CEA Standard

Multi-Room Audio Cabling Standard

CEA/CEDIA-2030-A

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CEA
Consumer Electronics Association

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(Formulated under the cognizance of the CEA/CEDIA **R10 Residential Systems Committee**.)

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FOREWORD

This standard was developed by the Consumer Electronics Association/Custom Electronics Design & Installation Association R10 Residential Systems Committee.

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Multi-Room Audio Cabling Standard

1 SCOPE

This standard defines cabling and connectors for use in distributing analog and digital audio signals throughout a home. This multi-room audio standard covers stereo content (either summed or two channels) only.

2 REFERENCES

2.1 Normative References

The following references contain provisions that, through reference in this text, constitute normative provisions of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below.

2.1.1 Normative Reference List

AIA A-201-1997 General Conditions of the Contract for Construction

ANSI/TIA/568-C, Generic Telecommunications Cabling for Customer Premises, February, 2009.

ANSI/TIA/EIA-568-C-2, Balanced Twisted-Pair Telecommunications Cabling and Components Standards (See Addendum 1 For category 6 Performance Specs), August 2009.

ANSI/CEA-863-A, Connection Color Codes for Home Theater Systems, March, 2005.

IEC 60603-7, Connectors for Electronic Equipment – Part 7: Detail Specification Unshielded, Free and Fixed Connectors, July 2008.

ANSI/NFPA-70, National Electrical Code®, August 2008.

ANSI/TIA-570-B, Residential Telecommunications Infrastructure Standard, January 2009.

ANSI/TIA/EIA-606-A Administration Standard for Commercial Telecommunications Infrastructure May 2002

ANSI/TIA-968-A, Telecommunications Telephone Terminal Equipment Technical Requirements for Connection of Terminal Equipment to the Telephone Network, August 2007

AES-48 AES Standard on Interconnections – Grounding and EMC Practices – Shields of Connectors in Audio Equipment Containing Active Circuitry May 2005

EIA/ECA 310-E Cabinets, Racks, Panels, and Associated Equipment, December 2005

ANSI-ASHRAE 55 - Thermal Environmental Conditions for Human Occupancy, 2004

UL 1678 – Household, Commercial, and Professional Use Carts and Stands for Use with Audio/Video Equipment, December 2001

ANSI/TIA/EIA-569-A: Commercial Building Standard for Telecommunications Pathways and Spaces, December 2007

CEA/CEDIA-CEB22: Home Theater Recommended Practice: Audio Design
NEC-225.30-39: More than One Building or Other Structure

2.1.2 Normative Reference Acquisition

AES Standards:

- Audio Engineering Society, International Headquarters, 60 East 42nd St, Room 2520, New York, NY 10165; Phone 212-661-8528; Fax 212-682-0477; Internet http://www.aes.org

TIA, CEA, IEC and EIA Standards:

- IHS, World Headquarters, 15 Inverness Way East, Englewood, CO USA 80112-5776; Phone 800-854-7179; Fax 303-397-2740; Internet http://global.ihs.com; Email global@ihs.com

NFPA Standards:

- National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269 USA; Phone: 800-344-3555 or +1-617-770-3000 if outside the U.S; Fax: 617-770-0700; Internet http://www.nfpa.org.

2.2 Informative References

The following references contain provisions that, through reference in this text, constitute informative provisions of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below.

2.2.1 Informative Reference List

CEA TechHome Rating System

2.2.2 Informative Reference Acquisition

CEA TechHome Rating System:

- Consumer Electronics Association, 1919 S. Eads St., Arlington, VA 22202 USA; +1 703 907 7600; http://www.ce.org/techhomerating.

2.3 Definitions

Authority Having Jurisdiction (AHJ)	An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.
Bundled Cable	For the purposes of this standard, bundled cable means category 5e or category 6 cable together with a minimum of four speaker conductors.
Block Diagram	A diagram showing the interconnections between the components of system (especially in an electronic system).
Category 5e Cable	A cable that meets the category 5e specifications in ANSI/TIA/EIA-568-B 2.
Category 6 Cable	A cable that meets the category 6 specifications in ANSI/TIA/EIA-568-B-2.

CEA TechHome Rating System	CEA's TechHome Rating System helps consumers evaluate and compare their homes' technological capabilities, including wiring networks for data and audio and other applications. The TechHome Rating System divides the electronic systems in a home into five categories - entertainment, communications, PC networking and Internet, security, comfort and convenience - based on the primary function or benefit the system provides. The higher the TechHome rating, the better the home's ability to support the latest technology. Information is available at www.ce.org/techhomerating.
Change Order	A signed document that sets out changes to a previously negotiated contract.
Control Device	A device used to control the system. Control devices include keypads, infrared devices, touch screen devices, radio frequency control devices, volume control, etc.
Destination Device	A component in a given zone that is to be connected to the head end. An example of this is a volume control, keypad or other such device.
Distribution Device	A device that takes a signal from a head end and amplifies and/or splits it into multiple signals for distribution throughout the home.
Global Access	Accessible from other parts of the home
Global Source Input	A non-head end device that provides an audio signal to the entire system.
Head End (Distribution)	A location in the home from which audio signals can be distributed throughout the home.
Head End (Source)	A location in the home into which two or more source signals can be fed for distribution throughout the home. The location that serves as the demarcation point between a home audio distribution system and outside media services is a source head end.
J-Box	An abbreviation for junction box.
Local Source Input	A non-head end device that provides an audio signal only to the local zone in which it is installed, and not to the entire system.
Local Access	Accessible within the room
Media Cabinet	A piece of furniture which is specifically designed to accommodate audio/video equipment
Rack Elevation Diagram	A diagram showing elevation of racks that hold electronics. EIA/ECA 310-E: Cabinets, Racks and Associated Equipment
RG6 Coaxial Cable	A coaxial cable that meets the specifications for Series 6 cable in Section 5.3 of ANSI/TIA-570-B.

Service Loop	A segment of continuous installed wire, at least 610 mm (24 in) in length, that is looped and left inside of an electrical box or other similar device for later cutting and connection to a switch, keypad, speaker, etc.
Source	A device that generates audio signals.
Speaker Device	A device that converts electrical signals into sound waves.
Substantial Completion	**T**he stage in the progress of the Work where the Work or designated portion is sufficiently complete in accordance with the Contract Documents so that the Owner can occupy or utilize the Work for its intended use. (as per AIA A201-1997)
T568A Telecommunications/ Outlet Connector	A connector that complies with the specifications in ANSI/TIA-570-B.
Volume Control	A user control that is used to vary the loudness of a reproduced sound by varying the audio-frequency signal voltage at the input of the audio amplifier.

2.4 Symbols and Abbreviations

AC	Alternating Current
AHJ	Authority Having Jurisdiction
AWG	American Wire Gauge
CATV	Community Access Television
CD	Compact Disc
CEA	Consumer Electronics Association
DVD	Digital Versatile Disk
EMI	Electromagnetic Interference
ESC	Electronic Systems Contractor
HVAC	Heating, Ventilation & Air Conditioning
IG	Isolated Ground
IR	Infrared
L	Line
G	Ground
RF	Radio Frequency
TIA	Telecommunications Industry Association
UTP	Unshielded Twisted Pair
UV	Ultra Violet
STP	Shielded Twisted Pair

2.5 Compliance Notation

As used in this document “shall” and “must” denote mandatory provisions of this standard. “Should” denotes a provision that is recommended but not mandatory. “May” denotes a feature whose presence does not preclude compliance, and implementation of which is optional. “Optional” denotes items that may or may not be present in a compliant device.

