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COMPARATIVE ANALYSIS AND PERFORMANCE FEATURES OF PLASMA, LCD AND CRT SCREENS: OPERATING FEATURES, MERIT AND RECOMMENDATIONS

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ABSTRACT

The quest for a better television (TV) and monitor displays for home theaters, business and academic programs gives rise to the progresses in video display technologies. The flat screen TV technologies have taken over the consumer market against the old bulky CRT TV technology displays. Again, researches have shown that Plasma based televisions, are better in their display features than, the liquid crystal display (LCD) based televisions. However, there are some complications associated with Plasma TVs especially in distribution, which made LCD TVs most common in the consumer market.

Keywords: CRT, LCD, PLASMA, TV Technology, Life-Span, Contrast Ratio

INTRODUCTION

There are several primary types of technologies used for monitors and televisions, including CRT and LCD in addition to plasma and projection displays [8].Instead of relying on traditional cathode ray tube technology, which is the driving force behind standard, bulky TV sets, plasma and LCD flat panel TVs rely on more advanced video display technology such as 3-Dimensional (3D) and High Definition (HD) TVs. And while plasmas and LCDs have some similarities, they differ in terms of function and performance. Plasma and liquid crystal display televisions are both flat-panel televisions that users commonly mount to walls or rest on mantels [2]. The unique reaction that creates a plasma display has several benefits over other display formats, such as CRT and LCD monitors, but it has several limitations as well [11].

As high-definition (HD) technology progresses, consumers are given more and more options for their home theater and computing needs. Cathode ray tubes (CRT) technology is giving way to flat screen TV displays [3, 10], which in turn, gives rise to the following questions: What is the difference between these technologies? Are LCD TVs more efficient? Why is LCD most common in the consumer market? [3] In attempt to answer these questions in consonance with the following parameters; technology, aesthetic nature, portability and consumer market, it was discovered that, Plasma based- and LCD based- TVs, respectively, have made tremendous impact than others. Major electronics stores have all but phased out the old CRT televisions, relegating them to the unseen corners [6].

Meanwhile, hordes of consumers are forced to make choices between two new technologies that they know little of. The objective of this research is to make comparative analyses of the three TV technologies that will provide the needed details to guide the consumers' interest. The life-span of the three TV technologies will be compared, following the series of improvements recorded by the vendors.

OVERVIEW

Television (TV) is a widely used telecommunication medium for transmitting and receiving moving

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images, either monochromatic ("black and white") or color, usually accompanied by sound. "Television" may also refer specifically to a television set, television programming or television transmission. Commercially available since the late 1930s, the television set has become a common communications receiver in homes, businesses and institutions, particularly as a source of entertainment, tutorials and news. Since the 1970s the availability of video cassettes, laserdiscs, DVDs and now Blue-ray Discs, have resulted in the television set frequently being used for viewing recorded as well as broadcast material.

A standard television set comprises multiple internal electronic circuits, including those for receiving and decoding broadcast signals. A television system may use different technical standards such as digital television (DTV) and high-definition television (HDTV). The different television technologies behind the CRT and the flat screen (LCD and Plasma) TVs continued to form a subject of comparison that consumers seem not to ignore especially when making a purchase.

CRT Technology

A cathode ray tube is a vacuum tube which consists of one or more electron guns, possibly internal electrostatic deflection plates, and a phosphor target [13]. In television sets and computer monitors, the entire front area of the tube is scanned repetitively and systematically in a fixed pattern called a raster. An image is produced by controlling the intensity of each of the three electron beams, one for each additive primary color (red, green, and blue) with a video signal as a reference [14]. In all modern CRT monitors and televisions, the beams are bent by magnetic deflection, a varying magnetic field generated by coils and driven by electronic circuits around the neck of the tube, although electrostatic deflection is commonly used in oscilloscopes, a type of diagnostic instrument [14].

Figure 1: CRT TV 549 × 517 [1].

