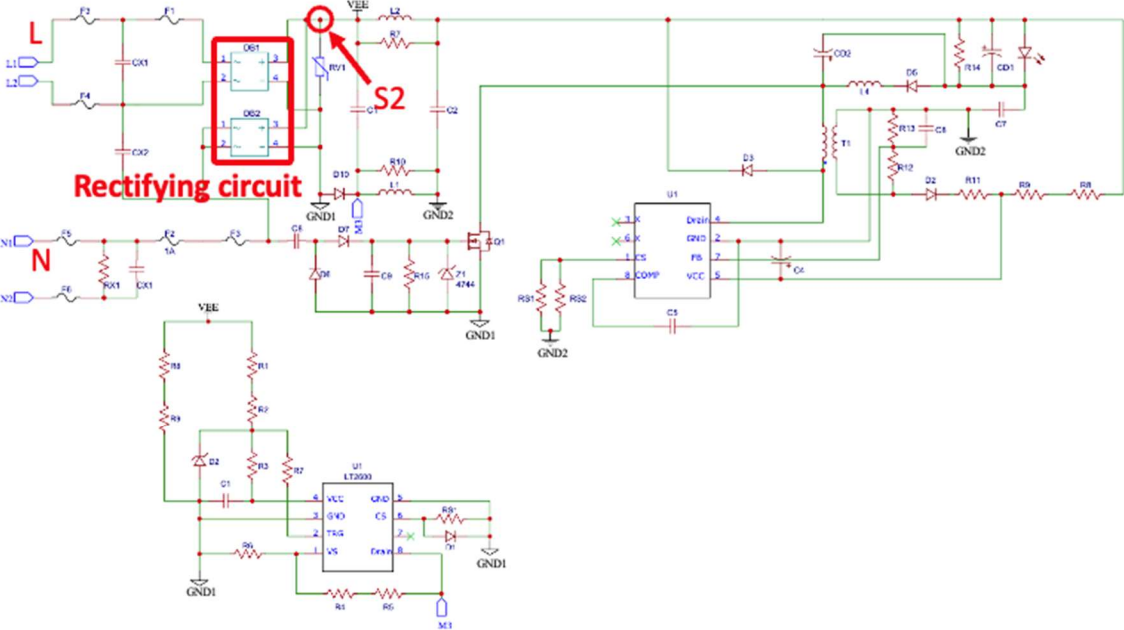


Figure 4. Equivalent circuit diagram of the GE LED13ABT8/G4/830 containing the LT2600 shock protection IC.

The top side of the main circuit board in the GE LED13ABT8/G4/830 LED tube lamp is shown in the top left of Figure 5 along with indicators noting where the external connection terminals are attached to the PCB. Two 4-pin packages respectively labeled as DB1 and DB2, outlined in red on both the circuit diagram (top right) and the bottom side of the circuit board (bottom left), is a bridge rectifier which forms the claimed rectifying circuit.

Claim 1	GE LED Tube LED13ABT8/G4/830 – Representative Product
	Top Side of Circuit Board  Bottom Side of Circuit Board   Figure 5. (Top left) Top of main PCB. (Bottom left) Bottom of main PCB. (Right) Equivalent circuit schematic of the circuit board in the GE LED13ABT8/G4/830 LED tube lamp. When an external driving signal is received by two external lamp terminal connections, L1/L2 and N1/N2, the components outlined in red represents a rectifying circuit with an output at node S2. The rectifying circuit receives the external driving signal from external connection terminals. For example, when an external driving signal is received by the GE LED13ABT8/G4/830 LED lamp tube in a double-ended configuration on L and N, the rectifying circuit performs the function of rectifying the external driving signal that is applied to the terminal pins L1 and N1. The rectified signal produced as a result of the rectifying circuit is output at the node S2. Note that the terminal labels printed on the lamp end caps are used here rather than the labels printed on the circuit board. Thus, for at least the reasons described above, the GE LED13ABT8/G4/830 LED tube lamp includes a rectifying circuit, coupled to the external connection terminals, for rectifying the external driving signal to produce a rectified signal, and therefore the GE LED13ABT8/G4/830 LED tube lamp satisfies all requirements of claim element 1[b] of the '174 Patent.
1[c] A filtering circuit, coupled to the rectifying circuit, for filtering the rectified signal to produce a filtered signal;	The GE LED13ABT8/G4/830 includes a filtering circuit, coupled to the rectifying circuit, for filtering the rectified signal to produce a filtered signal.

Claim 1	GE LED Tube LED13ABT8/G4/830 – Representative Product
	For example, capacitors C1 and C2 together with inductors L1 and L2 and resistors R7 and R10 form a filtering circuit, outlined in blue on both the photo of the circuit board and on the equivalent circuit diagram in Figure 6, which receives the rectified signal at S2 from the rectifying circuit (outlined in red) and outputs a filtered signal at S3.

Claim 1	GE LED Tube LED13ABT8/G4/830 – Representative Product
	The driving circuit receives the output of the filtering circuit as an input at node S3 (outlined in blue box in Figure 7). Thus, the driving circuit can be regarded as coupled to the filtering circuit, for converting the filtered signal into a driving signal where, under normal operating conditions, the driving circuit will receive the filtered signal from the filtering circuit as an input and the driving circuit will convert this to a driving signal, configured to drive the LED module at S1. The figure consists of three parts. On the top left is a photograph of the top side of a green printed circuit board (PCB) with various electronic components like capacitors, resistors, and a transformer. A pink rectangular box highlights a specific area on the board. On the bottom left is a photograph of the bottom side of the same PCB, showing components like a transformer, capacitors, and a microcontroller. A pink rectangular box highlights a specific area. On the right is a detailed circuit schematic. It shows a 'Rectifying circuit' (outlined in red) connected to a 'Filtering circuit' (outlined in blue). The output of the filtering circuit is at node S3. This node S3 is connected to the input of a 'Driving circuit' (outlined in pink). The driving circuit includes an LT2960 IC and various passive components. The output of the driving circuit is at node S1, which is connected to an LED module. Figure 7. ((Top left) Top of main PCB. (Bottom left) Bottom of main PCB. (Right) Equivalent circuit schematic showing driving circuit (outlined in pink) is coupled between the filtering circuit (outlined in blue) and terminals LED+ and LED- for connecting the LED module. Thus, the GE LED13ABT8/G4/830 tube lamp includes a driving circuit, coupled to the filtering circuit, for converting the filtered signal into a driving signal. Therefore, the GE LED13ABT8/G4/830 tube lamp satisfies all requirements of claim element 1[d] of the '174 Patent.
1[e] an LED module, coupled to the driving circuit, for emitting light based on the driving signal; and	The GE LED13ABT8/G4/830 tube lamp includes an LED module, coupled to the driving circuit, for emitting light based on the driving signal. The driving signal, output by the driving circuit at S1 (marked on the right side of Figure 8), serves as the input for the LED module and drives the LED module to emit light based on said signal. The driving circuit thus connects directly to the LED module via the terminals to the LED light strip.

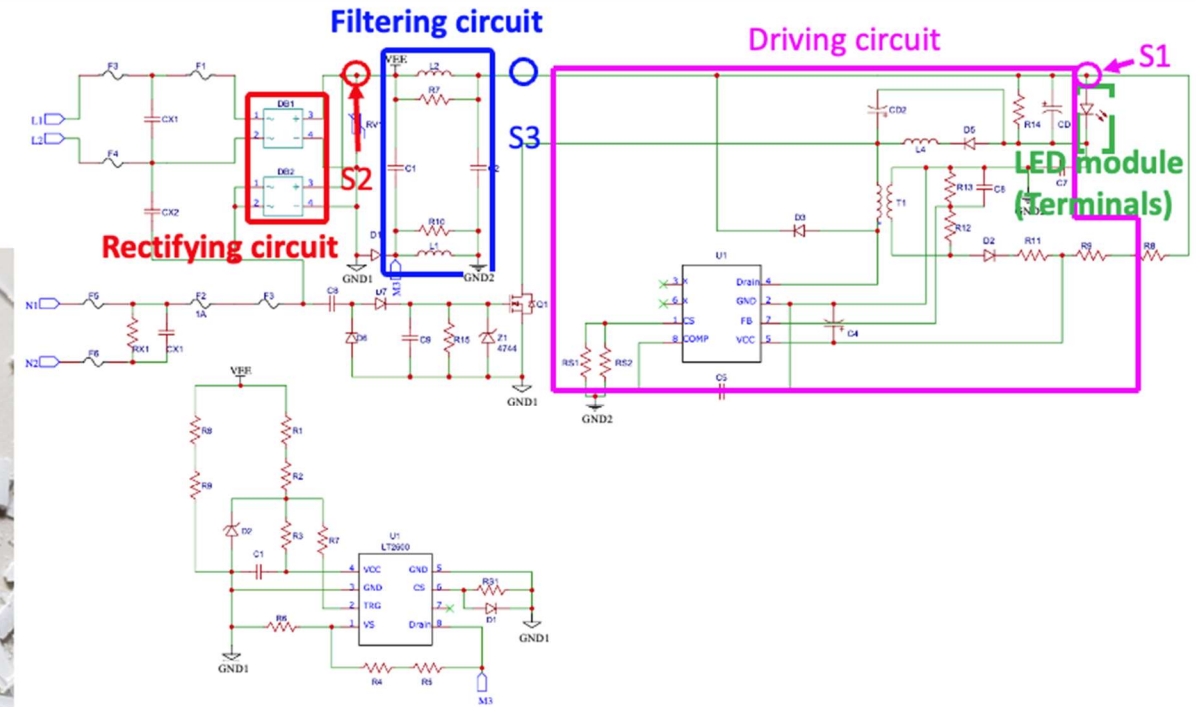
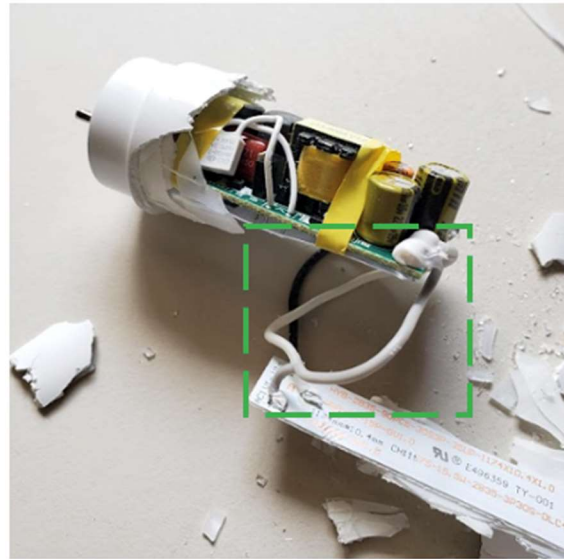
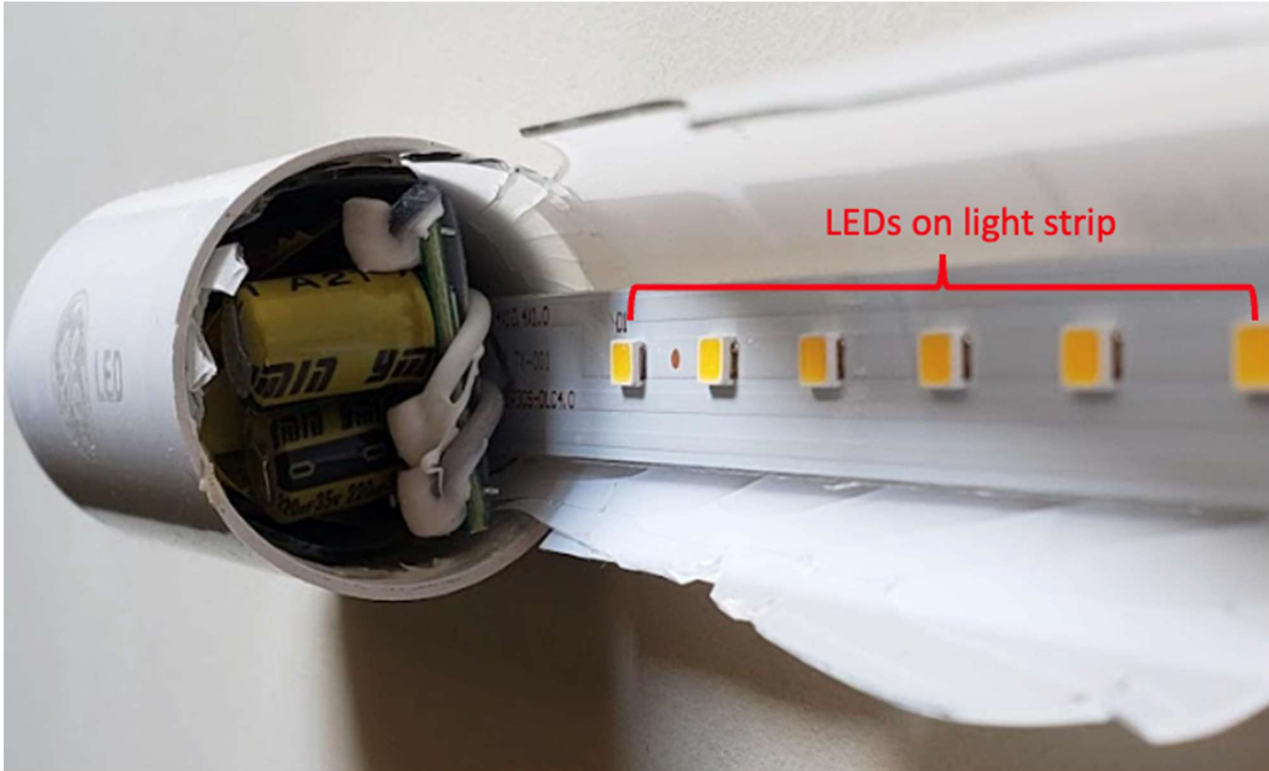
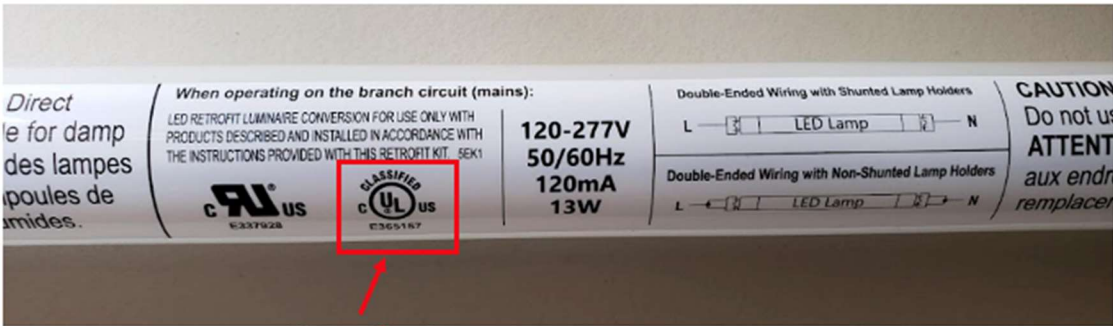


Figure 8. (Left) Photograph illustrating connections between the LED light strip and the power supply module of GE LED13ABT8/G4/830. (Right) Equivalent circuit schematic showing driving circuit (outlined in pink) is coupled to the LED module (LED module terminals outlined in dashed green line) and drives the LED module to emit light based on the driving signal.

The LED light strip, positioned inside of the lamp tube, contains many surface mount LEDs as indicated by the arrows in Figure 9.

Claim 1	GE LED Tube LED13ABT8/G4/830 – Representative Product
	 Figure 9. Photo of the inside of GE LED13ABT8/G4/830 showing a portion of the LED light strip with a linear array of individual LEDs. Thus, for the reasons detailed above, the GE LED13ABT8/G4/830 tube lamp satisfies claim element 1[e] of the '174 patent.
1[f] an installation detection module, configured to detect an installation state between the LED tube lamp and a lamp socket,	The GE LED13ABT8/G4/830 includes an installation detection module, configured to detect an installation state between the LED tube lamp and a lamp socket. The UL certification labels printed on the label affixed to the GE LED13ABT8/G4/830 lamp tube (as shown in Figure 10) indicate that the lamp is capable of providing electric shock protection for a user when touching or installing the GE LED tube lamp in a lamp socket. That is, the power supply circuitry of the lamp is configured such that when the GE LED13ABT8/G4/830 is properly connected to a lamp socket, current conducts through the lamp and causes the LEDs to illuminate; and when the GE LED13ABT8/G4/830 is not properly connected to a lamp socket, the lamp circuitry prevents the LED module illuminating. Thus, the lamp is configured to differentiate between a proper installation state and an improper installation state between the LED tube lamp and a lamp socket.



UL certification

Figure 10. Photo of text printed on the GE LED13ABT8/G4/830 LED tube lamp showing that the product has passed UL certifications.

The circuitry in the lamp that is configured to detect an installation state is the claimed installation detection module. The power supply module disposed in an end cap of the GE LED13ABT8/G4/830 LED tube lamp is shown in Figure 11. A smaller daughter board connected to a main PCB in the power supply module includes the claimed installation detection module, outlined in red, which includes the LT2600 IC (also shown on the right side of Figure 11). The top/first and bottom/second sides of the daughter board are shown in the top right side of this figure, below which are close up images of the circuit components contained in the installation detection module.

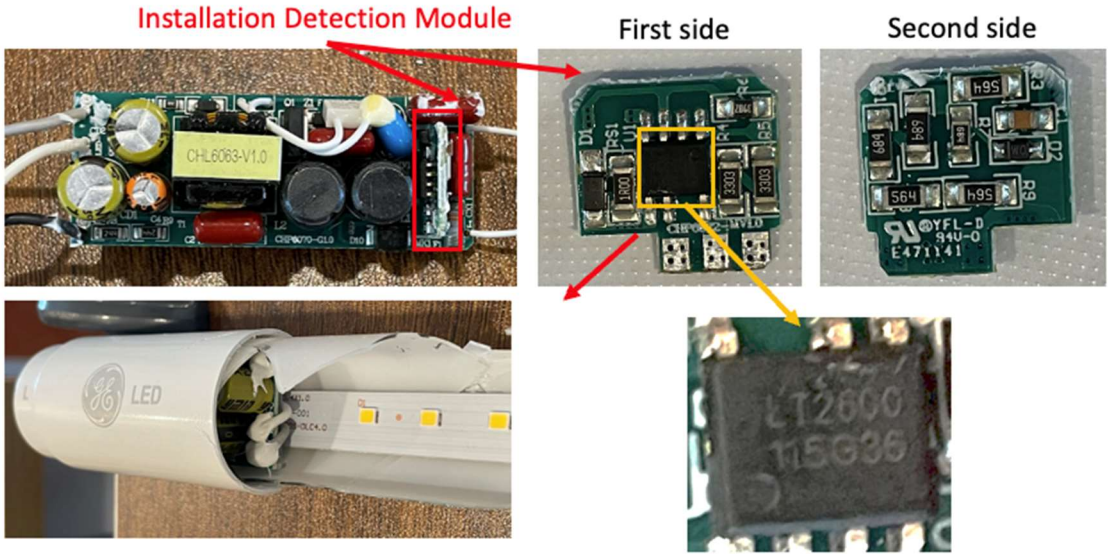


Figure 11. (Top left) Power supply module comprised of main circuit board and daughter board, outlined in red and identified as the claimed installation detection module. (Bottom left) Photo illustrates how the GE power supply module is disposed inside of an end cap of the lamp tube. (Top right) Photos of the first and second sides of the daughter board, labeled CHP6072-MV1.0, comprising the claimed installation detection module. (Bottom right) Integrated circuit on the GE daughter board.

Claim 1

GE LED Tube LED13ABT8/G4/830 – Representative Product

The equivalent circuit diagram of the GE LED13ABT8/G4/830 power supply module is shown in Figure 12. The portion of the schematic corresponding to the installation detection module is outlined in red.

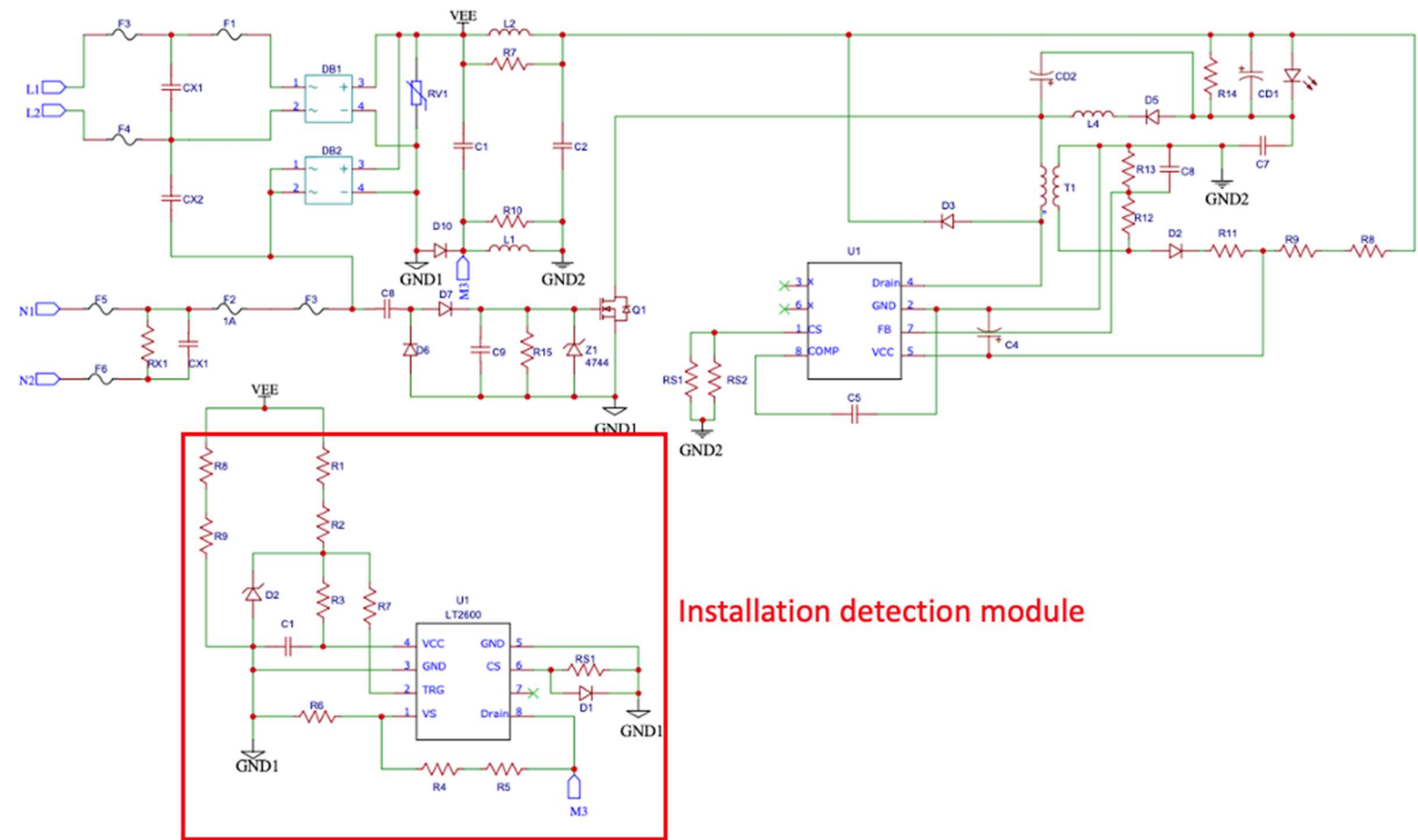


Figure 12. Equivalent circuit schematic of the circuit board in the GE LED13ABT8/G4/830 LED tube lamp. The installation detection module is represented by the portion of the diagram outlined in red.

The circuit board in the power supply module of the GE LED13ABT8/G4/830 includes the 8-pin integrated circuit package identified as a LT2600, which plays a central role in detecting the installation state between the LED tube lamp and a lamp socket. Figure 13 shows an X-ray image of the LT2600 as well as an optical microscope image of the decapsulated package illustrating that the LT2600 contains 2 chips, labeled here as CP1 and CP2.

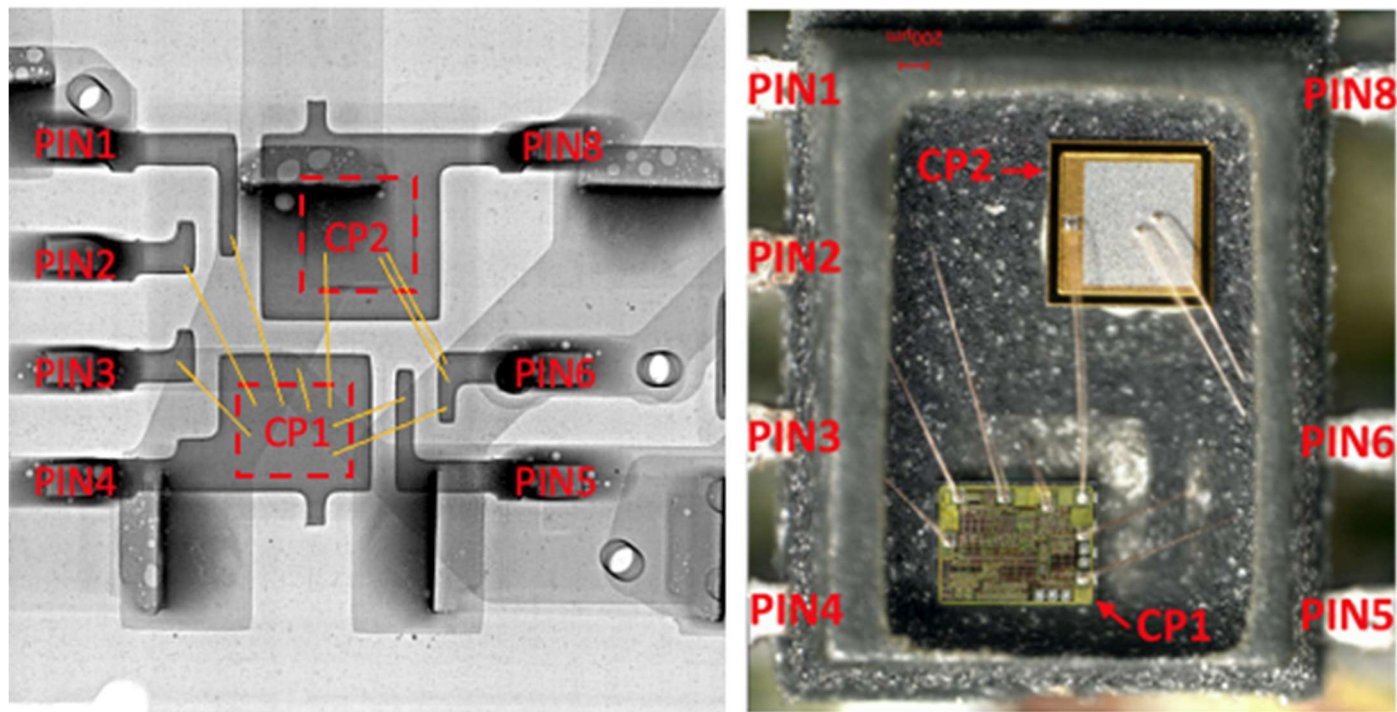


Figure 13. (Left) X-ray image of the LT2600 IC on the CHP6072-MV1.0 daughter board showing two chips, labeled as CP1 and CP2. Wire bonds between chips and the package pin outs are highlighted in yellow for visibility. (Right) Optical micrograph of decapped LT2600 on the daughter board.

An optical micrograph of chip CP1 in the LT2600, with the bonding wires removed, is shown on the left side of Figure 14. The right side of Figure 14 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 (Senio Corp). Further, 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 B1 and B2.