2.6 Manufacturer Recommendations and Requirements

Throughout this document general recommendations and requirements for equipment installations are described. In cases where equipment manufacturers include specific requirements with their products

those requirements (e.g., shielded twisted pair versus unshielded twisted pair) shall be followed, even if they conflict with recommendations or requirements in this standard.

2.7 Building Code Compliance

Throughout this document general recommendations and requirements for equipment installations are described. In cases where building codes include specific requirements that conflict with recommendations or requirements in this standard, the building code requirements shall be followed. Furthermore, in cases where building codes include specific requirements that conflict with manufacturer recommendations or requirements, the building code requirements shall be followed. The local Authority Having Jurisdiction (AHJ) will have final authority regarding products installed within the structure.

3 MULTI-ROOM AUDIO SYSTEMS

3.1 General

Multi-room audio systems include audio sources, a distribution network, and speakers. Audio sources may be devices such as radio receivers, satellite receivers, Compact Disc (CD) players, DVD players, Media players and servers or internet streaming devices (cloud based services). Distribution networks can be centralized with a head end location(s), or decentralized with no head end location(s) where audio signals enter the home and/or originate, and a network of wired or wireless devices that transport analog and digital signals throughout a home. Distribution networks are typically designed to permit the homeowner to exercise audio control over different rooms (frequently referred to as “zones”) independently. Each zone has at least one speaker in it and the audio to the speakers in each zone is typically controlled by either a volume control or a volume control with extended control functionality. Control over enhanced functionality features is commonly provided in devices such as keypads, touch screens and mobile devices.

3.1.1 Documentation for the Installer

In order to ensure that the installer has the tools to perform the installation properly and allow for future servicing and upgrades, the Electronic System Designer should provide the technician with proper documentation. The most essential document is the scope statement, which explains the job requirements, what is expected of the Electronic Systems Contractor (ESC) and what is not expected of the ESC. Other documents that should be included are as follows:

- System blueprints showing device locations, including any wiring intended for future use
- Block Diagram (See Annex A)
- Rack Elevation (See Annex A)
- Cable Schedule which includes for each cable run - cable ID, starting location, destination (include way-points), cable type, application, and termination. Each cable run should also have a place for a check or initials to verify it has been run, terminated, and tested (See Annex A)
- Equipment Schedule (See Annex A)
- Change Order Forms (See Annex A)
- As-built/redline documents (See Annex A)

3.1.2 Documentation for the Client

To ensure that the client and the ESC have mutual understanding of the system to be installed, the ESC should have signed documents and provide copies to the client.

. A copy of the contract
  - Including scope statement
    - Design specification document

- Terms of Intellectual Property license
- Anticipated completion dates of established milestones
- Payment schedule
- Definition of substantial completion

Copies of all signed change orders (as issued)

- Signature of client and all stakeholders

- Bill of Materials
- As-built/redline document showing all changes and final locations of wiring and equipment

3.1.2.1 Basic diagrams

Below lists some of the basic diagrams that should be included in all distributed audio system jobs:

- Blueprint (drawings)
  - Scale
  - Generally accepted scale is quarter inch equals 1 foot
  - Legend
- Cable Schedule

Plumbing/ Mechanical/Electrical

- Elevation
- Floor Plan
- Reflected ceiling plan
- Wiring Diagram/schematic
- Cable Records
- Cabinet/rack layout drawings where necessary

3.1.2.2 Breaker Panels and Power Ratings

All documentation should notate the circuit breakers which supply power to all equipment within the home. For purposes of power consumption, audio system equipment falls into two broad categories:

1. Equipment whose consumption does not significantly change regardless of its operating conditions. Such equipment includes computers, media servers, CD and DVD players, TV set-top boxes, FM tuners, etc.

2. Equipment whose consumption changes very significantly with operating conditions. The most notable are audio power amplifiers. With the exception of completely “Class A” designs, power consumption of audio power amplifiers changes drastically from “idle” (no signal) to “full power” during very loud program passages. Therefore, its maximum power consumption depends on both the total load (speaker) impedance and the peak to average power ratio in the program material.

The best course is to consult the power amplifier manufacturer for a recommendation of breaker rating.

3.2 Head End

Half the current of the rated power fuse as listed on the amplifier externally can be used as the typical current load from the breaker panel.
Device Locations

Unless devices need to be located in specific places for clients with special needs, the following is generally accepted practices for the proper location of control devices. The location of these devices

is critical to assure the best audio and control performance. Manufacturer's recommendations should be followed for optimum hardware mounting and locations.

- Non Display Devices such as rotary volume control approximately 45 to 48 inches OC
- Display Devices such as a touch screen display approximately 54 to 60 inches OC
- Speaker location is dependent upon speaker type and application

Class L/H Fuse Rule of thumb for amplifier current draw from the AC line; Class A/B amplifiers will draw ½ to 2/3 of their fuse rating at moderate listening levels (1/2 this value if used as background music), Class D amplifiers will draw ¼ to ½ of their fuse ratings at moderate listening levels (1/2 this value if used as background music).

3.2.1 Head Ends

The system head end(s) is/are where the centralized home systems controllers, signal amplifiers and component devices that do not require regular user accessibility shall be housed. Head ends can be source head ends, distribution head ends, or both. Head ends typically serve as the terminus for head end equipment such as control point devices, speaker devices, in-living area/local control devices and in-living area/local sub systems (such as home theater systems). The head end area has specific requirements necessary to properly support installation, operation, and proper maintenance of the head end equipment.

3.2.1.1 Head End Location

Although it historically has been common to locate a head end in a living area, housed in some form of "media cabinet," it proves desirable for numerous reasons to locate a head end in an area apart from the common living area. Suggested spaces include a dedicated closet or equipment room, a structured wiring cabinet, a partitioned section of a basement, a crawl space, or a garage (where the environment can be controlled properly). To facilitate efficient cabling of the home a central location within the structure is preferred. Head end locations should also provide ready access to service entrance points of all potential low voltage service providers. Where it remains preferable to install head end equipment within the living space all head end requirements shall be met.

3.2.1.2 Head End Support Requirements

At the source and distribution head end locations there should be sufficient space to support wire entry and wire management, to house a floor standing rack or hinged wall mounted rack or shelving, and to provide easy access to both the front and rear of the rack(s) and/or shelving. At head end locations there also shall be an electrical supply consisting of a dedicated circuit(s) properly bonded and sufficient to supply a rated maximum load at least equal to the total load required by all head end equipment, plus 30 percent or more for future expansion capabilities. There also should be sufficient air handling equipment to maintain the ambient temperature within the < 30 degrees Celsius (< 85 degrees Farenheit), and to maintain the relative humidity within the range 30-60 percent. (reference ASHRAE 55)

The head end space should be well lit allowing for ease of reading all equipment labels and or documentation within the space. The head end space should also be relatively free of dust and insects. If enclosed, it shall have a door with a minimum width of 91.5 cm (36 in) for ingress and egress.

Racks should be installed in such a manner that does not impede proper access to the back of the rack.

3.2.1.3 Amplifier Rack Considerations

Amplifiers, due to heat and weight should be placed on the bottom of the rack. Systems exceeding 500 watts should use active ventilation.

3.2.2 Non-Head End Source Inputs

Non-head end source inputs are locations throughout the home where audio devices can be connected to the multi-room audio system for global access or local access. There are a variety of connection methods to connect both analog and digital devices (such as analog line-level, Ethernet, proprietary digital) located where the homeowner may locate a desk, equipment rack, CD player, portable audio device, television, or other audio source.

