Design Issues in Switched Mode Power Supplies for Television Receivers

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Abstract

This study is about design issues encountered in the development of a new switched mode power supply for a television receiver. The design issues encountered are not standard design problems which one encounters with known technology in new applications. The issues encountered are due to advanced technology and novel solutions being introduced in the very competitive global market, and for which there have not been any known solutions. Terrance Smith, a former president of the IEEE Consumer Electronics Society defined Consumer Electronics as a high volume, low profit margin industry. In an academic environment, cost is generally not a driving factor, which is in stark contrast to consumer electronics. Every cent that can be shaved off a product is imported to the success of that product. Thus the design strategy aims at cost-effective solutions.

The study covers three topics which relate to important issues for consumer electronics. The first topic deals with voltage doubling and proposes an innovative overvoltage protection solution. The solution proposed has been patented internationally by Philips, and has found wide application in the automotive industry. The second topic introduces Sound-In-Vision (SIV) cross modulation. The phenomenon has been around for several decades. The root cause of this phenomenon changes as technology changes. In the early periods of television; it was due to cross modulation between the sound and vision carriers in the Intermediate Frequency (IF) Stage of a receiver. Then an underrated power supply was the next major issue. In this study, once more the root cause is in the power supply but is due to magnetic crosstalk in the core of the switching transformer. The third topic explores standby power consumption. One of the early proposals promised significant standby power reduction. However, the cost issues were the stumbling block. In order to provide a cost-effective solution, specific IEC 65 safety requirements were challenged. Thus the first attempt did not progress into a product. The proposal that is described in this dissertation is the world's first truly zero power standby solution. International patents have been granted for this solution.

Chapter two is about an overvoltage protection circuit for a multi-voltage TV receiver. Modern TV Receivers and consumer electronics products, in general, are designed for a global market which means they must be able to operate on any power grid system. The typical voltage range is 85 V_{AC} to 276 V_{AC} . If the power consumption of the set is small, then the power supply can operate over this wide mains supply range without a voltage doubler. For a set with a larger power requirements, a voltage doubler circuit is a must. The key concept of a voltage doubler is energy stored in electrolytic capacitors (elcaps), and arranging the capacitors in such a way that they can provide twice the voltage and adequate supply current during the charging cycles. A brief discussion of some of the critical design issues with the filter capacitors is provided. The elcaps are one of the most expensive components in a TV receiver, and if incorrectly designed will cause reliability and/or safety issues. Cost is a major consideration in consumer electronics design, and this is where the use of elcaps was reviewed. Whilst cost was one issue that led to the overvoltage protection circuit, another issue is safety. Thus the innovative solution proposed for the overvoltage protection circuit, which consists of a low-cost transistor based comparator circuit, which is followed by a gate drive circuit that is used to fire an SCR crowbar circuit. The operation of this circuit is described, and a brief discussion of some alternative approaches precedes this discussion. A mathematical model is developed to calculate the trigger threshold of the protection circuit and how to determine the component values. This is followed by a variety of practical considerations of the design, and a brief discussion of the safety and electrical design evaluation of the protection circuit.

The third chapter deals with the Sound-In-Vision (SIV) problem, a result of more relatively demanding performance requirements of the audio out amplifier in modern TV sets. SIV is a problem whereby the audio signal causes cross modulation in the video chain and is visible on the video display. As a result, the picture will move in sync with the audio signal. A brief overview is provided on historical root causes of the SIV. Power supply capacity is a well know SIV problem. If the power supply is not able to provide enough energy for peak load demands, the sound will modulate the video signal via the video supply rails. Then the root cause of the new problem is discussed, and a method is provided on how to detect this problem. As the problem is not due to the power supply being able to supply sufficient energy, the problem becomes more visible in low light, that is, during low video power requirements, when the audio power requirements exceed a certain threshold. The root cause for the new problem is magnetic crosstalk in the flyback transformer. The problem details are elaborated in this chapter. Unfortunately, there is no solution for this problem, other than to have two separate power supplies. One power supply is for the audio system, and a second one for the rest of the receiver. For high-end TV receivers, generally multiple power supplies are used.

The forth chapter describes a switching system that has resulted in the world's first true zero power standby solution. Standby is a method that allows the use of remote control units to switch a TV receiver, or other consumer products such a DVD player or Audio System, on and off. Once the equipment is switched off, it cannot be switched on again, unless there is power available during the "off state" which is known as standby. Therefore, in standby, there always has to be some form of energy provided in order to be able to respond to the "ON" command by the user. A typical household wastes approximately 15% of its total energy footprint on standby power. This high waste of energy and more environmentally conscious consumers are driving the demand for standby power reduction. Numerous countries are targeting replace one Watt standby power consumption. The first system described was able to bring standby power to below one Watt. The cost to implement this solution, and certain requirements for changes the IEC 65 safety requirements resulted in this approach not making it into production. This chapter provides a brief overview of substitute approaches to standby power reduction and then describes a switching system that can replace traditional standby methods. It is a true zero power method, as the equipment is completely disconnected from the mains supply in the off state. Thus it is no longer a standby system, but a switching system. It allows remote control units to switch equipment on. This technology is based on Radio Frequency (RF) technology and is described in this chapter. International patents have been granted for this method.

This dissertation concludes with a summary chapter and proposals for further study.

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Πιστεύω εις Θεον Πατερα, παντοκράτορα, ποιητην ουρανου και γης.

Και (εις) `Ιησουν Χριστον, υίον αυτου τον μονογενη, τον κύριον ήμων, τον συλληφθέντα εκ πνεύματος άγίου, γεννηθέντα εκ Μαρίας της παρθένου, παθόντα επι Ποντίου Πιλάτου, σταυρωθέντα, θανόντα, και ταφέντα, κατελθόντα εις τα κατώτατα, τη τρίτη `ημέρα αναστάντα απο των νεκρων, ανελθόντα εις τους ουρανούς, καθεζόμενον εν δεξια θεου πατρος παντο δυνάμου, εκειθεν ερχόμενον κρϊναι ζωντας και νεκρούς.

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So I saw that there is nothing better for a person than to enjoy their work, because that is their lot. For who can bring them to see what will happen after them?

Ecclesiastes 3:22

Noster, qui es in caelis, sanctificetur nomen tuum. Adveniat regnum tuum. Fiat voluntas tua, sicut in caelo et in terra.

Secundum Luca

List of Publications

Journals

- Mozar S., "Voltage Doubler Protection Circuit Results in Large Cost Savings," IEEE Transactions on Consumer Electronics, Volume: 44, Issue 2, May 1998, pp. 256-260, DOI: 10.1109/30.681935.
- Mozar S., "Intelligent Standby Concept," IEEE Transactions on Consumer Electronics, Volume: 46, Issue: 1, Feb 2000, pp. 179-182, DOI: 10.1109/30.826396.
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- Mozar S, Kao W. C., "What Does It Mean When Your Measurement Is Just Within, or Just Outside of Limits? Dealing With Risks Due to Measurement Errors and Their Implications on Safety," 2017 IEEE Symposium on Product Compliance Engineering (ISPCE), pp. 1-4, DOI:10.1109/ISPCE.2017.7935017.

Patents

- 1. Switching System
 - United States of America Patent: US-7,911,087.
 - AUS filing number 2007906044, filled November 2007.

The patent describes a zero power standby switching system.

- 2. Overvoltage Protection Circuit
 - European Patent Application, filling number: 95200401.8.
 - United States of America Patent: US-5,510,944.
 - Taiwan: Utility Model UM111480.

Details are available from Philips Corporate Patents and Trademarks, Eindhoven, The Netherlands.

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Chapter 1

Introduction

This thesis studies design issues in *Switched Mode Power Supplies for Television Receivers*. The issues encountered are due to the applications of new technologies, which required innovative solutions. The solutions implemented resulted in successful patent applications. This thesis consists of three chapters, which address three topics important to the applications of switch mode power supplies for consumer applications and have been implemented in TV receivers.

In Chapter 2, the design of an overvoltage protection circuit is described, which has been developed for voltage doubler applications. There were two main factors that motivated this solution. One was an enormous cost reduction in the doubler circuit. The other factor, which is more important is improved safety of power supplies. The protection circuit has been patented by Philips. International patents were issued for this design. The chapter describes a number of alternative approaches to the protection circuit, and a mathematical model is developed to predict the performance of this circuit. Practical aspects are discussed to ensure the design is reliable. Electrical design and safety evaluations are covered and detailed test results are provided. The protection circuit passed all compliance requirements for IEC 65 and Dentori.

In Chapter 3, a new root cause for the old *Sound-In-Vision (SIV)* problem is discussed. The new problem is due the magnetic crosstalk in the flyback transformer. An overview of the problem is provided, and a method to diagnose the magnetic crosstalk is described. The crosstalk issue is due to the increased demand for more audio power, and the resultant magnetic crosstalk in the switching power supply transformer.

In Chapter 4, several innovative solutions are described to reduce *standby power consumption.* The first method described, significantly reduces the standby power. The solution was not cost effective enough to make it into production. It also would have required amendments to the IEC 65 safety standards. The other method described is a switching system that allows the use of remote controls to switch on the equipment. This solution has been granted international patents, and it redefines a standby system.

Finally, in Chapter 5, the innovative solutions in this thesis are summarized, and possible further investigations are proposed for the consumer power field.

Chapter 2

Overvoltage Protection Circuit

2.1 Introduction

This chapter describes an invention that has been used in the industry, and that is finding wide application in the automotive industry. This protection circuit provides several benefits, namely, it allows the use of lower voltage rated electrolytic capacitors in voltage doubler circuits. In addition, it provides a voltage balancing circuit across electrolytic capacitors. Elecaps typically have a tolerance of $\pm 20\%$. Thus it distributes voltage equally across the elecaps. This helps prevent elecap venting due to over voltage stress. The proposed circuit is a low-cost discrete component solution, as this is more cost-effective than using an integrated circuit. The design evaluation performed has included an extreme value tolerance analysis, which covered component variations and variations due to temperature. Furthermore, it was evaluated for safety compliance of IEC 65, and Dentori standards. The Philips Design Evaluation team did a series of performance tests that included repeat on-off switching tests, various mains quality impairments, lightning simulation tests and electrostatic discharge tests. All tests were satisfactory. The estimated cost savings on the first production run of 1 million sets were over 8 million dollars. International patents were granted for this protection circuit.



Figure 2.1: G8 large signal panel.

2.2 A Description of the G8 Chassis Power Supply

Terrance Smith, a former President of the IEEE Consumer Electronics Society, defined Consumer Electronics as: "High volume, low-profit margin designs". This is important in order to understand the reasoning behind the design decisions for consumer products. Consumer Electronics (CE) design must be reliable, safe, and the lowest possible cost solution. It is cheaper over the life cycle of a product, to have an engineer spend two weeks to reduce the design cost by one cent than to spend the extra cent.

To unveil the design constraints of this project, a brief description of the power supply block diagram is provided. At the heart of this switching power supply, is the DC-DC converter. For consumer applications flyback type power supplies are used for the following reasons:

- The Flyback topology is a simple low component count design.
- The low component count results in a lower product cost.
- The transformer provides isolation from the mains supply for the secondary circuit, and also acts as the output inductor.
- Isolation is an important safety requirement (IEC 65).
- It is capable of multiple secondary voltages.
- Energy is delivered to the load only during off time of the control switch.
- Design of the power transformer is relatively simple.
- As there is no output inductor, good output transient response is achieved.

The disadvantages of the flyback topology are:

- Low efficiency
- Poor cross-regulation

The G8 power supply has the 5 secondary output voltages, and additional three output voltages, if a satellite broadcast receiver is used. The block diagram of the power supply is shown in Figure 2.1.

The secondary supply has three outputs, one for the vision supply (+140V), the sound supply (+28V and +24V), as well as the control circuit supply which is +5V and -5V. For receivers that are fitted with a Broadcast Satellite Receiver, three extra supplies are provided. These are a +17V supply for the Low Noise Converter (LNC) of the antenna amplifier, +12V and an additional +5V.

The front end of the power supply consists of an input protection circuit, a fuse, as well as an RFI filter that is used to prevent noise generated by the power supply and other parts of the receiver being transmitted into the mains supply. The TV Receiver has to comply with CISPR 13 requirements. The RFI filter is followed by a mains rectifier, and low pass filter (LPF) and an Automatic Voltage Selection (AVS) circuit. The output of the rectifier circuit and LPF is the input to the DC-DC converter.

The tables below show the different power supply configurations. In the tables, BS stands Broadcast Satellite Receiver and AVS does Auto Voltage Selection (Multi Input Voltage Set).

Item	Mains Voltage	Comments
1	85V-120V	No BS, hardwired doubler
2	85V-120V	With BS, hardwired doubler
3	90V-276V	With AVS, no BS
4	140V-276V	No AVS, no BS

Table 2.1: Mains voltage range of G8 power supply.

Table 2.2: Non broadcast satellite receiver output supplies.

Output Voltage	Current	Load Name
+140V	1.2 A	Vision Supply
33V	0.01A	Tuner Supply
28V	0.2A	Unregulated for miscellaneous
24V	1.8A	Audio Supply
8V	0.3 A	Unregulated for Signal input panel
5V	0.5 A	Control Circuit

Table 2.3: Broadcast satellite receiver output supplies.

Output Voltage	Current	Load Name
+140V	1.2 A	Vision Supply
33V	0.01A	Tuner Supply
28V	0.2A	Unregulated for miscellaneous
24V	1.8A	Audio Supply
8V	0.3 A	Unregulated for Signal input panel
17V	0.36A	BS, LNC, Short Circuit protection
12V	0.175A	BS
5V	0.1 A	BS, always on
5V	0.55A	Control Circuit
-5V	0.1 A	Control Circuit



Figure 2.2: Block diagram of G8 power supply.

2.3 Overvoltage Protection Circuit

2.3.1 The Need for Multi-Voltage Power Supplies

Consumer electronic products, such as television receivers, are sold in the global market. Thus the TV sets need to be able to work over a wide range of mains supply voltages. The mains voltage range over which consumer electronics products must be able to work with is $85V_{AC}$ to $276V_{AC}$. Power supplies designed for low power applications say less than or equal to 100W, do not need to use a voltage doubler. For high power applications, greater than 100W, it is better to use a voltage doubler circuit. The power supply can be designed without a voltage doubler but at a significant increase in real-estate and cost. This is due to components that must be able to handle higher power ratings, for example, a switching transistor which can handle larger currents. A switching transistor that can meet this requirement, has the following disadvantages. It is much more expensive, it requires a much larger heatsink, more PCB space, and will create more EMI problems. Thus not using a voltage doubler circuit becomes an unacceptable design option.



Figure 2.3: DC voltage vs mains supply voltage.

Figure 2.3 shows the DC voltage across the filter capacitors in the front end of the power supply. For the DC-DC converter to operate about 200VDC need to be across the elcaps. This is shown by the horizontal line in the graph. The vertical line shows where the doubler switching takes place.

For the G8 Chassis, a Sanken Voltage Doubler switching IC was used. The circuit schematic of the front end of the power supply, including the Sanken circuit, is shown in Figure 2.4.



Figure 2.4: Voltage doubler circuit.

2.4 Electrolytic Capacitor Filter Design Considerations

The filter capacitor selection is critical as the elcap must be able to supply the entire power for the DC-DC converter. It is a bulky item that occupies a considerable amount of space and its lifetime is limited as the electrolyte dries up with age.

The energy required for one cycle is given by Equation 2.1

$$W_{IN} = \frac{P_{IN}}{f} \tag{2.1}$$

Where:

 $W_{IN} = Energy [Wsec.],$

 P_{IN} = Power into the DC-DC Converter [W],

f= mains frequency [Hz], either 50 Hz or 60 Hz.

In a voltage doubler circuit, there are two elcaps in series. Each capacitor is charged during its half cycle. It is charged to the peak line voltage (V_{PK}). The elcap is discharged by the converter until V_{MIN} .