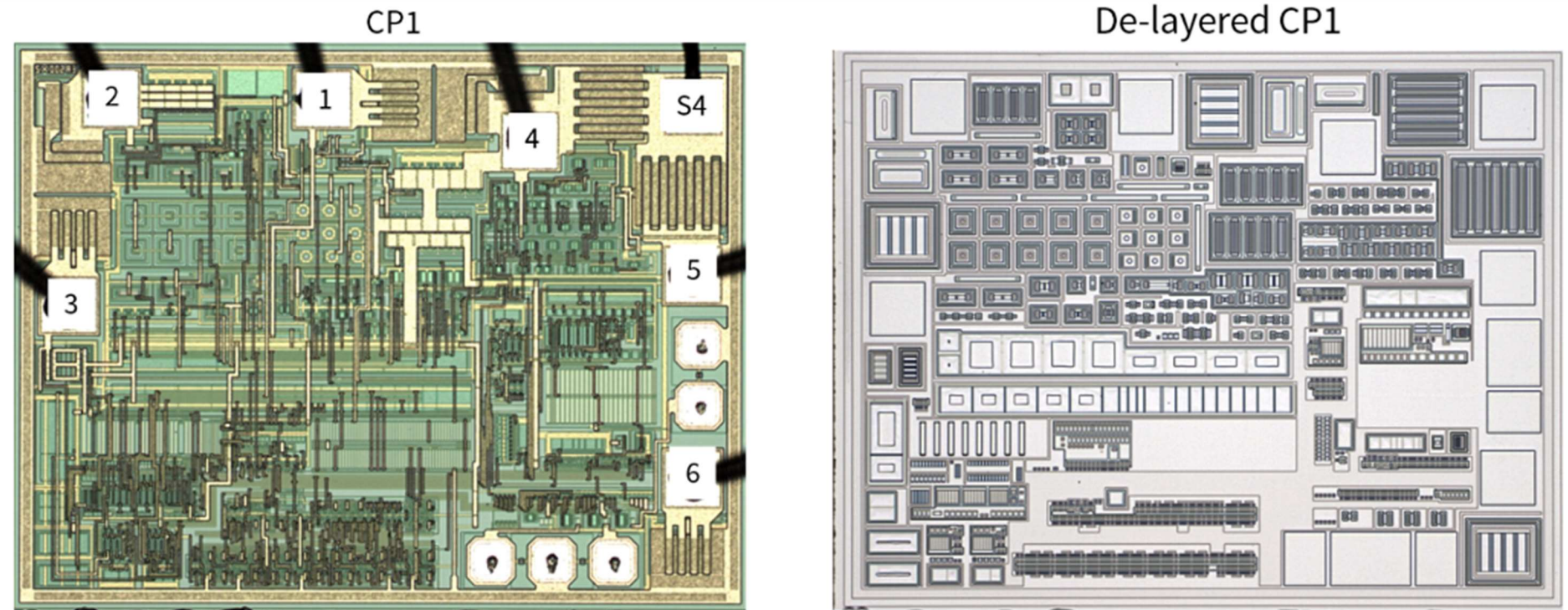


Figure 14. (Left) Optical micrograph of CP1 with wire bonds removed. (Right) Optical micrograph of CP1 after de-layering process to remove metallic traces and insulating layers.

High-resolution optical microscopy provided 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 15 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 15 exhibits images of CP1 in an LT2600.

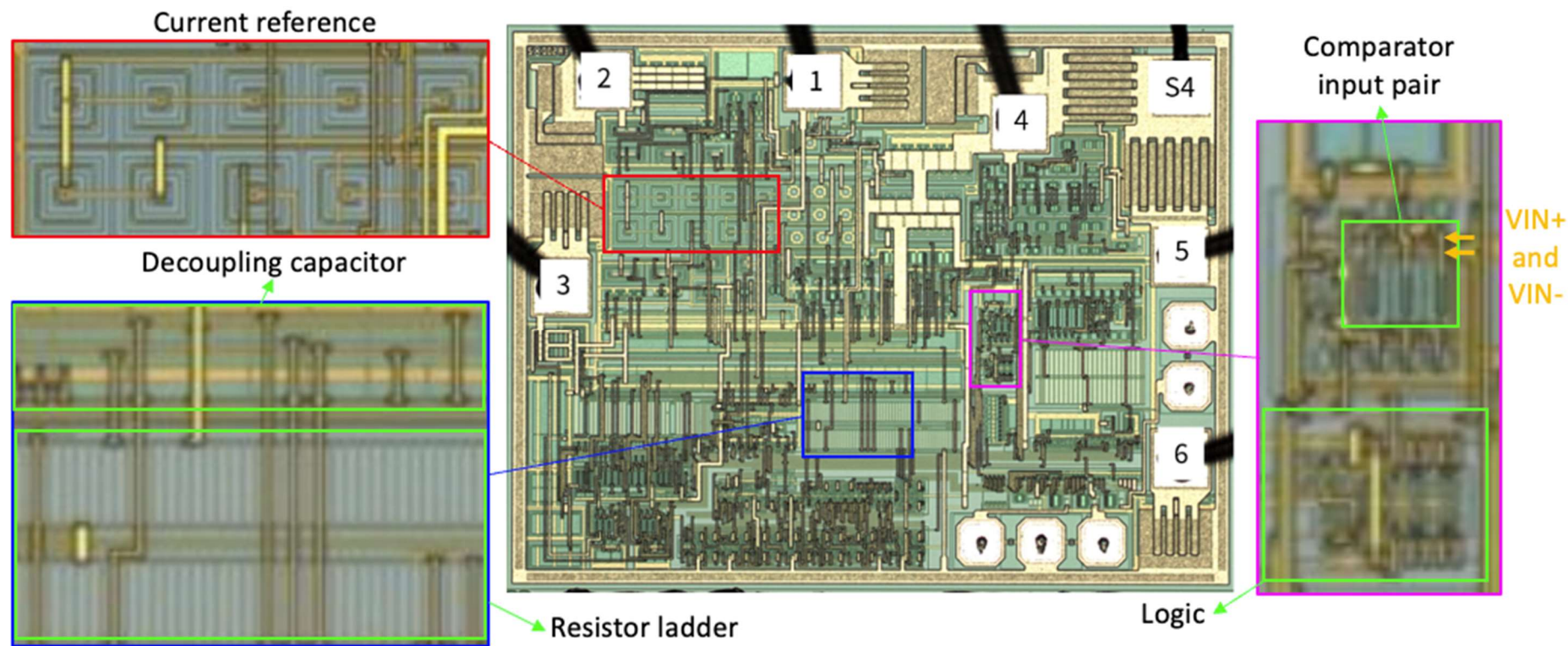


Figure 15. Integrated circuit components are identified on the CP1 die of an LT2600.

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 16 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.

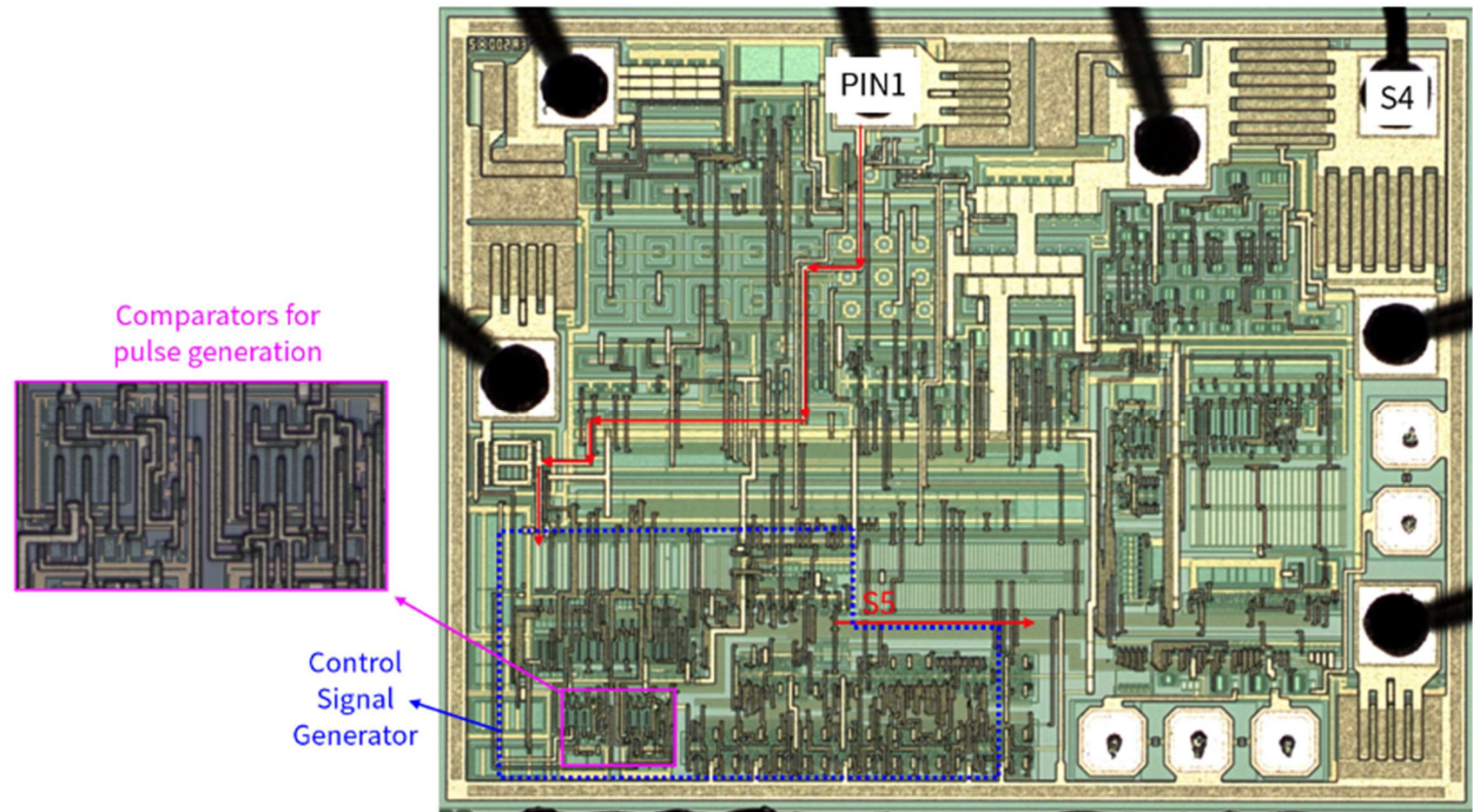


Figure 16. Image of CP1 die in an LT2600 (right). Signal traces from PIN1 serves as input for the pulse generator, which outputs signal S5. Close up image of comparators in the pulse generator of an LT2600.

Figure 17 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.

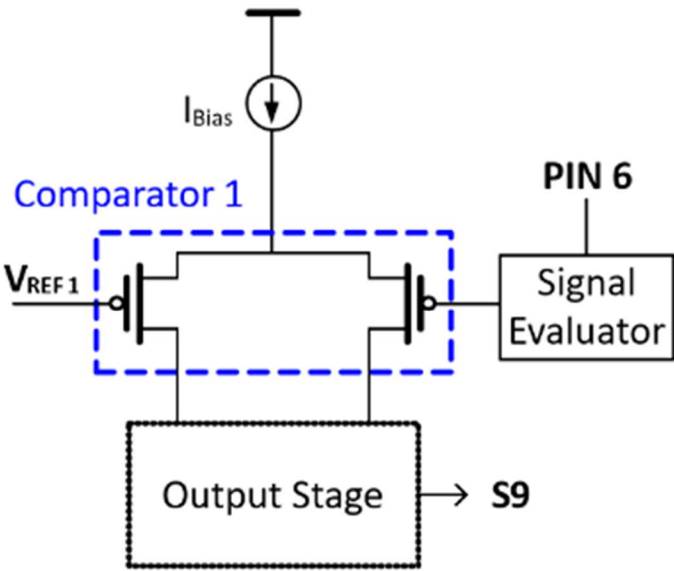
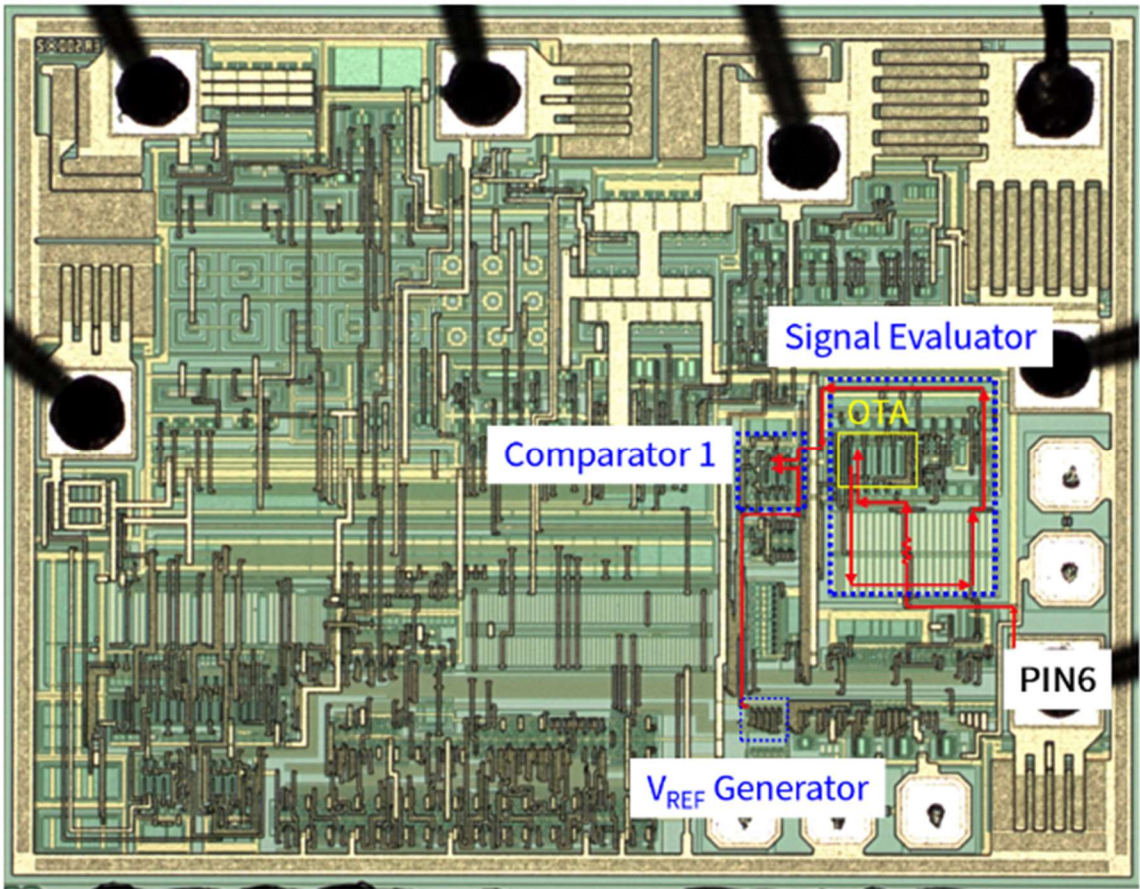


Figure 17. Signal traces from the output of the signal evaluator circuit and a voltage reference, V_{REF1} , provide a pair of input signals to comparator 1, which outputs signal S9.

In Figure 18, the S5 signal (orange trace) and S9 signal (magenta trace) serve as inputs for the logic blocks in the top right where they are processed and combined to generate a digital signal that is utilized as an input for the S4 driver.

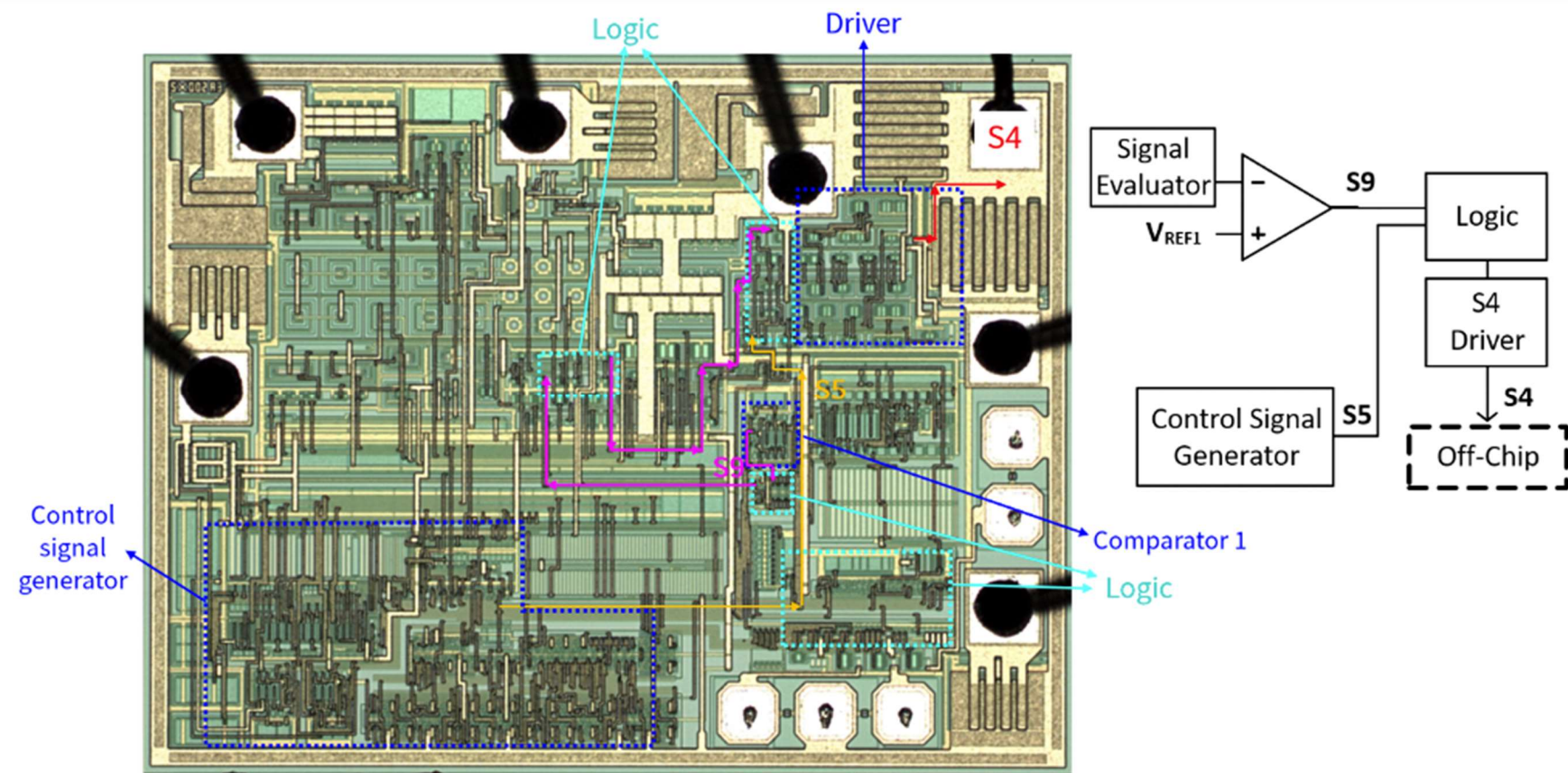


Figure 18. Signal traces from comparator 1 and the pulse generator provide S9 and S5, respectively, as input signals for the digital logic circuitry, which outputs a signal to the S4 driver.

The S4 driver receives an input in the form of a digital signal, via the logic circuitry, provided along the trace identified in Figure 18, 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 19 exhibits close up views of the 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.

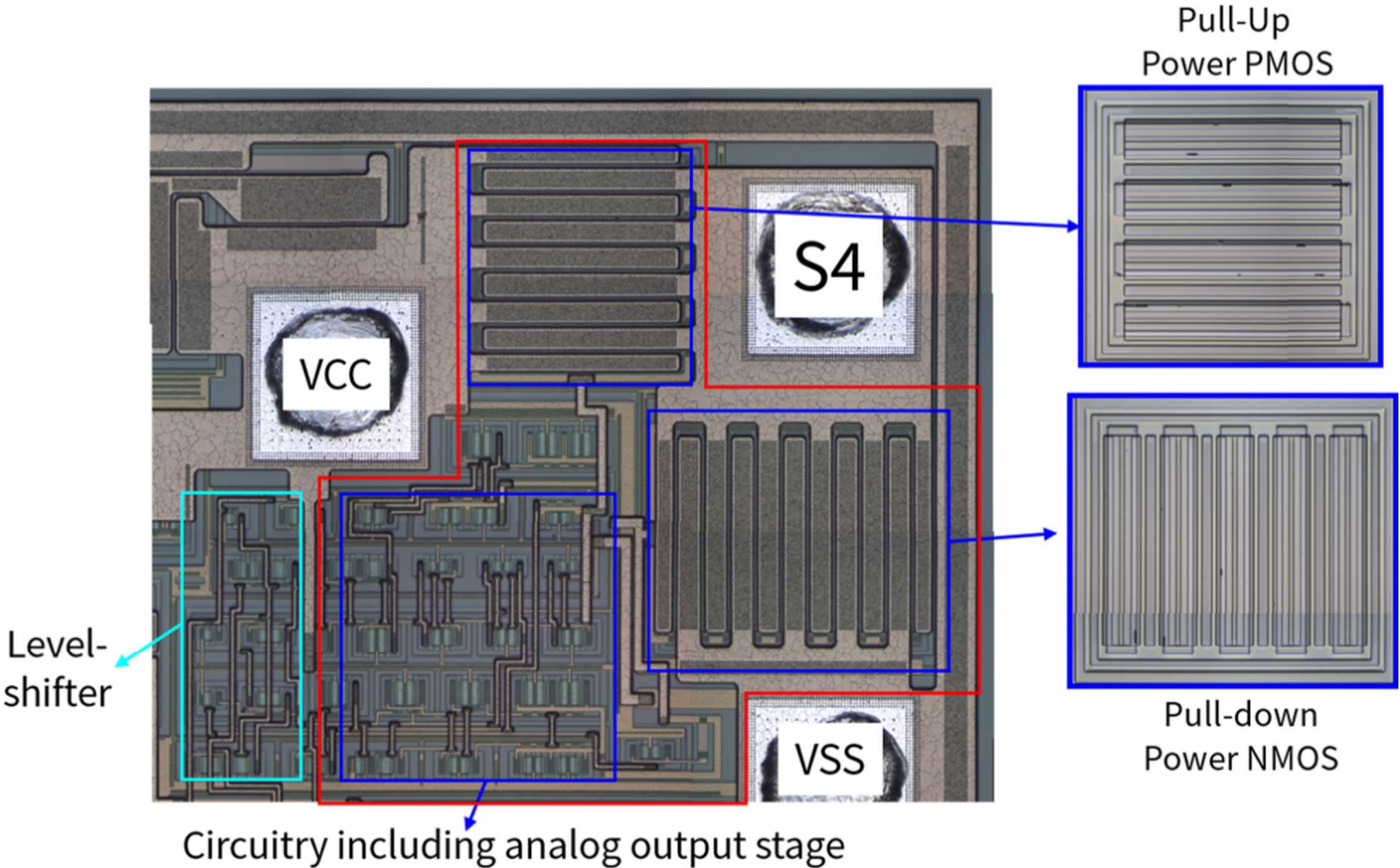


Figure 19. The S4 driver consists of sub-components including a digital input stage, deadtime generator, analog output stage, and large pull-up and pull-down transistors near the S4 pad.

The diagram in Figure 20 provides a simplified system schematic overview of the installation detection module in the context of the GE LED13ABT8/G4/830 LED 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.

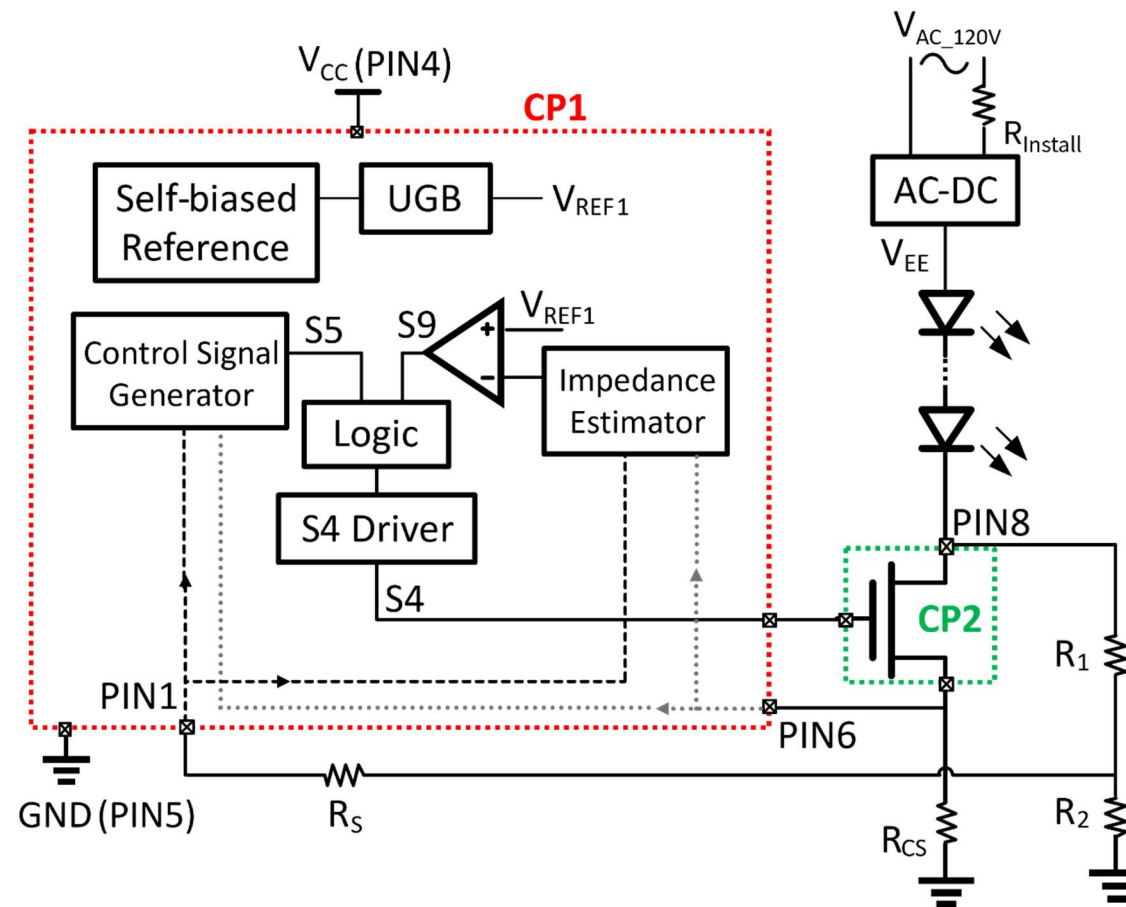


Figure 20. Simplified schematic showing system overview of the installation detection module. Comparator 1 follows the impedance estimator, which includes the signal evaluator shown in Figure 17. The output of comparator 1 and the output of the control signal generator are both used as inputs for the subsequent logic circuitry.

The installation detection module in the GE LED13ABT8/G4/830 LED tube lamp detects the installation state between the LED tube and the lamp socket by sensing a signal at PIN6 related to the current passing through resistor RS1 and diode D1 (together referred to as R_{CS}), as highlighted in Figure 21 on the circuit board (left) and on the equivalent circuit diagram (right). In this context, the “state” of the installation corresponds to whether the LED tube lamp is properly or improperly installed in the lamp socket.