Source input devices located behind a desk or furniture may be located at the same height as electrical outlets. In casework or other built-ins, the source input device may be located behind the appropriate component (*e.g.,* a television cabinet in a wall unit). It is recommended that source input devices be located next to or near a line voltage outlet as a convenience outlet for attached audio sources or other use.

3.2.2.1 Global Source Inputs

Global source inputs are non-head end source inputs that act as if they were located at the head end. Audio and control data signals injected at a global source input location may be carried back to the head end, distributed, peer-peer or may go to audio devices not located at the head end. Cables to this location shall consist of at least one category 5e or category 6 cable that runs from the global source input location to the source head end. For future use or higher bandwidth capabilities more category 5e, category 6 or fiber cables may be run to the head end.

3.2.2.2 Local Source Inputs

Local sources are sources that are located within the proximity that one is listening. There are a variety of local sources such as iPod Docks, wireless content, etc. These sources, not located at the head end, may override the multi room audio system in the room(s) in which they are located. Audio signals inserted at the local source input location may be carried to a local room preamplifier, amplifier or amplified speakers, or to other locations or to the head-end. There should be two cables, capable of handling the bandwidth requirements for the system, to the control device location serving the area in which the local source input is located.

3.2.2.3 Speaker Level Local Source Inputs

Speaker level local source inputs are speaker-level inputs that override the multi-room audio system in the room(s) in which they are located. The speaker-level outputs of a local stereo system or television are injected into the speakers via a device at this location.

3.2.3 User Control Locations

3.2.3.1 In Room Analog Volume Controls

In-wall analog volume controls usually are mounted at the same height from the floor as light switches or as provided for by manufacturer specifications. If the manufacturer recommends a specific housing for the volume control it shall be used. Although locations for installing a volume control within a room may vary, convenient access by the homeowner always should be a prime consideration. Volume controls installed at either side of a doorway provide a

convenient means of control when entering or leaving a room. Tabletop volume controls can provide a convenient bedside alternative. In-wall volume controls should not be installed in the same electrical boxes as 110-volt devices or adjacent to high wattage light dimmers because electromagnetic interference (EMI) generated by these devices may introduce noise in the form of hum or buzzing into the audio signal. Ideally, a minimum distance of at least one stud bay (16-inch on center studs) should be maintained between light dimmers and volume controls; more if multiple dimmers are being used.

3.2.3.2 Digital Keypads

In-wall keypads usually are mounted at the same height from the floor as light switches, or as provided for by manufacturer specifications. If the manufacturer recommends a specific housing for the keypad it shall be used. Like volume controls, keypads should be installed in user-friendly locations. Keypads should not be installed in the same electrical boxes as AC electrical power or adjacent to high wattage light dimmers because electromagnetic interference (EMI) generated by these devices may introduce noise onto the keypad data lines which may result in intermittent or total loss of system/source control. A minimum distance of at least one stud bay (16-inch on center studs) should be maintained between light dimmers and keypads – more if multiple dimmers are used. See 3.2.5.1 for information regarding the installation of keypads that have built-in IR receivers.

3.2.3.3 Wall-Mounted Touch Screens

The installation height of in-wall LCD touch screens will vary according to a particular screen's specified viewing angle. Generally, touch screens should be installed higher than standard light switches because line-of-sight viewing is required for optimal contrast and brightness. Refer to the touch screen manufacturer's installation recommendations before installing. As touch screens usually have their own specified rough-in boxes, the issue of EMI causing operational failures if co-located with AC electrical power should not arise. It is always prudent, however, to maintain a minimum distance of at least one stud bay (16-inch on center studs) between light dimmers and touch screens. See 3.2.5.1 for information regarding the installation of touch screens that have built-in IR receivers. Considerations should be made for the height level for touch screens with regards to those with disabilities.

3.2.3.4 Tabletop Control Devices

Tabletop volume controls, keypads and touch screens require that the control device wire run(s) be pulled to a location close to where the device will reside (*e.g.,* a desk or night table). In the case of tabletop keypads or touch screens, the control device wire run usually is terminated to a wall plate, specified by the manufacturer, into which the control device plugs. This wall plate should be installed at the same height as the telephone wall plates in the room, and usually may be hidden by the bed/desk/night stand on which the tabletop device will reside. These devices may provide charging/power to the control device. If charging power supplies and remotes, proper planning should be taken to meet manufacturers' specifications. .

3.2.4 Speakers

In the case of active components or specialty applications, twisted pair category 5e or category 6 cables and/or shielded cabling might be needed in addition to or in lieu of the aforementioned speaker cable. Speakers installed into surfaces (flush mount, semi-flush mount) such as in-wall and in-ceiling speakers have special installation concerns. Check with the speaker manufacturer to confirm that the identified speaker location provides the recommended cubic footage for the speaker to operate properly. Also confirm that the speaker is suitable for moisture rich environments such as bathrooms or porches if that is the intended installation location.

Many pre-construction brackets and back boxes exist to aid with the installation of flush mount speakers. In the case of back boxes, they can improve sound quality, help control sound leakage between adjoining areas and, if approved, satisfy fire code requirements. Be sure to follow all fire and safety codes and regulations in the local municipality when installing any speakers or low-voltage cabling. If penetrating any fire walls, make sure that any penetrations are sealed in accordance to the local or national building codes or as per dictated by the AHJ. Additional considerations may be required for compliance with energy/sustainability certified homes.

When planning speaker locations, other considerations such as furnishings and room treatments also need to be considered to obtain good sound quality and integration with the environment.

3.2.4.1 In-Wall/Ceiling Speakers

In-wall speakers vary in size and space requirements. Spaces where speakers are installed should be of the proper dimensions and free from debris. Care should be taken to ensure the space is constructed solidly for this particular application. Installation in walls should be done with care and installers should check local building and fire codes for specific requirements that may be related to these types of installations. Areas with congestion from infrastructures such as plumbing and electric and air returns or plenums should be avoided. In certain cases, such as the State of California, special cabling or installation codes or regulations may be presented. As in all cases the AHJ has the final say.

3.2.4.2 On-Wall Speakers

On-wall speakers attached to surfaces should be mounted according to the speaker manufacturer's recommended methods. This includes both mechanical mounting as well as weather proofing considerations in adverse environments. All walls that will have on-wall speakers attached should be able to handle four-time the static load as per UL 1678. If active devices are used, ensure that power requirements are considered and available at the active speaker location. Access to the wire should be installed in such a way that service and maintenance can be easily performed.

3.2.4.3 Speaker Termination Plate

Wall jacks may be used for bookshelf, floor standing, and wall mounted speaker installations. Mount the wall jacks according to the application, and label the polarity of the connections on the wall jack so that users will be able to connect speakers in a manner that will ensure proper polarity. The connector on the wall plate shall be adequately sized to carry the power involved. Applications such as floor standing speakers might require the jacks to be mounted at the same height as other wall mounted devices such as electrical outlets. Consider the application and the room and cabinet designs before committing to speaker jack locations. If active devices are used, ensure that power requirements are considered and available at the active speaker location. Be sure to follow all codes and regulations for installing junction boxes within a structure.

3.2.5 Infrared, RF, and Other Wireless Transceivers

In the case of active components or specialty applications, twisted pair category 5e or category 6 cables and/or shielded cabling might be needed in addition to or in lieu of the aforementioned cable. AC power maybe required in these locations.

