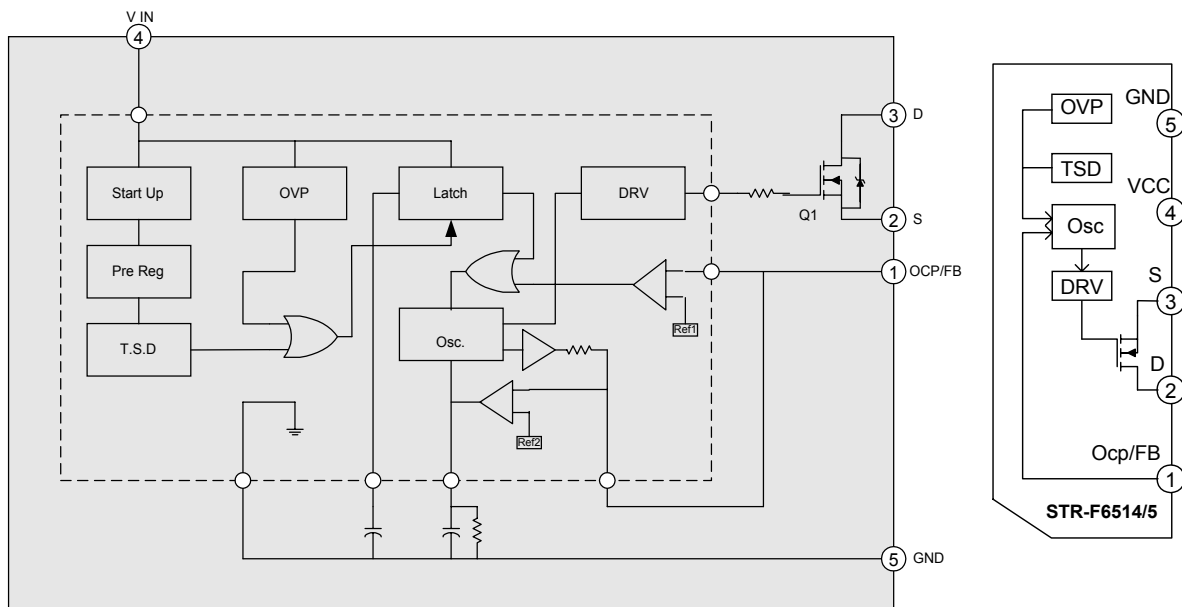


Power Supply description and trouble shooting procedure

In general, switching regulators, using a switching transistor, switches on and off a DC power supply through a transformer. When the transistor is turned on, the transformer charges from the DC supply. When the transistor is turned off, the transformer discharges into its secondary windings. These secondary outputs are then rectified and filtered for use. Thus by controlling the transformer's charging time and discharging time, it is possible to control (regulate) the secondary voltage efficiently.

In televisions using the FA, and FK, FV, GV, and GR chassis: the power supply uses an integrated switching regulator circuit (IC), **STR-F******. This switching regulator IC contains an oscillator (mono-stable), a switching transistor, protection circuits, etc. The IC's internal circuits are protected against over voltage, over current, and over heat. An internal block diagram of the IC is shown below.

Internal Circuits



Startup circuit:

In order for the regulator to function, the IC has to start functioning. For this purpose, from the unregulated supply, a start up voltage is supplied to the IC's power input.

Pre regulator:

The supply for the internal components of the IC is usually the unregulated supply. This could vary and affect the performance of the IC. An internal regulator is used to prevent drifting of IC's parameters due to the unregulated supply voltage variation.

OVP (Over Voltage Protection):

As mentioned earlier, the power supply to the IC is from the unregulated source. This voltage can vary with the line voltage. Excessive voltage can cause damage to the IC. The Over Voltage Protection circuit monitors the IC's supply voltage. If this voltage

exceeds approximately 22Volts, this circuit turns off the IC's drive circuits. The OVP circuit triggers an internal latch. See the internal block diagram

OCF (Over Current Protection):

The IC contains a power output FET. The current through this FET depends on different factors such as on time, load on the power supply, etc. Excessive current through the FET can damage it. Using a source resistor, the FET's current is monitored. This proportional voltage is then fed back to the IC's OCP circuit. This voltage, when exceeds the specified limit (0.75 V), the OCP circuit turns off the IC's output FET.