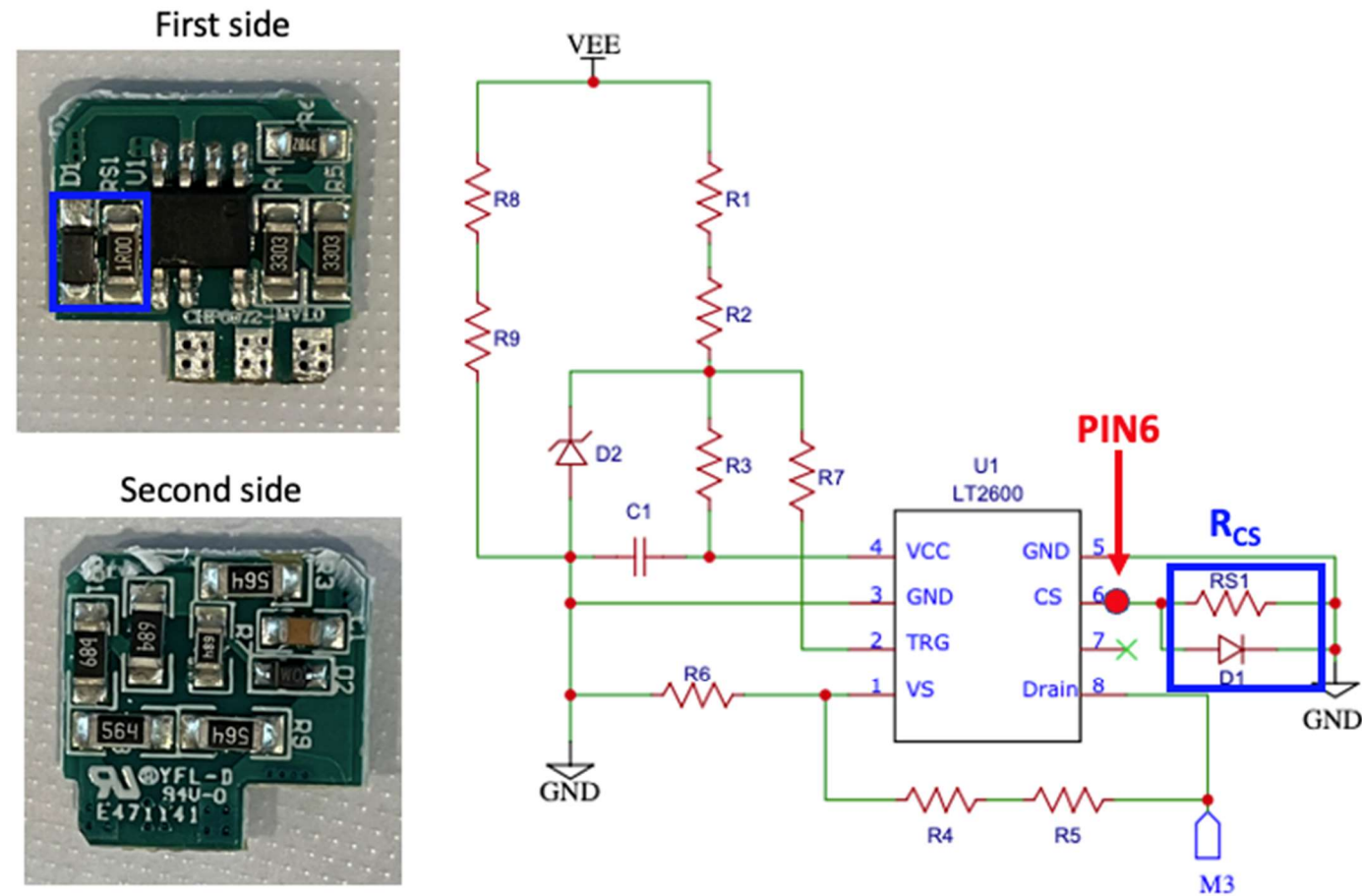


Figure 21. The installation detection module detects the signal on PIN6 as current passes through resistor RS1 and diode D1 (together referred to as R_{CS}) to determine whether the LED tube lamp is properly installed on the lamp socket.

With respect to the block diagram in Figure 22, 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 22, 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 PIN6 corresponds to a low I_{LED} . This signal is evaluated by comparing it to the VS signal on PIN1 in order to determine the impedance of the circuit through which I_{LED} flows. An impedance below a specified threshold will indicate a proper installation of the LED tube lamp, and an impedance above a specified threshold will indicate an improper installation.

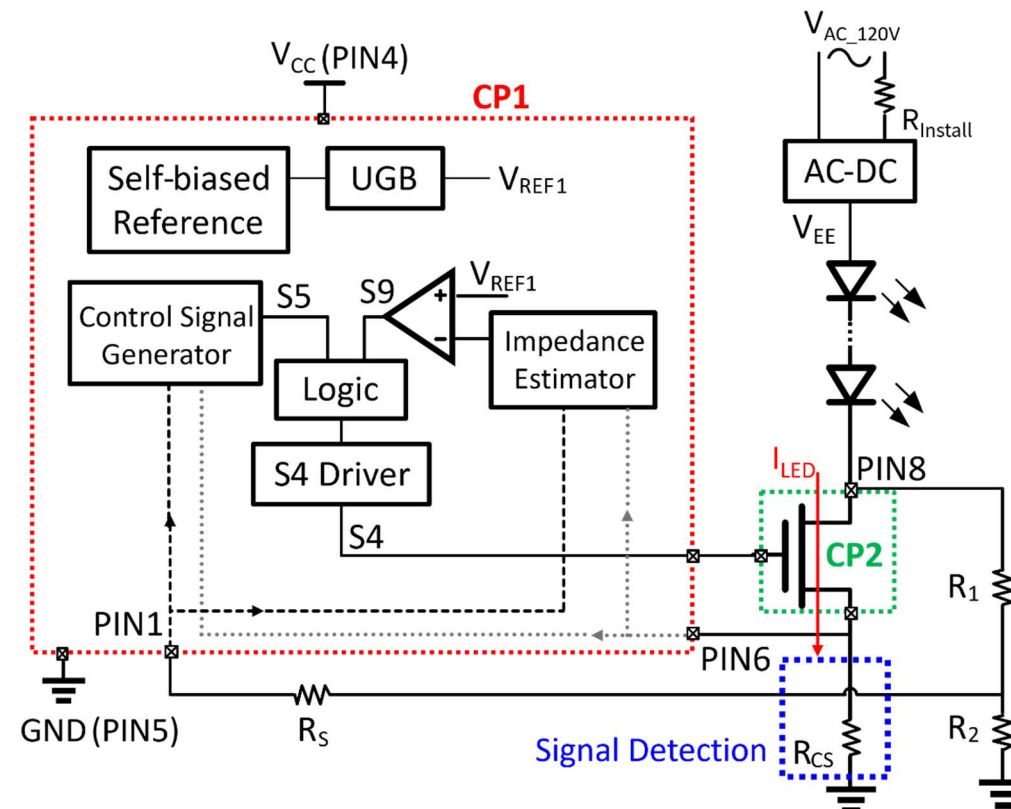


Figure 22. The installation detection module detects the signal on PIN6 as current passes through R_{CS} .

Tests performed on an exemplary GE LED13ABT8/G4/830 further demonstrate that the installation detection module is configured to detect an installation state between the LED tube lamp and a lamp socket. For example, a relamping test was performed in accord with UL 1993 (SA.19) and UL 935 (Section 24). This test assesses the risk of electric shock during a relamping procedure in which one end of the lamp tube is connected to a 277 VAC power source while the opposing end is accessible to a person installing the lamp. First, when the lamp connects to its intended power source (277 VAC) on both ends without excess line resistance, the result is that the lamp illuminates as the impedance detection mechanism in the installation detection module has determined that the lamp is in a state of “proper” installation.

In contrast, the test measurement setup shown in Figure 23 includes a 277 VAC line voltage supplied directly to the external connection terminals on the first end cap (which couple to circuit board connection labeled “L”). On the opposite end of the tube, a non-inductive 500 Ω resistor was connected in series between the external connection terminals on the second end cap end and the ground wire. The 500 Ω resistor represents the resistive equivalent of a human body, which is in accordance with the requirement of UL's test setup, providing an electrical pathway to ground. In this setup, the lamp does not illuminate as the installation detection module has detected that the lamp is in a state of “improper” installation.

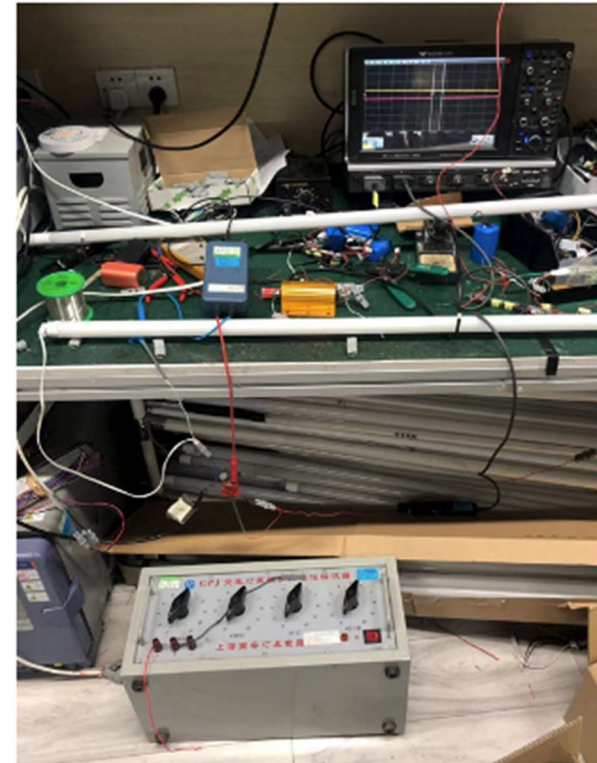
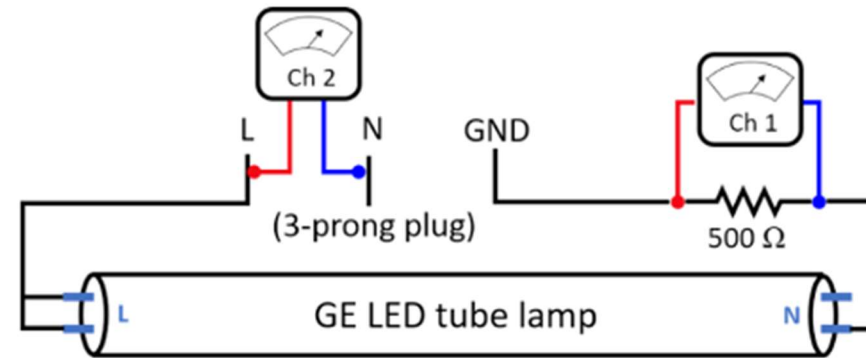
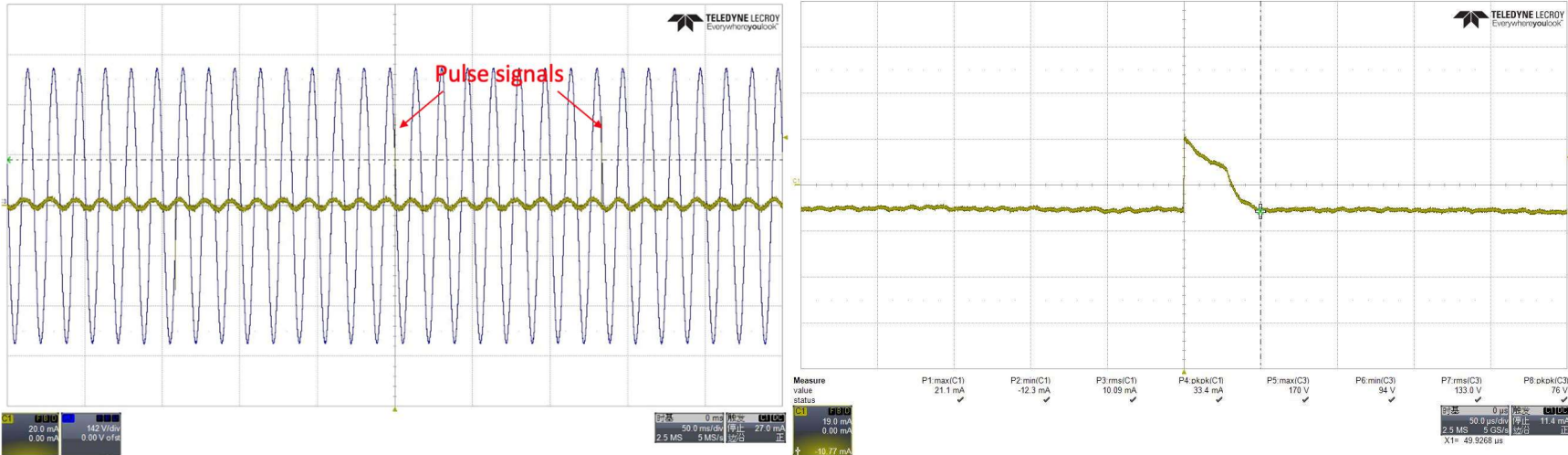


Figure 23. (Top) Schematic of measurement setup for re-lamping test, in accord with UL 1993, to ascertain whether switch circuit will turn on or remain off when the LED lamp tube is detected to be improperly installed. (Bottom) Photographs of measurement setup with GE LED tube lamp.

Figure 24 shows the results of the measurement. The red trace is a measurement of the external driving signal, and the green trace is a measure of the current, corresponding to the voltage measured across the non-inductive 500 Ω resistor that was connected in series with the GE LED13ABT8/G4/830 lamp and ground. The

Claim 1	GE LED Tube LED13ABT8/G4/830 – Representative Product data in this figure demonstrates that when power was applied, the RMS current is approximately 1.48 mA. This value is less that the UL required 5 mA/MIU, thereby indicating the lamp provided adequate shock protection. Thus, the current remains negligible, consistent with the fact that the lamp does not illuminate, because the installation detection module detects the improper installation state of the lamp.  Figure 24. (Left) Relamping test measurement. The red trace is a measurement of the external driving signal, and the green trace is a measure of the line current, corresponding to the voltage measured across the non-inductive 500 Ω resistor that is connected in series with the GE lamp and ground. Even after the external driving signal (277 VAC) is applied, the lamp does not illuminate and current through the lamp remains negligible because installation detection module has detected an improper installation state. Additionally, pulses are observed on the power line. (Right) Zoom-in image of the highlighted pulse signal The ability for the installation detection module to detect the installation state between the LED lamp and the lamp socket is further demonstrated through a test scenario in which additional line resistance may be added in series. The test setup shown in Figure 25 was used to enable measurements of loop current through the LED module by probing the voltage drop across a 1.0 Ω shunt resistor in both an improper installation state, when the mechanical switch in the top right of the schematic is open sending current through the 500 Ω resistor; and a proper installation state, when the mechanical switch is closed, thereby allowing one to effectively toggle between proper and improper installation states of the lamp.
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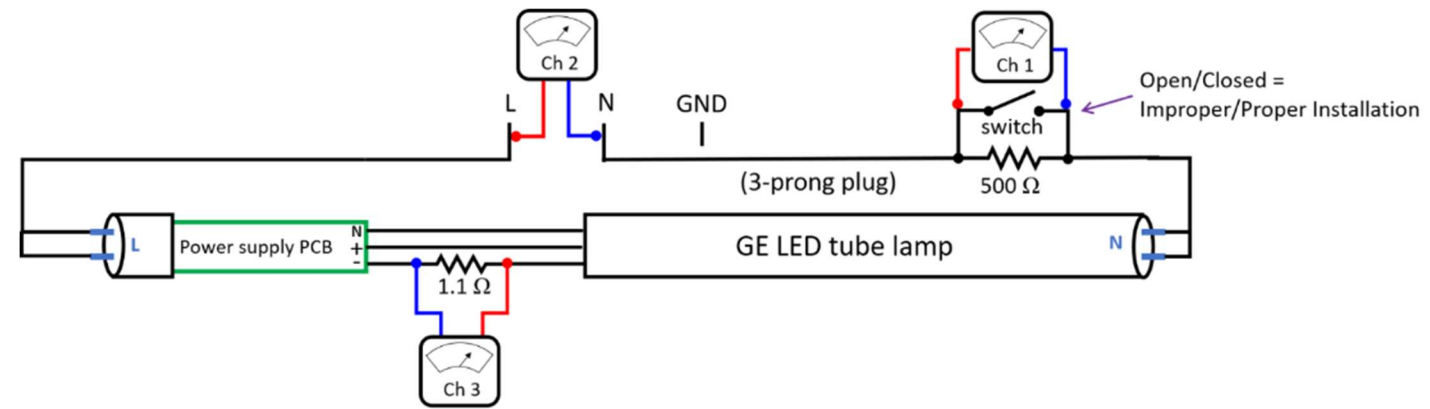
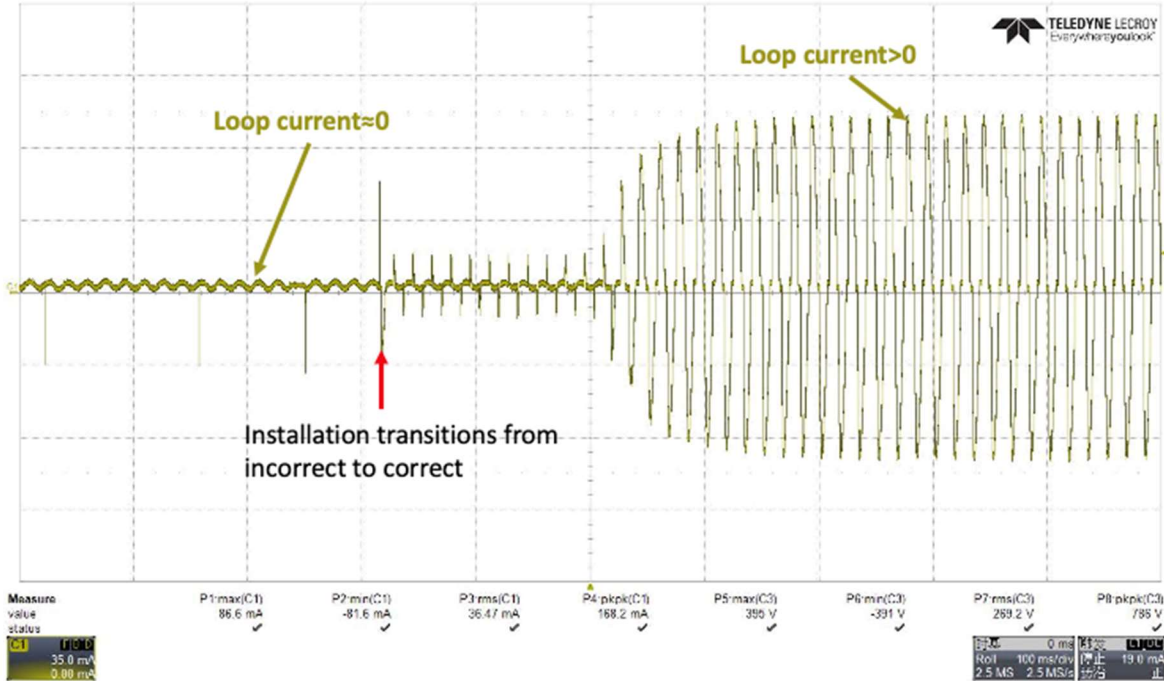


Figure 25. Schematic of measurement setup for probing loop current as the lamp is switched between an improper and a proper installation state.

Figure 26 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/G4/830 – Representative Product																											
	<table><tr><th>Measure</th><th>value</th><th>status</th></tr><tr><td>P1: max(C1)</td><td>86.6 mA</td><td>✓</td></tr><tr><td>P2: min(C1)</td><td>-81.6 mA</td><td>✓</td></tr><tr><td>P3: rms(C1)</td><td>36.47 mA</td><td>✓</td></tr><tr><td>P4: pkpk(C1)</td><td>168.2 mA</td><td>✓</td></tr><tr><td>P5: max(C3)</td><td>399 V</td><td>✓</td></tr><tr><td>P6: min(C3)</td><td>-331 V</td><td>✓</td></tr><tr><td>P7: rms(C3)</td><td>289.2 V</td><td>✓</td></tr><tr><td>P8: pkpk(C3)</td><td>730 V</td><td>✓</td></tr></table> 35.0 mA 0.00 mA 0.0 ms 100 ms/div 2.5 MS 2.5 MS/s 19.0 mA 100 V/div 2.5 MS/s Figure 26. Measurement data as lamp transitions 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 LED13ABT8/G4/830 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 the reasons detailed above, the GE LED13ABT8/G4/830 includes an installation detection module configured to detect the installation state between the LED tube lamp and a lamp socket, and thus this lamp satisfies claim element 1[f] of the '174 patent.	Measure	value	status	P1: max(C1)	86.6 mA	✓	P2: min(C1)	-81.6 mA	✓	P3: rms(C1)	36.47 mA	✓	P4: pkpk(C1)	168.2 mA	✓	P5: max(C3)	399 V	✓	P6: min(C3)	-331 V	✓	P7: rms(C3)	289.2 V	✓	P8: pkpk(C3)	730 V	✓
Measure	value	status																										
P1: max(C1)	86.6 mA	✓																										
P2: min(C1)	-81.6 mA	✓																										
P3: rms(C1)	36.47 mA	✓																										
P4: pkpk(C1)	168.2 mA	✓																										
P5: max(C3)	399 V	✓																										
P6: min(C3)	-331 V	✓																										
P7: rms(C3)	289.2 V	✓																										
P8: pkpk(C3)	730 V	✓																										
1[g] wherein the installation detection module comprises: a first circuit, configured to generate a pulse signal, wherein the first circuit comprises a discharge path;	As detailed above with respect to claim element 1[f], the GE LED13ABT8/G4/830 contains an installation detection module configured to detect the installation state between the LED tube lamp and a lamp socket. Additionally, as explained below, the installation detection module includes a first circuit, configured to generate a pulse signal, wherein the first circuit comprises a discharge path. The installation detection module in the GE LED13ABT8/G4/830 LED tube lamp includes a control signal generator, corresponding to circuitry contained on the CP1 die (outlined in red in Figure 27), which includes inputs from both the VS signal at PIN1 and the CS signal at PIN6, as indicated by the red annotations Figure 27, all of which constitutes the claimed first circuit.																											

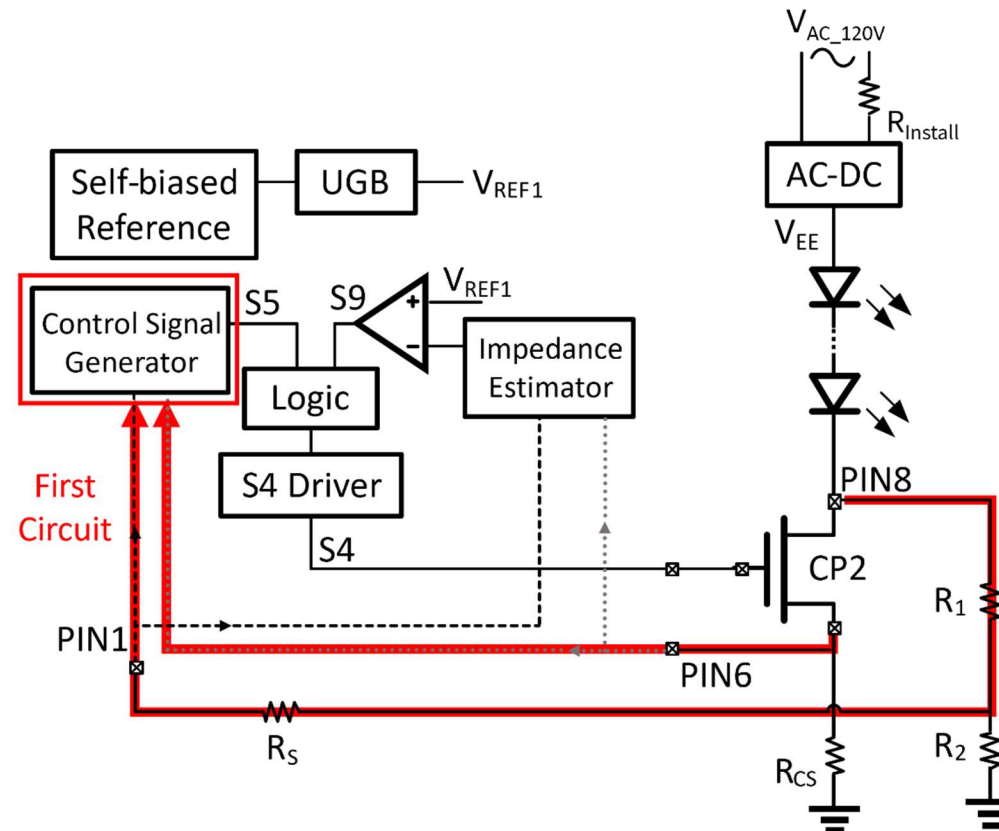


Figure 27. The claimed first circuit indicated by the red annotations in the simplified block diagram. The claimed first circuit is comprised of circuitry on die CP1, as well as components on the circuit board.

The simulation result of signal S5 shown in Figure 28 further evident signal S5 generated 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.

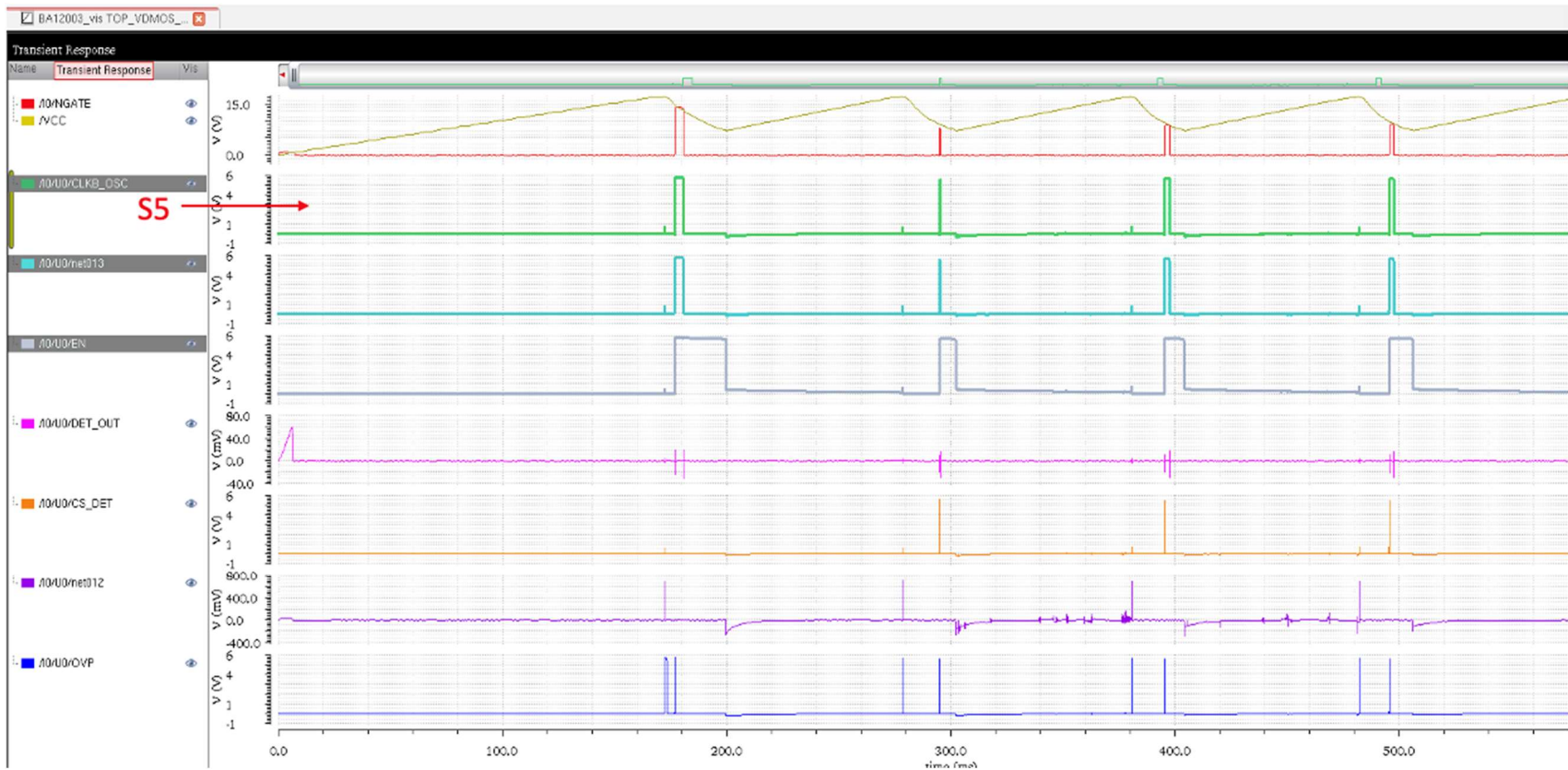
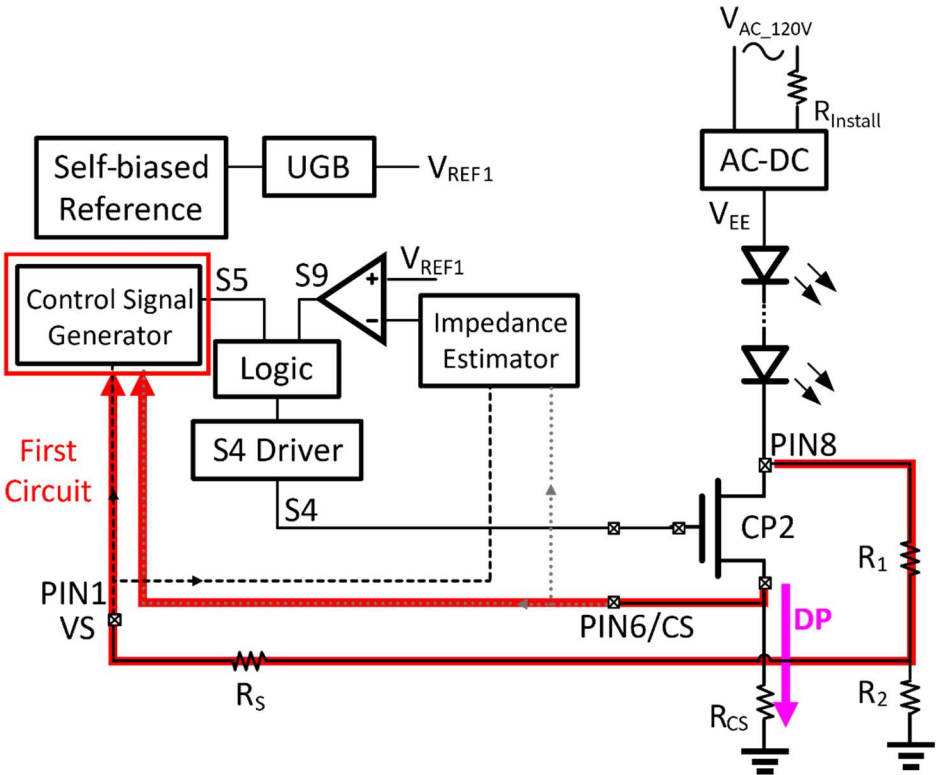


Figure 28. Simulation result of S5 based on the teardown analysis

Therefore, the claimed first circuit is configured to output signal S5, corresponding to what is labeled as the control signal in Figure 28.