3.2.5.1 IR Receivers

IR receivers (also called IR sensors or IR targets) come in a variety of configurations and mounting options (*e.g.,* surface mount, flush mount, in-wall, junction box, in-speaker, tabletop, etc.). Mounting locations should be selected to avoid interference from direct sunlight, fluorescent lights, radio transmitters, compact fluorescent lights, light dimmers, plasma television screens, etc., or room light sources shining directly into the IR receiver. Saturation of the IR receiver by a light source, known as IR 'flooding,' may result in intermittent or total loss of system/source control. The infrared receiver shall have line of sight from the sending device

3.2.5.2 RF and Other Wireless Transceivers

RF transceivers (also called RF gateways) should be installed in a manner where it is typically higher in relative position in room height. Installation should provide adequate ventilation and electric service, care should be taken to avoid locations where interference may occur such as metal surfaces, ducting, or stone.

3.3 Timing of Installation

The preferred timing of audio cabling installation shall be after plumbing, electrical and HVAC, and prior to insulation (when used) and sheet rock.

3.4 Cabling Topology

There are three distinct areas where cabling is installed between devices when installing an audio system. These include:

- source connection points to head end
- head end to a volume control/keypad (some systems may have a distribution device between the head end and volume control/keypad)
- volume control/keypad to speaker device(s) and then continued onto next speaker device(s)

Some devices may have unique cabling requirements. In cases where such devices will be deployed in a home, the cabling specified by the manufacturer shall be used.

3.4.1 Remote Source Connection Location to Head End

From the remote source connection location to the head end a minimum of one Twisted pair category 5e or category 6 cable shall be installed. The category 5e or category 6 cables will deliver audio, infrared/control signals and/or other signals to the audio head end.

3.4.2 Head End to Distribution Device

From the head end to the distribution device a minimum of four speaker wire conductors and one category 5e or category 6 cable shall be installed; a second category 5e or 6 cable allows for increased flexibility and future use. The category 5e or category 6 cable may be used for communication (*e.g.,* infrared control signals, digital audio, internet connection, etc.).

3.4.3 Distribution Device or Head End to Control Device

From the distribution device or head end to each control location, a minimum of four speaker wire conductors and one category 5e or category 6 cable shall be installed; a second category 5e or 6 cable allows for increased flexibility and future use. Control devices are typically large devices and may not fit well into a single-gang electrical box. Low-voltage brackets may be used as allowed by code. Additionally, at the control device location, a small service loop shall be provided for all cables.

3.4.4 Control Device to Speakers

From the control device location to one speaker in its zone, a minimum of four conductors of speaker wire and one category 5e or category 6 cable shall be installed. Additionally, at the speaker location, a small service loop shall be provided. After the service loop, a minimum of four conductors of speaker wire and one category 5e or category 6 cable shall be installed to the next speaker in the volume control/keypad/touch screen's zone.

3.4.5 Global Source to Source Head End

Global source inputs shall be connected to source head ends with at least one category 5e or category 6 cable.

3.4.6 Local Source to Control Device

Local source inputs shall be connected to the volume control/keypad/touch screen(s) that control the area in which the source inputs are located with at least two category 5e or category 6 cables.

3.4.6.1 High Level Local Source to Control Device

High level local source inputs shall be connected to the volume control/keypad/touch screen(s) that control the area in which the source inputs are located with at least two four-conductor speaker cables. If it is not known at the time of wiring that a local source input will be high-level, it is recommended that in addition to speaker cable, UTP, shielded or coaxial cables may also be run.

3.5 Continuous Cable

When cabling a home during new construction, the four conductor (minimum) cable and UTP category 5e or category 6 cables do not need to be cut or terminated at the volume control/keypad location nor at the first speaker location. The small service loops should be provided so that these wires may be cut and terminated at a later time.

3.6 Service Loops

A minimum of 610 mm (24 in) of cable should be used for all service loops. Care should be taken not to exceed minimum bend radius of the cable(s) and to ensure that there is sufficient room in the J-box to accommodate the wiring. When installing in-ceiling speakers, the length of service loop should be long enough to allow resting the ceiling speaker on the top of a ladder during maintenance.

Cable	Bend Radii
Category 5e/Category 6/UTP	4x Outer Diameter (1")
Coaxial Cable	10x Diameter
Fiber Optic	10x Diameter

4 CABLE AND CONNECTING HARDWARE

4.1 Suitability for Use

Cable and associated components shall be suitable for use in the environment to which they are exposed (e.g., ultraviolet [UV] resistant cable, listed cable, etc.).

4.2 Unshielded Twisted-Pair (UTP) Cabling

UTP cable shall meet the requirements of ANSI/TIA-568-C.2 and its applicable addenda. and shall be administrated as called out in TIA/EIA 606-A Administration standard.

4.2.1 UTP Equipment and Patch Cords

UTP equipment and patch cords, other than device specific cords, shall meet the requirements of ANSI/TIA-568-C.2. and shall be administrated as called out in TIA/EIA 606-A Administration standard.

Cross-connect jumpers and cables used for patch cords should be of the same category or higher as the outlet cables to which they connect. Due to the variety of cable types, connecting hardware types, tooling and testing required, field termination of patch cords is not recommended.

4.2.2 UTP Pulling Tension

The maximum pulling tension for a 4-pair UTP cable shall not exceed 110 N (25 lb/ft).

4.2.3 UTP Bend Radius

Cable bend radii shall not be less than four times the cable diameter.

4.2.4 UTP Connecting Hardware

All connecting hardware shall meet the requirements of ANSI/TIA-568-C.2. At outlet locations, UTP cable shall be terminated in eight-position modular connectors terminated using T568A or T568B pin assignments as specified in ANSI/TIA-568-C.0. The telecommunications outlet/connector shall meet the requirements of ANSI/TIA-568-C.2.

The eight-position telecommunications outlet/connector (see Figure 1) shall meet the modular interface requirements of IEC 60603-7. The pin-pair assignment configuration of the eight-position telecommunications outlet/connector shall comply with T568A as specified in ANSI/TIA/EIA-568-B-2. The eight-position modular outlet/connector shall satisfy the contact resistance requirements of ANSI/TIA/EIA-568-B-2 when mated to an eight-position plug per IEC 60603-7 after being subjected to 200 insertions of a six-position plug that meets the dimensional requirements of ANSI/TIA-968-A. The latching surface in the outlet/connector shall be set back from the face of the outlet/connector no more than 5.46 mm (0.215 in) so that the outlet/connector will not "capture" the plug clip.

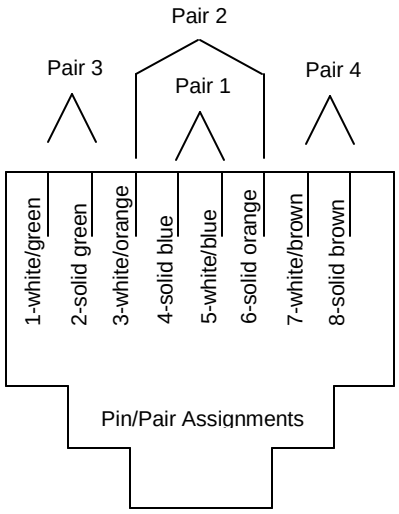


Figure 1: T568A Eight-Position Telecommunications Connector

Cables should be terminated with connecting hardware of the same category or higher. Transmission performance of installed components that meet requirements of different performance categories (e.g., cables, connectors, and patch cords that are not rated for the same transmission capability) shall be classified by the least performing component in the link. This performance category should be marked on the connecting hardware or noted in the administration records. In order to maintain cable geometry, no more cable jacket than required to terminate connecting hardware shall be removed. When terminating connecting hardware, pair-twist shall be preserved as close as possible to the point of mechanical termination. For category 5e and category 6 cables, the amount of pair untwisting as a result of termination to connecting hardware shall be no greater than 13 mm (0.5 in). A minimum of 200 mm (8 in) of excess cable should be stored at each outlet.