TSD (Thermal Shut Down):

The IC is protected against over voltage and over current as discussed earlier. Besides these protections, the IC is protected against over-heat-damage using the thermal shut down circuit. When the IC's temperature reaches a certain limit, the thermal shut down circuit operates and turns it off. TSD circuit triggers an internal latch.

Latch

The OVP circuit or the TSD circuit is activated, it then turns off the IC and also trigger an internal latch. This latch circuit holds the IC's output circuit off. In order to release the latch and turn on the FET again, IC's power must be removed and reapplied.

Oscillator

This IC has an internal mono-stable oscillator (time constant circuit). After power is applied, or the FET is turned off by OCP (see description above), the internal time constant circuit will turn on the FET again after approximately 45 microseconds. If required, it is possible to speed up the time constant circuit and turn on the FET earlier than the internal time constant. We will discuss this later in detail.

Drive

As discussed earlier, the switching regulator IC has a power FET. All the control circuits for the FET are applied to its drive circuit.

Pin Descriptions

Pin1, OCP/FB:

This pin has two functions.

- ***OCF***

When a DC (above 0.75V) is applied to this pin; the IC's internal FET will be turned off. After the applied DC is removed, depending on the internal time constant, the IC will turn on the FET again.

- ***FB***

In some applications it might be necessary to turn on the FET earlier than the time decided by the internal time constant. In this case, it is possible to speed up the internal time constant and turn on the FET by raising its pin1 DC above 1.4V and then lowering it below 0.7V.

Pin 2, S

This is the Source of the IC's internal power FET. When the FET starts conducting, the source resistor generates a source voltage, which is used to monitor the FET's current. When this voltage exceeds a specified limit (approximately 0.75V), it then

turns off the FET. After the FET is turned off, as discussed earlier, the FET will turn on again. This is how we get the switching function

Pin 3, Drain

This is the internal power FET's drain. In a switching power supply application, the drain is usually connected to the DC source through the switching transformer's primary winding.

Pin 4, VIN

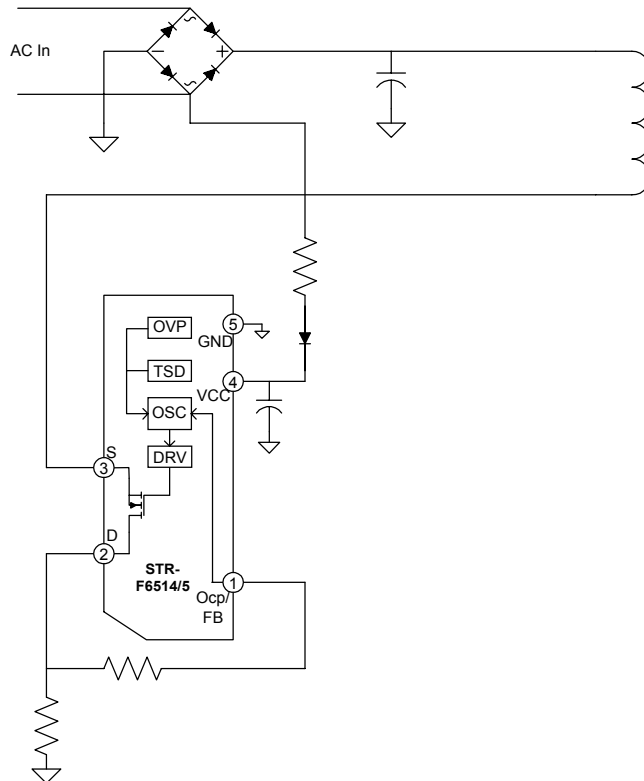
This pin has two functions

- ***V_{cc}***
The DC supplied to this pin is routed through an internal regulator for powering the IC's internal control circuits. The internal circuits will operate if the supply voltage is between 16.0 and 22.0 V
- ***OVP***
The DC supplied to this pin is also applied to an over voltage detector. If the applied voltage exceeds the specified limit (22 volts), then the OVP circuit turns off the IC and activates a latch. In order to restart the IC, the applied DC must be removed and reapplied.