LCD TV Technology

A **liquid crystal display** (**LCD**) is a flat panel display, electronic visual display, video display that uses the light modulating properties of liquid crystals (LCs). LCs do not emit light directly. They are used in a wide range of applications, including computer monitors, television, instrument panels, aircraft cockpit displays, signage, etc. They are common in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones. LCDs have displaced cathode ray tube (CRT) displays in most applications. They are usually more compact, lightweight, portable, less expensive, more reliable, and easier on the eyes. They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they cannot suffer image burn-in. LCDs are more energy efficient and offer safer disposal than CRTs. Its low electrical power consumption enables it to be used in battery-powered electronic equipment. It is an electronically modulated optical device made up of any number of segments filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in colour or monochrome. The most flexible ones use an array of small pixels. The earliest discovery leading to the development of LCD technology, the discovery of liquid crystals, dates from 1888 [16]. By 2008, worldwide sales of televisions with LCD screens had surpassed the sale of CRT units.

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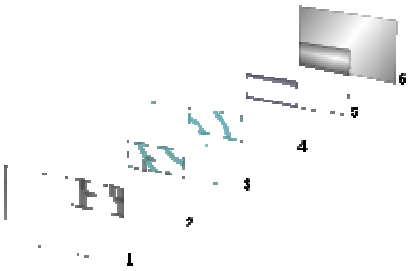

Figure 2: Reflective twisted nematic liquid crystal display [17].

1. Polarizing filter film with a vertical axis to polarize light as it enters.
2. Glass substrate with ITO electrodes. The shapes of these electrodes will determine the shapes that will appear when the LCD is turned ON. Vertical ridges etched on the surface are smooth.
3. Twisted nematic liquid crystal.
4. Glass substrate with common electrode film (ITO) with horizontal ridges to line up with the horizontal filter.
5. Polarizing filter film with a horizontal axis to block/pass light.
6. Reflective surface to send light back to viewer. (In a backlit LCD, this layer is replaced with a light source).

LCD TVs use a different technology compare to CRT and Plasma TV technologies. Basically, LCD panels are made of two layers of transparent material, which are polarized, and are "glued" together. One of the layers is coated with a special polymer that holds the individual liquid crystals. Current is then passed through individual crystals, which allow the crystals to pass or block light to create images. LCD crystals do not produce their own light, so an external light source, such as florescent bulb is needed for the image created by the LCD to become visible to the viewer. Unlike standard CRT and Plasma televisions, since there are no phosphors that light up, less power is needed for operation and the light source in an LCD TV generates less heat than a Plasma or traditional television. Also, because of the nature of LCD technology, there is no radiation emitted from the screen itself [7].

Figure 3: LCD TV 400 × 364 [1]

PLASMA TV Technology

Plasma television technology is based loosely on the fluorescent light bulb. The display itself consists of cells. Within each cell two glass panels are separated by a narrow gap in which neon-xenon gas is injected and sealed in plasma form during the manufacturing process. The gas is electrically charged

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at specific intervals when the Plasma set is in use. The charged gas then strikes red, green, and blue phosphors, thus creating a television image. Each group of red, green, and blue phosphors is called a pixel (picture element) [7].

Although Plasma television technology eliminate the need for the bulky picture tube and electron beam scanning of traditional televisions, because it still employs the burning of phosphors to generate an image, Plasma televisions still suffer from some of the drawbacks of traditional televisions, such as heat generation and screen-burn of static images [7].

Figure 4: A Plasma TV [9].

Underlying Flat Screen Technology

The technologies that underlie plasma and LCD TVs both rely on containing substances between plates of glass and stimulating those substances with electrical current. However, while plasma TVs stimulate ionized noble gasses, LCD TVs stimulate liquid crystals, which are substances that flow like liquids but polarize light like translucent crystalline minerals [2]. When plasma TV devices stimulate gases, the gas molecules emit adequate light for illuminating TV screens. In contrast, LCD TVs rely on separate sources of lighting, known as back-lighting, which provides stimulated liquid crystals with added brightness. While older LCD TVs rely on fluorescent lighting, newer models utilize light-emitting diodes [2].

Principal Features Associated with CRT- TV Displays

Oscilloscope CRTs: In oscilloscope CRTs, electrostatic deflection is used, rather than the magnetic deflection commonly used with television and other large CRTs. The beam is deflected horizontally by applying an electric field between a pair of plates to its left and right, and vertically by applying an electric field to plates above and below. Oscilloscopes use electrostatic rather than magnetic deflection because the inductive reactance of the magnetic coils would limit the frequency response of the instrument [18].