4.3 Multi-Conductor Cabling

Speaker cable shall be constructed of multiple stranded copper conductors, each conductor sized at a minimum cross-sectional area of 18-AWG. Bundled cables that meet or exceed the system design, such as speaker cable and category 5e or category 6 cable may be used. Category 5e or category 6 cable shall meet the requirements of ANSI/TIA/EIA-568-B.2. Special considerations for multi-conductor cabling may be taken into account when designing and installing an active speaker system

4.3.1 Speaker Wire (Conductor) Gauge Selection

The resistance of the cable connecting the speakers to the amplifier becomes relevant in determining how much power reaches the speaker. For example, a 30 m (100 ft) cable run of 16-AWG speaker wire will have a loop resistance of 0.8 ohms. If this is used with a 4-ohm speaker, approximately 17 percent of the power will be lost to the cable, resulting in only 83 percent of the power reaching the speaker. Larger gauge wire will reduce power loss. It is recommended that cable be selected so as to insert no more than a 20 percent loss of power for its length and gauge. Typically, 16-AWG or 14-AWG speaker wire connections are provided on electronic devices for multi-room audio systems. See Table 1 for typical cable run lengths for various AWG ratings and power losses.

Table 1: Cable Length at Various Wire Gauges for Speaker Impedance/Power Loss Combinations[1]

Speaker Impedance	Loss (dB)	Power Loss (percent)	18-AWG Run m (ft)	16-AWG Run m (ft)	14-AWG Run m (ft)	12-AWG Run m (ft)
4	0.5	11	11 (35)	17 (56)	27 (89)	43 (143)
4	1	21	23 (75)	36 (119)	58 (190)	92 (303)
4	2	37	52 (169)	82 (269)	131 (428)	209 (684)
4	3	50	88 (288)	139 (458)	222 (729)	355 (1164)
8	0.5	11	21 (71)	34 (112)	54 (179)	87 (285)
8	1	21	46 (150)	73 (238)	116 (379)	185 (606)
8	2	37	103 (338)	164 (538)	261 (857)	417 (1368)
8	3	50	175 (575)	279 (915)	444 (1458)	710 (2328)

[1]The cable lengths in this table were calculated using 6.92 ohms/1000 ft. (18-AWG), 4.35 ohms/1000 ft. (16-AWG), 2.73 ohms/1000 ft. (14-AWG), and 1.71 ohms/1000 ft. (12-AWG) as the values for maximum resistance at 68°F. They are good approximations for all types of stranded copper wire speaker cable, but when it is necessary to determine the cable length for a specific type of cable, the resistance data for that cable should be used.

The data for 18-AWG and 12-AWG is shaded gray because these wire gauges are not commonly used in multi-room home audio cabling systems.

4.3.2 Speaker Wire and Connector Color Codes

All speaker cable conductors should be color coded, or distinctively marked to ensure proper polarity. Two conductor cables generally contain a red and a black insulated conductor. The red conductor shall be used for the positive terminals and the black conductor shall be used for the negative terminals. Four conductor-unpaired cables generally contain red, black, white, and green conductors. Red and black shall be positive and negative respectively, for the right speaker in each zone. White shall be used for positive and green shall be used for negative to connect the left speaker. Other colors may be used, but all connections should be consistent.

Speaker terminals shall be color coded in accordance with the color-coding scheme in CEA-863-A.

Special considerations should be taken for active speakers; follow manufacturer's instructions.

4.3.3 Speaker Wire Polarity

Maintaining correct polarity from the speaker amplifier through the entire cabling system all the way to the speaker is critical for proper sound reproduction. Each speaker shall have its positive ("+" or red) terminal connected to the appropriate positive ("+" or red) terminal on the amplifier, and its negative ("-" or black) terminal connected to the appropriate negative ("-" or black) terminal on the amplifier.

Amplifier terminals should not be "commoned" (connected to each other), unless specifically allowed by the amplifier manufacturer for a specific purpose, such as bridging an amplifier for higher power output.

4.4 Construction Documentation

Documentation shall be provided with the home indicating the approximate locations of the volume control/keypad/touch screen service loops and equipment such as speaker and service loops in each room. Photographs of wire locations not installed in junction boxes or other boxes is recommended to

ease wire location after drywall installation. The distribution device or head end should expose all home run wire and each run should have labeling information.

Documentation of the entire cabling system shall be provided to the homeowner. This documentation shall include a list of the cable runs and their locations, a copy of any test results for each cable run, as well as any warranty information. If a distribution device is provided, the list of cable runs and their locations shall be affixed to this device. Copies of all instruction sheets, including instruction sheets for modules mounted inside distribution devices, should be provided to the owner. If the system implementation differs from the system design, notations shall be made in the final as-built document. A label with the installer's name and phone number should be affixed to the distribution device for future reference.

The documentation shall also specify the maximum power handling capability of each wire run, taking into account the gauge of the wire, the connectors attached to either end of the wire, and the devices attached to either end of the wire. The documentation shall include the jacket safety rating of all cables installed to insure compliance with all safety codes.

4.5 Multi-Room Audio Cabling Administration

This section covers the administration and identification of cabling and connectors for use in distributing analog and digital audio signals throughout a home.

4.5.1 Quality Assurance

Identification and administration work specified herein shall comply with applicable requirements of:
ANSI/TIA/EIA – 606-A Administration Standard.
ANSI/TIA/EIA – 569-A Pathway and Spaces
ANSI/TIA/EIA – 568-C Telecommunications Cabling Standard.
ANSI/TIA-570-B, Residential Telecommunications Infrastructure Standard
ANSI/TIA/EIA-568-C-2, Balanced Twisted-Pair Telecommunications Cabling and Components Standards
All labels shall be printed or embossed by a mechanical device and shall not be handwritten.
Label and associated imprinting shall be designed to be a permanent installation. Labels shall be resistant to the environmental conditions at the point of installation.

4.5.2 Labels
Shall be industrial adhesives that resist dirt and oil.
Shall have an easily removed backing.

4.5.3 Execution

4.5.3.1 Identification and Labeling

Confirm specific labeling requirements with customer's project coordinator prior to cable installation and termination.

Cables
Horizontal and Backbone Cables shall be marked within 12" of each endpoint.
Any cable installed in conduit shall be labeled at all intermediate pull or junction boxes.
Horizontal cables shall be marked at each end, on the sheath indicating termination panel and panel port to which cable is wired.

Termination Panels
Termination panels shall be labeled with an identifier and all individual ports shall be labeled with an identifier
Termination panel ports shall be labeled with adhesive type labels or non adhesive type labels may be used if the panel has a clear label strip.

5 ELECTROMAGNETIC COMPATIBILITY

5.1 UTP Separation Distance from Electrical Power

Separation between UTP cables for voice, data, video, and electrical power conductors shall meet applicable electrical codes. Additionally, when UTP cable is placed alongside AC electrical power cable inside a wall space or a ceiling space there shall be a minimum separation of 50.4 mm (2 in) between the UTP cable and the AC power cable. Any crossing of UTP cable with power cable shall be at a right angle in relation to the power cable.