Furthermore, the first circuit comprises a discharge path. As explained above, a high pulse signal will generate a high S4 signal, which will produce a voltage sufficient to activate switch CP2. This will result in a discharge path for current to flow to ground when the CP2 switch provides a conduction path, as highlighted by the pink line, labeled “DP” in Figure 29. This will result in current flow through R_{CS} and will cause the CS signal to decrease.

Claim 1	GE LED Tube LED13ABT8/G4/830 – Representative Product
	 Figure 29. The first circuit comprises discharge path “DP” when S4 is high and switch CP2 is activated to permit conduction to ground. Hence, for at least the reasons described above, the installation detection module of the GE LED13ABT8/G4/830 LED tube lamp includes a first circuit configured to generate a pulse signal, wherein the first circuit comprises a discharge path, and thus this tube lamp satisfies claim element 1[g] of the '174 patent.
1[h] a second circuit, coupled to the first circuit and configured to receive and output the pulse signal; and	The installation detection module in the GE LED13ABT8/G4/830 LED tube lamp includes a second circuit, coupled to the first circuit, and configured to receive and output the pulse signals, as explained below. The claimed second circuit comprises 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 are highlighted in Figure 30. These components are also outlined together by the dashed blue line in the simplified system overview diagram in Figure 31.

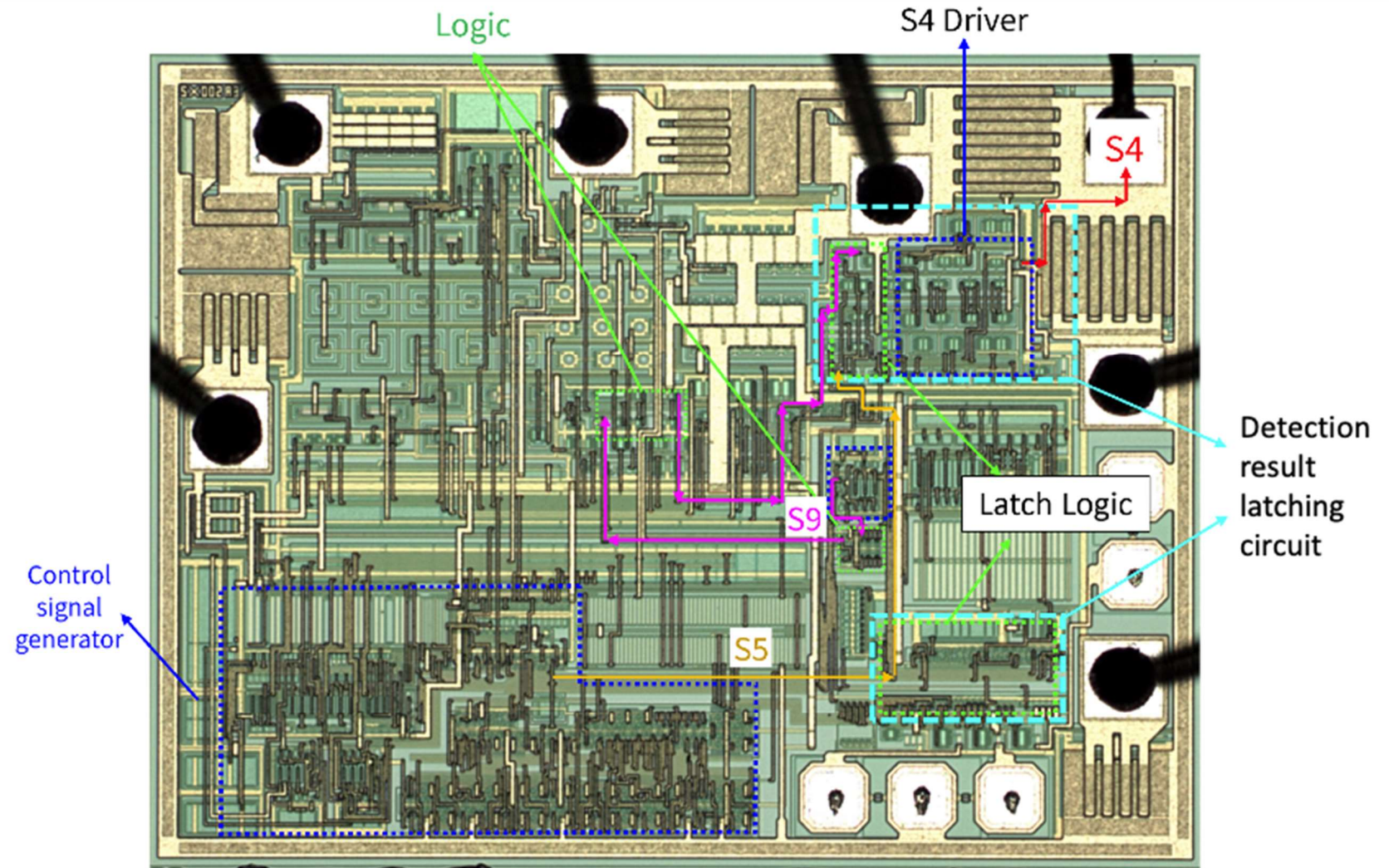
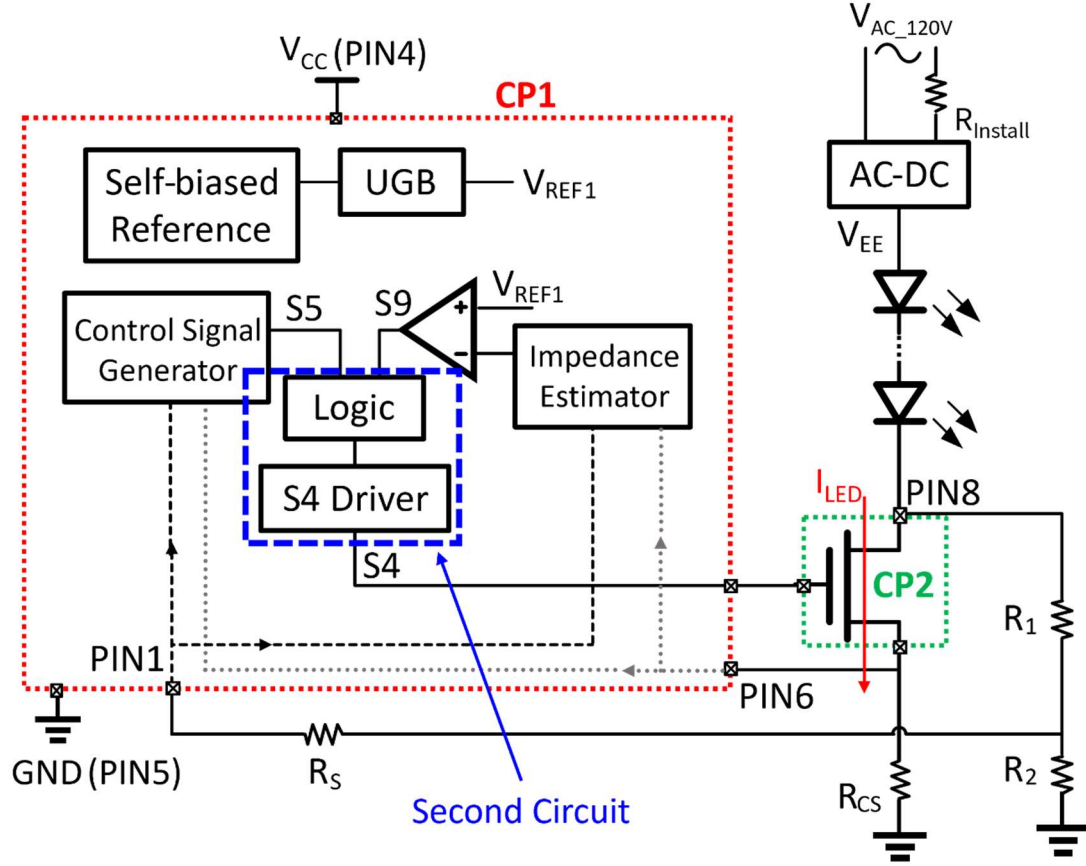
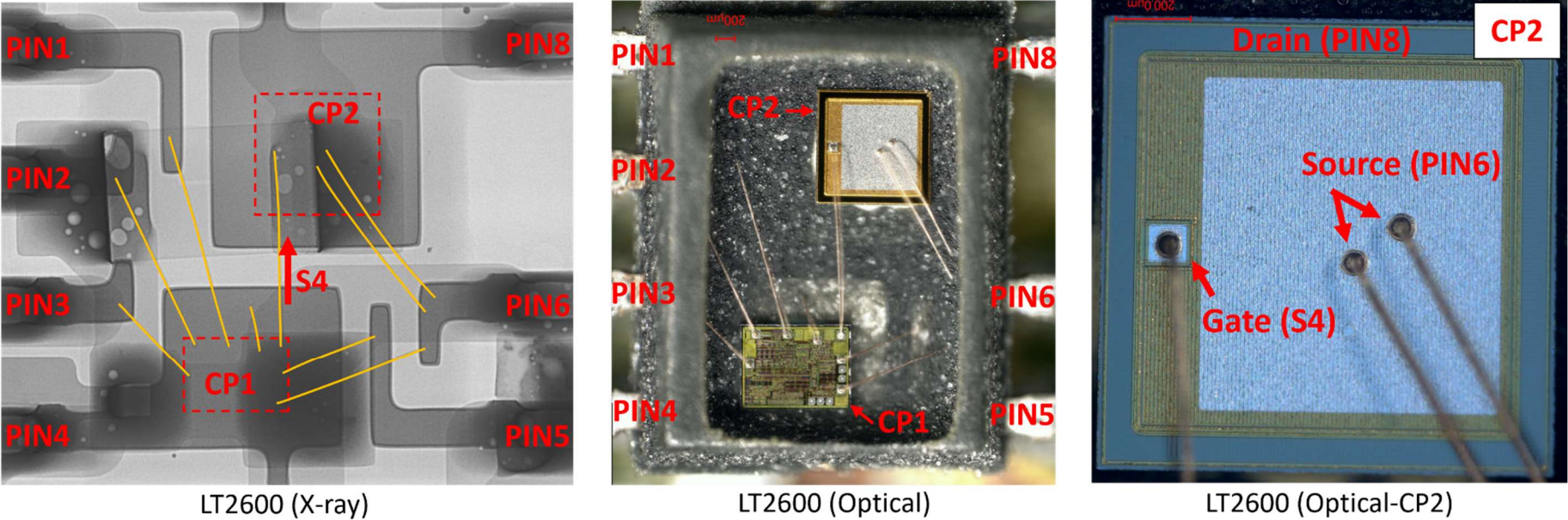


Figure 30. Photograph of the CP1 die on a LT2600 in the GE LED13ABT8/G4/830 tube lamp. Logic blocks (e.g., digital logic) and the S4 driver together form the claimed second circuit, outlined by the upper and lower dashed cyan boxes.

Claim 1	GE LED Tube LED13ABT8/G4/830 – Representative Product
	 Figure 31. The digital logic and S4 driver, both outlined in dashed blue, together form the claimed second circuit. The second circuit receives the outputs of comparator 1, S9, and the output of the control signal generator, S5, as input signals. The S5 signal, is the one or more pulse signals produced by the claimed first circuit. Thus, the second circuit is coupled to the first circuit and is configured to receive the pulse signal. The S5 and S9 signals are evaluated together by digital logic components in the logic block of the second circuit. The S4 driver takes the digital input and outputs an analog driving signal, which will operate to open or close the gate on the switch circuit CP2 (discussed in greater detail with respect to claim element 1[i]). When S9 is low, S4 will follow S5. Thus, the second circuit will receive and output the pulse signals of the first circuit, following S5 as long impedance is determined to be above a threshold value. Thus, the second circuit is also configured to output the pulse signal, as required by claim element 1[h] Therefore, the GE LED13ABT8/G4/830 LED tube lamp satisfies claim element 1[h] of the '174 patent

Claim 1	GE LED Tube LED13ABT8/G4/830 – Representative Product
1[i] a third circuit, coupled to a power loop of the LED tube lamp and the second circuit and configured to determine whether to conduct the power loop according to the pulse signal,	The GE LED13ABT8/G4/830 includes an installation detection module comprising a third circuit, coupled to a power loop of the LED tube lamp and the second circuit and configured to determine whether to conduct the power loop according to the pulse signal. In particular, the 8-pin LT2600 package contains 2 chips, one of which is labeled as CP2 in Figure 32, which is an N-type MOSFET labeled CP2 in the diagram in Figure 20, which represents the claimed third circuit. This circuit is also referred to herein as the so-called “switch circuit.”  LT2600 (X-ray) LT2600 (Optical) LT2600 (Optical-CP2) Figure 32. (Left) X-ray image of LT2600 on the GE LED13ABT8/G4/830 circuit 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 decapsulated 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 third circuit is coupled to the power loop of the LED tube lamp, as depicted on the circuit diagram of Figure 33. That is, the current flow of the power loop passes through the third circuit via the Drain and CS pins of the LT2600 IC.

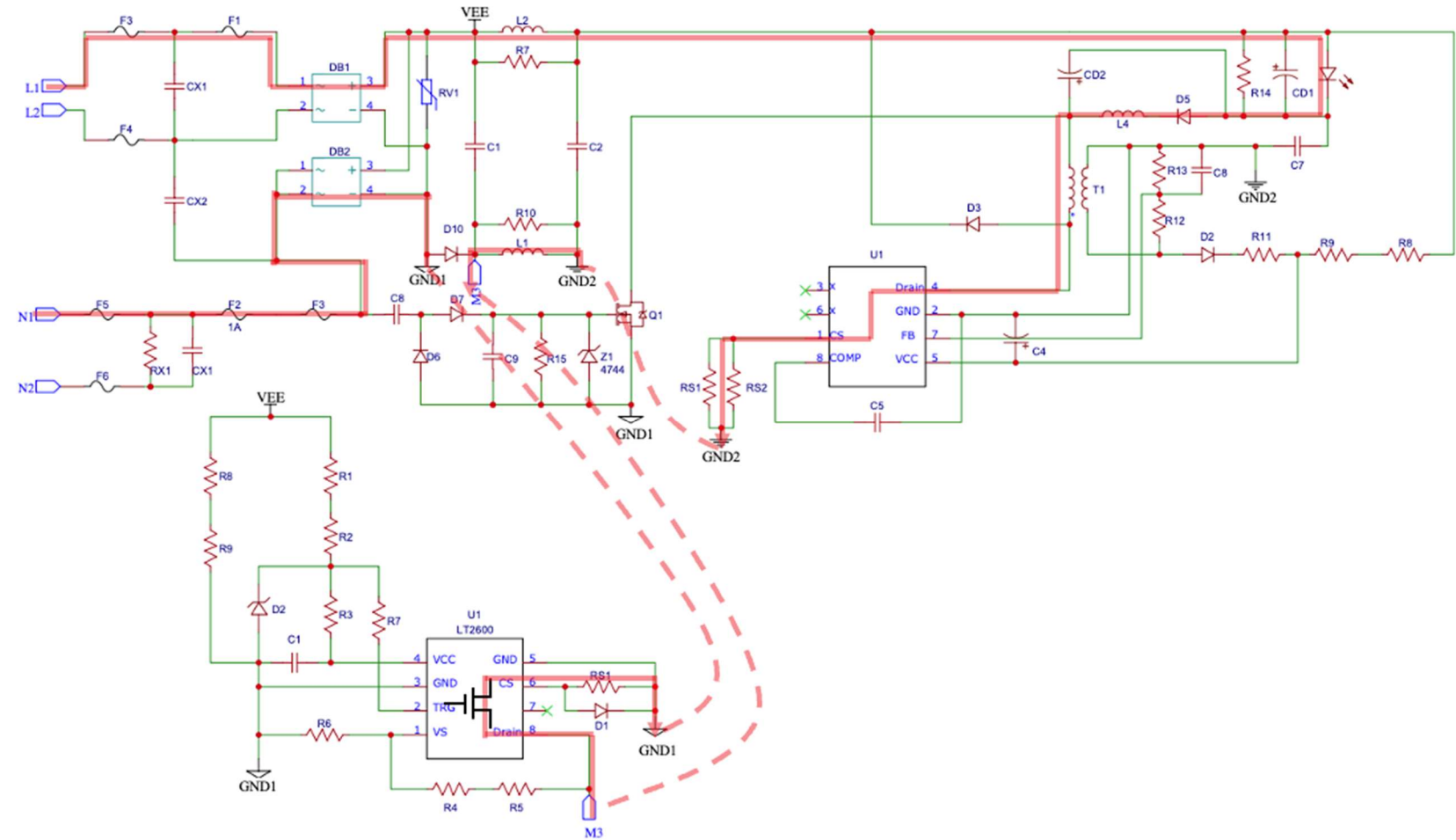


Figure 33. The power loop of the LED (red path) passes through the third circuit, contained in the LT2600 IC.

The third circuit is also coupled to the second circuit, as depicted in the block diagram and the circuit diagram in Figure 33, given that an output of the second circuit (S4) serves as an input for the third circuit (Gate electrode).

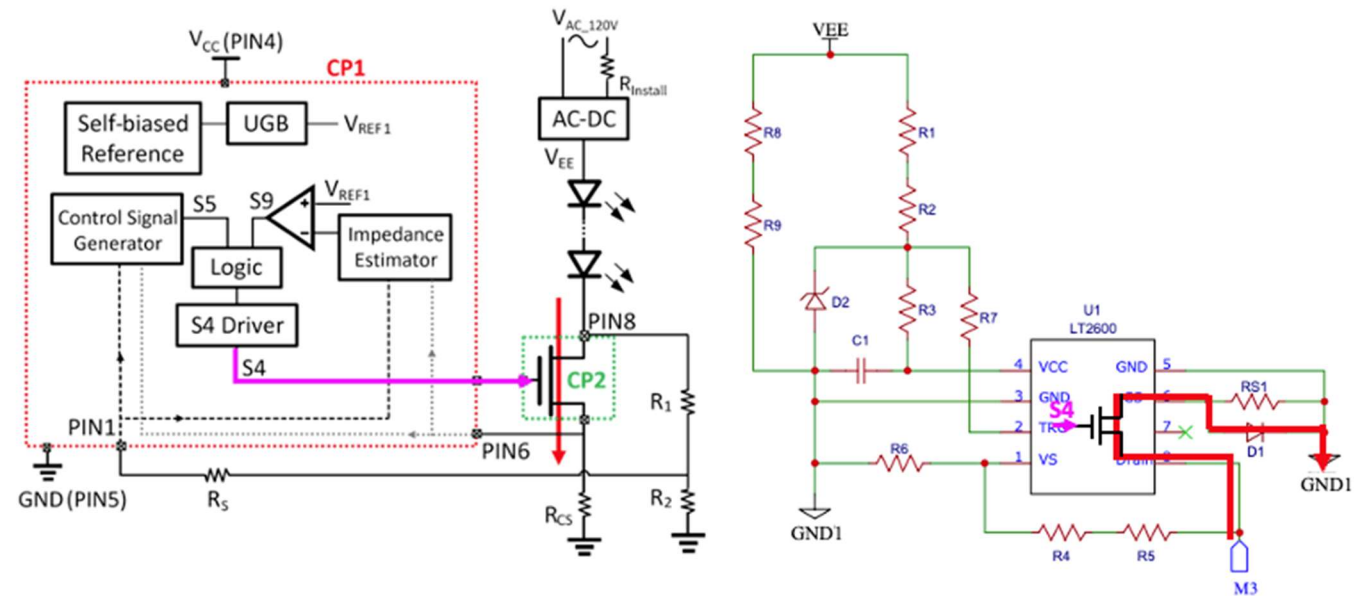
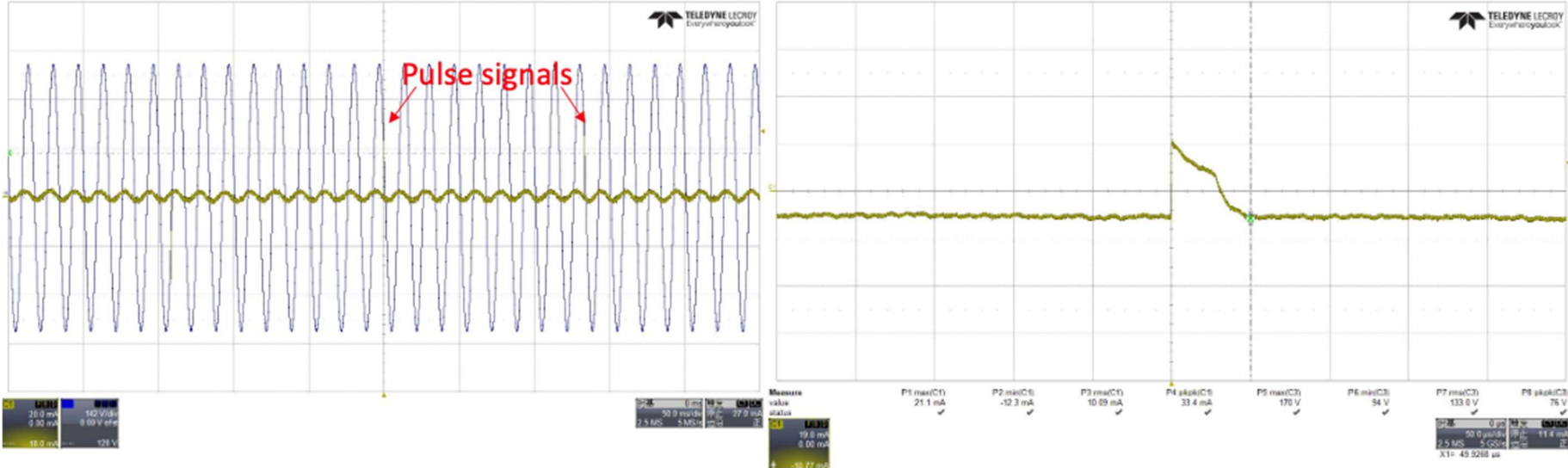


Figure 34. (Left) The third circuit (outlined in dashed green) couples to the second circuit (pink line) and to the power loop (red line). The power loop of the LED pass through the third circuit, which is the switch circuit. Whether or not the power loop is conducted is determined by the third circuit. When the path from PIN8 to PIN6 is conducting, the power loop is conducted, and when said path is an open circuit, the power loop is not conducting. This determination follows the pulse signal, S5, when the lamp is in an improper installation state.

The third circuit is configured to determine whether to conduct the power loop according to the pulse signal. This is evident by measuring the signal on the power loop while the lamp is in a state of improper installation. In this case, S5 pulses will be input into the second circuit, which will output S4 pulses that follow S5. The effect of the third circuit on the signal in the power loop is synchronized with the pulse signal, as evinced by the measurement shown in Figure 35.

Claim 1	GE LED Tube LED13ABT8/G4/830 – Representative Product  Figure 35. Lamp tube is configured into a state of improper installation. The pulse signal on the power loop (green trace) rises and falls with the opening and closing of the switch circuit, which is the claimed third circuit. Pulse signal on the power loop will have a sign (i.e., pulse up/pulse down) corresponding to the polarity of driving signal. Thus, the GE LED13ABT8/G4/830 includes a third circuit configured to determine whether to conduct the power loop according to the pulse signal. Therefore, for the reasons detailed above, the GE LED13ABT8/G4/830 satisfies claim element 1[i] of the '174 patent.
1[j] wherein the pulse signal is fed back to the discharge path of the first circuit, and the discharge path is conducted when the pulse signal is pulled to a high level voltage, and	The GE LED13ABT8/G4/830 tube lamp includes an installation detection module comprising a first circuit, configured to generate a pulse signal, wherein the first circuit comprises a discharge path; wherein the pulse signal is fed back to the discharge path of the first circuit, and the discharge path is conducted when the pulse signal is pulled to a high-level voltage. Also, see claim element 1[g]. When the pulse signal is output from the second circuit as it follows the signal output from the first circuit, said signal (S4) is applied along the blue line in Figure 36 to the switch associated with the third circuit, CP2, which also controls the discharge path. A high-level voltage on the pulse will allow the discharge path (pink) to be conducted to ground.