Phosphor persistence: Various phosphors are available depending upon the needs of the measurement or display application. The brightness, color, and persistence of the illumination depend upon the type of phosphor used on the CRT screen. Phosphors are available with persistence ranging from less than one microsecond to several seconds [19]. For visual observation of brief transient events, a long persistence phosphor may be desirable. For events which are fast and repetitive, or high frequency, a short-persistence phosphor is generally preferable [20].

Micro-channel plate: When displaying fast one-shot events the electron beam must deflect very quickly, with few electrons impinging on the screen; leading to a faint or invisible display. Oscilloscope CRTs designed for very fast signals can give a brighter display by passing the electron beam through a micro-channel plate just before it reaches the screen. Through the phenomenon of secondary emission this plate multiplies the number of electrons reaching the phosphor screen, giving a significant improvement in writing rate (brightness), and improved sensitivity and spot size as well [21, 22].

***Graticules*:** Most oscilloscopes have a graticule as part of the visual display, to facilitate measurements. The graticule may be permanently marked inside the face of the CRT, or it may be a transparent external plate. External graticules are typically made of glass or acrylic plastic. An

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internal graticule provides an advantage in that it eliminates parallax error. Unlike an external graticule, an internal graticule can not be changed to accommodate different types of measurements [23]. Oscilloscopes commonly provide a means for the graticule to be side-illuminated, which improves its visibility when used in a darkened room or when shaded by a camera hood [24].

Color CRTs: This can beSpectra of constituent blue, green and red phosphors in a common CRT. Color tubes use three different phosphors which emit red, green, and blue light respectively. They are packed together in stripes (as in aperture grille designs) or clusters called "triads" (as in shadow mask CRTs). Color CRTs have three electron guns, one for each primary color, arranged either in a straight line or in a triangular configuration (the guns are usually constructed as a single unit). A grille or mask absorbs the electrons that would otherwise hit the wrong phosphor. A shadow mask tube uses a metal plate with tiny holes, placed so that the electron beam only illuminates the correct phosphors on the face of the tube. Another type of color CRT uses an aperture grille to achieve the same result.

Convergence in color CRTs: The three beams in color CRTs would not strike the screen at the same point without convergence calibration. Instead, the set would need to be manually adjusted to converge the three color beams together to maintain color accuracy.

Degaussing: Most CRT television sets and computer monitors have a built-in degaussing (demagnetizing) coil, upon power-up creates a brief, alternating magnetic field which decays in strength over the course of a few seconds. This degaussing field is strong enough to remove most cases of shadow mask magnetization.

Vector monitors: Vector monitors were used in early computer aided design systems and in some late-1970s to mid-1980s arcade games such as Asteroids. They draw graphics point-to-point, rather than scanning a raster.

***CRT resolution*:** Dot pitch defines the maximum resolution of the display, assuming delta-gun CRTs. In these, as the scanned resolution approaches the dot pitch resolution, moire appears, as the detail being displayed is finer than what the shadow mask can render. Aperture grille monitors do not suffer from vertical moire, however, because their phosphor stripes have no vertical detail. In smaller CRTs, these strips maintain position by themselves, but larger aperture grille CRTs require one or two crosswise (horizontal) support strips [26].

Principal Features Associated with LCD- TV Displays

***Resolution*:** The horizontal and vertical screen size expressed in pixels (e.g., 1024x768). Unlike CRT monitors, LCD monitors have a native-supported resolution for best display effect [25].

Dot pitch: The distance between the centers of two adjacent pixels. The smaller the dots pitch size, the fewer granularities are present, resulting in a sharper image. Dot pitch may be the same both vertically and horizontally, or different (less common).

Viewable size is the size of an LCD panel measured on the diagonal (more specifically known as active display area).

***Response time**:* This is the minimum time necessary to change a pixel's color or brightness. Response time is also divided into rise and fall time. For LCD monitors, this is measured in BTB (black to black) or GTG (gray to gray). These different types of measurements make comparison difficult.

Input lag - a delay between the moment monitor receives the image over display link and the moment the image is displayed. Input lag is caused by internal digital processing such as image scaling, noise reduction and details enhancement, as well as advanced techniques like frame interpolation. Input lag can measure as high as 3-4 frames (in excess of 67 ms for a 60p/60i signal). Some monitors and TV sets feature a special "gaming mode" which disables most internal processing and sets the display to its native resolution.