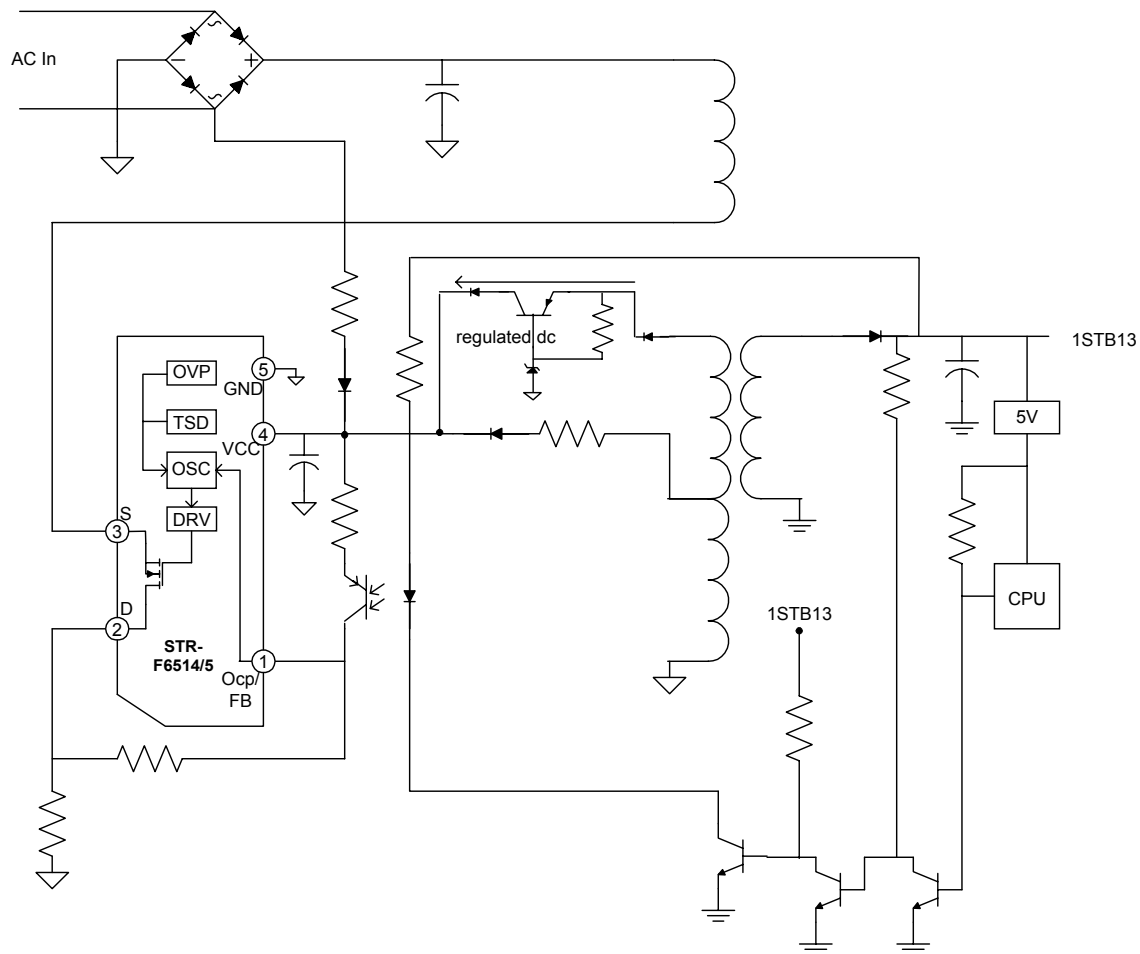
Pin 5, GND.

Circuit Description.