The energy drawn from the elcap during each half cycle is:

$$\frac{W_{IN}}{2} = \frac{C_{IN}(V_{PK}^2 - V_{MIN}^2)}{2}$$
(2.2)

The elcap size can now be calculated by Equation 2.3

$$C_{IN} = \frac{W_{IN}}{V_{PK}^2 - V_{MIN}^2}$$
(2.3)

The recharging time $t_{\rm C}$ given by Equation 2.4

$$t_C = \frac{\cos^{-1}\left(\frac{V_{MIN}}{V_{PK}}\right)}{2\pi f} \tag{2.4}$$

Assuming a rectangular charging current pulse which has a peak amplitude of i_{CHG} then charge stored on the capacitor is given in Equation 2.5

- -

$$dQ = i_{CH} * dt = CdV \tag{2.5}$$

From which the charging current is given by Equation 2.6

$$i_{CHR} = \frac{C(V_{PK} - V_{MIN})}{t_C}$$
 (2.6)

The total capacitor current I_{CAP} is given by Equation 2.7

$$I_{CAP} = \sqrt{I_{CHG}^2 + I_{DIS}^2} \tag{2.7}$$

The estimated life of an electrolytic capacitor is given in Equation 2.8 (from Nichicon)

$$L_N = L * 2 \frac{T - T_N}{10} * \frac{1}{B_N}$$
(2.8)

Where:

- $\mathrm{L}_{\mathrm{N}}{=}\mathrm{lifetime}$ under temperature T_{N} and applied voltage and ripple current
- L= Lifetime under maximum rated operating temperature
- $B_N {=} \ Acceleration \ coefficient \ of \ ripple \ current$

2.5 Background Information

2.5.1 IEC 65 Requirements

IEC publication 65, Section 2.4 requires safety tests to be conducted on capacitors. These tests include both short and open circuiting the capacitor. The G8/88 chassis power supply uses a voltage doubler circuit to allow the set to be used in most countries.

Figure 2.5 show the circuit of a voltage doubler. When the open circuit test is performed on the two electrolytic capacitors, no safety problem exists. In other words, no hot spot develops, and thus there is no safety hazard.



Figure 2.5: Voltage doubler concept circuit.

In the low mains supply range of $(85 V_{AC} \text{ to } 140 V_{AC})$ the AVS circuit puts the set in the voltage doubler mode. A short circuit across either of the two elcaps cause the short circuit current to exceed the mains fuse rating, resulting in the fuse rapturing. The fuse is of slow blow type, rated at 4 A (T4.0 A). Thus no safety hazard exists.

When the set is not in the voltage doubler mode (160 V_{AC} to 276 V_{AC}), the elcaps are in series, across a bridge rectifier. In this configuration, if one of the elcaps is short-circuited, then the full DC voltage is across the non-short circuited elcap. Thus the elcaps are rated at the maximum DC voltage that is across the bridge rectifier; about 400 V_{DC} . Apart from the fault condition of a short circuit in one of the elcaps, the elcaps only need to be rated at half the maximum DC Voltage. Using elcaps rated at half the Bridge voltage means that a 250V elcap can have 400 V across it if the other elcap develops a short circuit. The elcap will be stressed due to the too high voltage across it and heat up and vent. This situation is a potential fire hazard.

It would seem that using a higher voltage rating of the elcaps is a simple solution. If one elcap fails then other can easily withstand the higher voltage, and the set would be able to continue operation. IEC 65 requirements are fulfilled, and no safety hazard would exist.

2.5.2 Elcap Cost Considerations

Consumer electronics, however, are price driven, every cent counts. Typical production volumes are 1 million sets as a minimum. Elecaps, especially high voltage elecaps, are particularly expensive. Table 2.4 shows a cost comparison of electrolytic capacitors with the same capacitance, but different voltage ratings.

Elcap Voltage Rating	Cost Each
680F/400V	\$7.66
$680\mathrm{F}/250\mathrm{V}$	\$2.61
$680\mathrm{F}/200\mathrm{V}$	\$2.40

Table 2.4: Cost comparison of electrolytic capacitors.

The above table shows that the difference in price between the 400V and 250V elcaps is \$5.05 per elcap. As two elcaps are used, the total cost reduction is \$10.10 per set. After deducting the estimated cost of a protection circuit, the resulting saving is estimated to be about \$8.00 per set. This cost estimate was done by procurement staff.

A further advantage of using a protection circuit is it helps distribute the voltage across the elcaps more evenly. Elcaps have a large tolerance for capacitance value, which is typically $\pm 20\%$.

2.6 Evaluation of Possible Solutions

2.6.1 Protection with Transils

One of the first ideas to protect the elcaps against overvoltage was to use transils. Transils are semiconductor devices whose impedance becomes exceedingly low when their avalanche voltage is reached. Transils were placed in parallel with the filter elcaps (see Figure 2.6). When an elcap is short-circuited, the voltage across the elcap exceeds the avalanche voltage of the transil. For example, if C2128 in the figure below is short-circuited, then the avalanche voltage of T2 is exceeded. This will result in the transil becoming an effective short circuit and thereby capturing the mains-fuse. The first round evaluations were done with Sanken R4KL transils. This solution was not acceptable as the transils cannot reliably trigger over the wide DC voltage range across the elcaps. Another problem with this solution is the I²t rating of the fuse. The transil switches much faster than it takes for the fuse to rapture. The transil is not designed to withstand the high fault current (i.e. the junction temperature increases too fast) and consequently explodes. Other breakdown devices such as diacs were considered. But cost and a more complex trigger circuit, were the main issue with diacs that could handle the fault currents under short circuit conditions.



Figure 2.6: Transil protection circuit.

2.6.2 Diode-Comparator Protection Circuit

An alternative solution is to use a comparator circuit as shown in Figure 2.7. This circuit consists of a voltage comparator with transistor TR1. The comparator is triggered when the programmed threshold voltage is reached. The transistor compares the voltage across the resistive divider against voltage on its emitter. If elcap 2128 develops a short circuit, then the voltage across elcap 2120 exceeds its rating. The emitter becomes more positive than the base and triggers the transistor into conduction. The voltage at the collector then triggers the Silicon controlled rectifier (SCR) T2, which is a crowbar circuit. The crowbar places a short circuit fuse disconnects the mains supply. The SCR is connected after the RFI filter in order to prevent

false triggering by noise spikes. C1 is also used to prevent false triggering by electrical noise. If elcap 2120 develops a short circuit, the voltage across elcap 2128 is increased and current flows through zener diodes D3-D6, which puts TR1 into saturation and fires the crowbar circuit. The set is disconnected from the mains supply, and no safety hazard exists.



Figure 2.7: Diode-comparator protection circuit.

This circuit was evaluated by the Electrical Design Safety team and passed all evaluation tests. This circuit was not chosen as a final solution, as the large tolerance of the elcaps $(\pm 20\%)$ can cause a voltage imbalance, with which temperature variations can result in false triggering. This would then result in reliability issues. As the elcaps age, their capacitances may change at different rates due to different temperature profiles and result in reliability issues.

2.6.3 The Proposed Solution: Series Comparator Protection Circuit

This circuit is similar to the Diode-Comparator Circuit described in Section 2.6.2. The difference is that the series zener diodes are replaced by a second voltage comparator circuit. Thus there are two voltage comparator circuits in series. An advantage of using two voltage comparators is that there is a resistive voltage divider across both elcaps. To reduce variation due to component tolerances, resistors with $\pm 1\%$ tolerance were used. These resistors ensure that the voltage is equally distributed across both resistors. If a fault condition develops in either of the elcaps the set remains safe. As discussed previously, an open circuit elcap causes no safety hazard. If either of the elcaps develops a short circuit, then the voltage

comparator across the other elcap will sense the elevated voltage and trigger the crowbar circuit. This will then cause the mains fuse to rapture and the set is safe.



Figure 2.8: Series-comparator protection circuit.

This solution is cost-effective, as the estimated cost of all discrete components for both comparators and PCB space is \$1.07. This results in cost reduction of \$9.03, which excludes the assembly cost. The choice of using transistors is due to the cost advantage compared to using op-amps.

2.7 Circuit Analysis of the Overvoltage Protection Circuit

The protection circuit is made up of a number of functional blocks as shown in Figure 2.9. On the left side is the elcap which is to be protected. The voltage across the elcap is monitored by a voltage comparator circuit. When the comparator circuit detects a voltage above a threshold to which it is set, then it activates a signal to the crowbar trigger circuit. The trigger circuit fires the SCR of the crowbar, which places a short circuit across the mains input fuse. This in turn raptures the fuse and the set becomes safe.



Figure 2.9: Block diagram of the overvoltage protection circuit.

The circuit of the basic voltage comparator is shown in Figure 2.10 below. The figure shows the elcap across which the voltage is sensed, and the crowbar circuit.

The circuit diagram of the overvoltage protection circuit also illustrates the control strategy of how a small base current (I_B) from the comparator circuit can be used to generate a gate current (I_G) that is large enough to turn on an SCR. The gate current of the SCR is much smaller than the fault current (I_{SC}) through the SCR. The control current strategy is shown in the Equation 2.9.

$$I_B \ll I_G \ll I_{SC} \tag{2.9}$$

The current through the resistive network R1 and R2 should be low enough not to load (i.e. to discharge) the elcap, but high enough to allow reliable switching of the transistor. The current I_R can be determined by Equation 2.10, which is a rule of thumb.

$$I_R = 10I_B \tag{2.10}$$

This relation is necessary to ensure reliable triggering of the switching transistor Tr1.

In normal operation, Tr1 is in the off state. If a fault condition occurs, then V_{CC} will increase, and reach the pre-programmed trigger level V_{TRG} . The trigger level is set by the resistive network R1 and R2, and the zener diode D_Z . When the condition for Equation 2.11 is met, the comparator transistor becomes forward biased and drives Tr1 into saturation (i.e. switches Tr1 on).

$$V_{TRG} = V_{CC} \tag{2.11}$$

When the comparator transistor Tr1 saturates, the collector current shall to be set large enough to fire the SCR. The collector current I_C can be set by resistor R_G . When Tr1 is in the off state, the zener is biased on by ensuring there is a large enough current through the zener to bias it in the reverse bias or zener region. I_Z should be selected such that the zener



Figure 2.10: Voltage comparator circuit.

diode is reversed biased, and this is done with R_Z . The relationship for the gate current (I_G) to fire the SCR is shown in Equation 2.12.

$$I_C = I_G = \frac{(V_{CC} - V_Z - V_{EC} - V_D - V_G)}{R_G}$$
(2.12)

The collector or gate current are related to the base current by Equation 2.13

$$I_B = \frac{I_C}{\beta} \tag{2.13}$$

This shows that a small gate current can be used to control the firing of the SCR. When fired, the SCR is on for the duration it takes for the fuse to rapture. The comparator transistor will be on (t_{ON}) until the fuse opens and this relation is given by Equation 2.14

$$t_{ON} = t_{SCR} + t_{fuse} \tag{2.14}$$

The trigger point for the comparator is when the emitter of Tr1 is more positive than the base voltage. This is given in Equation 2.15

$$V_E = V_B + V_{BE} \tag{2.15}$$

The emitter voltage relates to trigger voltage V_{TRG} as shown in Equation 2.16

$$V_E = V_{TRG} - V_Z \tag{2.16}$$

Equation 2.15 and Equation 2.16 gives Equation 2.17

$$V_B + V_{BE} = V_{CC} - V_Z (2.17)$$

Equation 2.17 can be rearranged for V_B which is Equation 2.18

$$V_B = V_{CC} - (V_Z + V_{BE}) \tag{2.18}$$

At the trigger point the base voltage can also be expressed as shown in Equation 2.19

$$V_B = \frac{V_{TRG}}{R_T} \times R_2 \tag{2.19}$$

Where R_T is the total resistance of base bias resistors as shown in Equation 2.20

$$R_T = R_1 + R_2 \tag{2.20}$$

The voltage at which it is necessary to fire the SCR is the voltage which exceeds the voltage rating of the elcap (V_{TRG}) and from Equation 2.19 we can determine the values of the resistive bias network for the comparator. Resistor R2 can be calculated by Equation 2.21.

$$R_{2} = \frac{(V_{TRG} - V_{Z} - V_{BE})}{V_{TRG}} \times R_{T}$$
(2.21)

Resistor R1 can be determined by Equation 2.22.

$$R_1 = R_T - R_2 \tag{2.22}$$

Rearranging Equation 2.21 we can determine the trigger point as shown in Equation 2.23.

$$V_{TRG} = (V_{BE} + V_Z) \times \frac{R_T}{R_1}$$
 (2.23)

2.8 Some Practical Considerations

There are some practical considerations for the above circuit. To improve the reliability and at the same time make the design cost effective the bleeding resistors (R1, R2, R3, R4) in parallel with the elcap are were divided into several smaller resistors instead of just one larger power resistor. This is because the power dissipated in the resistor is:

$$P_R = (I^2 \times R) \tag{2.24}$$

If only one resistor were used, a higher power rating would be required. The base current (I_B) is dependent on the gate current, which is 15mA, and thus the base current is (given that β is 80 minimum) 188 A. The current through the series resistors should be about 10 times larger which is about 1.8mA. The power rating of a combined R3-R4 resistor would be using Equation 2.24, 1.2W.

If the resistor is split into two resistors, and the current is dropped to 1.2mA (7 times I_B) then the power rating decreases to about 0.48W for R3 and 0.065W for R4. A 0.5W resistor of SFR 25H type can be used for R3 and a quarter watt SFR16 resistor can be used for R4. R3 is still close to the 0.5W limit, thus the following needs to be done. The resistor should not be mounted directly on the printed circuit board (PCB), but should be mounted with long leads to allow airflow around the resistor. If space permits a hole should be place underneath the resistor R3 to allow better airflow for cooling. The copper pads on the PCB should be as large as possible to remove heat from the solder joint and the resistor.

When a fault condition develops and the circuit is triggered, the duration for which the over voltage protection circuit operates is

$$t_{On} = t_{Fuse} + t_{SCR} \tag{2.25}$$

Figure 2.11 shows a final version that went into production. The diagram is a production circuit diagram.

From the SCR data sheet we find that it takes 2sec to fire it, and from the fuse data sheet (Figure 2.11) the fuse breaking time is 100msec. This corresponds to about 100msec active on time for the protection circuit.

$$P_R = \frac{V^2}{R} \tag{2.26}$$

The pulse power rating for the SFR25H resistor is shown in Figure 2.12 below. From it we can see that maximum power that the resistor R3 can take for 100msec is about 10W. The maximum power that would be applied across the resistor is

$$I_{Zmax} = I_C + I_{RZ} \tag{2.27}$$

The zener power rating is

$$P_Z = V_Z + I_{Zmax} \tag{2.28}$$

The zener is rated at 0.5W, and the worst case power the zener needs to dissipate is 0.27W. This is well within specification. The power dissipated across the transistor T2 is

$$P_D = V_{CE} \times I_C \tag{2.29}$$



Figure 2.11: Elcap & overvolatage protection circuit.

The power dissipated in the transistor when it is triggered is 3mW, which is well below the maximum continuous rating of 830mW (from the data sheet). Thus the circuit is safe and all components are well within their ratings.

When the SCR is triggered, it is designed to let a large current through it. A short circuit current is very large, as the impedance to ground is assumed 0Ω . In reality, this is not the case. The impedance Z (R + X) is not equal to zero. From Figure 2.11 we can see that after the fuse there are the RFI transformers which are in series between the fuse and the SCR. They have about 5Ω each, and in addition there are the copper tracks. Thus the circuit board layout requires wider tracks to handle the large short circuit current. The solder pads of all components should be on the larger side. The solder pads for the RFI transformer should be as large as possible. They should also be either double soldered or fix mounted with cable ties or screws. This is to prevent the joints breaking and as there is high energy going through these joints, this will also prevent potential fire hazards.

These practical considerations have reduced the cost of the design, and at the same time increased the reliability. Low cost design is a major goal for consumer electronics designs. Reducing the power rating of a resistor by splitting the resistor into two resistors has resulted in 0.5 W resistors being used which are considerably cheaper than a 2 Watt resistor. It also generates a lot less heat, and stress the solder joints much less due to the reduced weight of the resistors. When the circuit is triggered it is on for about 100 msec worst case. The



Figure 2.12: Fuse breaking time curve.

power rating of all components when the circuit is triggered, are well below the maximum rating of the components. Thus the objective of a reliable and low cost solution is met.