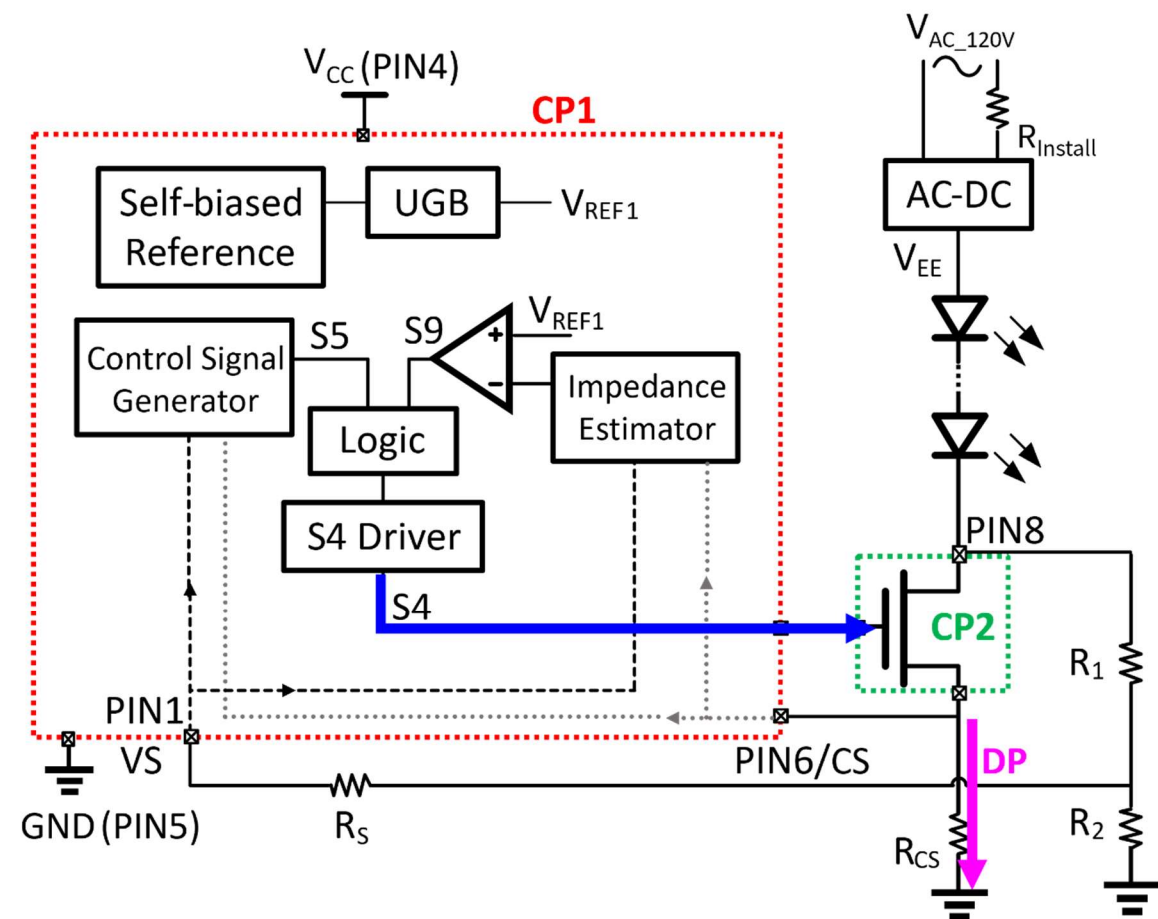
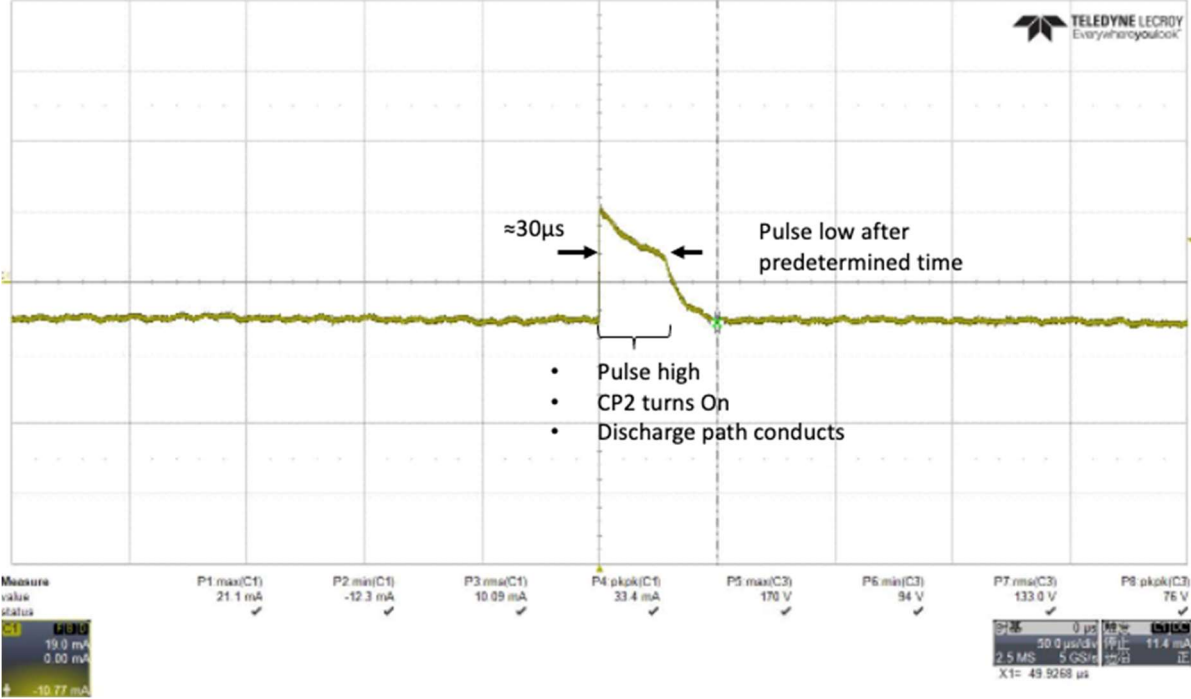


Figure 36. Pulse signal from second circuit (blue line) is fed to the gate electrode of CP2, which controls the discharge path. The discharge path (pink line) is conducted when the pulse signal is pulled high.

The behavior of the pulse signal and the discharge path can be seen in their impact on the pulse measured in the loop current, as shown in Figure 37. This is additionally illustrated by the timing diagram, depicting several system signals, in Figure 28.

Claim 1	GE LED Tube LED13ABT8/G4/830 – Representative Product
	 Figure 37. Lamp tube is configured into a state of improper installation. The pulse signal on the power loop (green trace) rises and falls with the opening and closing of the switch circuit, which is the claimed third circuit. Thus, for the reasons detailed above, the GE LED13ABT8/G4/830 satisfies claim element 1[j] of the '174 patent.
1[k] wherein the pulse signal is pulled to a low level voltage after the discharge path has been conducted for a predetermined time period.	The GE LED13ABT8/G4/830 LED tube lamp includes an installation detection module comprising a first circuit, configured to generate a pulse signal, wherein the first circuit comprises a discharge path; wherein the pulse signal is pulled to a low level voltage after the discharge path has been conducted for a predetermined time period. See claim elements 1[g] and 1[j]. Each pulse has substantially the same waveform which maintains at high level and drops after about 100μs as shown in Figure 37. This indicates the time period for conducting the discharge path is predetermined to be about 100μs. When the pulse signal is output from the second circuit as it follows the signal output from the first circuit, said signal (S4) is applied along the blue line in Figure 36 to the switch associated with the third circuit, CP2, which controls the discharge path. A high level voltage on the pulse will allow the discharge path (pink) to be conducted to ground. The pulse signal will be pulled to a low level voltage after the discharge path has been conducted for a predetermined time period. In particular, the pulse signal will be pulled to a low level voltage when the CS signal decreases below a threshold value. The behavior of the pulse signal and the discharge path can be seen in their impact on the pulse measured in the loop current, as shown in Figure 37. This is additionally illustrated by the timing diagram, depicting the synchronization of various signals, including the claimed pulse signal, in Figure 28.

Claim 1	GE LED Tube LED13ABT8/G4/830 – Representative Product
	Thus, for the reasons detailed above, the GE LED13ABT8/G4/830 satisfies claim element 1[k] of the '174 patent. Therefore, for all the reasons detailed above, the GE LED13ABT8/G4/830 satisfies each and every element of claim 1 of the '174 patent.

Claim 2	GE LED Tube LED13ABT8/G4/830 – Representative Product
2. The LED tube lamp according to claim 1, wherein the predetermined time period is a pulse-on period of the pulse signal.	See claim elements 1[j] and 1[k]. As shown in Figure 37, the predetermined time period, which is about 100μs, is within a pulse-on period of the pulse signal. Thus, the GE tube lamp satisfies all elements of claim 1, and further satisfies all additional limitation added to claim 1 by claim 2, and therefore infringes claim 2 of the '174 Patent.

Claim 3	GE LED Tube LED13ABT8/G4/830 – Representative Product
3. The LED tube lamp according to claim 1, wherein the discharge path is cut off when the pulse signal is pulled to the low level voltage	See claim element 1[j]. As shown in Figure 36, said signal (S4) is applied along the blue line to the switch circuit CP2, which also controls the discharge path. A low-level voltage on the pulse will allow the discharge path (pink) to be cut off. Thus, the GE tube lamp satisfies all elements of claim 1, and further satisfies all additional limitation added to claim 1 by claim 3, and therefore infringes claim 3 of the '174 Patent.

Claim 5	GE LED Tube LED13ABT8/G4/830 – Representative Product
5. The LED tube lamp according to claim 1, wherein the installation detection module further comprises: a fourth circuit, configured to detect a sampling signal on the power loop so as to determine the installation state between the LED tube lamp and the lamp socket.	The GE LED13ABT8/G4/830 LED tube lamp satisfies claim 5 of the '174 Patent for at least the following reasons. A circuit disposed on the GE daughter board, labeled in Figure 38 as DDC_1, together with a circuit integrated into the LT2600 package, and referred to as DDC_2, form the claimed fourth circuit. 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 resistors R107 and R108 and diode D101 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 the installation state between the LED tube lamp and the lamp socket.

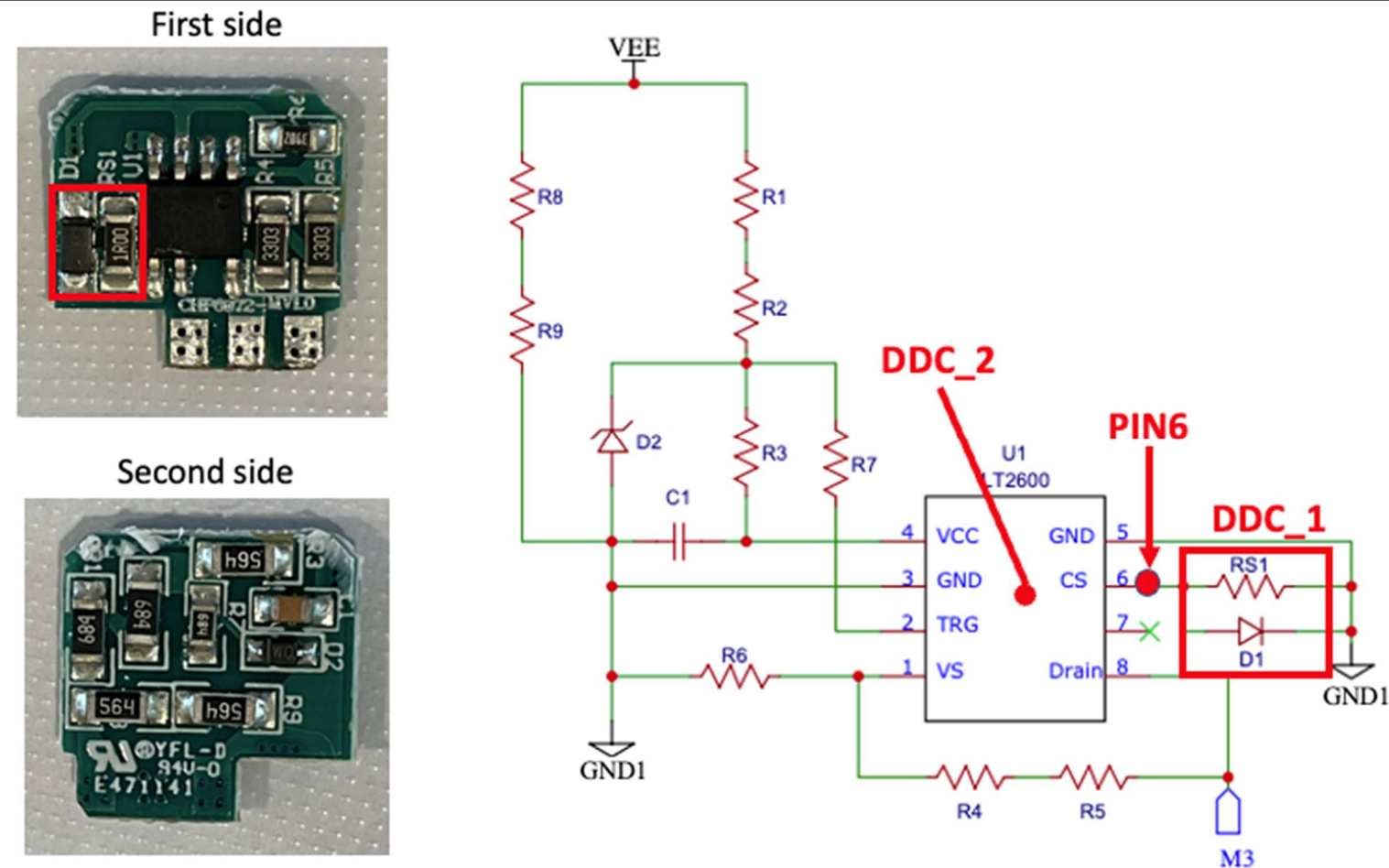


Figure 38. The fourth circuit is comprised of DDC_1 on the GE daughter board, outlined in red on the PCB (bottom left) and on the equivalent circuit schematic (right), and DDC_2 comprised of circuitry within the LT2600 package, labeled on the schematic as U1.

The diagram in Figure 39 also illustrates that the fourth 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 17, together with comparator 1, also shown in Figure 17. 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.

Claim 5

GE LED Tube LED13ABT8/G4/830 – Representative Product

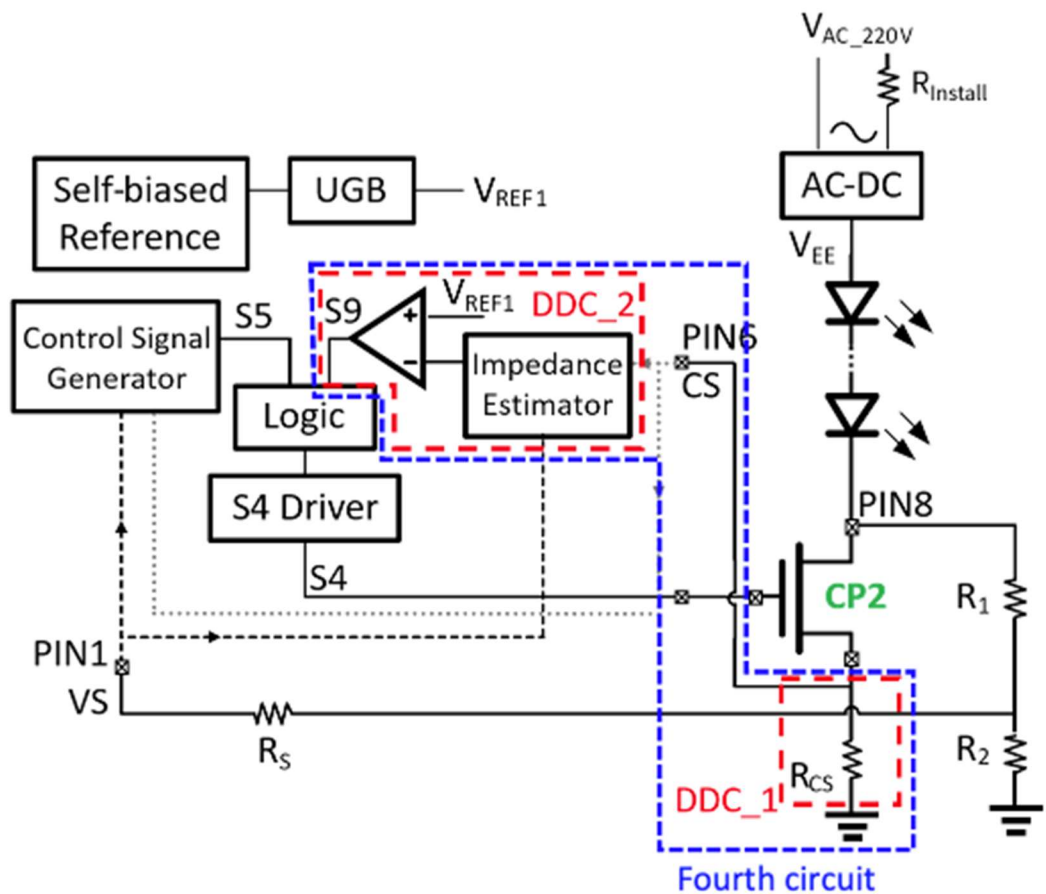


Figure 39. The fourth circuit in the GE LED tube lamp (outlined in dashed blue line) is comprised of a circuit, DDC_1, represented by components disposed on the daughter board of the power supply module, and a circuit, DDC_2, represented by circuitry disposed in the LT2600 IC.

Therefore, for at least the reasons described above, the installation detection circuit in the GE tube lamp includes a fourth configured to detect the sampling signal on the power loop so as to determine the installation state between the LED tube lamp and the lamp socket. Thus, the GE tube lamp satisfies all elements of claim 1, and further satisfies all additional limitation added to claim 1 by claim 5, and therefore infringes claim 5 of the '174 Patent.

Claim 10	GE LED Tube LED13ABT8/G4/830 – Representative Product
10[pre] A ballast by-pass light-emitting diode (LED) tube lamp, comprising:	As is evident from the information written on the lamp tube itself, the product can be operated directly with 120-277 AC MAINS (UL TYPE B), which the ballast by-pass configuration, and thus the GE LED13ABT8/G4/830 can be referred to a ballast by-pass light-emitting diode (LED) tube lamp under such configuration. As indicated by the part of the label in Figure 40, the lamp is capable of operating in Type B mode which is power via a direct connection to standard line power (e.g., 120-277 VAC).  Figure 40. Photograph shows a portion of the lamp tube packaging (Top) and written information on the lamp tube label of a GE LED13ABT8/G4/830, which indicates that it is a ballast by-pass light-emitting diode (LED) tube lamp. Thus, the GE LED13ABT8/G4/830 satisfies the preamble of claim 10 of the '174 patent because the lamp tube is a ballast by-pass light-emitting diode (LED) tube lamp.
10[a] a lamp tube; two end caps, each having an external connection terminal, and each coupled to a respective end of the lamp tube, wherein the external connection terminals are configured to receive an external driving signal;	See claim element 1[a].
10[b] an LED module, configured to emit light based on the external driving signal; and	See claim element 1[e].
10[c] an installation detection module, coupled on a power loop of the LED tube lamp and configured to detect a transient current on the power loop and compare the	The GE LED13ABT8/G4/830 LED tube lamp includes an installation detection module coupled on a power loop of the LED tube lamp and configured to detect a transient current on the power loop and compare the transient current with a predefined signal, as required by claim 10[c] of the '174 patent. An equivalent circuit diagrams of the GE LED13ABT8/G4/830 power supply module is shown in Figure 41. The portion of the schematic corresponding to the installation detection module is outlined in red.

Claim 10

GE LED Tube LED13ABT8/G4/830 – Representative Product

transient current with a predefined signal,

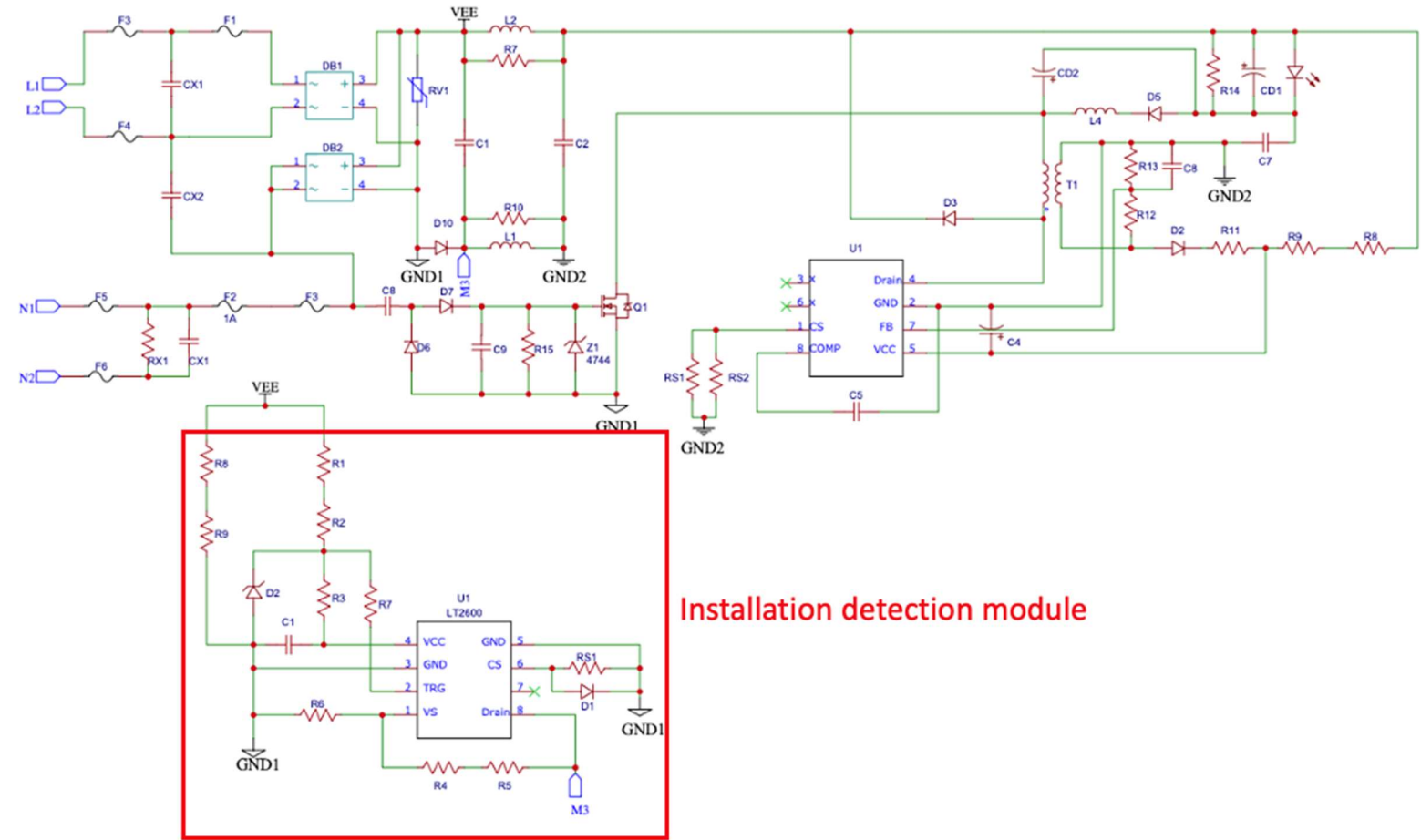


Figure 41. Equivalent circuit schematic of the main PCB and daughter board in the GE LED13ABT8/G4/830 LED tube lamp. The installation detection module is represented by the daughter board, and the corresponding schematic is outlined in red.

The circuit board in the power supply module of the GE LED13ABT8/G4/830 includes the 8-pin integrated circuit package identified as a LT2600. A portion of the power loop of the LED tube lamp is roughly traced out in the circuit diagram in Figure 33. Current that passes through the LED module of the LED tube lamp also passes through PIN8 (DRN) as well as PIN6 (CS) of the LT2600. Thus, the installation detection module is coupled on a power loop of the LED tube lamp.

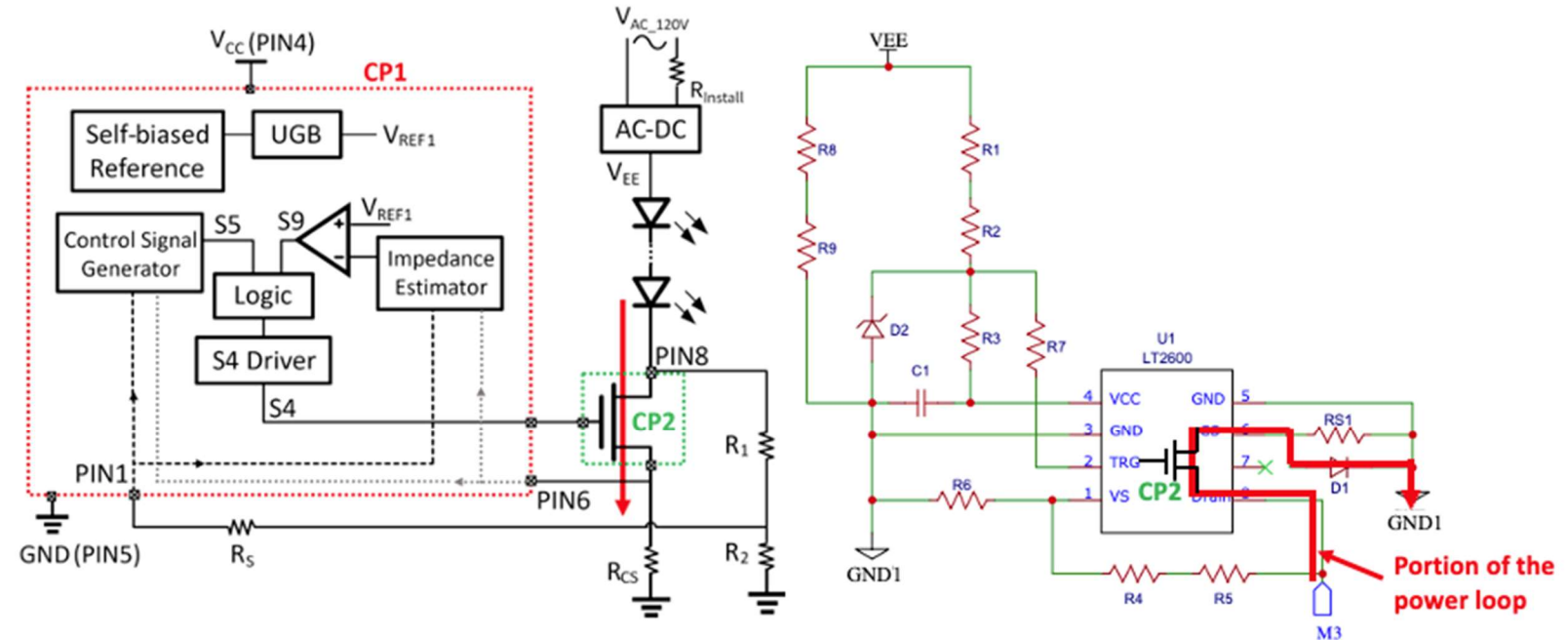


Figure 42. The power loop of the LED pass through the third circuit (i.e., the switch circuit), which is part of the installation detection module. This is shown in the simplified block diagram of the module on the left side of this figure, and in the equivalent circuit diagram on the right side.

Additionally, the installation detection module of the GE LED13ABT8/G4/830 is configured to detect a transient current on the power loop. The installation detection module of the GE LED13ABT8/G4/830 produces a pulse signal which generates a transient current on the power loop. This current is observed during a relamping test (see Figure 43), in which the power loop is monitored while the external driving signal is applied to an improper installation state (i.e., wherein a 500 Ω non-inductive resistor is on the line). The duration of each pulse is < 200 μ s. Since the current is “on” only a small fraction of the time it thus comprises a transient signal.

