

## A Practical Home Theater

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Recently a friend asked for advice on setting up a home theater. I have been critically observing home theater demonstrations at trade shows and assumed an installation would be not be complicated. This is far from the case and is a challenge to the consumer electronics industry.

Lots of claims have been made about the benefits of digital television (DTV) and high definition television (HDTV). Foremost are screen size and lines of horizontal resolution. Consumers are promised a greatly improved home theater experience. The reality is that DTV and HDTV are not always delivering the wow factor. In part this is caused by system complexity and compatibility problems between equipment and source material.

Many home theater problems stem from the traditional method of selling consumer electronics as self-contained boxed items. A home theater is composed of many devices including a display, speakers, DVD player, cable or satellite decoder, antenna, remote control unit, and cables. All these devices must be chosen to complement one another and must be connected properly, calibrated, and supplied with audio and video content. The content may be delivered via broadcast TV, satellite, cable, DVD (standard definition or HD), video cassette, or streamed from the Internet (IPTV – a technology under development).

### *Home theater components*

The intent of a home theater is to create a space with attributes of a commercial movie theater. This requires a comfortable viewing environment with suitable seating and lighting. Until 1952, a movie theater and TV presented an experience that shared similar features: an image with a 4:3 (width-to-height) shape and monaural sound. With the introduction and overwhelming success of Cinerama in 1952, Hollywood discovered that multi-channel sound and a wide screen could draw customers away from the TV and back into the theater.



The key components for a home theater are:

- A large rectangular room
- Multiple audio speakers
- A large display

A rectangular room offers better acoustics than other shapes. About 10 by 15 feet is a good size for a large display at the long end of the room. The display choices are:

- LCD
- Plasma
- Rear projection
- Front projection

The CRT (picture tube) actually can reproduce motion and colors more accurately than LCD or plasma displays. However, a CRT is not a practical choice for a home theater because the largest commercially available picture-tube TV measures about 40 inches diagonally. Plasmas offer a bright picture with excellent motion rendition. However, they operate at a higher temperature with a shorter life and consume about 30% more energy than an LCD.

A rear projection TV takes a small image, magnifies it, and bounces it via a mirror onto the back of a large display surface. The image quality when looking directly at the screen is good. The brightness falls off when the screen is viewed from the side of the room. Rear projection TVs cost considerably less than the other display technologies.

The front projector is used primarily in offices and conference rooms for slide presentations. Until recently, these projectors were designed with computer interfaces using a multi-pin VGA connector. Also, they have been optimized to display bright images composed mostly of primary colors. Projectors intended for home theater are adjusted for full-spectrum color and have inputs typically found on a TV. I prefer a projector with a zoom lens that can be adjusted to fill a large screen. A 10 by 15-foot room could accommodate an eight or nine-foot wide screen.