The circuit will trigger in worst case at 400V, which corresponds to about 0.5 W. This the resistor can operating during the time the protection circuit is active.



Figure 2.13: Pulse rating of SFR25H resistor.

The current through zener diode D1 is the collector current when the circuit is fired and the diode bias current I_Z .

2.9 Tolerance Analysis

A design is not complete until a number of circuit evaluations are completed. The first evaluation is about the effects of component tolerances on circuit behavior. The other important factor to consider is the effect of temperature variations. MathCad was used for these studies. A mathematical model was developed for the comparator circuit, to identify what effect component tolerances would have on the circuit performance. Then the effects of temperature variation were included in the models. The detailed calculations are shown in the appendix.



Figure 2.14: Comparator circuit used in tolerance analysis.

2.9.1 The Effect of Component Tolerances

Figure 2.14 shows a basic configuration that was used for this analysis. The base values of the components are listed below in Table 2.5.

Variable	Nominal Value
R1	10k Ω
R2	120k Ω
R3	15k Ω
R _T	145 k Ω
V _{BE}	$0.7\mathrm{V}$
Vz	15V

Table 2.5: Vales of the components.

Where,

$$R_T = \sum_{i=1}^{n} R_i$$
 (2.30)
The tolerances were considered as:

$$dR_i = \pm 1\%$$
, where I = 1,2,3 (2.31)

$$dV_z = \pm 2\% \tag{2.32}$$

Equation 2.33 is used to calculate the trigger point

$$V_{TRG} = (V_{BE} + V_Z) \times \frac{R_T}{R_1}$$

$$(2.33)$$

To allow for the effect of tolerances on the trigger point, the Equation 2.33 has been changed to make allowances for these tolerances. The highest voltage at which the circuit will trigger at 25°C is given by:

$$V_{TRGmax} = [V_{BE} + V_Z + V_Z] * dV_z$$
(2.34)

Where

$$R_{max} = \frac{R_1 - R_1 * dR_1 + R_2 + R_2 * dR_2 + R_3 + R_3 * dR_3}{R_1 - R_1 * dR_1}$$
(2.35)

The lowest trigger point at 25° C is

$$V_{TRGmin} = [V_{BE} + V_Z - V_Z] * dV_z$$
(2.36)

Where

$$R_{min} = \frac{R_1 + R_1 * dR_1 + R_2 - R_2 * dR_2 + R_3 - R_3 * dR_3}{R_1 + R_1 * dR_1}$$
(2.37)

Using the above equations to calculate the effect of component tolerances gives the following results:

$$V_{TRG} = 227.65V$$
 (2.38)

$$V_{TRGmax} = 236.36V$$
 (2.39)

$$V_{TRGmin} = 219.18V$$
 (2.40)

The results of the analysis show that component tolerances will shift the trigger point within a range of 17V. This analysis is based on extreme values. This range causes no problems as long as 250V elcaps are used, and the min trigger point is greater than 190V. The upper limit must be below 250V.

2.9.2 The Effect of Temperature

To evaluate the effects of temperature variations, the equations used for tolerance calculation were modified to include temperature coefficients. Thus the analysis includes both the effects of tolerances and temperature on the trigger point.

As the temperature increases, V_{BE} decreases by $2mV/^{\circ}C$. This change is compensated for by an increase in V_Z . This increase is slightly larger than $+2mV/^{\circ}C$, but in the opposite direction to the change in V_{BE} . This, therefore, results in a slight overcompensation as temperature varies.

The calculations using Equations 2.41 to 2.46 show no significant drift in the trigger point due to semiconductors. The variations in the zener diode are opposite to the variations in the transistor pn-junction, and therefore both devices compensate for each other. This results in circuit stability over the specified temperature range.

The changes of temperature in the resistors of the voltage divider network was considered. The effect of the temperature coefficient is so small that for practical purposes, it can be considered negligible. The temperature range over which the circuit was analysed is from - 10° C to + 60° C. The relatively lower temperature of - 10° C was chosen as it is the temperature that is found in the home of people in China during the winter. This value is obtained through field experience and was measured at a start-up temperature in Chinese homes during the winter. The sets need to be able to start up at this temperature. The design guidelines at Philips specify the temperature in a set is to be taken as + 60° C when the back cover is fitted. The published data for semiconductors is based on an ambient of 25°C. Temperature variation, S_Z, data was obtained from the datasheet of the zener diode and an allowance was made for the junction temperature T_J. The switching transistor in the protection circuit is normally in the off state, therefore only small leakage currents will flow. It is assumed that the transistor junction temperature is at approximately at ambient. At high temperatures, Equations 2.41 is used to determine the trigger level.

$$V_{TRGmax} = (V_{BE} - S_{BE} * dT) + (V_Z + V_Z * dV_Z + S_{Zmax} * dT) * R_{max}$$
(2.41)

Where

$$S_{BE} = \frac{dV}{dT} = -2mV/^{\circ}C \tag{2.42}$$

and

$$S_{zmax}\frac{dV}{dT} = +13mV/^{\circ}C \tag{2.43}$$

The minimum Trigger point at high temperature is given by:

$$V_{TRGmin} = (V_{BE} - S_{BE} * dT) + (V_Z - V_Z * dV_Z + S_{Zmin} * dT) * R_{min}$$
(2.44)

Where $S_{Zmin} \frac{dV}{dT} = +9.2 \text{mV}/^{\circ}\text{C}$; R_{max} is given by Equation 2.35, and R_{min} is given by Equation 2.37.

 V_{BE} is 0.7V at 25°C, which is taken as a reference. Equation 2.41 and 2.43 an allowance of $2mV/^{\circ}C$ is made as the temperature rises. When the temperature drops below the ambient, V_{BE} will increase. While the relationship between V_{BE} and temperature is non-linear, for simplicity it has been assumed to be linear. This approximation is acceptable for the temperature range analysed and the degree of accuracy required. For low-temperature analysis S_{BE} has an ambient reference of $+2mV/^{\circ}C$. The zener voltage will decrease with temperature at the rate of S_Z . For low temperature analysis we can use Equation 2.45 for the highest trigger voltage, and Equation 2.46 for the highest trigger voltage.

$$V_{TRGmax} = (V_{BE} + S_{BE} * dT) + (V_Z - V_Z * dV_Z + S_{Zmax} * dT) * R_{max}$$
(2.45)

$$V_{TRGmin} = (V_{BE} + S_{BE} * dT) + (V_Z - V_Z * dV_Z + S_{Zmax} * dT) * R_{min}$$
(2.46)

The results of this analysis are summarized in Table 2.6. The detailed calculations are demonstrated in the appendix. They were computed with Mathcad.

$Temp.(^{\circ}C)$	Min Trig.(V)	Nom.Trig. (V)	Max Trig. (V)
60	222.78	232.42	242.04
25	219.18	227.65	236.36
0	215.27	224.24	233.29
-5	214.49	223.56	232.46
-10	213.70	222.88	231.64

Table 2.6: Temperature vs protection trigger voltage.

2.9.3 Summary of Tolerance Analysis

The results of the temperature analysis show that the variations in the trigger voltage levels are within acceptable limits. They were obtained by extreme value analysis, as such, there is no chance of an outlier that could potentially cause a safety problem. Under normal operating conditions the working voltage is unlikely to exceed the 200V working limit of the elcap. It will only exceed this voltage under a fault condition. That is when the other elcap is short-circuited or of low impedance. Then the protection circuit will activate and keep the receiver safe. If an elcap is open circuit, there is no safety issue. Due to Philips internal derating guidelines, the elcaps used will be rated at 250V.

2.10 Safety Evaluation

International safety standards such as IEC 65 and EN60065 specify a number of safety tests. The assumption made is that only one fault can occur at a time. Consumer products are not high reliability products, thus only one fault is induced at a time.

One aspect of safety testing is to short-circuit each component and to open circuit each component. For integrated circuits, each adjacent pin is short-circuited, and each pin is open circuited. After the fault is activated, no fire phenomena are allowed, nor is the temperature allowed to exceed limits as specified in the standards.

The overvoltage protection circuit was evaluated by a safety engineer, in order to have an independent evaluation. The final TV receiver is later tested and evaluated by an in depended test house like TÜV, or UL.

The test report is included in the appendix of this thesis. The circuit passed all tests, but it was noted that the snubber circuit resistor became hot if the series snubber capacitor was short-circuited. It reached a temperature of 100°C. The applied solution was to add a second snubber capacitor in series.

2.11 Electrical Design Evaluation

The electrical Design Evaluation (DE Electrical) deals mainly with a functional performance evaluation of the design. A few of the performance issues may result in safety issues if the failure occurs that cause damage to the equipment. An example would be a simulated lightning test, which results in component damages that result in overheating, with the potential to cause the fire.

The overvoltage protection circuit was tested to examine how it impacts the performance of the TV receiver under the tests:

a) Father/Mother Test

This test involves the received being switched on and off for 1500 times. The aim is to detect any adverse effects, as surge limiting components are hot and are not very effective if an inrush current were to build up. Multiple components may be stressed due to their charge levels being stressed and reaching limit values.

b) Mains-Spike Test

Brown Out A mains spike generator is used to see if the set turns on or fails if the mains voltage is temporarily dropped out. This is also known as brownout.

Main Spikes are sent to the set and no fault condition is allowed. The protection circuit is not allowed to trigger. The set is tested when in standby mode, and in operational mode. It is tested at various mains voltages. The ranges are 90-140Vac, and 120-200Vac, and 150-276Vac. The appendix shows the different tests that were done on the protection circuit.

Mains Spike Tests at low, medium, and high energy spikes. A total of 100 spikes is applied for each energy level, and the phase angle of the spike is varied over a 360° range. The pulse amplitude is varied from 100V to 2.5kV. The heavy energy spikes are up to 3kV.

c) Lightning Simulation:

- Common Mode (high & low to ground)
 - $\circ\,$ Tested form 3kV to 6kV in 1.5kV steps
- Differential Mode (between high & low line)
 - $\circ~0.5 \mathrm{kV}$ to $2 \mathrm{kV}$ in steps of $0.5 \mathrm{kV}$
- Breakdown Test
 - $\circ~7 \rm kV$ to $10 \rm kV$ insteps of $1 \rm kV$

d) Static Discharge Test

10 discharges at 15kV Tests are done as per Philips test spec UAW-8002 Static Testing.

The test results are included in the appendix of this thesis.

2.12 Summary

This report has shown the proposed overvoltage protection circuit described meets the safety requirements of IEC 65 and complies with the most stringent Philips internal requirements.

The main advantage of this protection circuit is the large cost savings, by being able to use lower voltage rated elcaps in voltage doubler circuits. The protection circuit allows the voltage rating of the elcap to drop from 400 to 250 volts. This voltage reduction also results in space savings on the printed circuit board. The smaller size elcap, which has significantly less mass also reduces stress on solder joints and thus is a great improvement in safety due to the reduced fire potential. The resistive network across the elcaps, also helps balance the voltage distribution across them.

Simple solution's like parallel transils fail to function due to the large variation in mains voltage. Under fault conditions, they explode and may cause potential safety issues. The proposed circuit meets all safety requirements of ICE 65, and all requirements of the Philips internal design evaluation. The requirements include brownout, mains spike, electrostatic discharge and lightning tests. The in-house tests are more stringent than various industry standards. For example, a number of power supply tests limit lightning tests to 3kV. The Philips standards have a requirement of 8kV.

This design has been patented and more than 20 other patents make reference to it. This concept has found wide application in the automotive industry, as vehicles contain more electronic circuitry, and large capacitors can have a reduced voltage rating. This not only saves cost but adds an extra level of protection.



Figure 2.15: G8 power switching supply-front end.



Figure 2.16: G8 power switching supply-protection circuit in front end.



Figure 2.17: G8 power switching supply-DC-DC converter.



BS POWER SUPPLY

Figure 2.18: G8 power switching supply-BS supply.

Chapter 3

Sound-in-Vision

This chapter deals with the issue of audio cross modulation into the video signal. This problem has been around ever since TV receivers were designed. New technologies and design constraints have resulted in this problem reoccurring. The root cause is completely different to previous designs. The issue identified in the design of the G8 chassis relates to a consumer requirement of high audio power. The power supply was designed to deliver the peak power requirements of the receiver for both audio and picture peak powers simultaneously. The root cause consists in the power supply switching transformer.

3.1 Introduction

Sound-in-Vision (SIV) is a form of Picture distortion, which is due to cross-talk of the audio signal. SIV results in the audio signal modulating the video signal, in such a manner that the picture moves in rhythm with the audio signal. This study involves a new form of SIV, which is due to high power audio amplifiers. First, an overview is provided of well-known root causes of SIV. Then a method is discussed on how to identify the high audio output power related SIV problem. Then details of the SIV problem are described, which is followed by suggestions on what design changes may prevent SIV.

3.2 What is Sound-In-Vision?

Sound-in-vision is a well-known design problem for TV receivers. It is a phenomenon, whereby the picture moves in rhythm with the sound. The fundamental problem has traditionally been in either the small signal related, i.e. intermediate frequency (IF) crossmodulation; or in the large signal area, i.e. power supply related. Cross modulation of the sound carrier into the vision carrier happened in the Intermediate Frequency (IF) Filters.

3.2.1 Small Signal Related Sound-In-Vision

The sound-in-vision problem where the IF stage is the root cause is due to cross modulation between the sound and the visual signals. It occurs due to the placement of the IF coils on the IF transformer. Care must be taken to ensure that FM sound carrier is smaller in amplitude (the limit is typically 1/30) than the vision carrier [7]. It appears to be important that in the demodulation process of the FM sound signal, no undesired amplitude modulation is produced that can get into the unmodulated AM video signal. With modern IF filter techniques; the IF related sound-in-vision problems do not seem to be an issue. Below are images of what an IF filter looked like, and a drawing of the circuit and the desired frequency response is shown next to it.



Figure 3.1: Left picture is an old style IF transformer, and on the right-hand side is the schematic and a frequency response.

3.2.2 Large Signal Related Sound-In-Vision

The most common root cause of sound-in-vision problems is found in the power supply. A well-designed TV receiver power supply is able to provide enough power for the receiver to have a fully white screen (this requires a significant amount of energy from the power supply), and at the same time to have a maximum volume at low-frequency signals. This is the worst case power consumption for the receiver. This is not a static load, as the audio signal is dynamic and when an actual picture is displayed, its contents are dynamic as well. Transitions such as a white screen with narrow black lines also stress the power supply. One of the limiting factors with a TV switching power supply is the switching transformer core. The transformer is an expensive item, and the power supply rating is defined by the transformer core size. On particular occasions, perhaps due to design specification changes, the power requirement is increased. This may then require the power supply to step up to the next core size. The problems with this are that it requires more space on the PCB, which produces an evident increase in cost. Under most of the test conditions the smaller core seems to do the job, but under extreme conditions, as described above, the power supply falls short of delivering the required power, i.e. the peak demand.

The peak demands change with sound and picture content because the sound and vision content is dynamic. This instantaneous peak demand overloads the power supply. When this occurs, the power supply voltages drop as the current drawn exceeds its design limits. This drop in voltage affects the extreme high tension voltage (EHT) that supplies the picture tube anode. The result is that the picture is modulated by the audio signal. This can be seen on the screen, whereby the picture varies in synchronicity with the sound signal. The solution to this problem is to either reduce the peak audio power or increase the power rating of the power supply. TV sets are designed with high power audio amplifiers. Limiting or reducing the audio power is therefore not an option. To solve the problem, the power rating of the power supply needs to be increased.

3.3 What is the New Sound-In-Vision Problem?

3.3.1 The New Symptom

The "new" SIV problem is due to the customers' requirements for high quality and high audio output power. A further contributing factor is that the preferred power supply configuration is the flyback topology. The flyback topology is preferred as it can have multiple secondary supply rails, and is a simple design, with low component count. One problem with a flyback topology is the poor cross-regulation. With multiple secondary supplies as is the case for TV receivers, only one of the secondary supplies is regulated by the control loop. The other secondary supplies are therefore unregulated. The regulated winding is the one with the largest power rating. For TV receivers, that is the vision winding. The other windings are very "poorly" regulated, as the load variations are not compensated for by the control loop. To obtain a more complete control over the regulation of those windings, a voltage regulator is used. The secondary circuit is shown in Figure 3.2 and the transformer configuration is revealed in Figure 3.3.