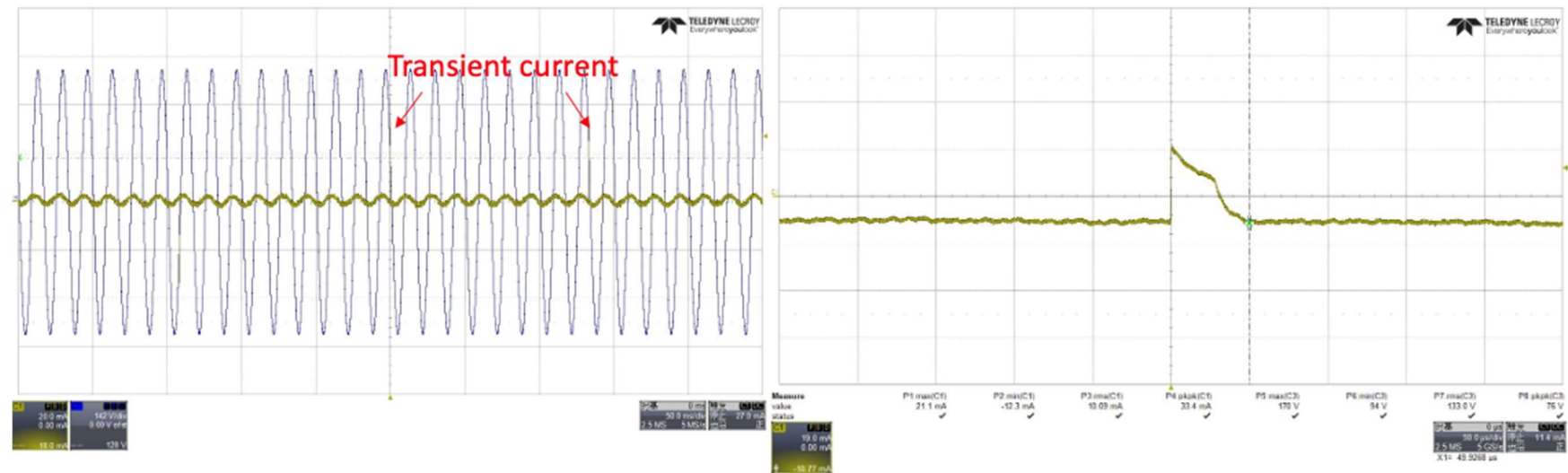


Figure 43. Transient current pulses are observed while driving signal is applied when 500 Ω resistor is in series with the lamp. (Right) Multiple pulses are observed. (Left) One pulse is shown.

The installation detection module in the GE LED13ABT8/G4/830 LED tube lamp detects a transient current on the power loop, with circuit DDC_1, by sensing signal CS at PIN6 related to the current passing through resistor R_{CS}, as shown in Figure 44. This CS signal corresponds to the transient current and is used for determining whether the LED tube lamp is properly installed on the lamp socket. This determination is made by comparing the measured signal to a predefined signal with circuit DDC_2 inside the LT2600 IC.

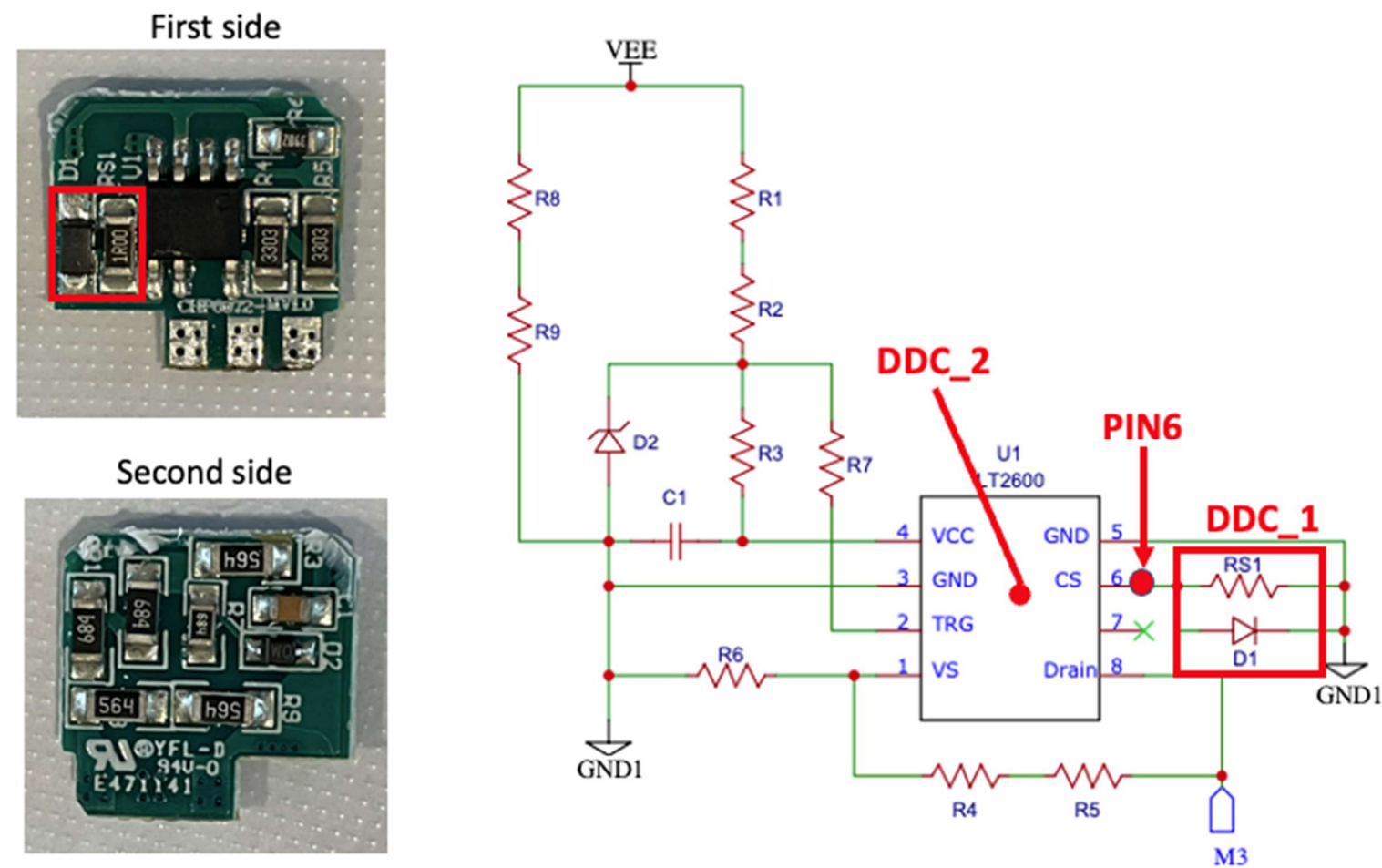


Figure 44. The installation detection module detects the signal on PIN6 as current passes through resistor RS1 and diode D1 (together referred to as R_{CS} within circuit DDC_1) to determine whether the LED tube lamp is properly installed on the lamp socket.

The simplified block diagram in Figure 45 also illustrates that the detection determining circuit is comprised of two sub-circuits: DDC_1 and DDC_2. DDC_1 is disposed on the circuit board of the GE LED13ABT8/G4/830, as described above. DDC_2 is disposed on chip CP1 in the LT2600, comprising both the impedance estimator circuit, which includes the Signal Evaluator circuit in Figure 17, together with comparator 1, also shown in Figure 17. The CS sampling signal at PIN6 (sampled just after the switch circuit is made conducting 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 turned on) 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 predefined 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.

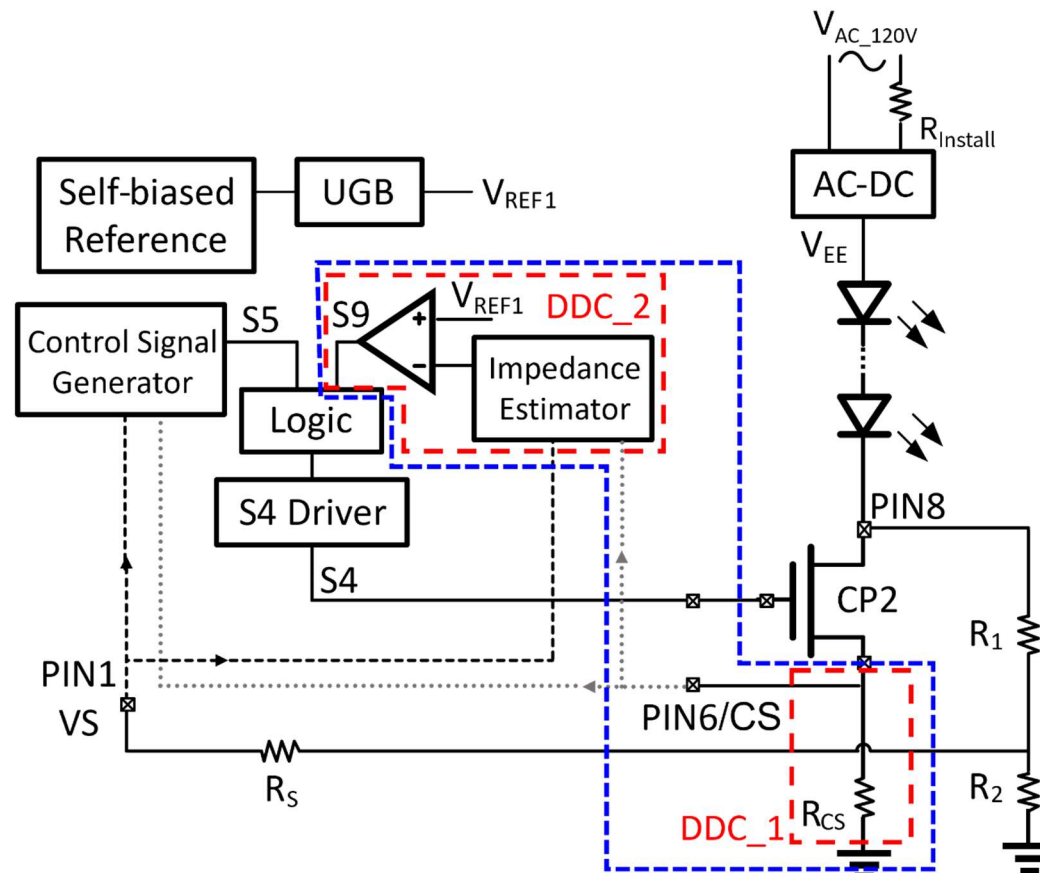
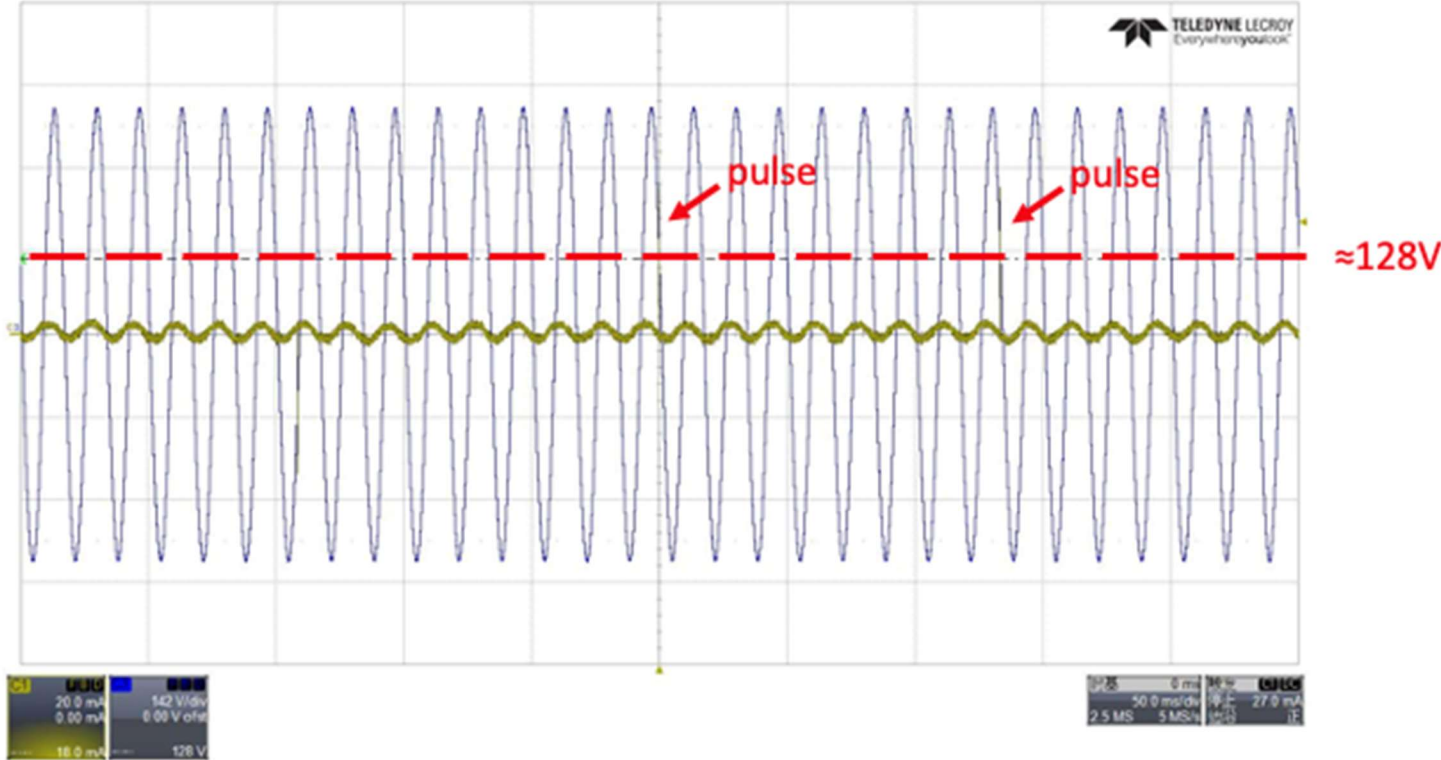


Figure 45. The detection determining circuit in the GE LED13ABT8/G4/830 LED tube lamp (outlined in dashed blue line) is comprised of a circuit, DDC_1, represented by components disposed on the daughter board of the power supply module, and a circuit, DDC_2, represented by circuitry disposed in the LT2600 IC. The transient current is detected in DDC_1, and the corresponding impedance this transient signal indicates is compared to predefined signal V_{REF1} at comparator 1, which outputs S9.

Furthermore, according to the measurement result during re-lamping test shown in Figure 46, 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. Based on 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 operation "compare the estimated impedance with reference voltage V_{REF1} " can be considered the same as "compare the transient current with predefined signal".

Claim 10	GE LED Tube LED13ABT8/G4/830 – Representative Product
	An oscilloscope waveform from a Teledyne Lecroy device. The main trace is a blue periodic waveform. A dashed red horizontal line is drawn across the middle of the waveform, labeled with a red asterisk and the text "≈128V". Two red arrows point to specific peaks on the waveform, each labeled with the word "pulse" in red. At the bottom left, there are two small inset boxes: the left one shows "20.0 mA" and "0.00 mA", and the right one shows "142 V/div" and "0.00 V/div". At the bottom right, there are two more small boxes: the left one shows "2.5 MS" and "5 MS", and the right one shows "27.0 mA" and "1P". Figure 46. Measurement result demonstrated the installation detection module triggers the detection and calculates the estimated impedance at a fixed voltage level (around 128V) during re-lamping test. Thus, for the reasons detailed above, the GE LED13ABT8/G4/830 LED tube lamp satisfies the requirements of claim element 10[c] of the '174 patent.
10[d] wherein when a signal level of the transient current is smaller than the predefined signal, the installation detection module limits a current on the power loop less than 5 MIU by controlling a conduction state of the power loop.	The GE LED13ABT8/G4/830 LED tube lamp includes an installation detection module configured such that when a transient current is detected with a signal level smaller the predefined signal, the installation detection module limits a current on the power loop to less than 5 MIU by controlling a conduction state of the power loop. As described above with respect to claim element 10[c], the signal corresponding to the transient current on the power loop, detected at PIN6, is compared to a predefined signal at comparator 1, which outputs signal S9, for determining if the tube lamp is properly installed in the lamp socket. When the PIN6 signal is lower than the predefined signal, indicating an impedance that exceeds a predefined threshold, the lamp is determined to be in an improper installation state, and the installation detection module limits a current on the power loop, thereby preventing the tube lamp from illuminating. The relamping test, as used above with respect to claim elements 1[f] and 10[c], can be used to establish a setup wherein the lamp is in an improper installation state. During this state, transient current is detected during the pulses of the pulse generating circuit (so-called “first circuit”) described above with respect to claim 1[g]. By

Claim 10

GE LED Tube LED13ABT8/G4/830 – Representative Product

placing a Simpson 228 current leakage meter in line with the GE LED tube lamp one can measure the RMS current permitted by the installation detection module during a period when the signal level of the transient current is smaller than the predefined signal.

We see that the conduction state of the power loop is controlled such that the current on the power loop has been limited to approximately 2 MIU, which is less than the 5 MIU limitation required by the claim, during a period when the signal level of the transient current is smaller than the predefined signal.

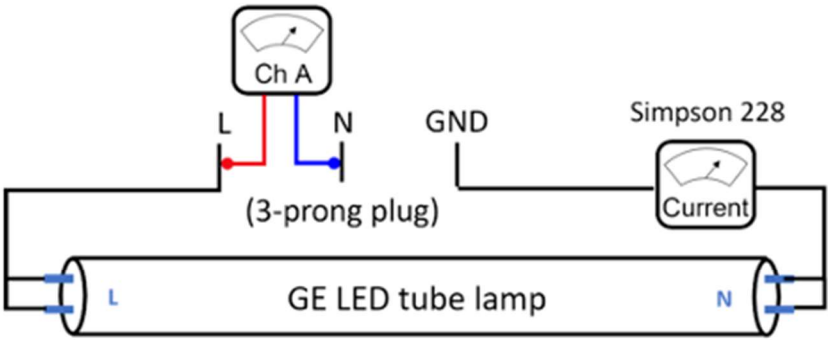


Figure 47. (Left) Relamping setup to monitor current on power loop. (Right) The Simpson 228 reads current on the power loop of the GE LED13ABT8/G4/830 LED tube lamp when the transient current is smaller than the predefined signal.

Therefore, the GE LED13ABT8/G4/830 satisfies claim element 10[d]. Thus, for the reasons detailed above, the GE LED13ABT8/G4/830 LED tube lamp satisfies all elements of claim 10, and therefore infringes claim 10 of the '174 patent.

Claim 11

GE LED Tube LED13ABT8/G4/830 – Representative Product

11. The LED tube lamp according to claim **10**, wherein the installation detection module comprises:

a detection determining circuit, configured to detect the transient current, compare the transient current with the predefined signal, and output a high level signal or a low level signal according to a comparison result.

The GE LED13ABT8/G4/830 tube lamp includes an installation detection circuit, as described above with respect to claim 1 and claim 10, which includes a detection determining circuit configured to detect the transient current, compare the transient current with the predefined signal, and output a high level signal or a low level signal according to a comparison result. Said result indicates whether it is detected that the LED tube lamp is properly or improperly installed on the lamp socket.

As detailed with respect to claim element 10[c], the installation detection circuit of the L10.5T8SDE435 tube lamp includes a detection determining circuit comprising both a circuit, DDC_1, disposed on the second side of the daughter board (Figure 48), and a circuit, DDC_2, disposed within the LT2600 package, as shown in Figure 49.

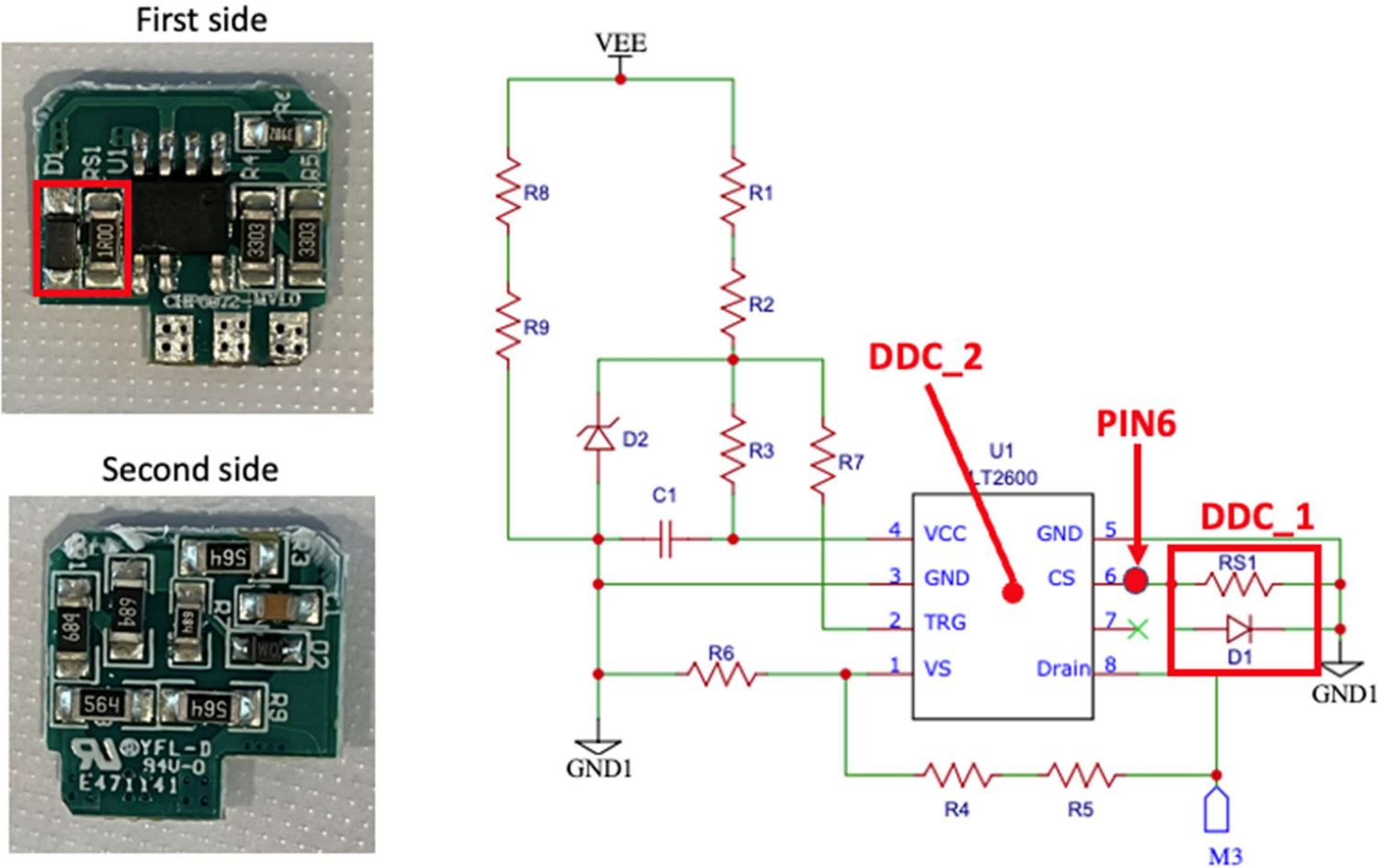


Figure 48. The detection determining circuit, DDC, is composed of DDC_1 on the daughter board, outlined in red on the PCB (left) and on the equivalent circuit schematic (right), and DDC_2 comprising circuitry within the LT2600 package.

Claim 11

GE LED Tube LED13ABT8/G4/830 – Representative Product

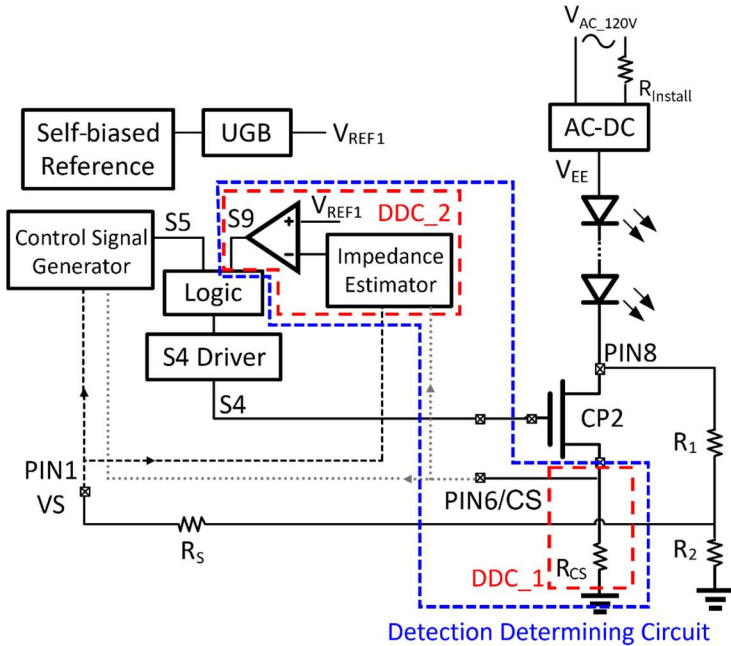


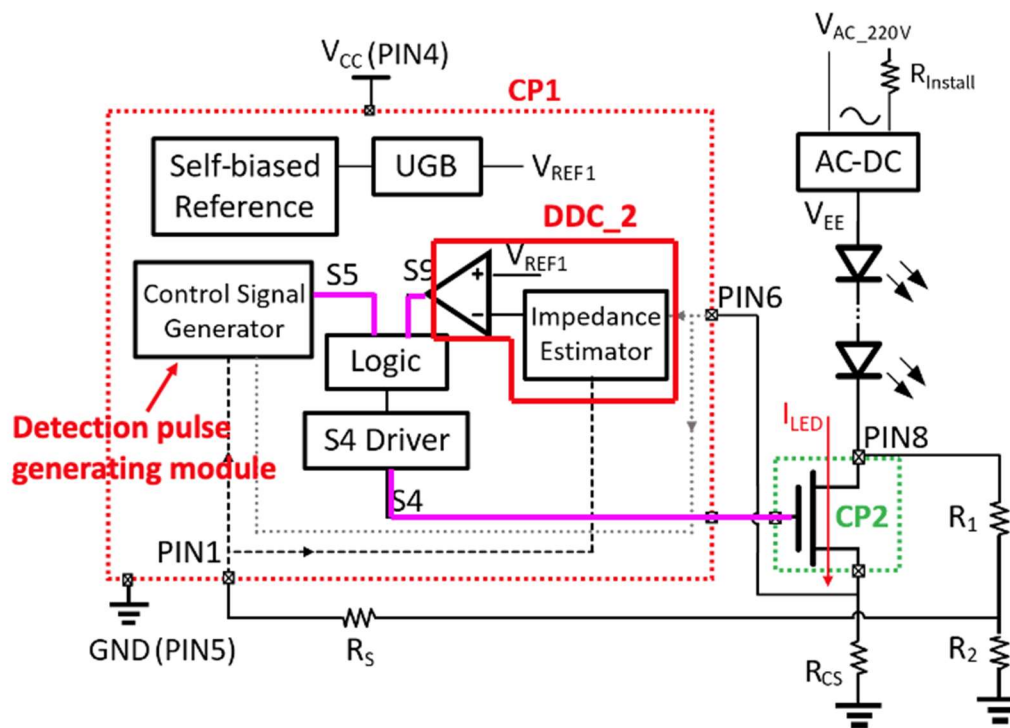
Figure 49. The detection determining circuit in the GE LED13ABT8/G4/830 LED tube lamp (outlined in dashed blue line) is composed of circuit, DDC_1, represented by a collection of components disposed on the circuit board of the power supply module, and a circuit, DDC_2, represented by circuitry disposed in the LT2600 IC.

As described above with respect to claim 10[c], DDC_1 is configured to detect the transient current signal at PIN6/CS. DDC_2 is disposed on chip CP1 in the LT2600, comprising both the impedance estimator circuit, which includes the Signal Evaluator circuit in Figure 17, together with comparator 1, also shown in Figure 17. The CS sampling signal at PIN6 (sampled just after the switch circuit is made conducting 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 turned on) 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 predefined reference signal 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.

Furthermore, 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, which corresponds to the transient current, at PIN6 with a predefined signal.

Therefore, the GE LED13ABT8/G4/830 LED tube lamp includes a detection determining circuit that is configured to detect the transient current, compare the transient current with the predefined signal, and output a high level signal or a low level signal according to a comparison result. Thus, the GE LED13ABT8/G4/830 LED tube lamp satisfies all elements of claim 10, and further satisfies all additional limitation added to claim 10 by claim 11, and therefore infringes claim 11 of the '174 patent.