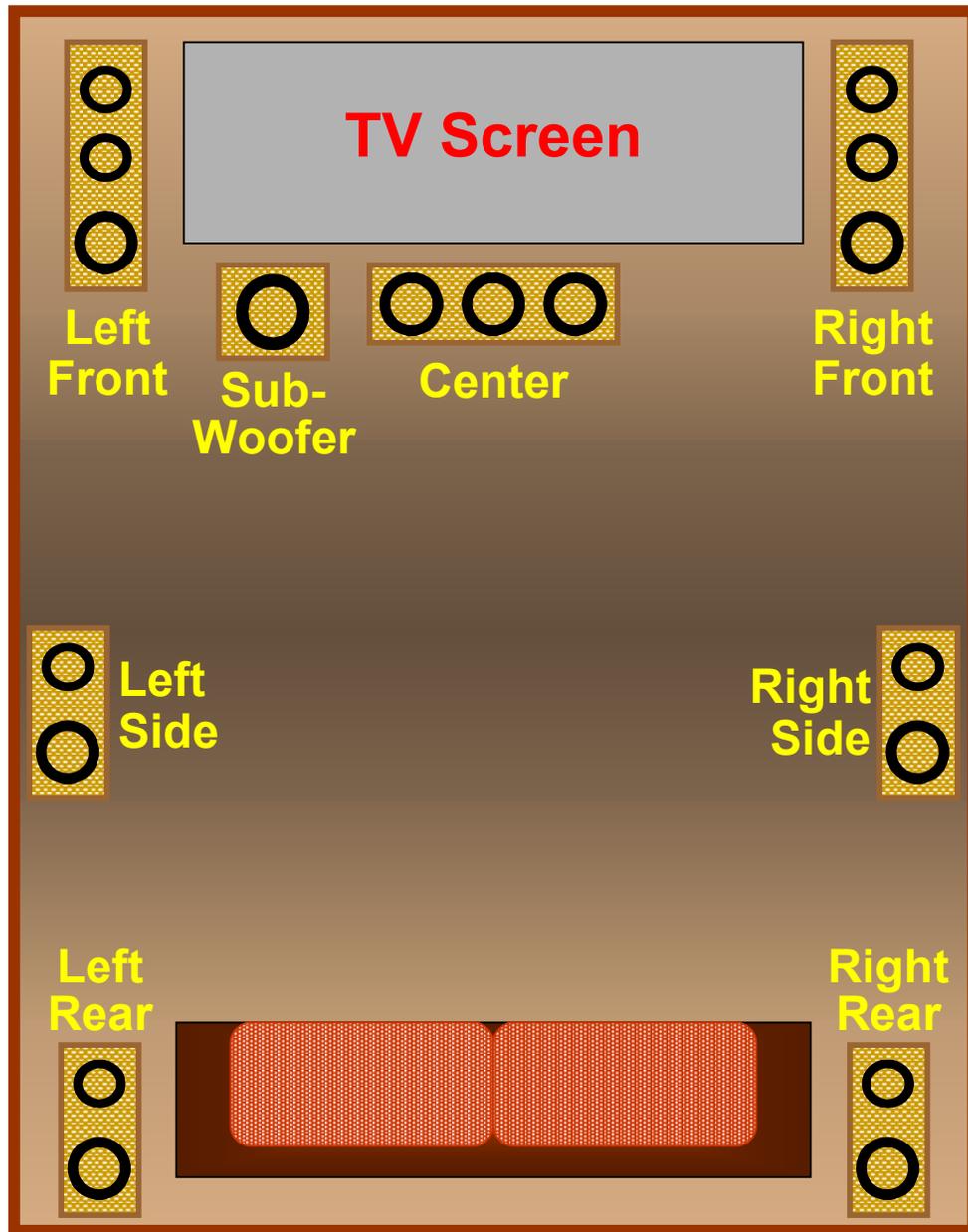
The resolutions of displays are measured by the number of horizontal lines. The three common options for DTV are:

- 480: standard definition TV (SDTV)
- 720: high definition TV (HDTV)
- 1080: high definition TV (HDTV)

A 720-line or 1080-line HDTV can accept signals with any of these three resolutions and convert them to the capability of the display.

### *Home theater audio*

The choices of audio systems for a home theater are primarily stereo and surround sound. Surround sound, as illustrated in Figure 1, may include rear speakers and even speakers on the sides of the room. These additional speakers add realism to action movies such as aircraft flying around in a dogfight.



**Figure 1 – Surround-sound Speaker Placement**

The speakers built into TV sets are usually not the best quality. They are chosen to fit a confined space inside the TV cabinet. The most important external speakers that make a home theater sound less like a TV set and more like a theater are the front left, front right, and subwoofer. The subwoofer reinforces very low tones such as a door slam, banging on the floor, the very low notes from an organ, or an orchestra kettledrum (timpani). Since low notes do not convey spatial location well, the subwoofer may be placed anywhere in the front of the room. However, an additional speaker placed below the center of the screen carries the actors' voices for enhanced spatial location.