Figure 3.2: Secondary power supply rails.

Figure 3.2 exhibits the video winding, which is the top winding on the secondary side of the transformer. The audio winding is the winding below the video winding. The video

ETSS P1 \sim PT \sim B1 \sim B2 \sim B4 \sim B3 \sim	4 A B 1 3 6 Q D 	+- 13 +- +-			
P1-PT-P2	Dia. 0.3x7	38T			
B1-B2, B3-B4	Dia. 0.45	3T			
Pri	Primary windings				
S1-ST-S2	2 x Dia. 0.45	36T			
S3-S4	Dia. 0.7	3T			
S4–S5	Dia. 0.7	3T			
S5-S6	Dia. 0.7	2T			
S7-S8	Dia. 0.7	8T			
Se	condary windings				

Figure 3.3: Power distribution in the secondary windings of a G8 power supply.

winding produces 140V and 1 A of current, which is 140W. The audio winding produces 28V and 1.8A. The audio power is thus 50.4 W.

Modern audio amplifiers produce high output power and cover a wide frequency range, that generally exceeds the Hi-Fi audio range. Typically modern audio amplifiers have a frequency response of 20 Hz to 20 kHz. The output voltage of the audio amplifier is 28V, and to achieve high audio power, the current record is nearly double that of the video winding.

Unlike in the older power supply related SIV problem which is due to the power supply not being able to meet peak power demands, the new SIV power supply has sufficient power handling capability to meet all peak power demands. Even peak audio power combined with peak vision power.

The root cause of the problem, although power supply related, is completely different from the "old" problem of insufficient power for peak demand. Although the video signal is modulated by the audio signal, the difference is that it is not related to the output capacity of the power supply. The power supply has adequate power to meet the demands of the high power audio amplifier and the video power requirements under peak demand conditions. So what is the problem?

The audio amplifier draws nearly twice the current of the Video Amplifier. It draws 1.8A, versus 1A for vision. As magnetic flux is proportional to current, not voltage, the problem is magnetic crosstalk in the transformer core. To understand this problem, power supply concepts are reviewed.

3.3.2 TV Power Supplies

TV receivers and many consumer electronic products use flyback type switch mode power supplies. The advantage of using this configuration is the simplicity compared to other switching supply topologies. The benefits include lower part count and cost. This power supply topology also meets the isolation requirement of the regulatory bodies. Furthermore, it is simple to add extra secondary supplies. Flyback supplies are used for equipment requiring up to about 190W peak output power. Their low cost makes them popular, and their simple circuit makes troubleshooting power supply failures easy for service technicians.

The disadvantages of this configuration are high transistor voltage stress, and poor crossregulation of auxiliary supplies, which is a critical factor for minimizing SIV. Figure 3.3 shows the G8 flyback power supply transformer. On the mains (hot) side of the transformer, we have the primary winding and the feedback loop winding of the control circuit. The secondary side contains windings for the video supply which is typically between 80V and 165V, depending on the size of the picture tube. The larger the tube is the higher is the required video voltage. These relative large voltages are required as they are used to supply the horizontal deflection stage. This stage generates the voltages for the picture tube, including the Extreme High Voltage (EHT), which have been stepped up in the horizontal output transformer. The anode voltage is applied to a voltage multiplier to generate the anode voltage (EHT) of the picture tube, which is over 30 kV. The video winding draws the largest amount of power from the supply. The audio supply winding draws the second largest amount of power. The voltage will depend on the output power of the amplifier, but will roughly vary between 15V and 30V. The audio voltage is substantially lower than the voltage of the video supply. But the current it draws is much higher than the current drawn by the video load. The audio current may be two to three times the video supply current. The other circuits in the TV set will draw substantially less power, and therefore much less current than the video or sound circuits. A problem, that is common to isolated switching supplies with multiple secondary windings of varying output power ratios, is that each secondary supply requires a different duty ratio for the switching transistor to control the load. An ordinary solution to this problem is to control the secondary supply, with the highest output power, via the control loop that sets the duty cycle of the power supply. The other supplies are not regulated by this control loop. They are each regulated by linear voltage regulators. The voltage of the video supply, which has the highest power requirement, is regulated by controlling the duty cycle of the switching transistor in the primary circuit. A sample of the video voltage is fed back to the control loop via the feedback winding on the primary side of the transformer.

Flyback switching power supplies can operate in continuous conduction mode (CCM) or in discontinuous conduction mode (DCM). CCM topologies have larger transformers, but lower peak currents, compared to DCM operation. The control loop equations for CCM and DCM operation are different. As the details of these are beyond the scope of this study, they are not discussed.

3.4 Analysis of the New SIV Problem

The new problem has been identified in TV receivers that use magnetic feedback in the control loop of the power supply, and which have multiple secondary supplies. The problem arises due to the large current required by the high powered audio amplifiers. The audio amplifiers draw a larger current from the power supply than the video supply does.

As the audio current is larger than the video current, the flux inside the transformer is modulated by the audio. This flux is also used to generate a feedback voltage for the control loop. The aim of the control loop is to regulate the voltage of the secondary winding supplying the highest power. In TV receivers this is the video winding. We know that the induced voltage is

$$V = L \frac{\mathrm{d}I}{\mathrm{d}t} \tag{3.1}$$

From the law of induction, we also know that

$$V = N \frac{\mathrm{d}\phi}{\mathrm{d}t} = NA \frac{\mathrm{d}B}{\mathrm{d}t} = L \frac{\mathrm{d}I}{\mathrm{d}t}$$
(3.2)

From this, we see that the voltage can be eliminated and we can rearrange for B the flux density.

$$NA\frac{\mathrm{d}B}{\mathrm{d}t} = L\frac{\mathrm{d}I}{\mathrm{d}t} \tag{3.3}$$

This can be solved for the flux density

$$B = \frac{LI}{NA} \tag{3.4}$$

Thus it is noticed that the current I is proportional to the Flux Density

$$B \propto I$$
 (3.5)

The flux density in the core is the sum of all the fluxes from all the secondary windings. Thus we can express the total flux density as

$$B_{\rm T} = \sum_{i=1}^{n} B_{\rm i} \tag{3.6}$$

As the audio current is nearly twice as large as the vision current, B_T will be more influence by the audio current as it produces significantly more flux in the core, i.e. flux density B. Equation 3.7 shows this

$$B_{\text{AUDIO}} >> B_{\text{VIDEO}}$$
 (3.7)

The control look which uses a primary winding to get the reflected current from the secondary windings, can't differentiate between the windings from the audio and Video. The much larger audio flux is more prominent in the control loop. As brightness is turned down and the audio volume is turned up the crosstalk effect increases. The audio current will become the dominant control factor and the compensation of the control loop follows the audio current. The video current is thus modulated by the audio signal.

It is worth noting that audio amplifiers are designed as current amplifiers as they drive an inductive load. The load of an audio amplifier is a loudspeaker. A loudspeaker is an inductive load. The push-pull output amplifiers of the audio stage have a voltage gain of almost 1, but the output power is increased by increasing the output current. The larger current is required to generate more force to drive the speaker cone. The speaker cone has an inductor fitted. Thus more air movement is achieved with more current. This current is the main driving force for audio, which in turn affects the power supply control loop, and consequently the visual quality.

Lower frequency signals have a larger time interval T. Thus the SIV symptoms are more visible at low frequencies. At high frequencies, the symptom is not visible.

As mentioned before, except for the main supply (video), the other secondary supplies use external regulators to keep the output voltage constant with the current (load) variations. But with high power audio amplifiers, the current required is large, and the power from the audio winding is also relatively high. In the case where this symptom was observed, the ratio of peak audio to video power is given by Equation 3.8.

$$P_{\text{Ratio}} = \frac{P_{\text{AUDIO}}}{P_{\text{VIDEO}}} \tag{3.8}$$

For the G8 Receiver, this ration is about 0.36. An audio amplifier is a dynamic load and is responsible for flux variations in the transformer core. As a result, the control signal is more influenced by the flux variations in the transformer core due to the audio signal. Therefore the video voltage is modulated in rhythm with the audio signal. As the brightness of the picture is reduced, the video supply draws less current, and therefore the ratio of audio to video current increases and the cross-modulation becomes more obvious; especially at lower frequencies.

The peak current ratios are shown in Equation 3.9.

$$I_{\text{Ratio}} = \frac{I_{\text{AUDIO}}}{I_{\text{VIDEO}}} \tag{3.9}$$

The peak current ratio is 1.8, which is nearly twice the vision current. Thus it can be seen that the audio current cross modulates onto the vision current. This results in SIV.

3.5 Symptoms of the New SIV Problem

If a receiver exhibits sound-in-vision, the problem will be either in the small or large signal section of the receiver. To explore the root cause of the problem, the audio amplifier can be powered by an external power supply. This will immediately identify if the audio amplifier is the root cause of the problem. If the problem is still visible, then the problem is in the IF. If the problem disappears, then the root cause is in the power supply. The succeeding issue is whether the problem is due to the power supply not being able to generate enough power, or whether the problem is due to magnetic cross-talk in the power supply transformer.

The new SIV problem can be identified by adjusting the picture brightness. As the picture brightness is reduced, i.e. as the picture is made darker, the effect of the cross modulation will become made more obvious. In contrast with the old SIV, as the brightness is increased the modulation of the picture gets worse. If the brightness is reduced the cross modulation is also reduced. In both cases the higher the volume is turned up, the more noticeable the problem is. For the new SIV, the low-frequency components of the audio make this problem more noticeable. Table 3.1 compares the symptoms of the "old and new" sound-in-vision problem.

Variable	"Old" SIV	"New" SIV
Brightness	More noticeable when picture	More noticeable when picture
	brightness increases.	brightness decreases.
Sound	More noticeable when	More noticeable when
	volume is increased.	volume is increased.
Power Supply	Occurs with all	Occurs with power supplies that
	types of power supply.	use magnetic feedback for
		the control loop.
Audio Frequency	Independent of frequency.	More noticeable with low
		frequencies (less than 100Hz).

Table 3.1: Symptoms of SIV.

3.6 Possible Solutions

If the problem is due to magnetic cross-talk, there is no remedy that can be easily applied. The possible solutions require a considerable effort in the redesign.

3.6.1 Changing the Feedback Configuration

Minor improvements can be achieved if an optical coupler is used instead of magnetic feedback. Different winding layer configurations will not remove the problem. Magnetic feedback is often used in TV receiver power supplies due to its robustness. Optical-couplers are more likely to fail from mains related power disturbances; like for example lightning induced mains spikes. Optocouplers are less reliable than magnetic feedback.

3.6.2 Additional Power Supply

In high-end sets, often more than one power supply is used. This is mainly done for cost reasons. Two flyback converters are cheaper than one high power converter of any other topology. In such a case it would be advisable to have a separate supply for the audio amplifier. In conjunction with a carefully planned grounding structure, a separate power supply could reduce the number of other interference issues that would have to be resolved later.

3.6.3 Band Limiting the Audio Signal

As the symptom is more visible at low frequencies, it was considered to solve the problem by filtering out low-frequency components of the audio signal. This solution is not acceptable from a marketing point of view. Customers expect higher power audio amplifiers, and these must have a remarkable frequency response. While the low-frequency components cannot be heard by most people, their harmonics and subharmonics contribute towards the sound quality.

3.7 Further Research

Sound-in-vision is a well-known problem in TV development laboratories. SIV due to magnetic cross-talk in the power supply transformer is a new phenomenon. There are a number of areas that that could be further explored to help better understand this problem. An example is to develop a model to predict the maximum current ratio (audio over vision) before cross-modulation takes place.

3.8 Summary

This paper has provided an overview of the sound-in-vision problem, which is due to the marketing requirement of higher power audio, and higher bandwidth audio. These high power audio amplifiers are current driven, and thus as the video current is reduced, the cross modulation becomes more noticeable. A number of solutions that require design concept changes are proposed. Methods that help pinpoint the root cause of this problem are provided.

Chapter 4

Switching System: A Zero Power Standby Solution

4.1 Introduction

In general, households' typically have 40 or more products on standby, even though they are seldom used. Standby is there for convenience, it allows us to use remote control units. But in order to use remote control units, the power supply needs to be kept switched on. In standby mode power supplies operate under no load mode. The individual load that is connected to the power supply is the microprocessor and the Infrared LED (IR LED). The remaining loads are disconnected in standby mode. When a power supply is in standby mode, with a light load it becomes extremely inefficient. Prior to 2010, typical standby power consumption was 10 to 30 Watts, depending on the size of the power supply. The EU directive EuP (Energy using Products) has set a target of 1 W for standby. This was to be further reduced to half that power consumption by 2015. Standby power contributes up to 10% of the household energy bills. Standby power is a major concern for power generators. In Europe standby power is equivalent to the total energy consumed by the country of Denmark. Thus the energy generators need to produce that much energy that will be wasted on standby. Apart from a substantial amount of wasted energy, there are the environmental impact factors. The greenhouse gases generated and the cost to the environment. Not considered in this equation, is the cost of energy conversion inefficiency. We generate energy as an alternating current (AC), at a high voltage. Then, we need to down convert this voltage and convert it to direct current (DC). The efficiency levels are low, and we waste plenty of energy in order to waste energy in standby. In order to have a common way of measuring standby power, IEC standard 62301 was developed. The challenge is how to reduce standby power. A number of different techniques have been developed. This chapter describes a "standby" solution which achieves zero power consumption by disconnecting the equipment completely from the mains supply. However, it still allows the use of a remote control unit to switch the equipment on and off. Thus the equipment is not in standby mode, but actually switched off. Therefore, this system is a switching system. Apart from the energy savings, this concept has additional safety features. For example, no fault or hazardous conditions can occur during standby. A great number of household fires are due to consumer products. Based upon the Tokyo Fire Department, approximately 17% of household fires in Tokyo is caused by consumer electronics products. Thus this new system provides an extra safety level.

4.2 Review of Standby Innovations

Numerous studies have been conducted on the energy wasted in households due to standby. According to Mohanty [13], it highlights the wasted energy due to products being in standby mode. The study not only shows the energy waste in consumer households, but includes standby energy consumption in offices.

In early consumer products, standby systems just disconnected high power loads from the power supply. In standby, the product had to appear to be switched off. For example, a TV set had a dark screen and no sound. To indicate the set is in standby mode, a definite form of indication such as an LED was required. In these systems, the main power supply was live on standby, with a significantly reduced load. Flyback power supplies perform poorly under low load conditions and have comparatively low efficiency. Typical standby power consumption has been between 10W and 30W, depending on the type of appliance and its total power rating.

Flyback power supplies are the most common topology used in consumer applications. This is because of their simplicity, and lower component count compared to other topologies, and they can have multiple isolated secondary supplies. As mentioned, the disadvantage of flyback supplies is their poor efficiency under low load conditions. For consumer products with higher power demands the inefficiency of the power supply is significant. In standby mode, the only loads are the microprocessor and the standby components. Although these components draw every little power, the losses are due to the power supply operation base energy consumption. These losses are higher than the prescribed newer standby requirements. One of the traditional solutions was to use a second, smaller, auxiliary power supply for standby. The smaller supply is more efficient than the main supply at low power. This solution resulted in a notable reduction in standby power, but it added extra cost which can only be justified in high-end products. The power consumption of such circuits would go down to one or two Watts.

Burst mode, also known as pulse skipping technology was the next step in standby evolution. When the load is reduced as is the case with standby mode, the switching frequency of the power supply is changed. In normal operation the switching frequency is high and the switching transistor is on for most of the time. In standby mode, less energy needs to be supplied to the load, so the switching frequency is dropped, and the switching transistor is off for most of the time. The skipping of switching pulses (burst mode) reduces the switching losses and thus increase the low load efficiency. The efficiency of power supplies is shown in Figure 4.1 below.