Claim 12	GE LED Tube LED13ABT8/G4/830 – Representative Product
12. The LED tube lamp according to claim 11, wherein the installation detection module further comprises: a detection pulse generating module, configured to generate a pulse signal, wherein the detection determining circuit detects the transient current on the power loop during a pulse-on period of the pulse signal.	The first circuit, described above with respect to claim element 1[g] satisfies the requirements of a detection pulse generating module, configured to generate a pulse signal. As detailed with respect to claim element 10[c] and claim 11, the GE LED13ABT8/G4/830 LED tube lamp includes a detection determining circuit that detects the transient current caused by the pulse signal on the power loop during a pulse-on period of the pulse signal. Therefore, the GE LED13ABT8/G4/830 LED tube lamp satisfies all elements of claim 10, and further satisfies all additional limitations added to claim 10 by claims 11 and 12, and therefore infringes claim 12 of the '174 patent.

Claim 16	GE LED Tube LED13ABT8/G4/830 – Representative Product
16. The LED tube lamp according to claim 12, wherein the installation detection module further comprises: a switch circuit, coupled to the detection determining circuit and the detection pulse generating module and configured to maintain a conductive state during the pulse-on period of the pulse signal or when receiving the low level signal from the detection determining circuit.	The third circuit, described above with respect to claim element 1[i] satisfies the requirements of a switch circuit, coupled to the detection determining circuit and the detection pulse generating module and configured to maintain a conductive state during the pulse-on period of the pulse signal. For example, the switch circuit, CP2, has a gate terminal coupled to the output of the control signal generator, which is the claimed detection pulse generating module, and the output of circuit DDC_2, which is part of the claimed detection determining circuit, through the digital logic and S4 driver as shown in Figure 50.  Figure 50. The coupling path, outlined in pink, between the switch circuit and the detection determining circuit and the detection pulse generating module As detailed with respect to claim 10[c] and 12, the transient current is generated, by turning on the switch circuit CP2, based on the pulse signal S5, which means the switch circuit CP2 maintains a conductive state during the pulse-on period of the pulse signal. The waveform observed from the measurement in Figure 24 also demonstrates the switch circuit CP2 maintains a conductive state during the pulse-on period. Thus, the GE LED13ABT8/G4/830 LED tube lamp satisfies all elements of claim 10, and further satisfies all additional limitations added to claim 10 by claims 11, 12, and 16, and therefore infringes claim 16 of the '174 patent.

Claim 17	GE LED Tube LED13ABT8/G4/830 – Representative Product
17. The LED tube lamp according to claim 16, wherein the installation detection module further comprises: a detection result latching circuit, coupled to the detection determining circuit, the detection pulse generating module, and the switch circuit, wherein at least one of the pulse signal, the high level signal, and the low level signal is provided to the switch circuit through the detection result latching circuit.	The installation detection module in the GE LED13ABT8/G4/830 LED tube lamp includes a detection result latching circuit, coupled to the detection determining circuit, the detection pulse generating module, and the switch circuit, wherein at least one of the pulse signal, the high level signal, and the low level signal is provided to the switch circuit through the detection result latching circuit, as explained below. The claimed detection result latching circuit comprises multiple blocks on the CP1 die (outlined in cyan) including digital logic circuitry and the S4 driver, as indicated in Figure 51. These components are also outlined in the simplified system overview diagram in Figure 52.

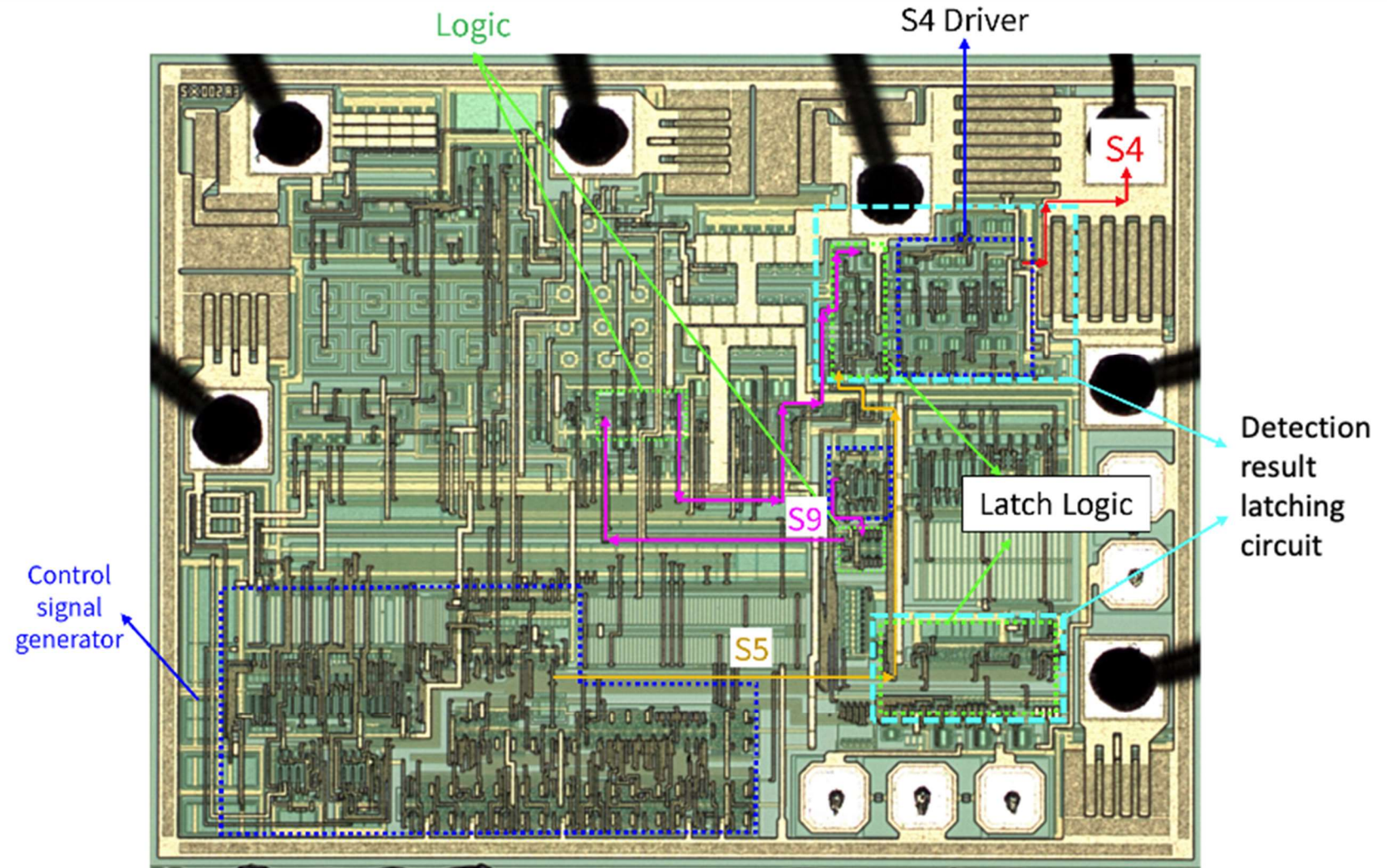


Figure 51. Photograph of the CP1 die on a LT2600 in the GE LED13ABT8/G4/830 LED tube lamp. Logic blocks (e.g., digital logic) and the S4 driver together form the detection result latching circuit, outlined by the upper and lower dashed cyan boxes.

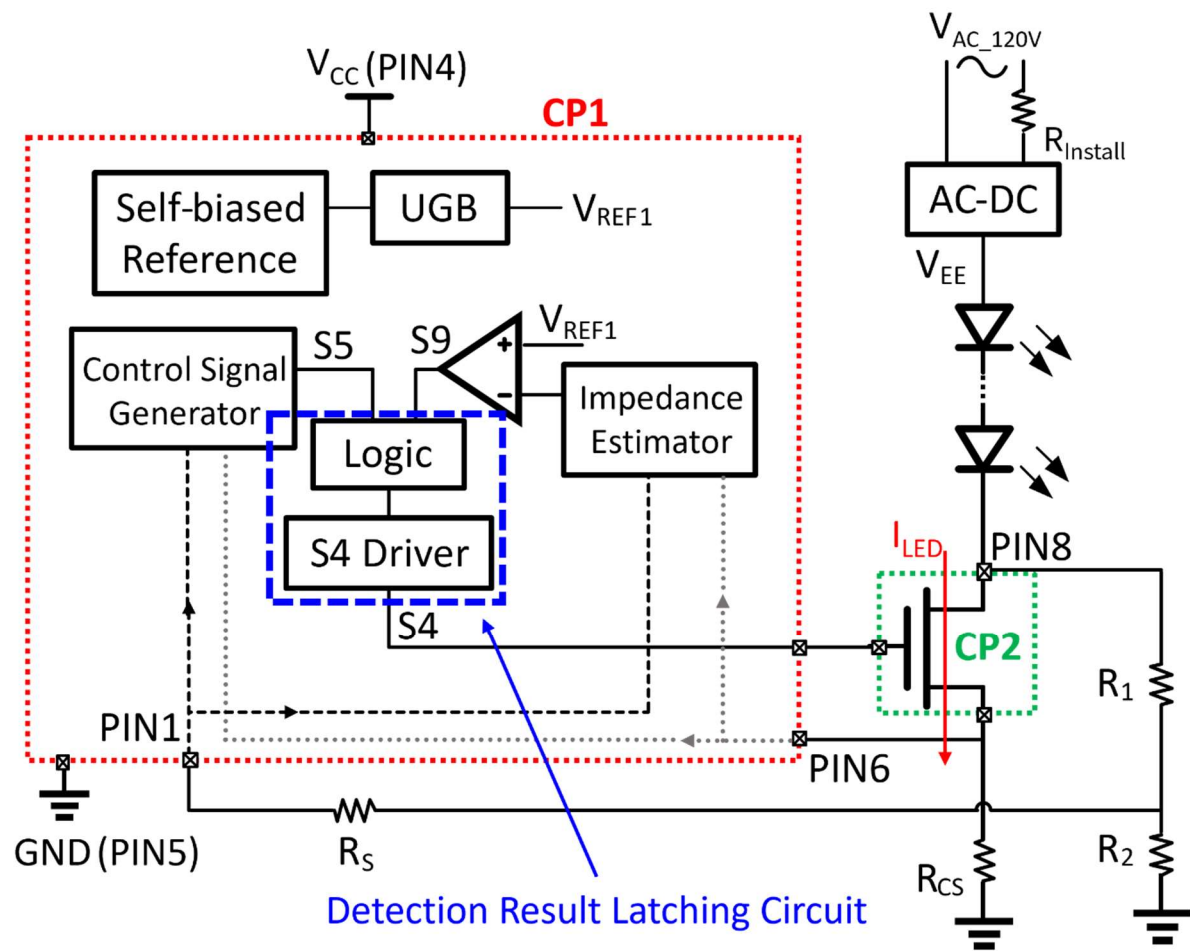


Figure 52. The digital logic and S4 driver, both outlined in dashed blue, together form the detection result latching circuit.

The detection result latching circuit receives the outputs of comparator 1 and the detection pulse generating module as input signals. The output of the detection pulse generating module, S5, is the one or more pulse signals produced by the pulse generating circuitry. 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. Thus, the detection result latching circuit is coupled to the detection determining circuit, the detection pulse generating module, and the switch circuit, as required by claim 17.

With respect to Figure 51, the one or more pulses enter the lower box of the detection result latching circuit. The at least one of the pulse signal is further propagated to the upper box of the detection result latching circuit. The digital logic component of the LT2600 contains circuitry (e.g., 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. The result of the logic component in

the top block of the latching circuit is 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.

This 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 53 with the individual transistor gates labeled with m_1 through m_9 . Together they 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).

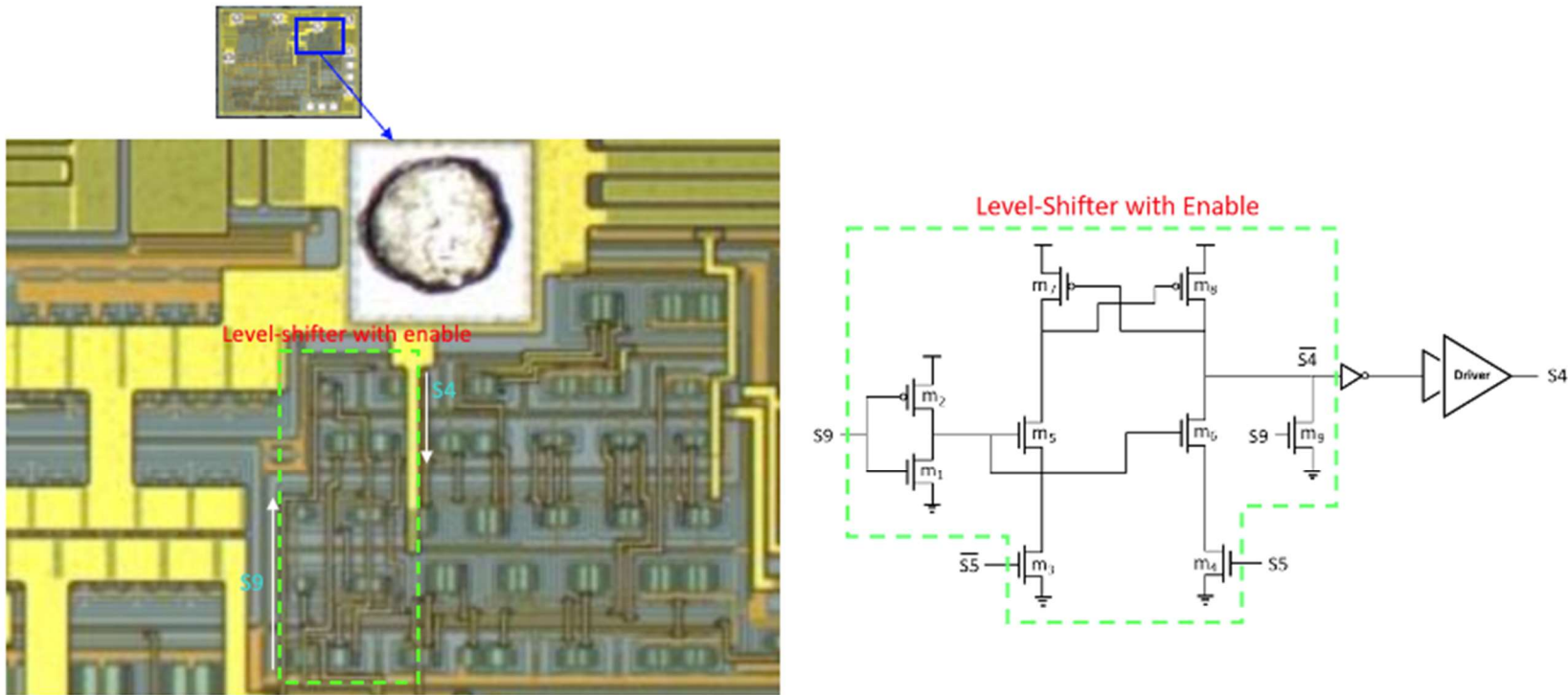


Figure 53. Circuit tracing a portion of the logic circuitry in the detection result latching circuit shows it to comprise a level-shifter. An image of the CP1 die with the transistor gates labeled is shown on the left and the equivalent circuit diagram is shown on the right. Images on left show CP1 from an LT2600.

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 rising/falling 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 generate 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 above with respect to claim element 10[c], and claim 11, S9 has two possible states, 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 module to detect the CS 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 52). When the lamp is installed correctly, $R_{Install}$ is low, the LED current (loop current) will be high, and the calculated impedance will be relatively low. Conversely, if the lamp is not installed correctly $R_{Install}$ will be high, the LED current will be low, and the calculated 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. Hence, for at least the reasons detailed above, the detection result latching circuit in the GE LED13ABT8/G4/830 LED tube lamp is coupled to the detection determining circuit, the detection pulse generating module, and the switch circuit, wherein at least one of the pulse signal, the high level signal, and the low level signal is provided to the switch circuit through the detection result latching circuit. Thus, the GE LED13ABT8/G4/830 LED tube lamp satisfies all elements of claim 10, and further satisfies all additional limitations added to claim 10 by claims 11, 12, 16 and 17, and therefore infringes claim 17 of the '174 patent.	Input: S5	Input: S9	Output: S4	Low/0	Low/0	Low/0	High/1	Low/0	High/1	Low/0	High/1	High/1	High/1	High/1	High/1
Input: S5	Input: S9	Output: S4														
Low/0	Low/0	Low/0														
High/1	Low/0	High/1														
Low/0	High/1	High/1														
High/1	High/1	High/1														

Claim 18	GE LED Tube LED13ABT8/G4/830 – Representative Product
18<pre>]</pre> A detection method for 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 detection method comprising:	The GE LED13ABT8/G4/830 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 54. 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 55. 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.

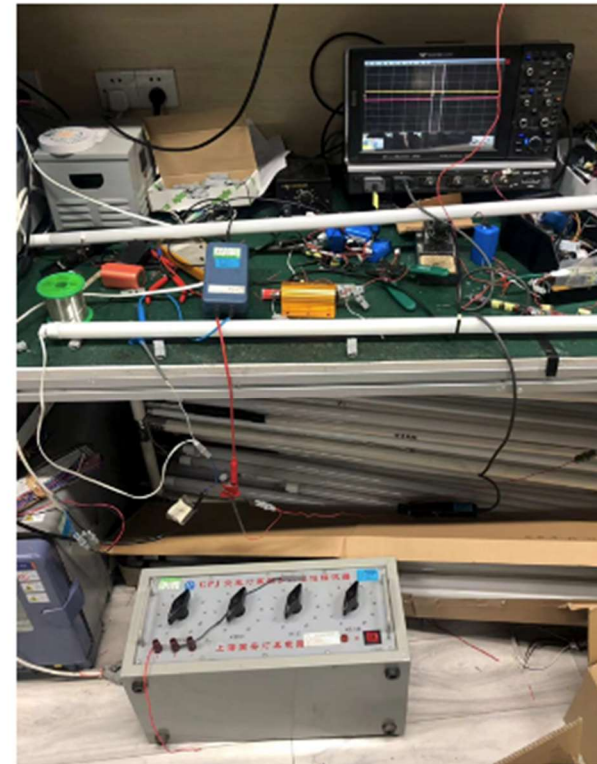
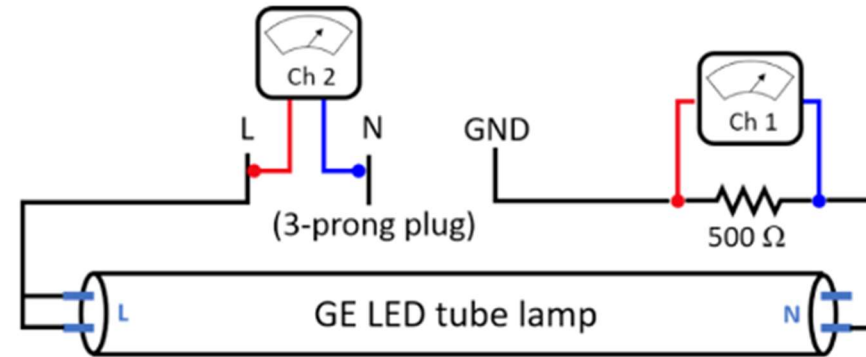


Figure 54. (Top) Schematic of measurement setup for re-lamping test, in accord with UL 1993, to ascertain whether switch circuit will turn on or remain off when the LED lamp tube is detected to be improperly installed. (Bottom) Photographs of measurement setup with GE LED tube lamp.

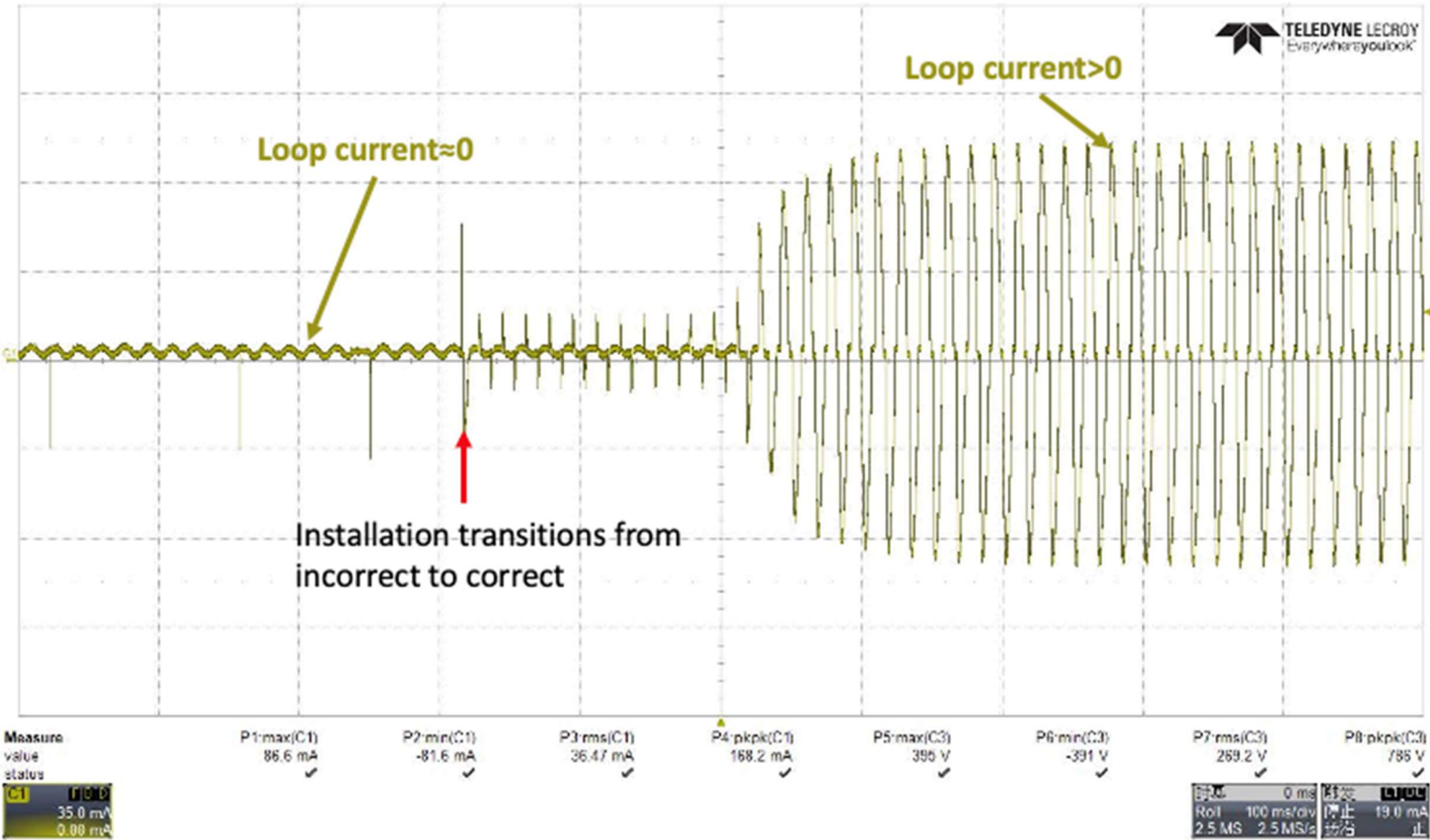
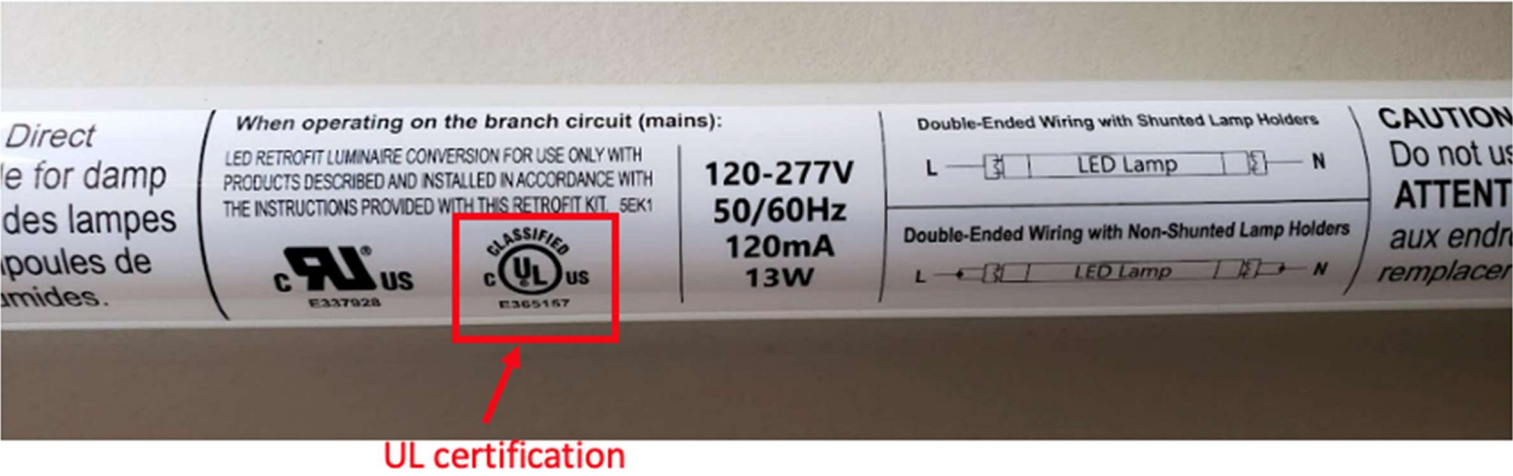
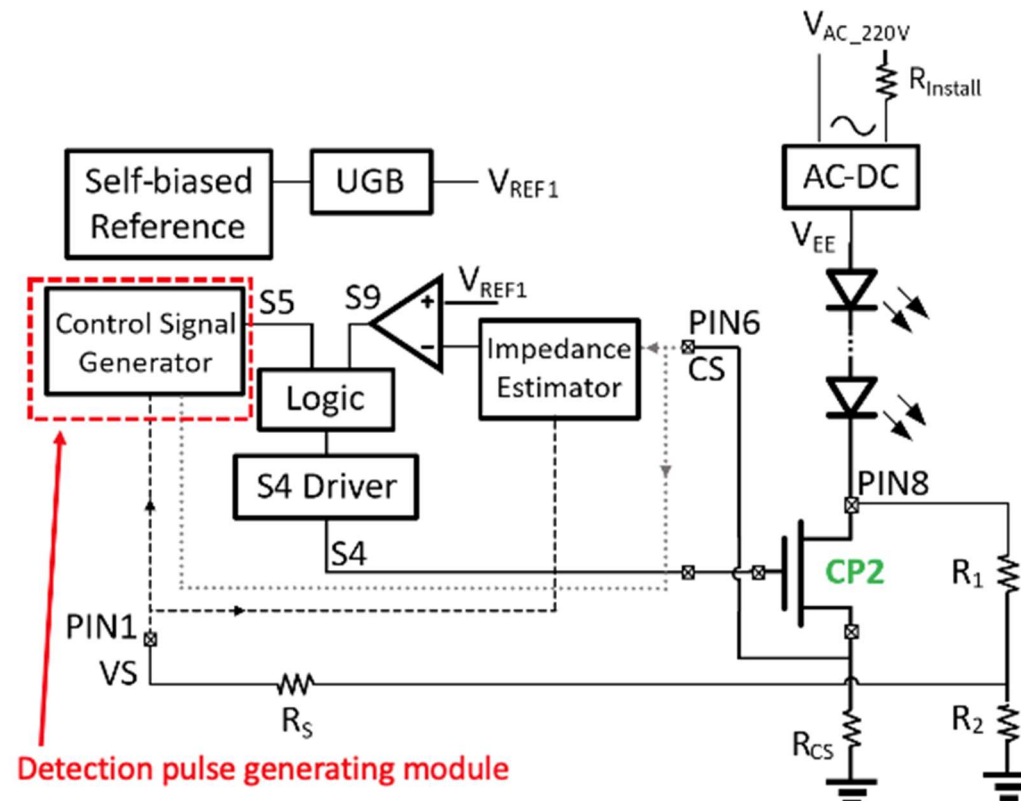
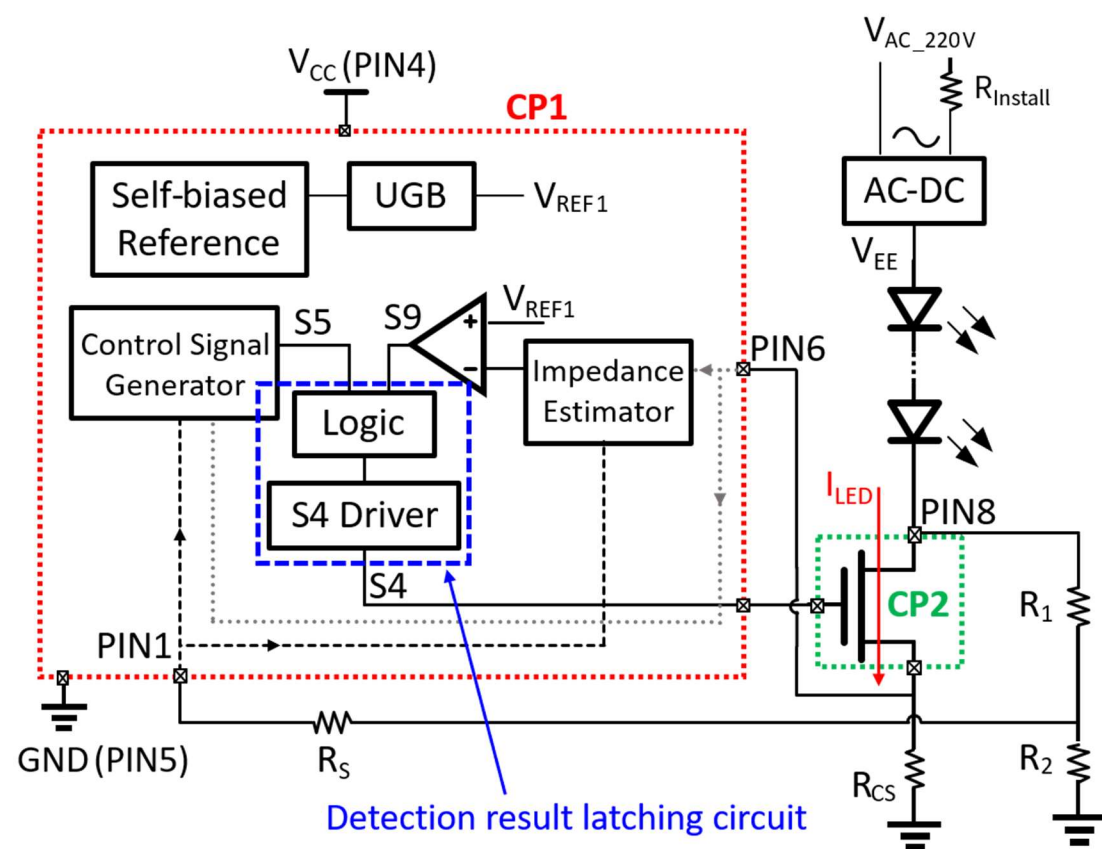


Figure 55. Leakage current measured during re-lamping test. The orange trace is a measure of the leakage current, corresponding to the loop current measured passing through the non-inductive 500 Ω resistor connected in series with the GE lamp and ground. The leakage current remains negligible (~1.48 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 56) 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 18	GE LED Tube LED13ABT8/G4/830 – Representative Product  Figure 56. 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 18 of the '174 Patent.
18[a] generating a pulse signal by a detection pulse generating module;	The GE LED13ABT8/G4/830 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 57 is a detection pulse generating module 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 elements 1[f] and 1[g].