5.2 Audio Cable Separation Distance from Electrical Power

Parallel runs of conductive audio cable and AC electrical power cable shall be separated by a minimum of 305 mm (12 in) to minimize induced electrical interference problems. Where conductive audio system cabling crosses a power cable, it should cross at a right angle.

5.3 Audio Cable Separation from Other Telecommunications Cables

When conductive audio system cables run parallel to other conductive telecommunications cables, the audio and telecommunications cables should be separated by at least 305 mm (12 in) to minimize induced electrical interference problems. Where conductive audio system cables cross other conductive telecommunications cables, they should cross at right angles. (ANSI/TIA-570-B Section 6.1.4.3.1)

5.3.1 Reducing Noise Coupling

To further reduce noise coupling from electrical power cabling and motors or transformers, the following installation practices for metallic telecommunications cable should be considered:

- Increased physical separation
- Electrical branch circuit line, neutral, and grounding conductors should be maintained close together (*e.g.,* twisted, sheathed, taped, or bundled together) for minimizing inductive coupling into telecommunications cabling.
- If telecommunications cable comes within close proximity of electrical power cabling, it is recommended that they cross at 90-degree angles.
- For low-current consumption devices should be connected to a UPS
    - Amplifiers should not be connected to a UPS
- Surge protectors may be connected to amplifiers
- Fully enclosed grounded metallic raceway or grounded conduit should be used only where required

6 POWER FEED CONSIDERATIONS

All local and state electrical procedures shall be followed; however, the following best practices should be considered in relation to audio system installation.

6.1 Mis-wired Outlets

Every outlet should be tested with a simple outlet tester. These generally have three indicators showing errors that threaten life safety, such as a line (L) to ground (G) swap. Such testers are widely available at low cost. Do not plug in or operate any equipment until errors detected by this tester are corrected.

6.1.1 Defeated Equipment Grounding

Code section 250 specifically prohibits interruption of equipment safety grounding. Never use a 3-to-2-prong adapter, cut off the grounding pin of a 3-prong power plug, or otherwise defeat the equipment grounding conductor - even if it cures a noise problem. There are alternative methods that are Code-compliant and do not put users at risk of electrocution or a premises fire. In addition, courts have held that the installer who defeats safety grounding is legally liable in subsequent lawsuits.

The following are common mistakes that, although they have considerable impact on audio system noise, are frequently missed because they cause no obvious operational symptoms. Bear in mind that the overwhelming majority of audio system noise problems (hum, buzz, clicks, pops, etc.) are caused by insufficient rejection of ground voltage differences between pieces of equipment linked by signal cables. Ideally, signal interfaces would completely reject these "common-mode" voltages. But, in actuality, this rejection capability varies widely. For a given amount of signal interface rejection, larger ground voltage differences create more severe noise problems.

6.1.2 Mis-wired Outlets

This type of mis-wire cannot be detected with a simple outlet tester. A swap of neutral (N) and ground (G) at an outlet or outlet strip allows load current to flow in the ground system. This creates abnormally high ground voltage differences in the ground system, which can create or aggravate audio system noise problems. Visual inspection for proper wire colors at the outlet will usually reveal the swap, but a sensitive clamp-on AC ammeter may also be used to directly sense excessive current in the ground conductor. Ground current in a branch circuit is generally under 100 mA and is due to normal "leakage" current in each powered device having a 3-prong AC power plug. A licensed electrician may be required to test for this.

6.1.3 Multiple Neutral-to-ground Bonds

Code requires a neutral-to-ground bond at the main disconnect panel but it prohibits any others ("separately-derived power" is an exception - see Code section 250). When sub panels are installed, the electrician sometimes either forgets to remove or mistakenly installs its N-G bond, allowing part of the circuit load current to flow in the ground system. This creates abnormally high ground voltage differences in the ground system, which can create or aggravate audio system noise problems. Sometimes this problem is caused by a neutral wire being pinched or pierced in a metallic J-box. Visual inspection of sub panels should be performed, corrective work shall be performed by a licensed electrician.

6.1.4 Breaching of Isolated Ground (IG) system

The intent of an isolated ground system is to reduce system ground voltage differences by isolating the ground system from contact, whether intentional or accidental, with other grounded objects. These objects might include building structural steel, plumbing, electrical conduit, HVAC ductwork, etc. This is generally accomplished by running an insulated ground conductor from the main ground busbar to an outlet or group of outlets that are themselves constructed to prevent

contact between their ground contact and their mounting saddle. Even if the ground system to the outlets is properly wired, the scheme can be breached by user equipment via signal cables that connect IG powered equipment to non-IG powered equipment. For remote buildings structures / multi building estates please reference NEC-225.30-39 and Section 250.2.

6.2 Entrance Protection

Surge protection should be applied to cables running into and out of a building in accordance with Article 800 of the National Electrical Code using devices rated for the purpose.

6.3 Power-Line Issues

As noted in section 6.1, ground voltage differences among the premises' AC outlets are fundamental contributors to audio system noise issues. Where feasible, ground voltage differences can also be minimized in the following ways:

Power all equipment in an interconnected (via signal cables) system from a single, dedicated branch circuit.

If multiple branch circuits should be used, feed them from the same "phase" of the incoming "split-single-phase" utility power.

Do not allow non-electronic loads, such as household appliances or lighting, to share a branch circuit with audio system equipment.

Magnetic coupling, or induction, between current-carrying (L and N) conductors and ground conductors is the major source of ground voltage differences between outlets. This can be minimized by tightly twisting L and N conductors for each branch circuit in a run of conduit.

Be sure that ground connections for other cables that enter the premises, such as CATV, are grounded in a fully Code-compliant manner. With CATV, for example, Code requires a #6 AWG bonding wire connecting the CATV grounding block to the main power-utility ground electrode. In addition to providing protection from "downed" power lines, this connection minimizes audio system ground voltage differences where receivers, set-top boxes, or television sets are part of the audio system.

Do not add ground connections unless they are required for Code compliance. Additional ground connections nearly always create new noise issues.

7 ANNEX A

(Informative)