During burst mode, the losses are in the start-up circuit, the switching device, and power losses in the control IC circuit, and hysteresis losses in the transformer. A lower switching frequency requires a number of design trade-offs. Reducing the switching frequency will reduce the losses in the switching device, but it may result in poor regulation of the output voltage. The low switching frequency may result in audible noise. The noise level can be reduced by limiting the peak switching current. This, in turn, reduces the supply efficiency. Thus the designer must find a balance between noise and efficiency.

As microprocessors became available with a sleep mode which would reduce the micro's energy consumption to micro Watts, new standby concepts were proposed [13]. Generally, these were able to achieve exceeding low power consumption levels. This led to the development of a variety of new approaches for standby mode, which have been published by academic researchers with practical limitations. Many have proposed the use of solar panels



Figure 4.1: Efficiency versus load current.

as a standby supply, thus claiming zero power standby. But these methods still consume power in standby, they draw current from the solar cells instead of the mains supply. Given the practical demands of a product that consumers will purchase, these academic solutions fall short with a good deal of unsolved problems. For example, what if there is no light? Then their standby system will not work. They also have not included solutions for safety and interference issues. Thus, most proposed concept models are often not practical and too expensive for a consumer product.

4.3 Switching System

The zero power solution to be described has the following advantages:

- It does not require any internal power source to operate.
- It completely disconnects the appliance from the mains supply.
- It is safer in "Standby mode", as no energy is present in the equipment.
- There is no Electro Magnetic Interference (EMI) on standby.

This standby solution is actually an on-off switch; therefore the patent for this invention describes it as a switching device. This is a more accurate name than standby. Standby has been used in this chapter, as it makes it easier to understand the function of this system. The aim of this system is to use a remote control to switch an appliance, like a TV set, on or off. A conventional standby system needs internal power to be able to receive the Infra-Red (IR) signal from the remote control transmitter. This new system does "energy harvesting" from an RF signal that is emitted from the remote control transmitter. The signal transmitted is in the unlicensed frequency band. A block diagram of the proposed system is shown in Figure 4.2.



Figure 4.2: Switching system block diagram.

The system consists of an antenna which is connected to a passive RF module that rectifies and filters the received signal. The voltage obtained from this signal is then used to activate an electronic switch, which in turn connects the appliance to the mains supply. Thus this system does not have a standby mode while only has two states, on or off. This is shown in the state diagram of Figure 4.3 below. The conventional standby system has three states, compared to the two states of the switching system. This system also isolates the appliance from the mains supply in the off state, thus contributing to safe operation.



Figure 4.3: State diagram.

4.4 Switching Circuit Design Considerations

This section provides an overview of the design considerations and issues.

4.4.1 RF Frequency Selection

The first consideration is the frequency selection. A frequency needs to be chosen that falls in the unlicensed bands. The choice of the frequency affects the antenna size. The size of the antenna is determined by Equation 4.1.

$$\lambda = \frac{c}{f} \tag{4.1}$$

Where c = wave velocity $(3 \times 10^8 m/s)$, f = frequency in Hz, λ = wavelength in m

The Frequency determines the energy required to transmit the on/off signal to the appliance, which in our example is a TV receiver. The energy drops at the rate of the cube of the distance. The trade-offs in the frequency selection are:

4.4.1.1 Frequency Selection

A low frequency will require a larger antenna, and if data transmission is to be by RF, it may result in relatively slow data transmission. If the frequency is higher, it will require more energy for a given distance than a lower frequency.

4.4.2 **RF or IR**

In its simplest form, the RF signal may only be used for the on-off function, and the other remote control functions may continue to be performed by an Infra-Red system (IR). For either choice, the RC-6 or other existing protocols can be used.

4.4.3 Passive RF Stage

The switching system is not connected to any power when switched off (or in "standby mode"). The only energy source is the transmitted RF signal from the remote control

transmitter. It needs to be converted into a DC voltage. Figure 4.4 shows the basic circuit that will generate the DC voltage. The RF signal is rectified and its energy is stored in a capacitor. In order to get a large enough voltage to activate the switch, a number of conditions must be satisfied. These are discussed in the next sections.



Figure 4.4: Passive RF circuit.

4.4.4 Voltage Magnification Factor

There are a number of trade-offs to make in order to supply the switching circuit with an initial startup voltage. The proper selection of components allows the Q of the input circuit to produce a larger voltage to the input of the electronic switch.

$$Q = \frac{f}{BW} \tag{4.2}$$

From Equation 4.2, it is observed a relationship that can be used to determine the voltage multiplication factor of the input circuit. In our design, we used 900MHz, which is in the unlicensed band in most countries. The bandwidth in this band (860MHzto960MHz) is 100MHz. This gives a Q of about 9 to 10. At 900MHz, the cycle time T is 1.1ns. The load resistance can be calculated based on the voltage we need to drive the switch and the current or power requirement. This resistance is the load (R_{Load}) . As a rule of thumb, the time constant τ to uphold the supply should be about 100 Ås at this frequency. From this, the filter capacitor can be calculated by Equation 4.3

$$C = \frac{\tau}{R_{Load}} \tag{4.3}$$

If the RF circuit is also to be used for data reception, then a second circuit is required. One path of the circuit will be required to supply DC voltage. Here a larger capacitor will be required to store the required energy for the switch to operate. The second path needs to be able to cope with data signals. Therefore a separate circuit is used for the data path. Here a smaller filter capacitor is used. The concept of this circuit is shown in Figure 4.5.

4.4.5 The use of a Voltage Doubler

A voltage of about 1V is needed to drive the switch. Although the input circuit Q factor will help, a charge pump, also known as the voltage doubler, may be needed. Figure 4.6



Figure 4.5: RF circuit for DC supply and data reception.

shows the circuit of the doubler. The voltage can be scaled by adding one or more stages to the voltage doubler. It must be noted that we cannot just add multipliers to obtain the desired voltage. The energy that can be extracted from the RF signal is limited by the signal strength. The signal must supply enough energy to overcome the diode voltage drops.



Figure 4.6: Voltage doubler circuit.

4.4.6 Switching System

4.4.6.1 Mains Switch

The mains switch can be implemented with a variety of devices that are compliant with IEC 65. For appliances that consume 35 W or more, a mains switch must be used. Below 35 W, the switch is optional.

4.4.6.2 Solid Sate Switch

The choice of a switch can be a solid state device such as an SCR or Triac. Using these devices extra components will be needed to meet the safety requirements. A further consideration

is that devices will need to have noise suppression components so that false triggering won't occur. They will also contribute towards an increase in EMI. In addition, large noise spikes may also affect the performance of an electronic switch.

4.4.6.3 Mechanical Switch

A mechanical switch can be used. In this application, a mechanical switch can be placed at a location in the receiver, where the mains cable layout will result in a minimal EMI pickup. A relay may also be used as an electromechanical switch. This is easy to control with a simple transistor that can handle the latching and holding currents. The circuit controlling the relay will need to be compliant with all safety standards as specified in IEC 65. This generally results in extra components to prevent safety issues under fault conditions. A relay has an advantage that the switching noise is audible. This noise can be regarded as an excellent feedback that the appliance is changing state, i.e. from on to off or vice versa. An optical indicator of whether the appliance is drawing current from the mains supply needs to be included in the circuit.

4.4.7 Control Logic

The appliance needs to be able to distinguish between valid signals and keep track of several functions associated with switch control. As the signal is RF and disperses, it may be that a command is received from another appliance that is located close by. The circuit needs to be able to detect if it is a valid signal that has arrived. These types of logic control functions can be implemented in hard or software.

4.4.8 Safety Issues

The switching system was designed for a TV receiver, thus IEC 65 was used as a reference for safety issues. As the circuit interfaces with high energy parts, safety tests will need to be done. The feasible solutions to ensure a safe design will depend on the method used to disconnect from the mains supply.

The switching device has a number of benefits regarding safety. In the OFF Mode, the appliance is completely disconnected from the mains supply. This is in contrast to current standby systems, where the appliances are always connected to the mains supply. Being disconnected makes the appliance safer.

4.5 Summary

The obvious benefit of this system is that no power is drawn during what would be called "standby". In this mode, the appliance is completely disconnected from the mains supply. Thus, there is complete isolation between the appliance and the mains supply. With current technology, nearly 10% of household electricity is used for standby. That means 10% of a household energy bill is wasted. With increasing energy costs, that is a potential for saving. More importantly, than saving is the environmental impact due to wasted standby energy. Thus reducing the energy that is wasted in form of standby has a huge impact on society.

Having the appliance completely disconnected from the mains supply has another advantage. It is safety. An appliance that is in active or standby mode can through a fault condition become unsafe. Data collected on household fires shows that about 17% of domestic fires in Tokyo are due to faulty consumer products. In Germany, the figure is 30% of household fires. That is, top of the list appliances that contribute towards household, fires are washing machines and dryers. Safety issues of the consumer product are in the news frequently. The ability to isolate an appliance from the mains helps improve safety and reduces the electricity bill. A further benefit of the proposed system is the low cost to implement it. Cost is a critical factor in consumer electronics.

Chapter 5

Conclusion

This study covered three major design issues, which required innovative approaches to come up with new solutions. The problems encountered did not belong to the day to day type problems that would occur in the daily R&D work. By contrast, the problems encountered were due to advanced new technologies, requiring innovative solutions. These problems have not been discovered before. The solutions had to be cost effective as consumer electronics is about low cost solutions. Cost is a typical design constraint and driving factor for consumer products. They are manufactured in high volumes, and market forces drive the prices down. Thus profit margins are low and require low cost designs. The implication of this is that an op-amp is particularly expensive, and a transistor is generally used.

The first chapter deals with an innovative design for which international patents were granted, namely, the design of an overvoltage protection circuit for electrolytic capacitors. It is primarily used for voltage doubling circuits. Modern Television Receivers are sold in a global market. Thus, they have to be able to operate over a wide range of input voltages. The design requirements specify an input voltage range of $90 \sim 276$ Volts. This requires an auto voltage switching circuit (AVS). The AVS detects the mains input voltage by starting in the high mains range, to avoid any damage to the receiver power supply. If a low mains input voltage is detected, it switches down to a low mains input configuration, which puts the set in doubler mode. In principle, a doubler is not needed. But the penalty for designing a set that will work over this wide input range without a doubler is the high cost due to components that need to be able to handle extreme specifications, and further issues are that a larger heatsink and more PCB space are required. This is an unacceptable solution, even for non-cost sensitive industrial applications. Thus, voltage doubler circuits are required. For low mains voltage countries such as Japan ($85V_{AC}$ to $120V_{AC}$) a hardwired doubler circuit is used. International safety standards such as IEC 65 (the safety standard for audio and video equipment) and the equivalent Dentori standard require that during the safety evaluation of the doubling circuit, the elcaps are open circuited and short circuited. Under both fault conditions the power supply must remain safe. An unsafe condition would be a hot spot or the overheating of an elcap that could result in a potential fire. This solution meets all safety requirements, and has the additional benefit of substantial cost savings. This invention allows the use of 250VDC rated elcaps, instead of the traditional $400V_{DC}$ elcaps. This resulted in cost savings of \$5.05 per capacitor; or \$10.10 per set. After allowing for the cost of components and assembling these components, the net savings are \$8.00 That translates into \$8.00 million dollars saving for a production run of 1 million sets. A further benefit is that the resistive network across the elcaps provides voltage balancing. Without the resistors the voltage may be unevenly distributed, given that the tolerance of the elcaps is $\pm 20\%$ the voltage distribution can be substantial without the resistors. The overvoltage protection circuit components, are physically positioned in the front end of the power supply. Here they are subject to many potentially hazardous mains pollution problems. Therefore, a number of safety and performance tests were completed, which involve the standard open short safety tests, mains voltage disturbance injection, lightning injection, and electrostatic performance evaluation. It is noted that the proposed design has passed all tests.

The second chapter has shown how innovations in technology and new customer demands have created a new root cause for an old problem. This chapter describes two well-known root causes to the sound-in-vision (SIV) problem. The new root cause is due to a more demanding audio amplifier specification. As the power of the audio amplifier increases, the current required to provide full load increases. The output stage of an audio amplifier is a common-collector type amplifier. As such, it has approximately unity voltage gain, but it has a large current gain. The advantage of the common collector configuration is that acts as a buffer to the driving stage, and has a low output impedance, which helps match the low impedance of the speaker. The speaker is an inductive load and thus current driven. The output stage can provide the necessary current to deliver the high output power requirement of modern audio amplifiers. This large output current is the root cause of the SIV problem. The switch mode power supply obtains the feedback for its control loop from an auxiliary winding on the primary side of the power supply transformer. The high audio current is larger than the video or picture current. The power supply feedback loop is designed to control the voltage of video output supply, as it has the largest output power. Nevertheless, as the audio amplifier current is almost double that of the video supply and the transformer flux is proportional to the current, the control loop cannot differentiate between the audio and video currents. Thus the high current demand of the audio amplifier modulates the vision with the sound signal. A method had been developed to help pinpoint which type of SIV problem exists. This method is shown in a table in Chapter 3. There is no real solution to this problem. The only feasible solution could be cut off the low frequency of the audio signal, as the SIV effect is more visible at low frequencies. However, this would affect the audio quality, thus filtering out the low frequency is not an acceptable solution. The only effective solution is that a separate audio power supply is used. For the G8 chassis, management decided the effect is not very severe and accepted the Set with the SIV problem.

Chapter three covers Standby power consumption. A brief review is provided of historical concepts, and several academic solutions are not working for a real TV application or other consumer products. In other words, hidden issues exist that if one is not familiar with the requirements of consumer electronics and with usability issues imposed by the constraint that a broad spectrum of people needs to be able to use and operate the product. One early solution was the use of sleep mode in microprocessors. The main problem was the cost of an energy storage element. The energy storage element could be a battery or low leakage capacitor. Both options raised issues with respect to safety, and cost. Many of the objections from safety were overcome, but required amendments to IEC 65. This would be a time consuming effort. Given the constraint and the time to market issue, Philips decided not to file a patent for this innovation. Rather, prior art was established by publishing this method in a low circulation Philips publication. Another popular solution was pulse stretching. Pulse stretching allows the power supply to "slow down" and thus transfer substantially less energy. With this method, high efficiencies were achieved in standby mode. Pulse stretching is a method that is widely used to reduce standby power. The proposed solution is the

world's first true zero power "standby circuit". Unlike in a conventional standby solution, the state diagram has three stages: Power On, Standby, and Power Off. The new solution has only two states, which "On or off". Thus the proposed solution switches the product fall off. Therefore, it does not appear to be a standby solution, but a switching system. This solution is achieved with harvesting Radio Frequency (RF) Energy. The remote control unit needs to be changed from Infra-Red transmission of RF. It could also just be simple RF add on to an Infra-Red remote control. The basic concept of this switching system is described in this chapter.

The research completed and shown in the three chapters still has potential for further study. Chapter 1 has shown a novel solution to ensure a safe and cost effective solution in reducing the size and cost of electrolytic capacitors. There are at least 10 patents that reference this solution. Most modify the control circuit and are in general more expensive. Better protection circuits may be developed, given the advances in power electronics. It is expected that further improvements will be made to improve noise immunity of the circuit. The input EMI filter may be used for this improvement.

The standby circuit proposal is a topic of great importance, and the proposed solution has fairly extensive applications. Further research can be implemented in miniaturizing this solution, and to further reduce the cost of the switching system. There are many applications that this solution can be applied to in order to make more energy efficient products. The SIV problem has a considerable number of variables, and a detailed study which can help identify the relationships between these variables would not only be beneficial to Television receivers, but to the power supply community in general.

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${\bf Standards}$

IEC 65 (EN60065).

UL 1492 (for USA).

CSA (for Canada).

CISPR 13.

DENTORI (Japanese legal requirements for electrical appliances and materials).

Philips Internal Documents:

UAW-0141 Safety Standard for Philips Consumer Electronics Products.

UAM-D1750 Approbation Manual Philips CE.

BG-TV Standards.

Patents

- 1. Switching System
 - United States of America Patent: US-7,911,087.
 - AUS filing number 2007906044, filled November 2007.

The patent describes a zero power standby switching system.