1. The AC is inputted to the TV through line filters to prevent any line interference such as spurious spikes from getting into the television. In addition, it blocks high frequency interference from the television going back to the power line.
2. The inputted AC is rectified using a bridge rectifier and filtered using a capacitor. This DC is known as the raw DC and it measures about 160V with respect to the live ground. This DC is supplied to the switching transistor through a transformer's primary winding.
3. In order for the IC to start functioning and to turn on the FET, it needs a power supply. A start up DC voltage is generated from the inputted AC line through a resistor and a diode. Diode is not used in some chassis. The reason is that current flows only in one direction because of the bridge rectifier.
4. This voltage, then charges a capacitor and when the DC voltage reaches the IC's start up voltage, the IC starts functioning.
5. When the IC starts functioning, its internal FET is turned on and a current flows through the primary of the switching transformer, the FET, and the FET's source resistor. Since the FET conducts through an inductor (the transformer's primary), the current ramps up from zero charging the transformer. This generates a ramp voltage across the source resistors. This ramp voltage is fed back to the IC's OCP/FB input (pin 1) through a feedback resistor. When this ramp reaches 0.75V, the internal FET is turned off. From the time the FET started conduction until it is turned off is the FET's on period
6. After the FET goes off, the energy stored in the transformer is discharged to the transformer's other windings. In other words, when the FET is ON, the transformer charges from the raw DC and when the FET is OFF, it discharges in to its secondary windings

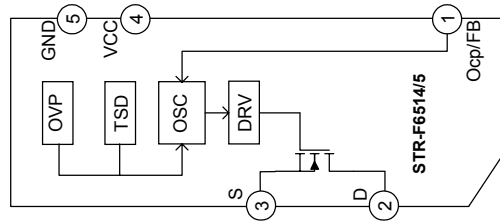


7. When the IC starts functioning, the IC's power consumption increases. The current through the start up resistor is not sufficient to maintain the IC's conduction. The DC at IC's VCC will drop and cause the IC to shut down. To avoid this, when the transformer discharges into its secondary windings (FET goes off), one of the secondary voltages is used to provide additional VCC to the IC. This is known as RUN-DC, and is necessary for the IC's uninterrupted operation. This DC is obtained via a resistor and a diode. Every time the IC's output transistor turns off, the transformer discharges its energy through its windings and charges up the startup capacitor and maintains the IC's Vcc.



8. The secondary voltages are now rectified by the diodes to obtain the STBY 12V. The standby 12V, through a 5V regulator, powers up the CPU. The CPU outputs power control signal and controls the power on/off.
9. In stand by mode, the TV's consumption is minimum and the FET's on time could be reduced. In order to reduce the FET's on time, an additional DC is added to the ramp voltage. This is achieved using a photo coupler. In the standby mode, the photo coupler's LED is turned on. When the LED is on; the photo coupler conducts and additional DC is applied to the regulator IC's pin1.

10. When FET's on time is reduced, the transformer's secondary voltage reduces. In some cases, this reduced secondary voltage affects the run DC and is not sufficient to maintain the IC's conduction. In these cases, an additional regulated run dc from a higher voltage winding is supplied to the IC's Vcc
11. The off time of the IC is fixed internally and is approximately 45 microseconds. This means the IC will turn the FET on again after about 45 microseconds. When the FET is on, its source voltage increases. This source voltage is fed back to the OCP/FB input and will cause the IC to turn it off. The switching occurs when this process repeats.
12. When the television's power is turned on, the televisions video-circuits, deflection, audio circuits, and any other circuits are turned on. This increases the power demand. More power can be transferred to the secondary by the following methods
 - Increasing the on time (the transformer's charging time)
 - Reducing the off time (the transformer's discharging time)
13. Removing the voltage feedback from the photo coupler can increase the FET's on time. When the television is turned on, the photo coupler's LED control transistor is turned off (refer to the diagram above). This increases the FET's on time and it depends on the source's ramp voltage.
14. In order to reduce the off time, the FET has to be turned on earlier than 45 microseconds (its natural off time). This is done using the inhibit voltage, the transformer's AC (switched DC) output is applied to IC's pin1. When this voltage is added to the feedback voltage, the feedback voltage rises above 1.4V and collapses. This restarts the FET's drive. The inhibit controller has a zener diode so that when the television is off, the voltage developed at the secondary winding is below its threshold and it will not refresh.
15. In addition to the above mentioned controls, when the television's power is turned on, an error amplifier IC monitors B1 voltage. If it exceeds the specified voltage, the error amplifier activates the photo coupler to reduce the FET's on-time (see standby mode for details). Reducing the FET's on-time will reduce the B1 voltage. The error amplifier IC includes one transistor (open collector), one zener diode, and three resistors. The zener diode is at the transistor's emitter and it provides the reference voltage. When the input increases above the specified voltage, the transistor's base voltage increase and turns on the transistor. The transistor (inside the error amplifier IC) will then turn on the photo coupler momentarily to control the FET's on time.