The audio from HD sources includes multiple channels that are combined with a technique developed by Dolby Laboratories. An audio amplifier with built-in Dolby® Digital technology extracts the audio from the content and decodes the various sound tracks. Dolby Digital supports the speaker configurations listed in Table 1. The arrangement of speakers illustrated in Figure 1 is called “7.1 sound” because there are seven speakers and one subwoofer.

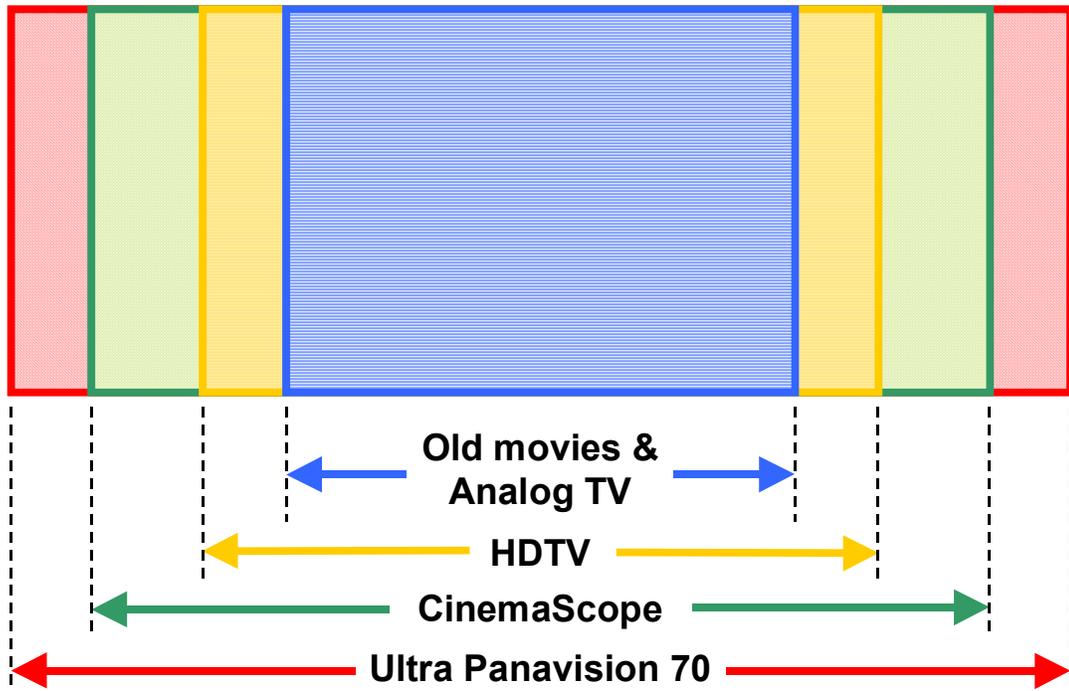
Sound System Name	Speakers				
	Left & Right Front	Sub-Woofer	Center	Left & Right Rear	Left & Right Side
<b>Stereo Sound</b>	✓				
<b>2.1 Sound</b>	✓	✓			
<b>5.1 Sound</b>	✓	✓	✓	✓	
<b>7.1 Sound</b>	✓	✓	✓	✓	✓

**Table 1** – Sound Systems and Speaker Configurations

*Matching the screen to the show or movie*

The shape of the screen is an important ingredient in achieving a great viewing experience. TVs are sold in 4:3 (1.33:1) and 16:9 (1.78:1) aspect ratios (width-to-height). Within a few years, all new TV programs will be presented in the wider aspect ratio. This is the reason for the narrow horizontal bars seen at the top and bottom of conventional TVs when viewing many of the network shows that are already produced in the 16:9 format.