- 2. Overvoltage Protection Circuit
 - European Patent Application, filling number: 95200401.8.
 - United States of America Patent: US-5,510,944.
 - Taiwan: Utility Model UM111480.

Details are available from Philips Corporate Patents and Trademarks, Eindhoven, The Netherlands.
Appendices

- 1. Tolerance Calculations for Over Voltage Protection Circuit
- 2. Safety Evaluation Report
- 3. Design Evaluation Electrical

TOLERANCE CALCULATIO (iile:d3tol.)	ON OF ELCAP OV PROTI mcd; prt:d3tprt.mcd	ECTION	page 1
By: S.Mozar		Date: 8.3.94	
Input Data:			
4 Rl := 10	dR1 := 0.01	Vbe := 0.7	-3 Sbe := 2·10
R2 := 120·10	dR2 := 0.01	Vz := 15	dVz := 0.02
R3 := 15-10	dR3 := 0.01	-3 Sz := 11.4·10	
dT1 := 35	i := 13		3
RT := R1 + R2 + R3	dT :=	Szmin := 9.2.10	- 3
-6 0 := 50·10	25 30 35		
Resistance Calculation	s:		
Rma := R1 - R1 dR1 +	R2 + R2 dR2 + R3 +	R3·dR3	
Rmi := R1 + R1 dR1 +	R2 - R2 dR2 + R3 -	R3 dR3	
$Rmax := \frac{Rma}{R1 - R1 \cdot dR1}$	$Rmin := \frac{R}{R1 + 1}$	mi Rl·dRl R :	= RT R1
Rmax = 14.775	Rmin - 14.255		
Considering temperatur	coefficients of re	sistors, tu>25°C	, t1<25°C
Rmatu := (R1 - R1 dR1 + 0	• dT1 R1} * (R2 * R2	·dR2 + 0·dT1·R2}	
* (R3 * R3 dR3 +	O dT1 R3)		
Rmitu := (R1 + R1 dR1 + 0	- dT1 · R1) + (R2 - R2	'dR2 + ⊖'dT1'R2)	•••
+ (K3 - K3.dK3 +	9. di 1. k3 j		

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```
page 3
   Tolerance Calculations (component toler. only) :
   Normal Trigger point at 25°C is given by:
  Vtrg := (Vbe + Vz) \cdot \left[ \frac{RT}{R1} \right]
  Vtrg = 227.65
  The highest trigger point at 25°C is:
  Vtrgh := (Vbe + Vz + Vz dVz) Rmax
  Vtrgh = 236.364
  The lowest trigger point at 25°C is:
  Vtrgl := (Vbe + Vz - Vz dVz) (Rmin)
  Vtrgl = 219.183
 TAKING TEMPERATURE INTO CONSIDERATION (allowing for res temp coeff)
 The highest trigger point at 60°C is:
      Vtrght := ((Vbe - Sbe'dT1) + (Vz + Vz'dVz + Szmax'dT1))'(Rmaxtu)
      Vtrght = 242.043
 The lowest trigger point at 60°C is:
      Vtrgl := ((Vbe - Sbe·dTl) + (Vz - Vz·dVz + Szmin·dTl)) (Rmintu)
      Vtrgl = 222.777
Nominal trigger pt at 60°C:
       Vtrgnh := ((Vbe - Sbe dTl) + (Vz + Sz dTl)) R Vtrgnh = 232.421
```

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page 4 The extreme low temperature at which we analyse the circuit is -10°C, the max becomes:

$$Vtrgh := \left[\begin{bmatrix} Vbe + Sbe dT \\ i \end{bmatrix} * \begin{bmatrix} Vz + Vz dVz - Szmin dT \\ i \end{bmatrix} \right] \cdot Rmaxt$$

Vtrgh	
1 213 699	1 1 0 0 0 1
233.166	[-5°C]
232.633	[-10°C]

At -10, the min value becomes:

Vtrgl := i	[[Vbe + Sbe·dT_i]	*	[Vz	-	Vz∙dVz	-	Szmax·dT i]]·[Rmint i]
Vtrgl							
215.274 214.492 213.711	[0°C] [-5°C] [-10°C]						

.

.

Nominal low temperature values:

$$\begin{array}{c} \texttt{Vtrgn} := \begin{bmatrix} \texttt{Vbe} + \texttt{Sbe} \cdot \texttt{dT} \\ \texttt{i} \end{bmatrix} + \begin{bmatrix} \texttt{Vz} - \texttt{Sz} \cdot \texttt{dT} \\ \texttt{i} \end{bmatrix} \cdot \texttt{R} \end{array}$$

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Not taking resistor temp. coeff. (0) into consideration: page 5

```
Max trigg at low temp:
```

$$Vtrgh := \left[\begin{bmatrix} Vbe + Sbe \cdot dT \\ i \end{bmatrix} + \begin{bmatrix} Vz - Vz \cdot dVz + Szmin \cdot dT \\ i \end{bmatrix} \right] \cdot Rmax$$

$$Vtrgh$$

```
231.636 [ 0°C]
232.464 [-5°C]
233.291 [-10°C]
```

Min trigg at low temp:

 $Vtrgl := \begin{bmatrix} Vbe + Sbe dT \\ i \end{bmatrix} + \begin{bmatrix} Vz - Vz dVz - Szmax dT \\ i \end{bmatrix}$ Rmin

Vtrgl	
î.	
215.269	[0°C]
214.486	[-5°C]
213.704	[-10°C]

(Not taking res.temp. coeff into account)

```
Max trigg at 60°C:
```

Vtrgh := ({Vbe - Sbe·dT1} + (Vz + Vz·dVz + Szmax·dT1})) (Rmax)
Vtrgh = 242.051