Trouble shooting

Before applying any power to the television, it is recommended to check the circuit and ensure that there are no shorted components. *If you are using an analog multimeter, ensure that the negative side of the internal battery (in some cases, the Red probe) is connected to the ground.* A few recommended measuring points are 1STB13V, CPU's VDD, CPU's power on/off control pin, Audio VCC, 2STB13V, B1 (135V), etc.

Since the power supply's control circuit includes feed back circuit, it is very important that all the control circuit must be functional for safe operation. There are critical components; if defective, that can cause extensive damage to the power supply. A systematic trouble shooting procedure is described below.

Equipments needed:

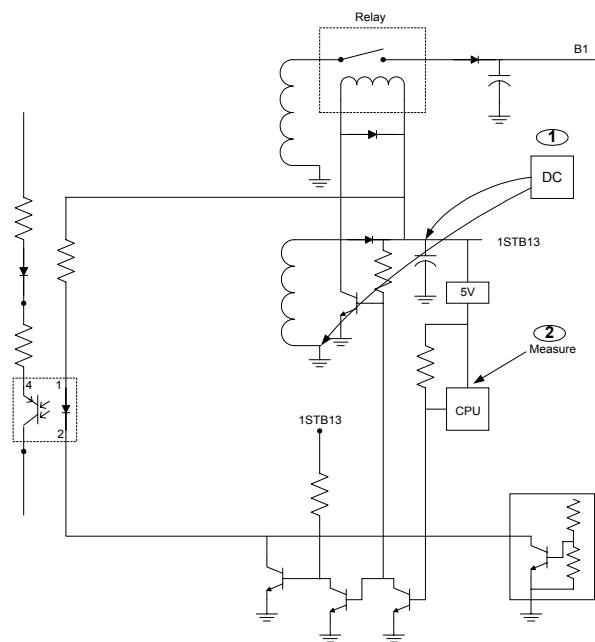
- Variable DC-power-supply
- Voltmeter
- Audio generator (100 KHz 1V p-p signal)
- Oscilloscope

Do not connect the TV to the AC supply before confirming the procedures listed below

1. Ensure the 5V DC-supply to the microprocessor

Without connecting the AC supply, in order to confirm the proper functioning of the power supply circuit using the following procedures, we need to apply a 13V external DC supply to the TV's 12V supply line. When applying a 12V, if the microprocessor is not powered, the microprocessor could get damaged. Confirm the 5V supply, following the procedure shown below. (Refer to the figure shown below.)

- Disconnect the TV from the AC power supply
- Carefully discharge all capacitors using a suitable resistor
- Adjust the variable DC power supply's DC output to 0V
- If the supply has a current limit control, then set it to limit at approximately 0.75A.
- Connect the external power supply's negative lead to the **cold** ground.
- Connect the positive lead to STB13V (this is also termed as STB13, 1STB13, etc). Refer to the schematic for convenient connection point
- Connect a voltmeter to CPU's Vcc. While monitoring the CPU's Vcc, slowly increase the DC voltage from 0 to 6V.



- If the CPU's Vcc does not become 5V, then troubleshoot the 5V regulator circuit first.
- Ensuring that the CPU's Vcc does not exceed above 6.0V, slowly increase the DC supply's output to 13V. If the CPU's Vcc exceeds above 6.0V, then trouble shoot the 5V regulator
- Ensure the current is less than 0.75A