Refresh rate: The number of times per second in which the TV draws the data that it is being given. Since activated LCD pixels do not flash on/off between frames, LCD TVs exhibit no refresh-induced flicker, no matter how low the refresh rate. High-end LCD televisions now feature up to 240 Hz refresh rate, which allows advanced digital processing to insert additional interpolated frames to

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smooth up motion, especially with lower-frame rate material like the Blue-ray disc. However, such high refresh rates may not be supported by pixel response times, and additional processing can introduce considerable input lag.

Viewing angle: LCD TVs have a viewing angle of up to 165°. The corresponding angle is 175° in case of LCD.

Color support*:* This can be defined as the types of colors supported by the technology.

Brightness: The amount of light emitted from the display or, more specifically known as luminance.

Contrast ratio: The ratio of the intensity of the brightest bright to the darkest dark.

Aspect ratio: The ratio of the width to the height (for example, 4:3, 5:4, 16:9 or 16:10) [25].

Principal Features Associated With Plasma- TV Displays

Native plasma television resolutions: Fixed-pixel displays such as plasma TVs scale the video image of each incoming signal to the native resolution of the display panel. The most common native resolutions for plasma display panels are 853x480 (EDTV), 1,366x768 or 1,920x 1,080 (HDTV). As a result picture quality varies depending on the performance of the video scaling processor and the up scaling and downscaling algorithms used by each display manufacturer.

Enhanced-definition plasma television*:* Early plasma televisions were enhanced definition (ED) with a native resolution of 840x480 (discontinued) or 853x480, and down-scaled their incoming high definition signals to match their native display resolution [12].

ED Resolutions [12]:

- 840x480
- 853x480

High-definition plasma television*:* Early high-definition (HD) plasma displays had a resolution of 1024x1024 and were alternate lighting of surfaces (ALIS) panels made by Fujitsu/Hitachi. These were interlaced displays, with non-square pixels. Modern HDTV plasma televisions usually have a resolution of 1,024x768 found on many 42 inch plasma screens, 1,280x768, 1,366x768 found on 50 in, 60 in, and 65 in plasma screens or 1,920 x 1,080 found in plasma screen sizes from 42 in to 103 in. These displays are usually progressive displays, with square pixels, and will up-scale their incoming standard-definition signals to match their native display resolution [12].

HD Resolutions [12]:

- 1024x1024
- 1024x768
- 1280x768
- 1366x768
- 1280x1080
- 1920x1080

Contrast ratio: Contrast ratio is the difference between the brightest and darkest parts of an image, measured in discrete steps, at any given moment. Generally, the higher the contrast ratio, the more realistic the image is (though the "realism" of an image depends on many factors including color accuracy, luminance linearity, and spatial linearity.) Contrast ratios for plasma displays are often advertised as high as 5,000,000:1. On the surface, this is a significant advantage of plasma over most other current display technologies, a notable exception being OLEO. Although there are no industry-wide guidelines for reporting contrast ratio, most manufacturers follow either the ANSI standard or perform a full-on-full-off test.

Screen burn-in: Plasma display suffered severe burn-in from stationary text with phosphor-based

electronic displays (including cathode ray and plasma displays), the prolonged display of a menu bar or other static (fixed in place and unchanging) graphical elements over time can create a permanent ghost-like image of these objects since phosphor compounds which emit the light lose their luminosity with use. As a result, when certain areas of the display are used more frequently than others, over time the lower luminosity areas become visible to the naked eye and the result is called burn-in. While a ghost image is the most noticeable effect, a more common result is that the image quality will continuously and gradually decline as luminosity variations develop over time, resulting Thin a "muddy" looking picture image. Most plasma display producers state a 100,000 hours time before brightness halves, theoretically allowing for over ten years of normal viewing before the display dims significantly.

Comparing CRT, LCD and Plasma TV Technologies

The advantages and disadvantages of the three TV technologies, CRT, LCD and Plasma TVs are compared as shown in table 1.

Table 1: Comparing CRT, LCD and Plasma TV Technologies [6].