```
Min trigg at 60°C:
        Vtrgl := ({Vbe - Sbe-dTl} + (Vz - Vz·dVz + Szmin·dTl))·(Rmin)
        Vtrgl = 222.77
```

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Report No.: PHILIPS SUBJECT: SVR07-G8-p.4233. G8 - POWER SUPPLY SINGAPORE PRIVATE LIHITED Date :03-03-94 CTV FACTORY Page : 1/7 Dealt with by: LEE T8 Dev-Evaluation **OBJECTIVE** : To test the solution 1 & 2 as recommended for G8 Elcap protection circuit, according to IEC 65 requirement. RESULT : Solution 1 & 2 : Temperature rise is within the safety limits of IEC 65.(See attached report.) REMARK : When S/C C2, Resistor R7 >100°c .Proposal is to add another capacitor in series. CONCLUSION : The recommended solution fulfills to the requirements of IEC65. Tested by LEE TB Copy : Mr S Mozar.

FILENAME: SUBJECT.FRM



Solution 1.



ELCAP & OVERVOLTAGE PROTECTION CIRCUIT (SOLUTION 2)

VIDE	O DIVISIO	DN		PA	ART B		REPORT NUMBER:
				SAFETY T	EST REPORT		SVR07-G8-p.4233
PAGI	E: 4		FAULT	CONDITI	ONS TEST RES	ULTS	DATE: 03-03-94
			G8: El	cap Overv	oltage (Solution	n 1)	
Fault Conc appli	i. I.			c	Observed Items		
FC	ltem Nos.	ltem Nos.	Description	Power Diss. At FC	Temp. rise In deg. C Sold. Junct	Mains Volt. (RMS)	Additional Information
s O	2128 2128	T1 2120	680μF 250V 680μF 250V c-BF 423 680μF 250V			160- 276V	Fuse 1100 4A O/C immed. Hickup mode
s o	2120		680μF 250V 680μF 250V			160- 276V	Fuse 1100 4A O/C immed. Hickup mode
s	CI	2128 T1 T2	100µF BF423 BT151		35°C 36°C	160- 276V	No noticeable deviation.
s	C3	R7	15µF 1k PRO2		>120°C	160- 276V	Set working (set w/o C2)
s	C2	R7	15µF 1k PRO2		30°C	160- 276V	Set working No high temp.
s	T2 d-g		BT151			160- 276V	Fuse 1100 4A O/C immed.
s	T2 a-c		BT151			160- 276V	Fuse 1100 4A O/C immed.
S= Sh	ort Circu	it O=	Open Circuit	NFP=	No Fire Phenom	ena	FP= Fire Phenomena

Note:-

Component 2*** represent capacitor type no. is #F

3*** represents resistor

5*** represents windings component, eg coil. Transformer

Type no. is #H

Whereis any number

VIDE	O DIVISIO	ON		P	ART B		REPORT NUMBER:
			_	SAFETY T	EST REPORT		SVR07-G8-p.4233
PAG	E: 5		FAULT	CONDITI	ONS TEST RES	ULTS	DATE: 03-03-94
				G8: Elcap	Overvoltage		
Fault Cond appli	l.			(Observed Items		
FC	Item	Item	Description	Power	Temp, rise	Mains	Additional
	Nos.	Nos.		Diss. At FC	In deg. C Sold. Junct.	Volt. (RMS)	Information
S	T2		BT151			160 -	No noticeable
	g-c	R7	1k PRO2	-	30°C	276V	deviation
0	T2 a g	R7	BT151 1k PRO2			160 - 276V	No noticeable deviation
	c						
s	Т1 С-Е		BF423			160 - 276V	Fuse 1100 4A O/C immed.
s	T1 B-C		BF423			160 - 276V	Fuse 1100 4A O/C immed.
s	T1 B-E	R6 R7	BF423 75k 6k8		35°C 38°C	160 - 276V	No noticeable deviation
s	D1		1N1418		-	160 -	Fuse 1100 4A O/C
Ű.						276V	immed.
0	D1	eT1 2120	1N1418 BF423 680µF		32°C 30°C	160 - 276V	Set working normal.
s	D2		B68			160 - 276V	Fuse 1100 4A O/C immed.
0	D2	cT1	B68 BF423		34°C	160 - 276V	No noticeable deviation
0	Т1		BF423			160 -	
5	C B E	D1 2128	1N1448 680µF		35°C 32°C	276V	No noticeable deviation
S= Sh	ort Circu	it O=	Open Circuit	NFP=	No Fire Phenom	ena	FP= Fire Phenomena

VIDE	O DIVISIO	ON		P/	ART B		REPORT NUMBER:
			FAULT	SAFETY T	EST REPORT ONS TEST RES	ULTS	5VK07-G8-p.4233
PAG	E: 6						DATE: 03-03-94
				G8: Elcap	Overvoltage		
Fault Conc appli	t 1. ied			0	Observed Items		
FC	ltem Nos.	Item Nos.	Description	Power Diss. At FC	Temp. rise In deg. C Sold_lunct	Mains Volt. (RMS)	Additional Information
s O	2128 2128	cT1	680μF 250V 680μF 250V BF423 680μF 250V		32°C	160- 276V 160- 276V	Fuse 1100 4A O/C immed. Hickup mode
s	2120		680µF 250V			160- 276V	Fuse 1100 4A O/C immed.
U	2120	cT1 2128	BF423 680µF 250V		33°C 38°C	160- 276V	Hickup mode
s	T1 C-E		BF423			160- 276V	Fuse 1100 4A O/C immed.
s	T1 B-C		BF423			160- 276V	Fuse 1100 4A O/C immed.
s	T1 B-E		BF423			160- 276V	No noticeable deviation.
0	T1 B C E	2120 2128 R1	-BF423 680μF 250V 680μF 250V 27k		32°C 34°C 30°C	160- 276V	No noticeable deviation.
s	D2	D1 2128	GP15J BZX79B15 680μF 250V		32°C 36°C	160- 276V	No noticeable deviation.
0	D2	2128	GP15J 680μF 250V		32°C	160- 276V	No noticeable deviation.
S= Sł	nort Circu	it O=	Open Circuit	NFP=	No Fire Phenom	ena	FP= Fire Phenomena

VIDE	O DIVISI	ON		P/ SAFETY T	ART B TEST REPORT		REPORT NUMBER: SVR07-G8-p.4233
PAG	E: 7		FAULT	CONDITI	ONS TEST RES	ULTS	DATE: 03-03-94
				G8: Elcap	Overvoltage		
Faul Conc appl	t d. ied			(Observed Items		
FC	ltem Nos.	Item Nos.	Description	Power Diss. At FC	Temp. rise In deg. C Sold. Junct.	Mains Volt. (RMS)	Additional Information
s	C1	T1 D2	100μF BF423 GP15J	-	32°C 36°C	160- 276V	No noticeable deviation.
0	СЗ	R7	15µF 1k2		>100°C	160- 276V	Set working. High temp. Resistor R7
s	C2	R7	15μF 1k2		36°C	160- 276V	No noticeable deviation.
s	D1		BZX79C15			160- 276V	Fuse 1100 4A O/C immed.
s	D3		BZX79C15			160- 276V	Fuse 1100 4A O/C immed.
0	D1		BZX79C15			160- 276V	No noticeable deviation.
0	D3	R6 cT1	BZX79C15 27k BF423		32°C 30°C	160- 276V	No noticeable deviation.
S= Sh	nort Circu	uit O=	Open Circuit	NFP=	No Fire Phenom	ena	FP= Fire Phenomena

Note: S/C C3, R7 high temperature.

Solution: to add C2 in series to C3 capacitor.

PHILIPS	SUBJECT	Report No.
LIMITED	STANDARDISED TEST FOR G8	SVR20-G8-DE-P.4406
CTV Dev – DE	PROTECTION CIRCOT	DATE : 04/05/94
	Dealt with by : ERIC GOH	SHEET : 1 / 1

MILESTONE : DR

MODEL/VERSION : 25SX8673/61R

OBJECTIVE :

To ensure that the above set can fulfill the following standard test after the introduction of the new protection circuit.

RESULT :

See attached for detail result.

RESULT SUMMARY

STANDARD TEST	RESULT	REMARKS
FATHER/MOTHER	POSITIVE	1500 ON/OFF were done in lab. ambient condition. Test not done in chamber due to the constraint of the stamp-print.
MAINSPIKE	POSITIVE	-
MAINS INTERRUPTION	POSITIVE	-
MAINS VARIATION	POSITIVE	-
MAINS SURGE (LIGHTNING)	POSITIVE	 * The set will turn on from standby at a energy level of 4 KV and above. * This is an existing problem and it is not caused by the protection circuit. * The +5V regulator fails at 7 KV.
ELECTRO STATIC DISCHARGE	POSITIVE	 * Error occurs at 15 KV, the picture will hang with no control over the local keyboard and remote control. * The set will turn on from standby at a energy level as low as 8 KV. * Unknown OSD characters are displayed on the screen. * The above are existing problems and it is not caused by the protection circuit.

CONCLUSION :

The test is positive based on the stamp print of the new protection circuit. It does not have any hardware failures or behave differently from the existing set. Problems found are inherited from the existing set. Further test will be conducted when the relayout PCB is ready.

Eric Goh / Lim YS DEV-EVAL

cc. Tan TL, Mozar Stefan

SINGAPORE PRIVATE LIMITED	SUBJECT MAINS I			Report No. SVR20-G8-I	DE-P.4406
CTV Dev - DE	(LINE FAILOR		/ N)	DATE : 0	4/05/94
	Dealt with by : EF	IC GOH		SHEET: 1	/2
Biblionedi MILESTONE : DR			MODE	L/VERSION: 2	9SX8673/61
OBJECTIVE :					
To check the suscep	tibility of the set when	subject to the mains	interruption	test.	
¢11	nder aller a	55 - 2-3			
LATEST STATE OF ART	: (PCB po	nt#).7			
ATEST CIRCUIT DIAGE	RAM : (attached	i) —			
EQUIPMENT	: NSG 230 NSG 200	A E Main frame			
	of e No Novela	60 ms at 110 Vac.			
RESULTS	ৰন্দ এই তপ গাঁপাৰ্ভ See atta	ched for details.			
RESULTS	ৰণ এই তথা গোলাই See atta প্ৰকৃতিৰ কৰা	ched for details.			
RESULTS	ৰন আ তথা গোলাৰে <mark>See atta</mark> প্ৰকৃতিৰ কথা	ched for details.			
RESULTS	ৰদ আ তথ গেললে <mark>See atta</mark> পথ্যসময় কল	ched for details.			
RESULTS	ৰদ এই ভগ ি গোল ে Seé atta পথ্যসক্ষ কৰ	ched for details.			
RESULTS	ৰন এই তথা গোলাৰে <mark>See atta</mark> পথ্যসময় কল	ched for details.			
RESULTS CONCLUSION :	ৰন এই ভৰ্মা গোলাৰে <mark>See atta</mark> পথ্যসময় কল	ched for details.			
RESULTS CONCLUSION : The test is positive.	ৰন আ ভলি বাবে গোল ে Seé atta কয়ন্দ্ৰৰ কল	ched for details.			
RESULTS CONCLUSION : The test is positive.	ৰন এই তথ গোলাই <mark>উল্লি atta</mark> কেন্দ্ৰোৱা কল	ched for details.			
RESULTS CONCLUSION : The test is positive.	का प्रदे छम् गिर्माण ि Seé atta कालका कर्त	ched for details.			
RESULTS CONCLUSION : The test is positive.	का प्रदे स्थि गिर्माण ि Seé atta कालका कर्त	ched for details.			

	V B	non	THE ALL AND A	214.44		11-2 TIME 1
ULTS :						
1.319						10 253 935
(33	ee		LINE FAI	LURE	diana()	
Ma	ain Voltage	Duratio	on of failure	Specific	ation	Remarks
: HOI8	HODEL MER	Short	Long	100%	50%	i ni i aveller
110V	Standby	0	K OK	>20ms	>40ms	
	orandoy					NUTCHE ALL
110V	Operation	35ms	45ms	>20ms	>40ms	
	test noikpro	etre and see and	itel canari	e huller pou		ne nels, sus si
230V	Standby	0	K OK	>60ms	>120ms	
					1.100	
230V	Operation	80ms	130ms	>60ms	>120ms	
		r.				
		br	LINE VA	RIATION	TER New DAA	ה הפצר אהרד סדו היה איצה הפכעיר ש היא שישייה
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il to 3 Ma	in Voltage	en ne Duratie	LINE VA	RIATION	TRA New 3A ation _{n O} min	UTO THAT & T & STAT ROTOLO PETERSON T THAT Remarks and a
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276V-1	in Voltage 150V Stand	book Duratio	LINE VAI on of failure OK OK	Specific No failure	TRA Accessors ation _{in content} a a	UTO TA A BARBARA RAMONALA Inte Remarks and a
276V-1	in Voltage 150V Stand 150V Oper	by to get ation	LINE VAI on of failure OK OK	Specific No failure	TRA Nearo GA ation _{in OPP} T	10 51 A 18 1 8 51 A 1 10 110 D 81 E 1810 C 1 10 110 D 81 E 1810 C 1 10 10 Remarks 10 C 1
276V-1 140V-9	in Voltage 150V Stand 150V Open 90V Stand	by	LINE VAI on of failure OK OK	No failure No failure	TRA Accessed ation_constitu- e	10 That 8 h 8 sha h Rh 1990 Philippine Inte Remarks and a Inter Remarks
276V-1 276V-1 140V-5	tin Voltage 150V Stand 150V Oper 20V Stand 20V Oper	by by ation	LINE VAI on of failure OK OK OK	RIATION Specific No failure No failure No failure	TRA Acade GA ation	10 51 A 18 1 8 51 4 1 10 110 0 91 1 18 10 1 10 10 0 91 1 18 10 1 10 10 0 91 1 18 10 18 10 10 1 10 10 0 91 1 18 10 18 10 10 1 10 10 0 91 1 18 10 18 10 10 1 10 10 0 91 1 18 10 10 10 10 10 10 10 0 91 1 18 10 10 10 10 10 10 0 91 1 18 10 10 10 10 10 10 0 91 1 18 10 10 10 10 10 10 0 91 1 18 10 10 10 10 10 10 0 91 1 18 10 10 10 10 10 10 0 91 1 18 10 10 10 10 10 10 0 91 1 18 10 10 10 10 10 10 0 91 1 18 10 1
276V-1 276V-1 140V-9	in Voltage 150V Stand 150V Open 90V Stand 90V Open	ation	UNE VAI on of failure OK OK OK	No failure No failure No failure	TRA Accessor ation Control e e e	I HO THAN & HE BHA H ROMULAR HE BHA H HIMA Remarks HANK
276V-1 276V-1 140V-5 140V-5 200V-1	in Voltage 150V Stand 150V Oper 90V Stand 90V Oper 120V Stand	by ation	LINE VAI on of failure OK OK OK OK	RIATION Specific No failure No failure No failure No failure No failure	TRA Acres 3A ation control e e e	10 TALE 18514 1 10 TUDR 1 (810.24) 10 TUDR 1 (810.24) 10 TUDR 1 (810.24)
276V-1 276V-1 140V-9 140V-9 200V-1	in Voltage 150V Stand 150V Open 90V Stand 90V Open 120V Stand	ation dby	LINE VAI on of failure OK OK OK OK	No failure No failure No failure No failure No failure	TRM Acres 33A ation accounts e e e	10 51 A 18 1 8 51 4 1 10 110 0 91 1 1 8 51 4 1 10 110 0 91 1 1 8 51 4 1 10 1 10 0 91 1 1 8 51 4 1 10 1 10 0 91 1 2 1 10 0 99

PHILIPS SINGAPORE PRIVATE LIMITED	SUBJECT MAIN SPIKE TEST	Report No. svR20-G8-DE-P.4406
CTV Dev - DE	(LOW, MEDIUM, HIGH ENERGY)	DATE : 04/05/94
salesees?	Dealt with by : ERIC GOH	SHEET: 1/3
		1.14 C
MILESTONE : DR		ODEL/VERSION : 29SX8763/61
OBJECTIVE :		
To check the suscer	ibility of the set when subject to the main spike t	lest.
ART OF VORT	 A state of the second se	
LATEST STATE OF ART	: (PCB point #) . 7	
EQUIPMENT	NSG 222A (Low energy)	
	NSG 224 (Medium energy)	
	NSG 223 (High energy)	
CONDITION	: Low energy pulse - 1	00 spikes starting at line frequency
CONDITION	Medium energy pulse – 1	00 spikes per combination
	Phase of spikes is varied against m	ains sine wave over an
	angle of 360 Degree.	a
RESULTS	See attached for detail result.	
CONCLUSION :		
The test is positive.		
		SPIKE WK1

CTV	Dev – DE						SHEET: 2/3
-	in a		070	NSG	222A LOV	ENERGY	PULSES
тг ⁰¹ Т.19	Pulse Duration	Mode	+/-	Freq.	Amplitude FICO DI	Phase 83 at 21	Remarks
5nS	-	Sym	+	n.	100V - 2.5KV	Variable (free)	@1 - 1.25 KV
5nS)	CARVE RO	Sym	-	fi	100V - 2.5KV	Variable (free)	@1 - 1.38 KV //C
5nS	-	Sym	+	0.2 fl	100V - 2.5KV	Variable (free)	@1 - 1.64 KV
5nS	-	Sym	-	0.2 1	100V - 2.5KV	Variable (free)	@1 - 1.51 KV 52 (1.21.)
5nS	-	Asym	ita a	ft in sp	100V - 2.5KV	Vaciable (free)	@1 0.82 KV state in such states of the
5nS	-	Asym	-	1	100V - 2.5KV	Variable (free)	@1 - 0.61 KV, @2 - 1.04 KV, @3 - 1.16 KV
5nS	-	Asym	+	0.2 fl	100V - 2.5KV	Variable (free)	@1 - 0.81 KV
5nS	-	Asym	-	n 2.0	100V - 2.5KV	Variable (free)	@1 - 0.84 KV, @2 - 1.16 KV, @3 - 1.30 KV
10nS	-	Sym	+109	810.0	100V - 2.5KV	Variable (free)	@1 - 2.30 KV 1 M REPUBLIC
10nS	-	Sym	Diens Dens	1	100V - 2.5KV	Variable (free)	@1 - 2.01 KV
10nS	-	Sym	+	0.2 fl	100V - 2.5KV	Variable (free)	@1 - 2.36 KV
10nS	uste Henlega Hang owie gan	Sym	-	0.2 ft	100V - 2.5KV	Variable (free)	@1 - 2.43 KV
10nS	and service	Asym	+	fi	100V - 2.5KV	Variable (hee)	@1 - 0.76 KV
10nS	-	Asym	-	6	100V - 2.5KV	Variable (free)	@1 - 1.02 KV
10nS	-	Asym	+	0.2 fl	100V - 2.5KV	Variable (free)	@1 - 1.13 KV
10nS	-	Asym		0.2 fl	100V - 2.5KV	Variable (free)	@1 - 1.03 KV

REMARKS

@1 - Colour Flickering

@2 - Picture tearing

@3 - Picture blank off (Blue mute appeared)

MORE DAMON

STV (V Dev – DE							SHEET: 3/3
Tr	Pulse Duration	Mode	+/-	Freq.	Amplitude	Phase		Remarks
25nS	lus	Sym	+	1 Hz	100V - 2.5KV	Variable (free)	@1 - 2.50 KV	
25nS	1us	Sym	-	1 Hz	100V - 2.5KV	Variable (hee)	@1 - 2.50 KV	
25nS	tus	Asym	+	1 Hz	100V - 2.5KV	Variable (free)	@1 - 1.82 KV	
25nS	Tus	Asym	-	1 Hz	100V - 2.5KV	Variable (free)	@1 - 1.70 KV	
25nS	lus	Sym	+	10 Hz	100V - 2.5KV	Variable (free)	@1 - 1.89 KV	
25nS	tus	Sym	-	10 Hz	100V - 2.5KV	Variable (free)	@1 - 1.85 KV	
25nS	tus	Asym	+	10 Hz	100V - 2.5KV	Variable (free)	@1 - 1.31 KV	
25nS	lus	Asym	-	10 Hz	100V - 2.5KV	Variable (free)	@1 - 1.76 KV	
35nS	Jus	Sym	+	1 Hz	100V - 2.5KV	Variable (free)	@1 - 1.38 KV	
35nS	3us	Sym	-	1 Hz	100V - 2.5KV	Variable (free)	@1 - 1.54 KV	
35nS	3us	Asym	+	1 Hz	100V - 2.5KV	Variable (free)	ок	
35nS	Jus	Asym	-	1 Hz	100V - 2.5KV	Variable (free)	ок	
100nS	10us	Sym	+	1 Hz	100V - 2.5KV	Variable (free)	@1 - 1.83 KV	
100nS	10us	Sym	-	1 Hz	100V - 2.5KV	Variable (free)	@1 - 2.15 KV	
100nS	10us	Asym	+	1 Hz	100V - 2.5KV	Variable (free)	ок	
100nS	10us	Asym	-	1 Hz	100V - 2.5KV	Variable (free)	OK	

NSG 223 HEAVY ENERGY PULSES

Tr	Pulse Duration	Mode	+/-	Freq.	Amplitude	Phase	Remarka
100nS	-	Sym	+	1/8 fl	0 - 1.0KV	Variable (free)	ок
100nS	-	Sym	-	1/8 fl	0 - 1.0KV	Variable (free)	ОК
500nS	-	Asym	+	1/8 fl	0 – 3.0KV	Variable (free)	@1 - 2.40 KV
500nS	-	Asym	-	1/8 fl	0 - 3.0KV	Variable (free)	@1 - 2.40 KV
1.2us	-	Sym	+	1/8 f	0 - 1.0KV	Variable (tree)	ок
1.206	-	Sym	-	1/8 fl	0 - 1.0KV	Variable (hee)	ок
1.2us	-	Asym	+	1/8 fl	0 - 3.0KV	Variable (free)	@1 - 2.80 KV
1.2us	-	Asym	-	1/8 fl	0 - 3.0KV	Variable (free)	@1 - 2.80 KV

REMARKS

1000

@1 - Colour Flickering

LIN	RE PRIVATE	SUBJECT SURGE TEST	Report No. SVR20-G8-DE-P.4406		
CTV Dev – DE		(LIGHTNING SIMULATION)	DATE : 04/05/94		
CIVI	Dev - DE	Dealt with by : EBIC GOH	SHEET : 1/2		
ILESTO	NE: DR	MODE	L/VERSION : 295X8673/61		
BJECTIV	/E	: To check the susceptibility of the set whe	n subject to the surge test.		
ATEST S ATEST C	TATE OF ART	: (PCB point #) . 7 AM : (attached) -			
QUIPME	NT	: 801-PLUS Main frame (Keytech) M801-5A Surge Network (Keytech)			
AFETY R		All Surge tested set should fulfil hig current) before and after the surge te cap across ho and cold ground and spark gap.	h tension tests (leakage st. measure isolating cer I cer cap in series with		
COEFIA	NUE UNITERI	1) Set shall not malfunction (e.g	harware failure).		
		 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= 	y consequences. t & cold ground) 7KV.		
	Paramotors	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= Common mode (high and low to 	a.g. memory loss, etc). y consequences. t & cold ground) 7KV.		