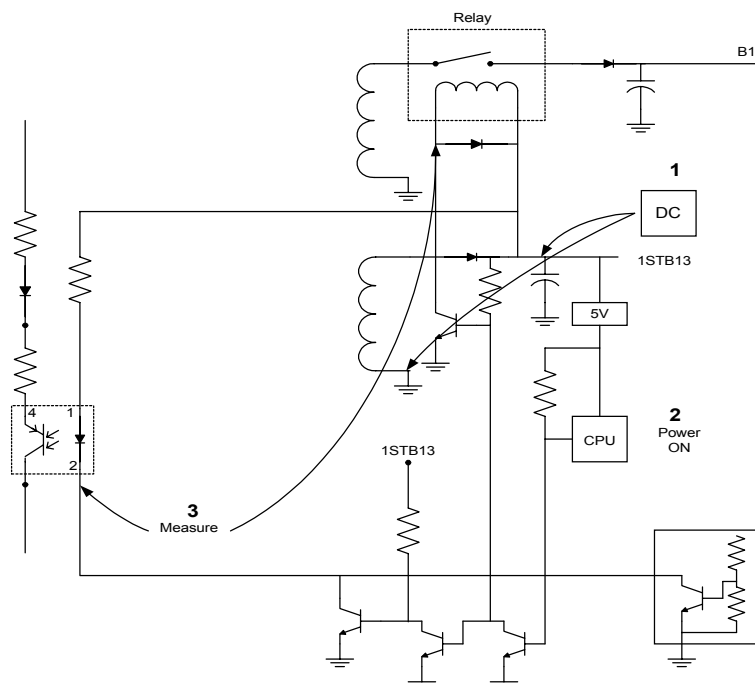
2. If necessary, disable the CPU's protection inputs

In some models; the CPU monitors the Vertical yoke failure (VNECK), power failure (AC OFF), or shorted supplies (SHORT). When performing the following test procedures, if emergency (flashing LED) occurs or power goes off after a few seconds, refer to the schematic and confirm that the emergency is not due to a defective component.

3. Check the power control circuit and other communications

After connecting the external 13V DC to the STB13V as described above, press the Power-button and confirm the following.

- CPU's IIC bus: Using an oscilloscope, confirm the CPU's IIC bus activity. When any function is selected, if no data or clock is found, troubleshoot the CPU or its peripheral components.
- Power LED: visually confirm LED on/off. If not troubleshoot the related components.
- B1 relay: Measure the voltage at the B1 relay driver transistor. Confirm that the voltage changes from 13V to 0V and the relay operates.
- SW13V (2STB13): Measure and confirm.
- Degauss relay (if present): Similar to the B1 relay confirmation confirm the degauss relay function.
- If any of the above does not function, then trouble shoot the related components



4. Check the operation of Photo coupler

After confirming the power control circuit's operation; connect a jumper from STB13V to the main regulator IC (STR-Fxxxx) pin 4 (Vcc). Connect another jumper between the **cold** ground and the **hot** ground. As shown in the table below, while measuring the Photo coupler's voltages, operate the power switch and confirm the voltage measurements