Claim 18	GE LED Tube LED13ABT8/G4/830 – Representative Product
	 Figure S7. The detection pulse generating module is outlined by the dashed red line and consists of circuitry contained on the CP1 die inside the LT2600. Therefore, the GE LED tube lamp satisfies the claim element 18[a] of the '174 Patent.
18[b] receiving the pulse signal by a switch circuit coupled on a power loop of the LED tube lamp, wherein the switch circuit is conducted during a pulse-on period of the pulse signal to cause the power loop to be conductive;	The GE LED13ABT8/G4/830 LED tube lamp contains LT2600 IC employing the step of receiving the pulse signal by a switch circuit coupled on a power loop of the LED tube lamp, wherein the switch circuit is conducted during a pulse-on period of the pulse signal to cause the power loop to be conductive. For example, the digital logic and S4 driver, both outlined in dashed blue, together form a detection result latching circuit as shown in Figure 58. 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 17.

Claim 18	GE LED Tube LED13ABT8/G4/830 – Representative Product
	 Figure 58. Switch circuit CP2 receives S5 through the detection result latching circuit comprised of the digital logic and S4 driver, both outlined in dashed blue. 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 18[b].
18[c] detecting a sampling signal on the power loop;	See claim element 1[f] and claim 10. The signal on PIN6 represents a sampling signal and is used to determine whether the LED tube lamp is properly installed on a lamp socket.
18[d] comparing the sampling signal with a predefined signal; and	See claim element 10[c].

Claim 18	GE LED Tube LED13ABT8/G4/830 – Representative Product
18[e] limiting a current on the power loop less than 5 MIU when a signal level of the sampling signal is smaller than the predefined signal.	See claim element 10[d]. Therefore, for at least the reasons described above, the GE LED13ABT8/G4/830 LED tube lamp satisfies all elements of claim 18, and therefore infringes claim 18 of the '174 patent.

Claim 23	GE LED Tube LED13ABT8/G4/830 – Representative Product
23[pre] A light-emitting diode (LED) tube lamp, comprising:	See claim element 1[pre].
23[a] a lamp tube; two end caps, each having an external connection terminal, and each coupled to a respective end of the lamp tube, wherein the external connection terminals are configured to receive an external driving signal;	See claim element 1[a].
23[b] an LED module, configured to emit light based on the external driving signal; and	See claim element 1[e].
23[c] an installation detection module, coupled to a power loop of the LED tube lamp and configured to detect a sampling signal on the power loop and compare the sampling signal with a predefined signal,	See claim element 10[c] and claim element 18[c]. The signal on PIN6 represents a sampling signal and is used to determine whether the LED tube lamp is properly installed on a lamp socket.
23[d] wherein a leakage loop is formed between the external connection terminal on one of the end caps and a ground when the one of the end caps is inserted into a lamp socket but the other one is grounded by an object, and wherein the installation detection module is activated by a driving voltage on the leakage loop.	The GE LED13ABT8/G4/830 includes an installation detection module which is activated by a driving voltage on the leakage loop, wherein a leakage loop is formed between the external connection terminal on one of the end caps and a ground when the one of the end caps is inserted into a lamp socket but the other one is grounded. The required leakage loop as shown in Figure 59 – formed between the external connection terminal on one of the end caps and a ground when the one of the end caps is inserted into a lamp socket but the other one is grounded by an object – is modeled during the relamping test setup detailed with respect to claim elements 1[f] and 10[c], when one end of the lamp is connected to ground through a 500 Ω resistor, or with respect to claim 10[d], when one end of the lamp is connected to ground through a Simpson 228 current leakage meter.

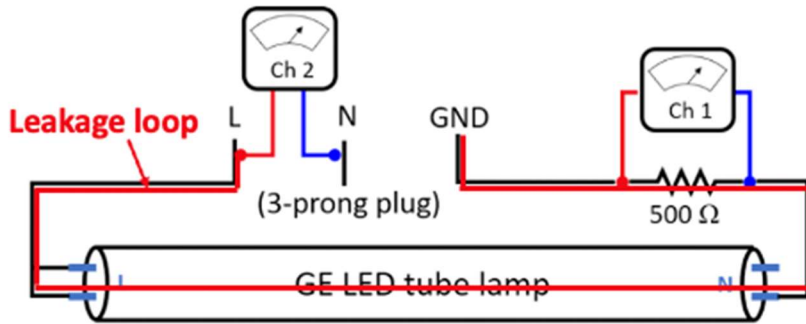


Figure 59. Leakage loop formed between the external connection terminal on one of the end caps and a ground when the one of the end caps is inserted into a lamp socket but the other one is grounded by a 500 Ω resistor.

In said relamping tests, when a 277 VAC line voltage is applied to one end of the lamp and the opposing end is connected to ground through a 500 Ω resistor or through the Simpson 228 current leakage meter, the leakage loop is formed between Live wire L and ground via a 500 Ω resistor or a simulated human impedance in the Simpson 228 current leakage meter. See Figure 60, when the external driving signal (e.g., 277VAC) applies to one end and the other end is connected to ground via a 500 Ω resistor, a driving voltage is generated at the output of the rectifying circuit BD. The driving voltage charges capacitor C1 on the daughter board through resistors R1, R2 and R3 to make the voltage at PIN4 (VCC) of LT2600 increasing. The LT2600 IC will be activated when the voltage at PIN4 (VCC) reaches a certain level and start to send pulses for detecting the installation state.

Claim 23

GE LED Tube LED13ABT8/G4/830 – Representative Product

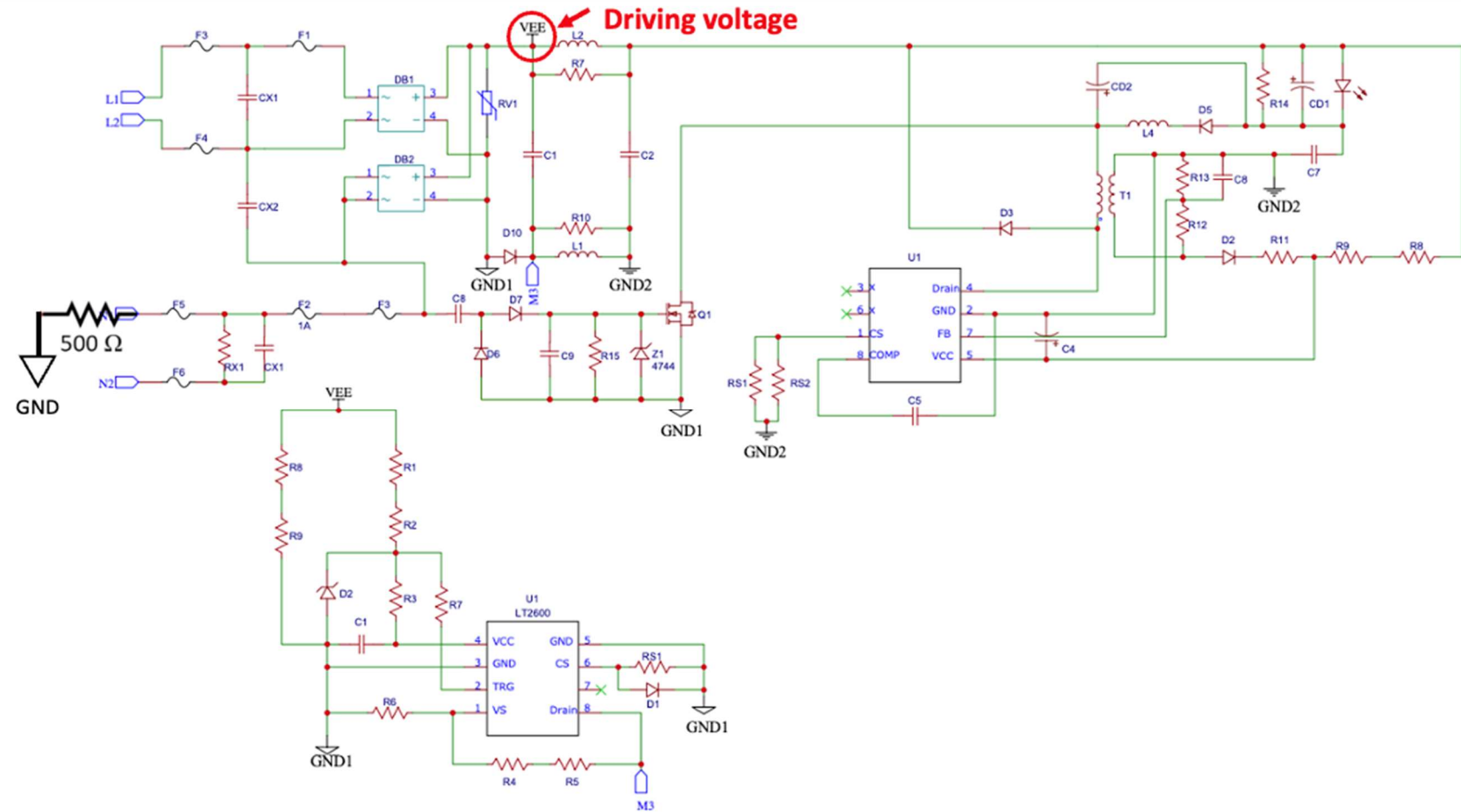


Figure 60. The driving voltage charges capacitor C1 through resistors R1, R2, and R3 to activate LT2600 IC when the external driving signal applies to one end and the other end is connected to ground via a 500Ω resistor which forms the leakage loop.

Therefore, the L10.5T8SDE435 satisfies claim element 23[d]. Thus, for the reasons detailed above, the GE LED13ABT8/G4/830 LED tube lamp satisfies each and every element of claim 23, and therefore infringes claim 23 of the '174 patent.

Claim 25	GE LED Tube LED13ABT8/G4/830 – Representative Product
The LED tube lamp according to claim 23 , wherein the driving voltage is generated based on the external driving signal when the leakage loop is formed.	See claim elements 1[e] and 1[f], claim elements 10[c] and 10[d], and claim element 23[d].

Claim 26	GE LED Tube LED13ABT8/G4/830 – Representative Product
26[pre] A light-emitting diode (LED) tube lamp, comprising:	See claim element 1[pre].
26[a] a lamp tube; two end caps, each having an external connection terminal, and each coupled to a respective end of the lamp tube, wherein the external connection terminals are configured to receive an external driving signal;	See claim element 1[a].
26[b] an LED module, configured to emit light based on the external driving signal; and	See claim element 1[e].
26[c] an installation detection module, coupled to a power loop of the LED tube lamp and configured to detect a sampling signal on the power loop and compare the sampling signal with a predefined signal,	See claim elements 10[c] and claim element 18[c]. The signal on PIN6 represents a sampling signal and is used to determine whether the LED tube lamp is properly installed on a lamp socket.
26[d] wherein the installation detection module comprises: a control module, configured to output a control signal for controlling a conduction state of the power loop and when a signal level of the sampling signal is smaller than the predefined signal, the control module limits a current on the power loop less than 5 MIU by controlling the conduction state,	The GE LED13ABT8/G4/830 has an installation detection module including a control module, configured to output a control signal for controlling a conduction state of the power loop and when a signal level of the sampling signal is smaller than the predefined signal, the control module limits a current on the power loop less than 5 MIU by controlling the conduction state. The digital logic together with S4 driver, outlined in dashed blue line as shown in Figure 61, in the LT2600 IC constitutes the claimed control module. CP1 die in the LT2600 IC (see Figure 61), within the installation detection module, constitutes the claimed control module configured to output a control signal. Signal S4 highlighted in pink, output from the control module and input to the gate electrode of the CP2 die (comprising the switch circuit), is the claimed control signal.

Claim 26	GE LED Tube LED13ABT8/G4/830 – Representative Product
	Figure 61. The digital logic and S4 driver, both outlined in dashed blue, together form the control module. As discussed above in claim 17, when the voltage corresponding to the estimated impedance is greater than or equal to reference voltage V_{REF1}, S9 will be low, and control signal S4 will follow pulse signal S5. Because the voltage at PIN1 is a constant during the impedance calculation (see Figure 46), "the voltage corresponding to the estimated impedance is greater than or equal to reference voltage V_{REF1}" can be considered the same as "a signal level of the sampling signal (i.e., signal at PIN6) is smaller than the predefined signal " based on Ohm's law. On the other hand, according to the measurement result during re-lamping test as shown in Figure 47, the current on the power loop is limited to about 2 MIU which is less than 5 MIU. Hence, the control module limits the current on the power loop to less than 5 MIU by sending control signal S4 having pulse waveform. Therefore, the GE LED13ABT8/G4/830 satisfies claim element 26[d].
26[e] wherein the control module generates the control signal having a first waveform during a detection stage and generates the control	The GE LED13ABT8/G4/830 has a control module capable of generating the control signal having a first waveform during a detection stage and generating the control signal having a second waveform during an operating stage. As described above with respect to claim element 26[d], control signal S4 is output from the control module outlined in dashed blue line. Furthermore, the control module generates S4 with a first waveform during a detection stage and generates S4 with a second waveform during an operating stage.

Claim 26	GE LED Tube LED13ABT8/G4/830 – Representative Product
signal having a second waveform during an operating stage.	The S4 signal is internal to the LT2600 package and could not be probed directly. However, the test measurement setup detailed above with respect to claim element 1[e] (Figure 24 and Figure 25) shows the signal on the power loop and the voltage drop across the 500 Ω resistor in series with the lamp power when the mechanical switch is toggled, as the lamp is transitioned between an improper and a proper installation state. This is synonymous with a “detection stage” and an “operating stage” of the lamp. As shown in Figure 62, during the “detection stage” the S4 signal will pulse with a waveform that follows the pulse signal S5 (first waveform). In contrast, during the “operating stage” the S4 signal will remain high (second waveform). Thus, the control signal will have a first waveform during a detection stage and a second waveform during an operating stage. The moment LED is installed correctly Control/S5 S4 First waveform (pulse) Second waveform (fixed level) Figure 62. Timing diagram showing the first waveform (pulse) during the detection stage and the second waveform (fixed level) during the operating stage. Thus, for the reasons detailed above, the GE LED13ABT8/G4/830 satisfies each and every element of claim 26 of the '174 patent.

Claim 27	GE LED Tube LED13ABT8/G4/830 – Representative Product
27[a] The LED tube lamp according to claim 26, wherein the control module comprises: a detection result latching circuit, coupled to a detection determining circuit, a detection pulse generating module, a switch circuit, wherein at least one of a pulse signal, a high level signal, and a low level signal is provided to the switch circuit through the detection result latching circuit.	See claim 17.

Claim 28	GE LED Tube LED13ABT8/G4/830 – Representative Product
28[pre] A light-emitting diode (LED) tube lamp, comprising:	See claim element 1[pre].
28[a] a lamp tube; two end caps, each having an external connection terminal, and each coupled to a respective end of the lamp tube, wherein the external connection terminals are configured to receive an external driving signal;	See claim element 1[a].
28[b] an LED module, configured to emit light based on the external driving signal; and	See claim element 1[e].
28[c] an installation detection module, coupled on a power loop of the LED tube lamp and configured to generate a pulse signal for controlling a conduction state of the power loop and detect a sampling signal on the power loop during a pulse-on time of the pulse signal,	See claim elements 1[f], 1[g], 18[c], and 18[d].
28[d] wherein the installation detection module limits a current on the power loop to less than 5 MIU by setting the pulse-on time less than or equal to 1 millisecond.	The GE LED13ABT8/G4/830 has an installation detection module which limits a current on the power loop to less than 5 MIU by setting the pulse-on time to less than or equal to 1 millisecond. As an initial matter, I understand that the Court has ruled that the term “[limits/limiting] a current on the power loop [to] less than 5 MIU” is to be construed as “not allow[ing] the current on the [power loop/current path of the power supply module] to exceed [5 MIU/a value defined in advance].” I have applied this construction to my analysis The relamping test, as used above with respect to claim element 1[f], can be used to establish a setup wherein the lamp is in an improper installation state. During this state, transient current on the power loop is detected during the pulse-on period of S4. The longer the pulse-on period of S4, the higher transient current should be detected. By placing a Simpson 228 current leakage meter in line with the GE LED tube lamp during the relamping setup described above with respect to claim element 1[f], and shown on the left side of Figure 63, we can measure the RMS current permitted by the installation detection module under the current pulse setting. The readout shown on the right side of Figure 63 indicates that the current on the power loop has been limited to approximately 2 MIU, which is less than the 5 MIU limitation required by the claim.

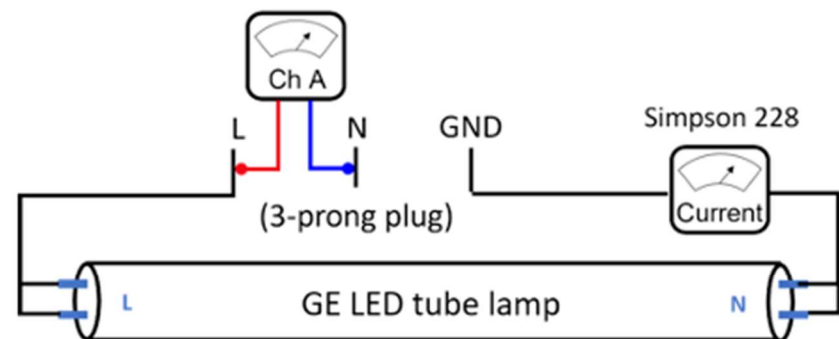
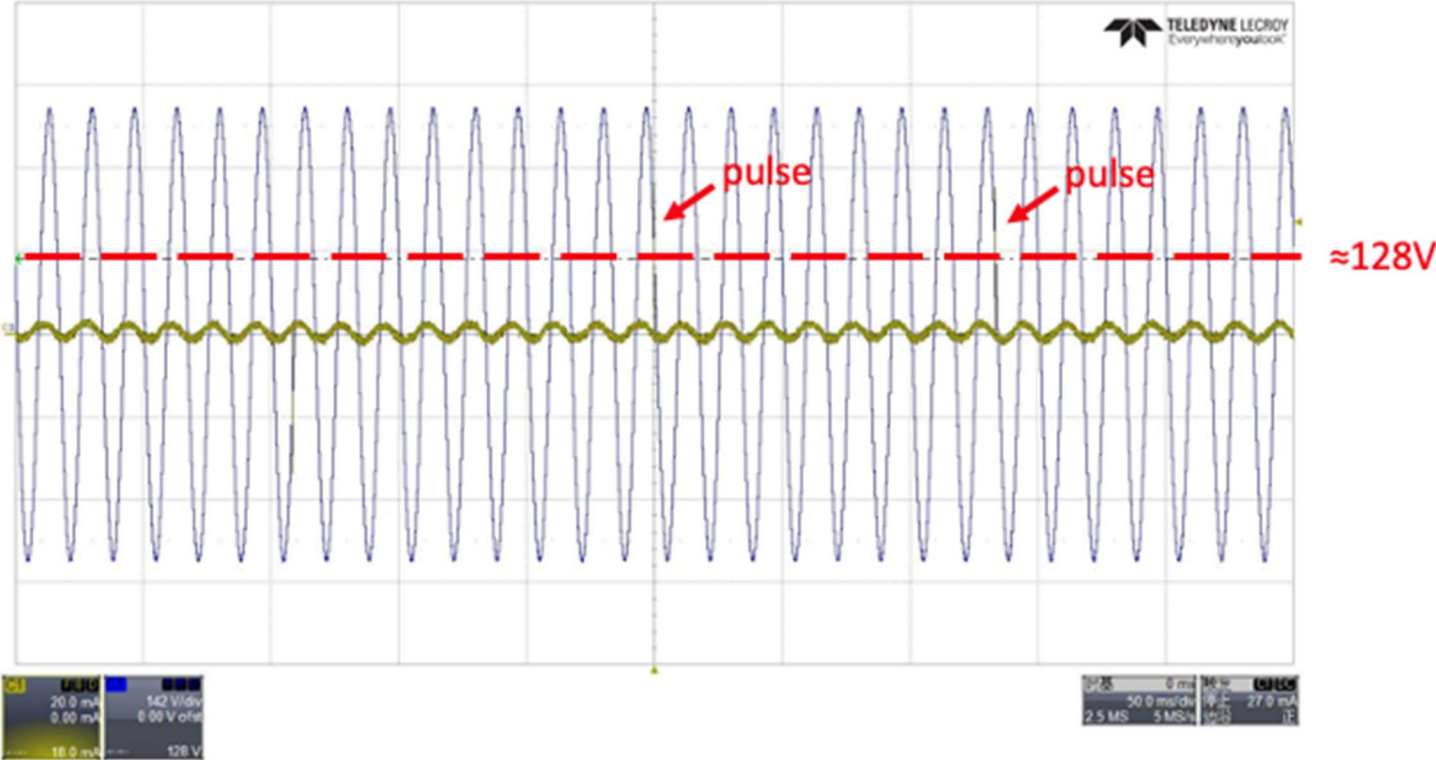


Figure 63. (Left) Relamping setup to monitor current on power loop. (Right) The Simpson 228 reads current on the power loop of the GE LED13ABT8/G4/830 LED tube lamp when the transient current is smaller than the predefined signal.

Additionally, using the setup shown in Figure 23, the voltage drop across 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 μ s, as shown on the bottom of Figure 35. This width is less than 1 millisecond.

Claim 29	GE LED Tube LED13ABT8/G4/830 – Representative Product
The LED tube lamp according to claim 28 , wherein the installation detection module limits a current on the power loop to less than 5 MIU by setting the pulse-on time between 10 microseconds to 1 millisecond.	See claim element 28[d].

Claim 32	GE LED Tube LED13ABT8/G4/830 – Representative Product
32[pre] A light-emitting diode (LED) tube lamp, comprising:	See claim element 1[pre] .
32[a] a lamp tube; two end caps, each having an external connection terminal, and each coupled to a respective end of the lamp tube, wherein the external connection terminals are configured to receive an external driving signal;	See claim element 1[a] .
32[b] an LED module, configured to emit light based on the external driving signal; and	See claim element 1[e] .
32[c] an installation detection module, coupled to a power loop of the LED tube lamp and configured to generate a plurality of pulse signals for controlling a conduction state of the power loop and detect a sampling signal on the power loop during a pulse-on time of each of the pulse signals,	As detailed above with respect to claim element 1[f]. in the GE LED13ABT8/G4/830, the current pulses generated from a plurality of pulse signals (S5) are observed under the re-lamping test setup (see Figure 24). The pulse signals are used to control the switch circuit CP2 on the power loop so as to control a conduction state of the power loop. CP1, which is the claimed installation detection module, can detect the current passing through R _{CS} during the pulse-on time of the pulse signals which turns on the switch circuit CP2. CP1, by receiving the CS signal at PIN6 (see Figure 22).
32[d] wherein a time interval between at least two consecutive pulse signals of the pulse signals is designed such that at least one of the two consecutive pulse signal occurs when the external driving signal is at non-zero level.	The GE LED13ABT8/G4/830 has an installation detection module which outputs a plurality of pulse signals having a time interval between at least two consecutive pulse signals of the pulse signals to be designed such that at least one of the two consecutive pulse signal occurs when the external driving signal is at non-zero level. For example, it can be observed in Figure 65 that two consecutive pulse signals sequentially occur when the external driving signal is falling and reaches around 128V, which is a non-zero level. Thus, for the reasons detailed above, the GE LED13ABT8/G4/830 LED tube lamp satisfies all elements of claim 32, and therefore infringes claim 32 of the '174 patent.

Claim 32	GE LED Tube LED13ABT8/G4/830 – Representative Product
	 The figure is an oscilloscope screenshot from a Teledyne Lecroy device. It displays two waveforms: a blue one and a green one. The blue waveform is a high-frequency, high-amplitude periodic signal. The green waveform is a lower-frequency, lower-amplitude periodic signal. A horizontal red dashed line is drawn across the screen at a level labeled '≈128V' on the right. Two red arrows point to specific peaks in the blue waveform, each labeled 'pulse' in red text. At the bottom left, there are two small data boxes. The first box shows '20.0 mA', '0.00 mA', and '16.0 mA'. The second box shows '142 V/div', '0.00 V/div', and '128 V'. At the bottom right, there are two more data boxes. The first shows '50.0 ms/div', '2.5 MS', and '5 MS'. The second shows '27.0 mA' and 'IF'. The Teledyne Lecroy logo is in the top right corner. Figure 65. Measurement result demonstrated two consecutive pulse signals occur at around 128V.

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.