A	Parameters Test voltage	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= Common mode (high and low to from 3KV to 6KV in steps of 1.5KV 	a.g. memory loss, etc). y consequences. t & cold ground) 7KV.		
A	Parameters Test voltage Waveforms	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= Common mode (high and low to From 3KV to 6KV in steps of 1.5KV Open circuit voltage : 2/50 usec. Short circuit	e.g. memory loss, etc). y consequences. t & cold ground) 7KV. o ground) current : 8/20 usec.		
A B C	Parameters Test voltage Waveforms Phase angle	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= Common mode (high and low to From 3KV to 6KV in steps of 1.5KV Open circuit voltage : 2/50 usec. Short circuit 90 deg and 270 deg (0 deg. 180 deg for zero cross	e.g. memory loss, etc). y consequences. t & cold ground) 7KV. o ground) current : 8/20 usec. ing circuit)		
A B C	Parameters Test voltage Waveforms Phase angle Polarity	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= Common mode (high and low to From 3KV to 6KV in steps of 1.5KV Open circuit voltage : 2/50 usec. Short circuit 90 deg and 270 deg (0 deg, 180 deg for zero cross Positive & negative	e.g. memory loss, etc). y consequences. t & cold ground) 7KV. o ground) current : 8/20 usec. ing circuit)		
A B C D F	Parameters Test voltage Waveforms Phase angle Polarity Pulse type	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= Common mode (high and low to From 3KV to 6KV in steps of 1.5KV Open circuit voltage : 2/50 usec. Short circuit 90 deg and 270 deg (0 deg, 180 deg for zero cross Positive & negative Common mode (high & low to ground)	e.g. memory loss, etc). y consequences. t & cold ground) 7KV. o ground) current : 8/20 usec. ing circuit)		
A B C D E F	Parameters Test voltage Waveforms Phase angle Polarity Pulse type Mains supply	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= Common mode (high and low to From 3KV to 6KV in steps of 1.5KV Open circuit voltage : 2/50 usec. Short circuit 90 deg and 270 deg (0 deg, 180 deg for zero cross Positive & negative Common mode (high & low to ground) Set should be on, set off, & in standby. 	e.g. memory loss, etc). y consequences. t & cold ground) 7KV. o ground) current : 8/20 usec. ing circuit)		
A B C D E F G	Parameters Test voltage Waveforms Phase angle Polarity Pulse type Mains supply Connections	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= Common mode (high and low to From 3KV to 6KV in steps of 1.5KV Open circuit voltage : 2/50 usec. Short circuit 90 deg and 270 deg (0 deg, 180 deg for zero cross Positive & negative Common mode (high & low to ground) Set should be on, set off, & in standby. Aerial input grounded to surge network ground. (Use)	e.g. memory loss, etc). y consequences. t & cold ground) 7KV. o ground) current : 8/20 usec. ing circuit) e antenna isolator)		
A B C D E F G H	Parameters Test voltage Waveforms Phase angle Polarity Pulse type Mains supply Connections Firing interval	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= Common mode (high and low to From 3KV to 6KV in steps of 1.5KV Open circuit voltage : 2/50 usec. Short circuit 90 deg and 270 deg (0 deg, 180 deg for zero cross Positive & negative Common mode (high & low to ground) Set should be on, set off, & in standby. Aerial input grounded to surge network ground. (Us	e.g. memory loss, etc). y consequences. t & cold ground) 7KV. o ground) current : 8/20 usec. ing circuit) e antenna isolator)		
A B C D E F G H	Parameters Test voltage Waveforms Phase angle Polarity Pulse type Mains supply Connections Firing interval No. of shots	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= Common mode (high and low to From 3KV to 6KV in steps of 1.5KV Open circuit voltage : 2/50 usec. Short circuit 90 deg and 270 deg (0 deg, 180 deg for zero cross Positive & negative Common mode (high & low to ground) Set should be on, set off, & in standby. Aerial input grounded to surge network ground. (Us 1 shots per combination.	e antenna isolator)		
A B C D E F G H	Parameters Test voltage Waveforms Phase angle Polarity Pulse type Mains supply Connections Firing interval No. of shots	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= Common mode (high and low to From 3KV to 6KV in steps of 1.5KV Open circuit voltage : 2/50 usec. Short circuit 90 deg and 270 deg (0 deg, 180 deg for zero cross Positive & negative Common mode (high & low to ground) Set should be on, set off, & in standby. Aerial input grounded to surge network ground. (Us 1 shot per minute. 15 shots per combination. Differential mode (between high	e antenna isolator)		
A B C D E F G H I	Parameters Test voltage Waveforms Phase angle Polarity Pulse type Mains supply Connections Firing interval No. of shots Test voltage	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= Common mode (high and low to From 3KV to 6KV in steps of 1.5KV Open circuit voltage : 2/50 usec. Short circuit 90 deg and 270 deg (0 deg, 180 deg for zero cross Positive & negative Common mode (high & low to ground) Set should be on, set off, & in standby. Aerial input grounded to surge network ground. (Us 1 shot per minute. 15 shots per combination. Diferential mode (between high From 0.5KV to 2KV in steps of 0.5KV 	e.g. memory loss, etc). y consequences. t & cold ground) 7KV. o ground) current : 8/20 usec. ing circuit) e antenna isolator) a & low line)		
A B C D E F G H I I A B	Parameters Test voltage Waveforms Phase angle Polarity Pulse type Mains supply Connections Firing interval No. of shots Test voltage No. of shots	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= 2) No breakdown allowed at <= 3) No breakdown allowed at <= 3) No breakdown allowed at <= 2) No breakdown allowed at <= 3) No breakdown allowed at <= 3) No breakdown allowed at <= 3) No breakdown allowed at <= 4) No breakdown allowed at 4) No breakdown allowed at 4) No	e antenna isolator)		
A B C D E F G H I I A B C	Parameters Test voltage Waveforms Phase angle Polarity Pulse type Mains supply Connections Firing interval No. of shots Test voltage No. of shots Other cond.	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= 2) No breakdown allowed at <= 3) No breakdown allowed at <= 3) No breakdown allowed at <= 3) No breakdown allowed at <= 	e.g. memory loss, etc). y consequences. t & cold ground) 7KV. o ground) current : 8/20 usec. ing circuit) e antenna isolator) 1 & low line)		
A B C D E F G H I I A B C	Parameters Test voltage Waveforms Phase angle Polarity Pulse type Mains supply Connections Firing interval No. of shots Test voltage No. of shots Other cond.	 2) No non-resettable failures (e B) Breakdown test (Overstress) Set should not have any safet (e.g. shock hazard across ho No breakdown allowed at <= 2) No breakdown allowed at <= Common mode (high and low to From 3KV to 6KV in steps of 1.5KV Open circuit voltage : 2/50 usec. Short circuit 90 deg and 270 deg (0 deg, 180 deg for zero cross Positive & negative Common mode (high & low to ground) Set should be on, set off, & in standby. Aerial input grounded to surge network ground. (Us 1 shot per minute. 15 shots per combination. Diferential mode (between higt From 0.5KV to 2KV in steps of 0.5KV 5 shots per combination. As under common mode. 	e.g. memory loss, etc). y consequences. t & cold ground) 7KV. o ground) current : 8/20 usec. ing circuit) e antenna isolator) a & low line)		
A B C D E F G H I I A B C	Parameters Test voltage Waveforms Phase angle Polarity Pulse type Mains supply Connections Firing interval No. of shots Test voltage No. of shots Other cond.	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= Common mode (high and low to From 3KV to 6KV in steps of 1.5KV Open circuit voltage : 2/50 usec. Short circuit 90 deg and 270 deg (0 deg, 180 deg for zero cross Positive & negative Common mode (high & low to ground) Set should be on, set off, & in standby. Aerial input grounded to surge network ground. (Us 1 shot per minute. 15 shots per combination. Diferential mode (between high From 0.5KV to 2KV in steps of 0.5KV 5 shots per combination. As under common mode. Breakdown test From 7KV to 10KV in steps of 1KV 	e.g. memory loss, etc). y consequences. t & cold ground) 7KV. o ground) current : 8/20 usec. ing circuit) e antenna isolator) a & low line)		
A B C D E F G H I A B C A B	Parameters Test voltage Waveforms Phase angle Polarity Pulse type Mains supply Connections Firing interval No. of shots Other cond. Test voltage No. of shots	 2) No non-resettable failures (e B) Breakdown test (Overstress) 1) Set should not have any safet (e.g. shock hazard across ho 2) No breakdown allowed at <= Common mode (high and low to from 3KV to 6KV in steps of 1.5KV Open circuit voltage : 2/50 usec. Short circuit 90 deg and 270 deg (0 deg, 180 deg for zero cross Positive & negative Common mode (high & low to ground) Set should be on, set off, & in standby. Aerial input grounded to surge network ground. (Us 1 shot per minute. 15 shots per combination. Diferential mode (between high From 0.5KV to 2KV in steps of 0.5KV 5 shots per combination. As under common mode. Breakdown test From 7KV to 10KV in steps of 1KV 5 shots per combination. 	e.g. memory loss, etc). y consequences. t & cold ground) 7KV. o ground) current : 8/20 usec. ing circuit) e antenna isolator) a & low line)		

CONCLUSION

The test is positive. Set can be turn on from standby.

AIN SURGE	TESTS: (15X per o	combination,	1X per min	ute)				
Common mod	e :							
Test voltage	Phase angle	Polarity		1	Results			
3 KV	90 deg.	Positive	OK		MC COME 1 DW			
3 KV	270 deg.	Negative	OK					
4.5 KV	90 deg.	Positive	OK		pro de citori			
4.5 KV	270 deg.	Negative	OK					
6 KV	90 deg.	Positive	OK		ADD HALF IN MAL			
6 KV	270 deg.	Negative	OK	100000	IBT HIGGHOF (GLOCK)			
Set with zero-	crossing circuit							
6 KV	0 deg.	Positive			OF 66 3 GO 3			
6 KV	180 deg.	Negative	1.000 M					
Differential mo	Phase and	Polarity	5-5-415 - 4864		Results			
0.5 KV	90 deg	Positive	OK					
0.5 KV	270 deg.	Negative	OK					
10 KV	90 deg.	Positive	OK	P.18, 171.	THE SOMERSON			
1.0 KV	270 deg.	Negative	OK					
1.5 KV	90 deg.	Positive	OK					
1.5 KV	270 deg.	Negative	OK					
20 KV	90 deg.	Positive	OK					
20 KV	270 deg	Negative	OK					
Test voltage	Phase angle	Polarity			Results			
7.0 KV	90 deg.	Positive	+5V regul	ator failure	Alawy war. Y			
7.0 KV	270 deg.	Negative	NA	maches 1	DIRACK DIT O			
8.0 KV	90 deg.	Positive	NA		išui Aseru – S			
8.0 KV	270 deg.	Negative	NA	1000 C	WINCON U.			
9.0 KV	90 deg.	Positive	NA		addinana i i			
9.0 KV	270 deg.	Negative	NA		didne muntur i			
10.0 KV	90 deg.	Positive	NA					
10.0 KV	270 deg.	Negative	NA		ineran general and a second			
Safety require	ement : Vora							
		Bef	ore	After	Specification			
Test perform	ent	OK		OK	<= 300uA			
Test perform Leakage curre	10101	OK	Say and say	OK	no flashover			
Test perform Leakage curre High Tension	at 3 KVrms 1min			OK	no flashover			
Test perform Leakage curre High Tension High Tension	at 3 KVrms 1min at 4.2 KVrms 1min	OK	denotes a series a series de					
Test perform Leakage curre High Tension High Tension	at 3 KVrms 1min at 4.2 KVrms 1min	OK	deno se de este Oformo til Silvi	N CA .				
Test perform Leakage curre High Tension High Tension	at 3 KVrms 1 min at 4.2 KVrms 1 min	OK	denos de ele obtenes til pier	N-64 - 3				

PHILIPS SINGAPORE PRIVATE	SUBJEC			
LIMITED	30	STATIC DISCHAR	1GE 37H20-00	-DE-F.4400
CTV Dev - DE	030000	COLUMN AND AND AND AND AND AND AND AND AND AN	DATE	04/05/94
AND A REAL PROPERTY OF	Dealt wit	h by : ERIC GOH	SHEET :	1/3
			MODEL/VERSION :	29SX8673/6
			Set 1. Dec. 4	
OBJECTIVE :				
To check the suscept	bility of the	set when subject to the e	lectrostatic discharge test.	
ATEST STATE OF ART		(PCB point #) .7		
		,,		
LATEST CIRCUIT DIAGR	AM :	(attached) -		
	(NSG 431 (Positive and I	Vegative)	
EGOIPMENT		Hou to the counter and t	oguno,	
PERFORMANCE FAULT	: ~	UAW-8002 used as ref	erence.ac.ac.ac.ac.ac.ac.ac.ac.ac.ac.ac.ac.ac.	
nor color appende.	· · · ·	10 discharges at 15 KV	(acceptance criteria)	
CONDITION Dried analor9	i di i	Design reserve up to 18	KV	
		10x fast and slow appro	aching speed respectively	
		Relative Humidity < 60	%	
	1.10	Ambient temperatue : 2	5 Deg C +/- 5 Deg C.	
		Test Cync with 20 cm le	ngth wire	
			 O edis; 	
RESULTS	. I	See attached for detail r	result.	
CONCLUSION :				
The test is positive ba	used on the	stamp-print. The set dis	play error codes when subjected	d to
+15KV or -15KV cha	arges. Occ	asionally, the picture will h	ang and the set will not be	
controllable via local	or remote	control, but can be restore	d by on/off. It will also switch on	from
standby.				
Poten nang				
From contrast automation				
The management of the second second second				

- 10	Bellick	1110	STAT		SCH	ARGE		LENGT POL
GRO	UNDING : TELESCOPIC	AERIA	L/A	NTEN	INA G	ROU	NDED	HUMIDITY :
NO.	DESCRIPTION	-4 XV	-8 KV	-15-80	+4.15	+8 KV	+ 15 KV	REMARKS
	FRONT					-		
8 C 14	NODEL/VERSIO							DO 3660 MA 1 188
1	SPEAKER GRILLE	OK	ox	ox	ox	ox	OK	
2	HEADPHONE	ок	ox	ок	ox	ок	ox	સંયુપ્ય મહાત્ર છે.
3	KNOBS / BUTTONS	licik (ок	. ok	oK	ox	OK	a practication of the
4	METALLIC ACCESSIBLE PARTS	ок	ок	oĸ	ок	ок	ок	
	SIDE	-	-	Medic	809			TRA NY STATE (8-472)
	CAMCORDER			(D)=	1433			SIDER THORS TO LATE
1	VIDEO IN (CINCH)	ок	ox	ij x 8	ок	ок	x	Picture hang methods to a
2	AUDIO IN LEFT OR MONO	OK	· ok		OK	oĸ	x	Picture hang
	AUDIO IN RIGHT (CINCH)	ок	ox	x	oĸ	ок	x	Error codes appeared.
3	S-VHSY IN	ox	OK	ora n	ox	ок	x	Picture hang
	S-VHS Y GROUND	OK	OK	(x)	: ok	OK	x	Error codes appeared.
	S-VHS C IN	OK	OK	X	OK	oĸ	x	
	S-VHS C GROUND	ok	oĸ	X	ox	ox	x	
	a own raight	1000	10	0.20%	100	-	-	
	VIDEO 1	-			-	-	+	
	2524	1040	CE D	01242	5.66	-		Disturs hand
4	VIDEO IN (CINCH)	OK	OK	X	ox	ox		Picture hang
5	AUDIO IN LEFT OR MONO	OK	OK	x	oĸ	ox	x	Picture hang
	AUDIO IN RIGHT (CINCH)	ox	oĸ	x	ок	ок	x	Error codes appeared.
6	S-VHS Y IN	ок	OK	x	oĸ	ox	x	Picture hang
auto i	S-VHS Y GROUND	OK	OK	2 0.8-	OK	oK	6 (X)	Error codes appeared.
	S-VHS C IN Section of the section	OK	l lok	1/8	oĸ	OK) x .:	Unknown OSD characters.
10 (5	S-VHS C GROUND	ок	ं०к	() ()	ं ०४	o ok	. X .	r is not see al desiration of
	VIDEO 2			-				
7	VIDEO IN (CINCH)	ок	ок	x	ox	ок	x	Picture hang
-	AUDIO IN LEFT OR MONO	ок	oĸ	x	ox	ox	x	Picture hang
	AUDIO IN RIGHT (CINCH)	OK	CK	x	ок	ок	x	Error codes appeared.
5	9 S-VHSYIN	ок	ok	x	ok	ox	x	Picture hang
	S-VHS Y GROUND	OK	OK	x	ok	OK	x	Error codes appeared.
	S-VHS C IN	OK	ox	x	ок	OK	x	
	S-VHS C GROUND	OK	OK	x	OK	OK	x	

G : TELESCOPIC PTION R OUT UT (CINCH) UT LEFT OR MONO UT RIGHT (CINCH) Y OUT Y GROUND COUT	-4XV -4XV 0K 0K 0K	-8 KV -8 KV OK OK	- 15 XV	NA G +4 KV OK	+8 KV	• 15 KV	D HUMIDITY : REMARKS
PTION R OUT UT (CINCH) UT LEFT OR MONO UT RIGHT (CINCH) Y OUT Y OUT Y GROUND COUT	-4 KV 0K 0K 0K	-8KV OK OK	- 15 KV	+4.KV OK	+8KV	+ 15 KV	REMARKS
R OUT UT (CINCH) UT LEFT OR MONO UT RIGHT (CINCH) Y OUT Y GROUND	0K 0K 0K	0X 0X	x	ox	ox		
UT (CINCH) UT LEFT OR MONO UT RIGHT (CINCH) YOUT GROUND	OK OK OK	ox ox	x	ок	ox		
UT LEFT OR MONO UT RIGHT (CINCH) Y OUT Y GROUND COUT	OK OK	ox ox				x	Picture hang
Y OUT Y GROUND	OK	ox	x	ок	ox	x	Picture hang
GROUND	oĸ		x	ок	ок	x	Error codes appeared.
GROUND	OK					-	Distance have
GROUND		OK	x	oĸ	oĸ	x	Picture hang
COUT	OK	OK	x	OK	ox	x	Error codes appeared.
0.00011110	OK	OK	x	ok	ox	×	Chichown CSD characters.
GROUND	OK	OK	×	ox	OK		
ND LEFT SOCKET	ок	OK	x	oĸ	OK	x	Picture hang
ND RIGHT SOCKET	oĸ	ox	x	ox	ок	x	Error codes appeared.
	_	-		-			
		-	+		-	-	
ANTENNA	ок	ок	ox	ox	oĸ	ок	
					-		
	_	-			-		
		-				-	
	_	-		-	+		
	_	+			-	-	
				-	+	+	
		+			-	-	
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		+					-
		-		1	-	-	
	F ANTENNA	IND RIGHT SOCKET OK	IND RIGHT SOCKET OK OK FANTENNA OK OK FANTENNA OK OK I I I I	IND RIGHT SOCKET OK OK X I I I I FANTENNA OK OK OK I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I	IND RIGHT SOCKET OK OK X OK I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I I	IND RIGHT SOCKET OK OK X OK OK	IND RIGHT SOCKET OK OK X OK X OK X I