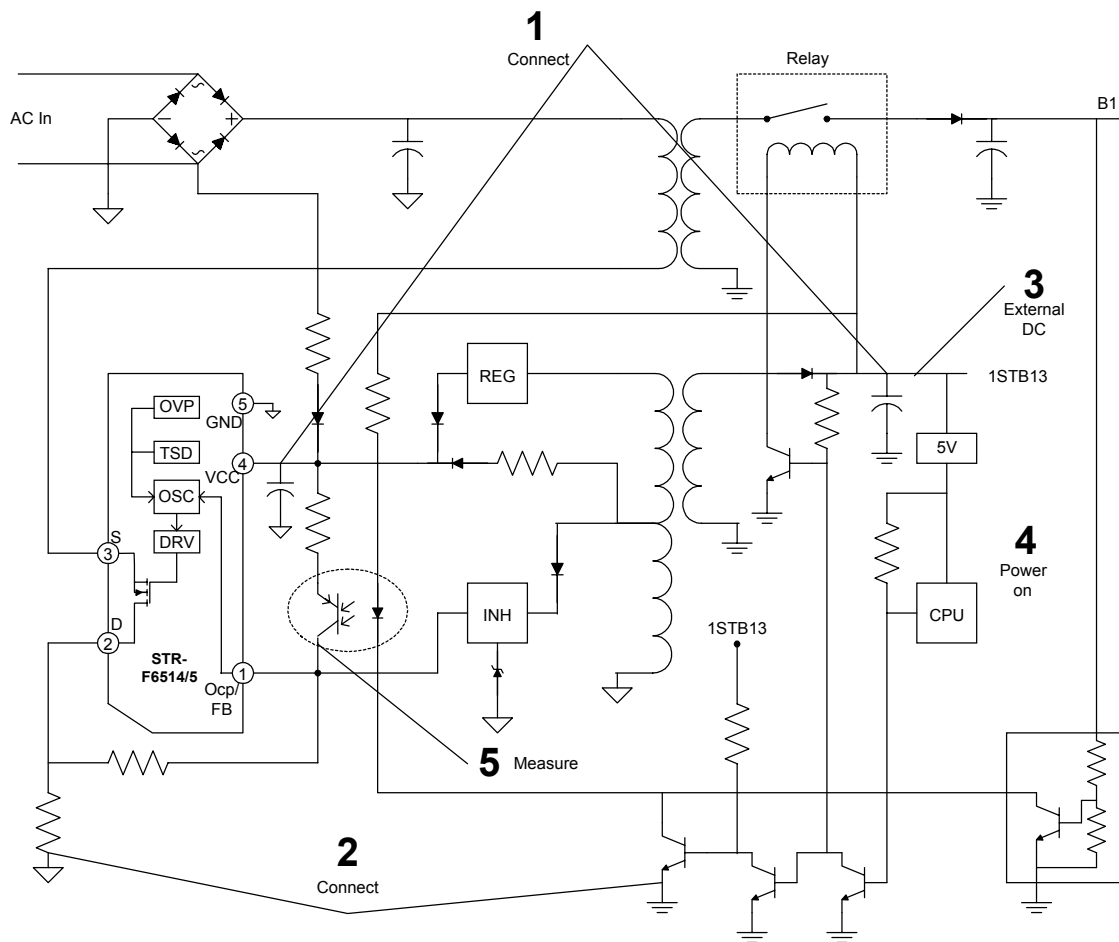


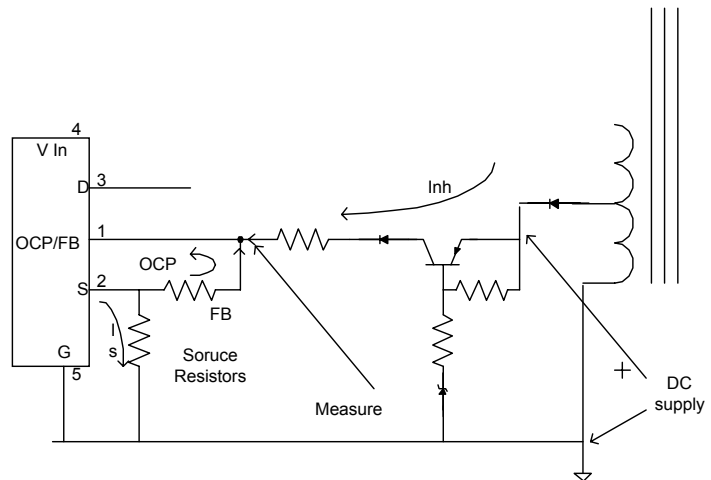
	Photo coupler's pins			
	Pin1	Pin2	Pin3	Pin4
Power OFF	<2.0V	0.0V	2.5V	3.0V
Power ON	13.0V	13.0V	0.0V	13.0V

If the specified measurements are not obtained, then trouble shoot the related components. Remove the jumpers between STB13V and regulator IC pin4. Also remove the jumper between the cold ground and hot ground.

5. Check the inhibit control circuit

The inhibit control circuit refreshes the regulator's internal oscillator depending on the transformer's discharge rate (secondary load). If this circuit does not function properly, poor regulation or regulator shut down might occur. In order to confirm the proper operation of this circuit, connect the variable DC supply between the inhibit controller transistor's emitter and the hot ground. Connect a voltmeter between the regulator IC pin1 and the hot ground.