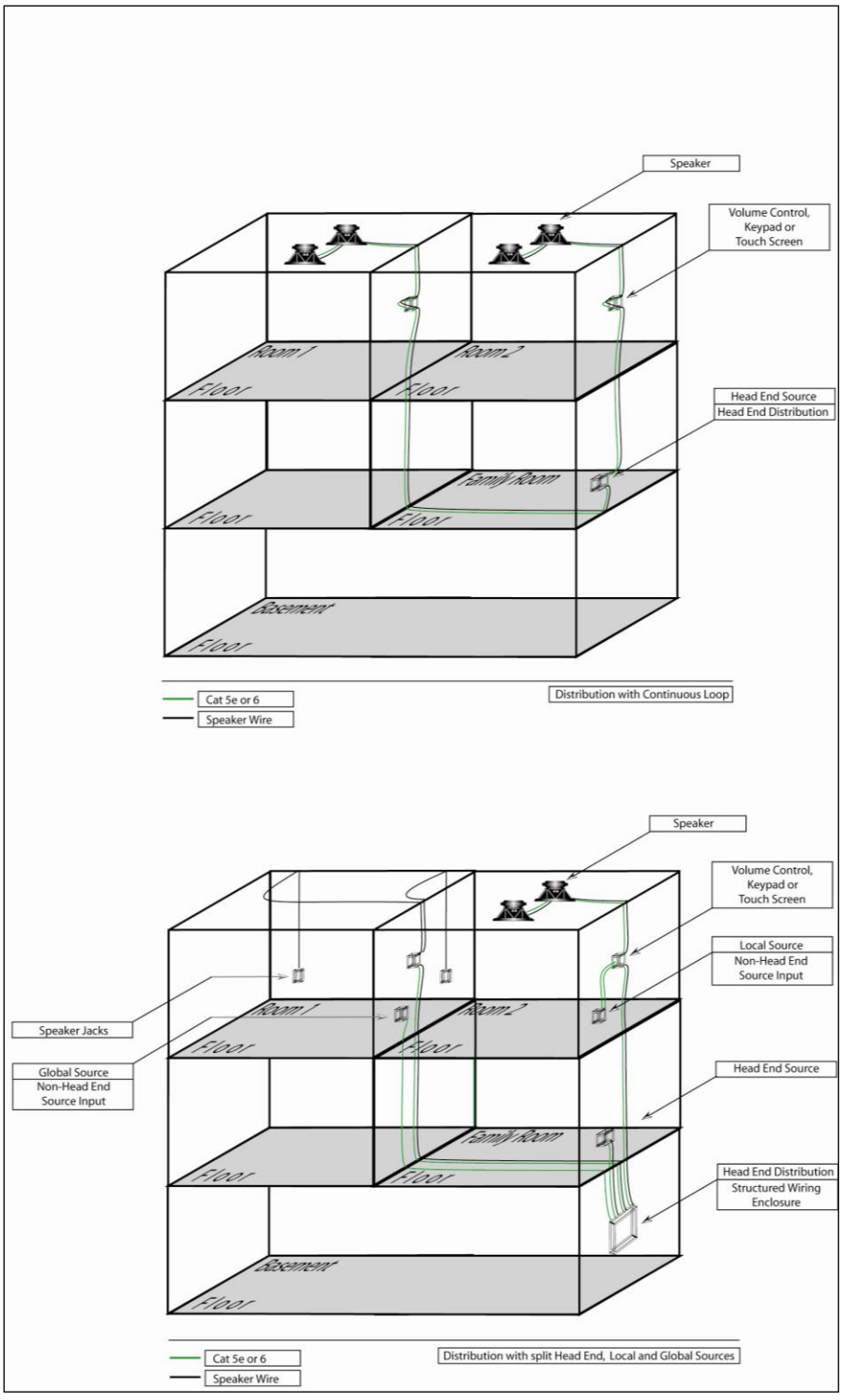


Figure 2: Typical Home Audio Cabling Systems

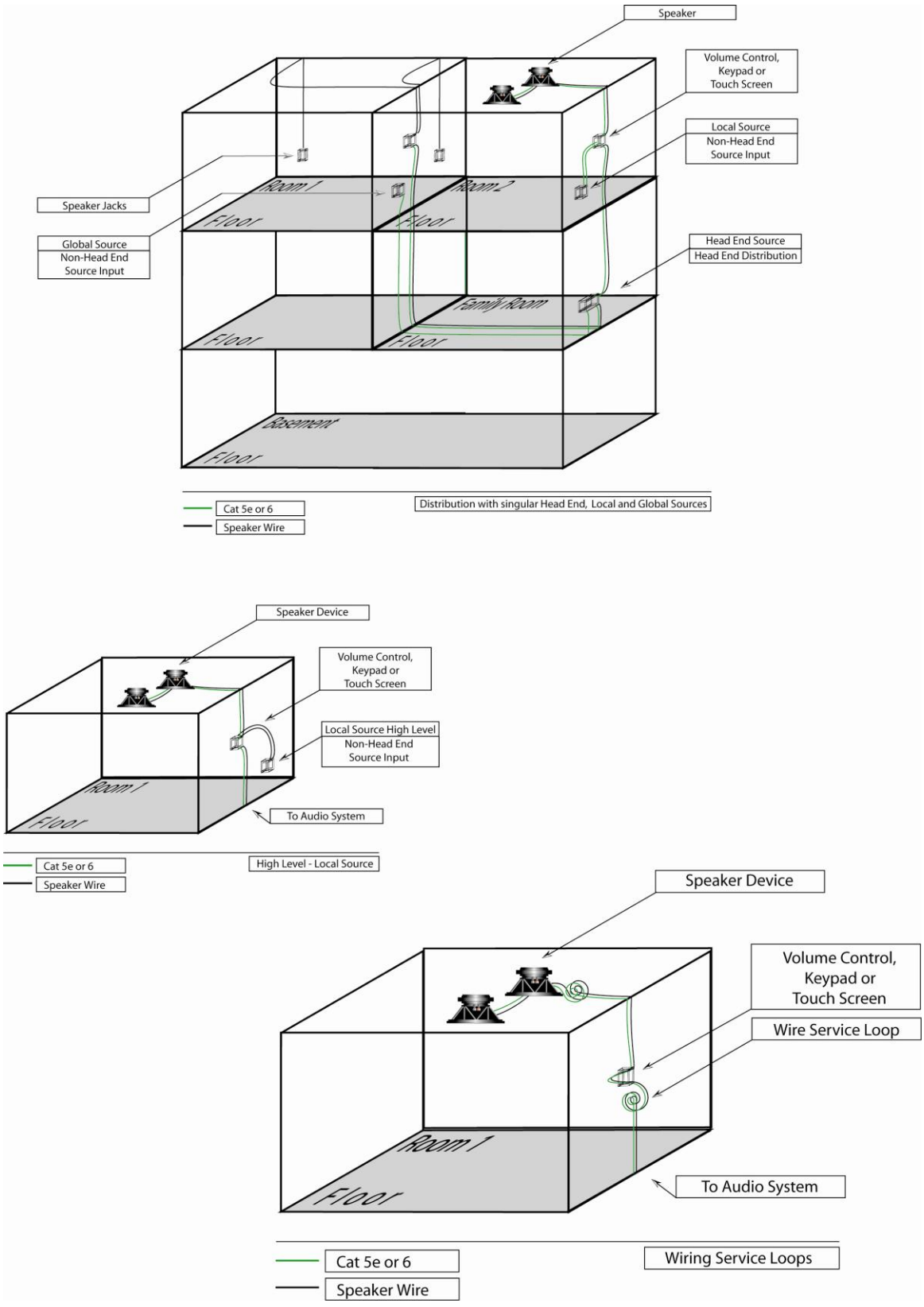


Figure 3: Typical Home Audio Cabling Systems

Sample Elevation Drawing