Comparison	CRT TV	LCD TV	PLASMA TV
Screen Size (measured on the diagonal).	CRT TVs are limited to about a 40-inch screen size [4].	Average screen sizes range from 13 inches to 65 inches As with plasma, there are larger LCD TVs made, like a 108 inch display released 2008 by Sharp, but they are not cheaply affordable at the consumer level.	Average screen sizes range from 32 inches to 63 inches. Larger plasmas, like a 103 inch unit and 150-inch plasma display from Panasonic were announced 2010, but are prohibitively expensive for consumer use.
Viewing Angle	They can be viewed from any angle in any light [4].	LCD TV can be viewed from up to 176 degrees; there is always a "sweet spot" which will produce brighter, higher contrast images	Up to 178°. Plasma images do not suffer from the same degradation at higher viewing angles like LCD TVs.
Screen Refresh Rates / Pixel response time	CRT TVs have better refresh rates with Plasma TVs than LCD TVs.	LCD TVs were originally designed for static data display, and not moving video. LCD TVs are now available with refresh rates specified by manufacturers as low as 5ms.	Plasma displays refresh and handle rapid movements in video about as well as CRT televisions, which is about the standard most viewers expect.
Burn-in or Stuck Pixels	CRT TVs suffer from burn-in.	LCD TVs do not suffer from burn-in, but can have a "retained pixel charge" which may also produce ghosting. Stuck pixels are also possible with an LCD display	Plasma TVs can suffer from burn-in produced by static images. With technologies such as 'pixel orbitor,' new plasma TVs have addressed burn-in.
Product Life-span	CRT TVs have longer life span than LCD and Plasma, lasting over 80,000 hours.	LCD TVs have a backlight that is specified to last between 30,000 and 60,000 hours. LCD TVs also have replaceable backlights, but the expense of replacing one may	Plasma TVs have a reported half life of 30,000 to 60,000 hours. Half-life is the time it takes the lamp to fade to half its original brightness. Panasonic recently reported

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		be greater than simply replacing the entire TV.	life span's approaching 100,000 hours.
Weight	They weigh more than LCD and Plasma TVs.	LCD TVs weigh less than comparably sized plasma TVs.	Plasma displays are fairly heavy, and may need additional supports to be mounted onto a wall.
Durability	CRT TVs are more durable than LCD and Plasma TVs.	Somewhat more durable than older plasmas. End users can easily mount an LCD TV themselves if desired, although LCD TVs should still be shipped with special care, and the screen itself should be cleaned with a streak free cleaner	Plasmas are somewhat fragile making them tricky to ship and install. Unlike the commercials where plasmas are mounted on the ceiling, plasmas are best installed by a professional. However, recent improvements to plasma screens have made them significantly more durable and lighter weight.
Shipping	Shipping is neither difficult nor expensive.	Shipping LCD TVs is not difficult, and is not as expensive as shipping plasma displays.	Due to their fragile nature, plasma TVs need to be shipped by specialty carriers. Overnight or fast delivery options are not recommended. Special shipping methods and their heavier weight add to higher shipping costs
Installation	Installation is straight forward and no professional is required.	End users can easily install LCD TVs themselves, or can use them just as they use a traditional TV using a stand.	Plasmas are heavier, use more power, and run hotter than LCD TVs, and therefore require more planning when mounting them. Plasmas are generally best installed by professionals.
Brightness / Contrast	CRT TVs tend to have good contrast ratios than most of the flat screen TVs [5].	LCD TVs can often look better in 'real-world' situations. Plasmas are made with a special glass surface that can reflect light, which dulls the brightness and contrast of the image. LCD TVs reflect very little light, allowing them to maintain levels in well-lit rooms.	Plasma TVs report higher brightness and contrast levels than LCDs. Under ideal conditions (no ambient light) this is a true advantage of plasma technology, because LCD TVs are backlit and therefore light must be blocked to create blacks. Plasmas have individual pixels that either on or off, creating deeper blacks and better contrast.
Thickness	CRT TVs are more bulky and are thicker than the flat screen.	As thin as 2 inches deep.	As thin as 3 inches deep.

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Performance at High Altitude	Performance can be affected by high altitudes.	LCD TVs are not affected by high altitudes.	High altitudes can affect the performance of plasma displays because gas held inside each pixel will be stressed, and has to work harder to perform. Some plasma are specifically designed for high-altitudes, but are priced higher than standard models.

RESULTS AND RESEARCH FINDINGS

The findings are based on Quarterly Advanced Global TV Shipment and Forecast Report [15]; total TV shipments grew by nearly 18% Y/Y in 2010 to 248 million units. However, shipment growth is expected to slow to less than 4% Y/Y in 2011, as slower price erosion cools demand in developed markets. The total TV market is increasingly defined by the replacement of CRT TVs with flat panel TVs, especially in emerging markets, as growth begins to slow for many developed countries that have strongly adopted flat panel TVs already. Flat panel TVs grew 32% in 2010 on a unit basis, but that growth will slow to 12% in 2011.