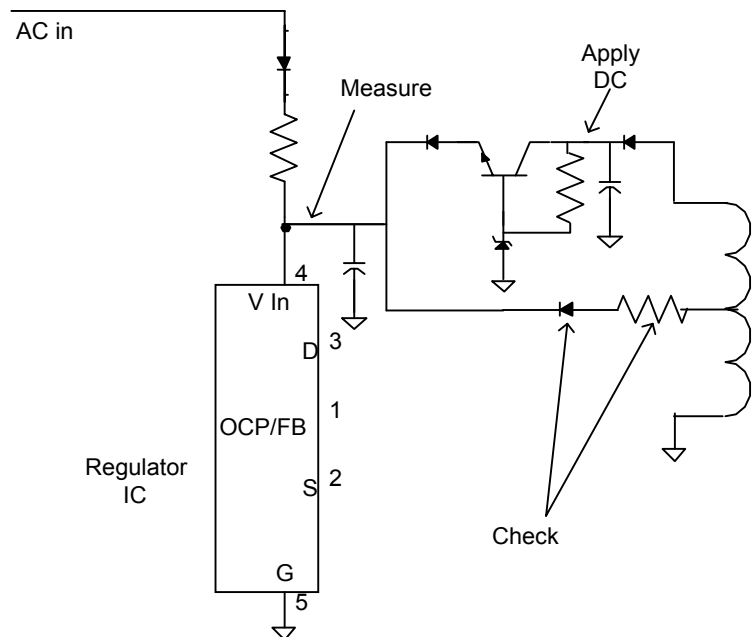
While monitoring the voltage at IC pin1, slowly increase the DC supply's voltage. The regulator IC pin1 voltage should be zero until the applied DC voltage exceeds the zener break down voltage. Above the zener break down voltage, pin1 DC should increase. If not troubleshoot the related components.



6. Check the Run-DC circuit

In order to maintain the IC's functioning, additional power supply is provided using one of the windings from the switching transformer. If this circuit does not function, the power supply will turn on and off periodically. Check the diode and resistor using a multimeter. Apply the variable DC between the regulator transistor's collector (diode's cathode) and the live ground. While monitoring the regulator IC pin4, slowly increase the DC voltage unto 18V DC.

Confirm that IC pin4 voltage appears and it does not exceed the zener voltage. If the measurement is not satisfactory, then troubleshoot the related components.



7. Switching transformer measurement

On the primary side, through the transformer, the FET switches 165 volts on and off.

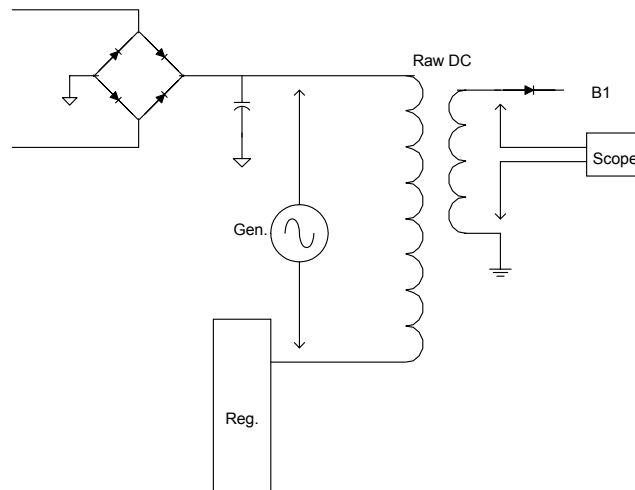
This means it can be considered as 165 volts peak square wave input.

In order to get a 135 volts DC output in the secondary, the transformer must output 135 volts peak square wave. This means the turns ratio of the Primary winding to B1 winding is 165:135.

Similarly the other windings turns ratio can be calculated from the DC output.

In order to confirm there is no shorting in the transformer windings, when the television is unplugged, apply 1.65

volts p-p 100 KHz sine wave across the transformer's primary winding. The B1 secondary output should be 1.35 volts p-p. Measure other winding's output and confirm the readings according to the specified DC voltage.



Television Power supply troubleshooting difficulties

In our Television power supplies, the reference for all control circuits is the STB13V. In order for the circuits to operate properly, we need a stable DC at this output. If there is any instability for this STB13V, this unstable DC is passed on to the regulator IC's pin 1 through the photo coupler. If pin1 goes above the shutdown voltage, the IC might shut down and latch.

In the flow charts and previous procedures, we used an external DC supply to test the control circuits. After confirming the operation of the control circuits, we have to make sure that when the TV operates, we obtain a stable STB13V. Since it does not give us enough time to measure this supply before a shutdown occurs, please use the following procedure.

Except D922 that outputs the STB13V, disconnect all secondary diodes. Ensuring that the startup voltage side of the bridge rectifier is positive, connect an external DC supply (30V) to the AC terminal through a current limiting resistor (see diagram below). The current limiting resistor prevents the IC from shutting down. Measure STB13V (D922 Cathode) and confirm that there is no AC ripple. If you notice AC ripples, replace the filter capacitor after D922