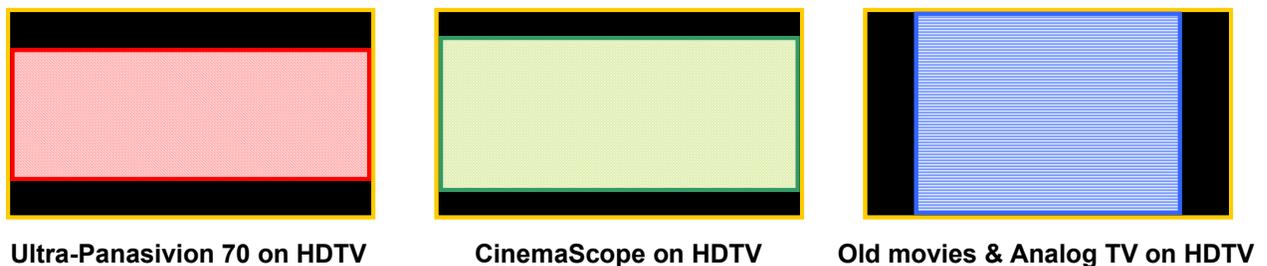
After wide-screen movies were introduced in 1952, many studios and production companies invented proprietary wide-screen formats. Some of these formats have familiar names like Cinemascope, Panavision, and Vista Vision. The screen shapes vary from 1.85:1 to 2.76:1 with the most popular being 1.85:1 and 2.35:1. Movie theaters accommodated these aspect ratios by projecting all movies on a screen with the same height and varying the width according to the movie aspect ratio. The various screen widths are compared in Figure 2.



**Figure 2 – Wide-screen, Fixed-height display**

In older theaters, curtains on the far left and right covered unused portions of the screen. For dramatic effect, theaters in the 1950s and 1960s would show a newsreel in 4:3 and then open the curtains wider (almost doubling the width) as the feature film began, usually with a trumpet fanfare.

The 16:9 format for the HDTV display was selected as a compromise to accommodate limitations in fabricating wide CRTs. Wide-screen movies on an HDTV are displayed to fill the width of the screen with black bars on the top and bottom, as shown in Figure 3. Conventional TV (analog 4:3 TV) and old movies need bars on the sides. Some TVs electronically stretch images to fill the screen. However, this distorts the actors and objects so they look bloated.



**Figure 3 – Wasted Display Areas (black bars)**

The imaging circuits in most HDTV projectors display the picture with 720 horizontal lines. (1080-line projectors are available for about double the price.) A wide-screen movie matted with horizontal black bars on the top and bottom for an HDTV display is wasting up to one third of

the available scan lines and picture brightness as illustrated in Figure 3. The resulting images are displayed with resolutions that are comparable to standard-definition TV!

To re-create the optimal theater experience at home requires a screen with the widest aspect ratio of any movie to be viewed. Some projector manufacturers have developed high-end products designed for 2.35:1 screens to maximize resolution for wide-screen movies. Bars appear on the left and right when viewing 1:85:1 movies, 16:9 HDTV, or 4:3 old movies and analog TV programs.

### *Home theater on a budget*

I find that a wide-format standard-definition DVD movie on a large screen with two-channel stereo sound and a subwoofer (a “2.1 sound system”) provides a good viewing experience. Therefore, consumers with a limited budget might choose an SDTV front projector and 2.1 sound to create a home theater that can be quite impressive even at standard definition resolution. With more funds, the customer can upgrade to an HDTV projector and additional speakers for surround sound.

Home theater prices have been falling while quality is improving. Good equipment is available even at warehouse stores. However, consumers can make mistakes when choosing compatible equipment and connectors. Retailers should educate the sales staff on recommending systems, not just individual boxes. This will benefit consumers and generate increased sales of profitable peripheral equipment.

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*Dr. Kenneth Wacks has been a pioneer in establishing the home systems industry and a management advisor to more than 100 companies and utilities worldwide. Corporate managers depend on Dr. Wacks to identify business trends with clear and practical advice on business development strategies in home and building systems. The Consumer Electronics Association (CEA) chose Dr. Wacks to chair the international committee (ISO/IEC) responsible for world standards in home systems. For more information, please visit [www.kenwacks.com](http://www.kenwacks.com).*