LCD TVs continue to be the primary TV type shipped worldwide, and are expected to account for about 84% of all TV shipments in 2011. As CRT TVs become scarce, LCD TVs will become the de facto choice for consumers looking to upgrade their CRT TVs. Worldwide LCD TV shipments will increase from about 192 million units in 2010 to almost 217 million units in 2011, a 13% increase. Total LCD TV shipments are expected to increase steadily, reaching 270 million units by 2014.

Within the LCD TV category, several key features are gaining share as cost premiums decline. LED backlights will account for about 50% of the total LCD TV units shipped during 2011, penetrating a large number of screen sizes, especially above 40". Larger screen size sets are usually fully featured and focused on performance. As a result, performance-oriented features like high frame rate and 1080p resolution have much better penetration among larger screen sizes. 120Hz and higher refresh rates will account for about a quarter of total LCD TV units in 2011, but for 40"+ sizes, the share is more than 60%.

Plasma TV experienced a huge turnaround in 2010, with Y/Y shipment growth of 30%, up from -1.5% in 2009. Much of the growth was the result of cost-conscious consumers looking for value, as well as relatively slow ASP erosion in competitive LCD products. LCD TV ASPs were down 10% in 2010, while plasma TV ASPs fell 15%.

Emerging regions, which include China, Asia Pacific, Latin America, Eastern Europe, Middle East, and Africa, will have the strongest flat panel TV growth over the next four years, averaging 17% growth each year. The Asia Pacific region is positioned for strongest growth as the late adopting India market begins to boom. By comparison, developed regions (North America, Japan, and Western Europe) will see no growth over the same time period.

COMMENTS

From the analysis of figure 4, the Cathode Ray Tube based- TVs continued to record the highest life span of the three TVs compared within the first three classes, class A, B, and C of 80,000 hours until recently, when Plasma TVs recorded the highest life span of the other two TVs in the last class, (class D), which is 100,000 hours. However, LCD TVs continued with the same life span behaviour with the Plasma TVs, but showed to be the least in the last classification of the three TVs as recorded in the result.

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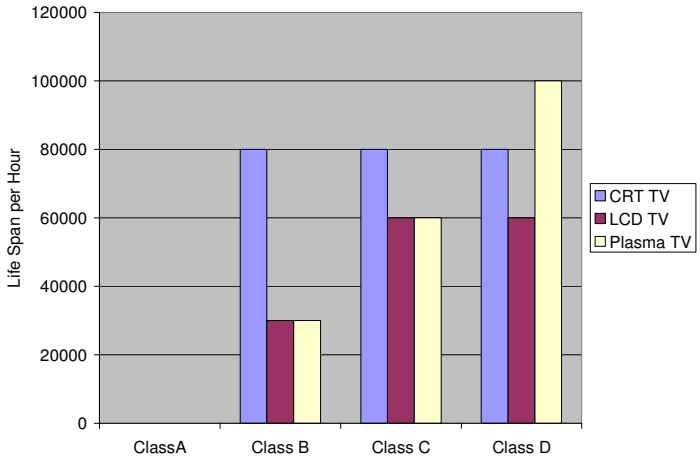

Figure 5: The Life Span for four classes of three TVs

CONCLUSION

Television (TV) Technologies, in general, made significant progresses along side other digital display technologies including computer monitors. The CRT TVs are known for the oldest TV technology and were designed with numerous advantages over most of the new TV technologies. However, the high-definition progresses made in the design of the flat screen TVs (LCD and Plasma TVs), addressed most of the CRT technology flaws, compelling it to give way for the new technology TVs.

Moreover, the Plasma TVs were designed to make use of the advantages of CRT technology which gave it an edge over the LCD TVs that were designed with a different technology entirely. On the other hand, due to the fragile nature and cost of shipping of Plasma TVs in most developing economies LCD TVs are most commonly marketed and distributed to the consumers.

The television device vendors are expected to fully penetrate the consumer markets in the developing economies so that consumers can make proper choice of the type of the TV device they need. TV producers should resolve the problem of fragility and shipment of the flat screen TVs especially the Plasma TVs so that the consumer can satisfy their wants at a cheap and considerable rate.

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