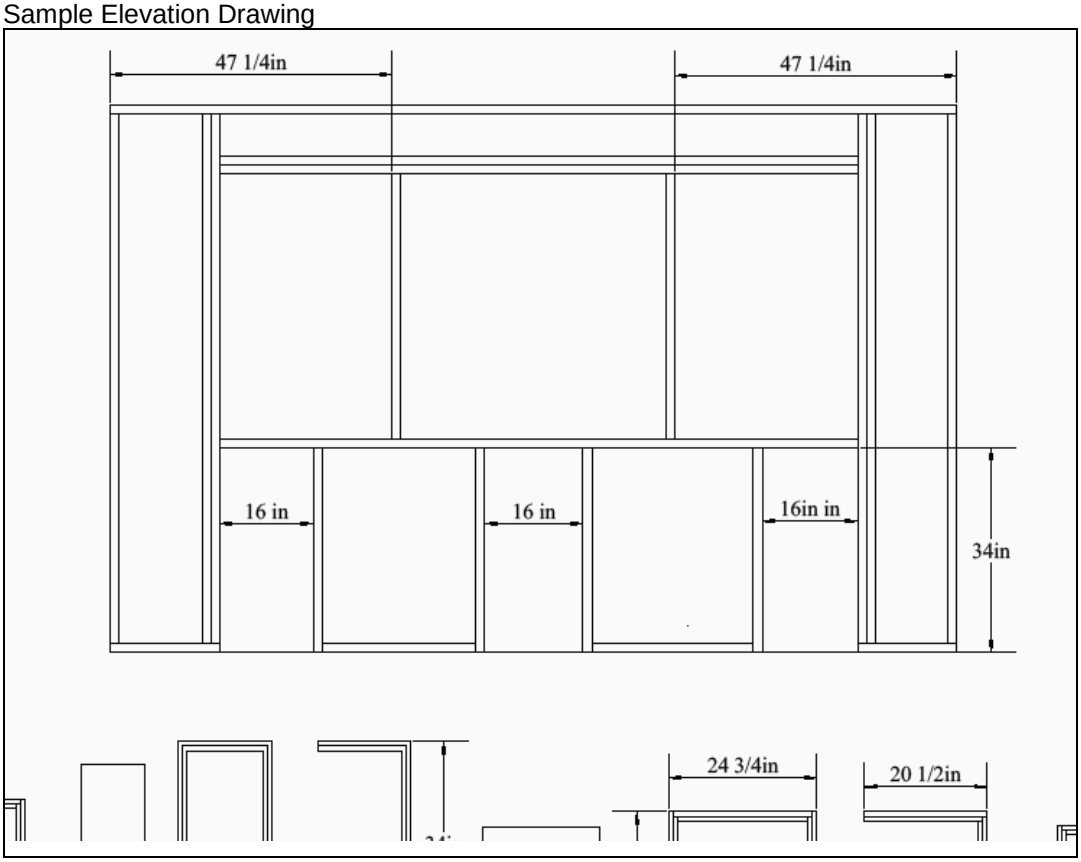


Figure 4: Sample Elevation Drawing

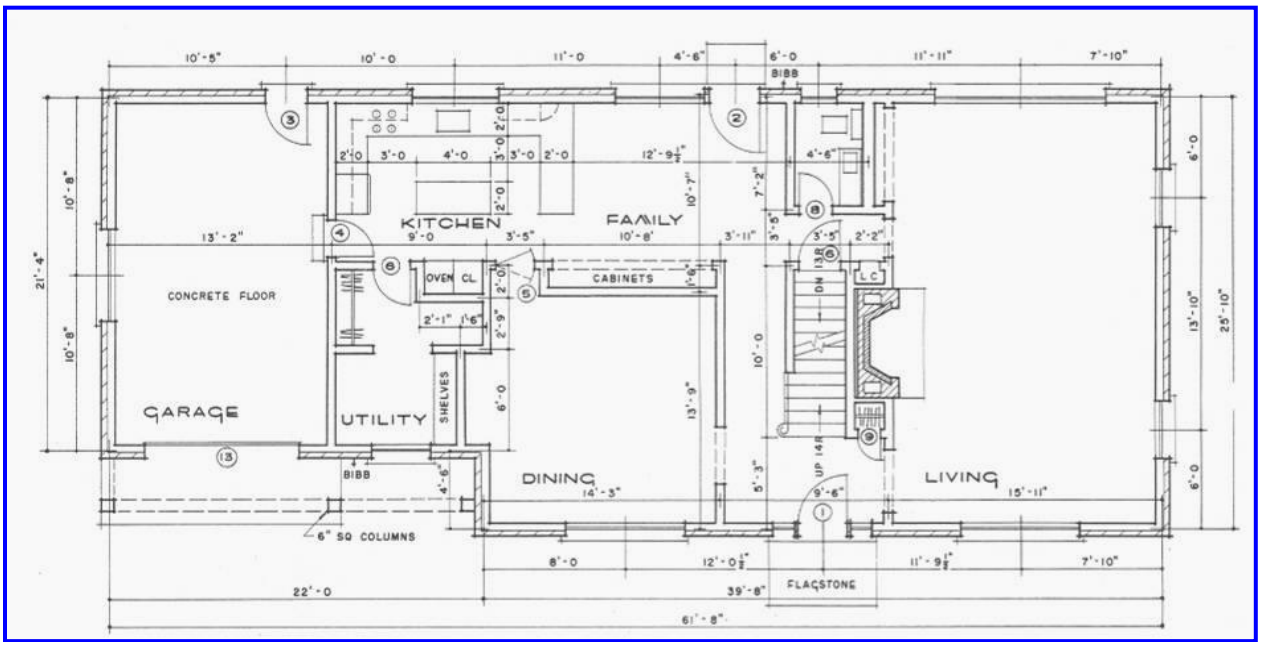


Figure 5: Sample Floor Plan

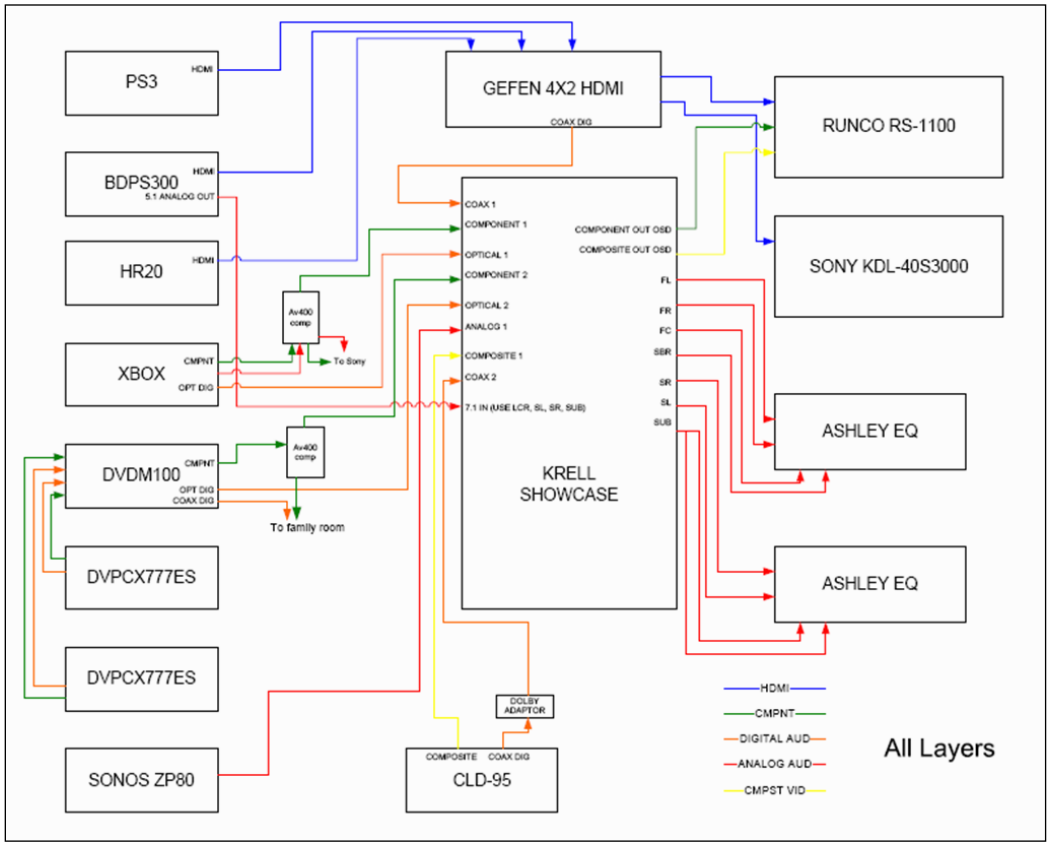
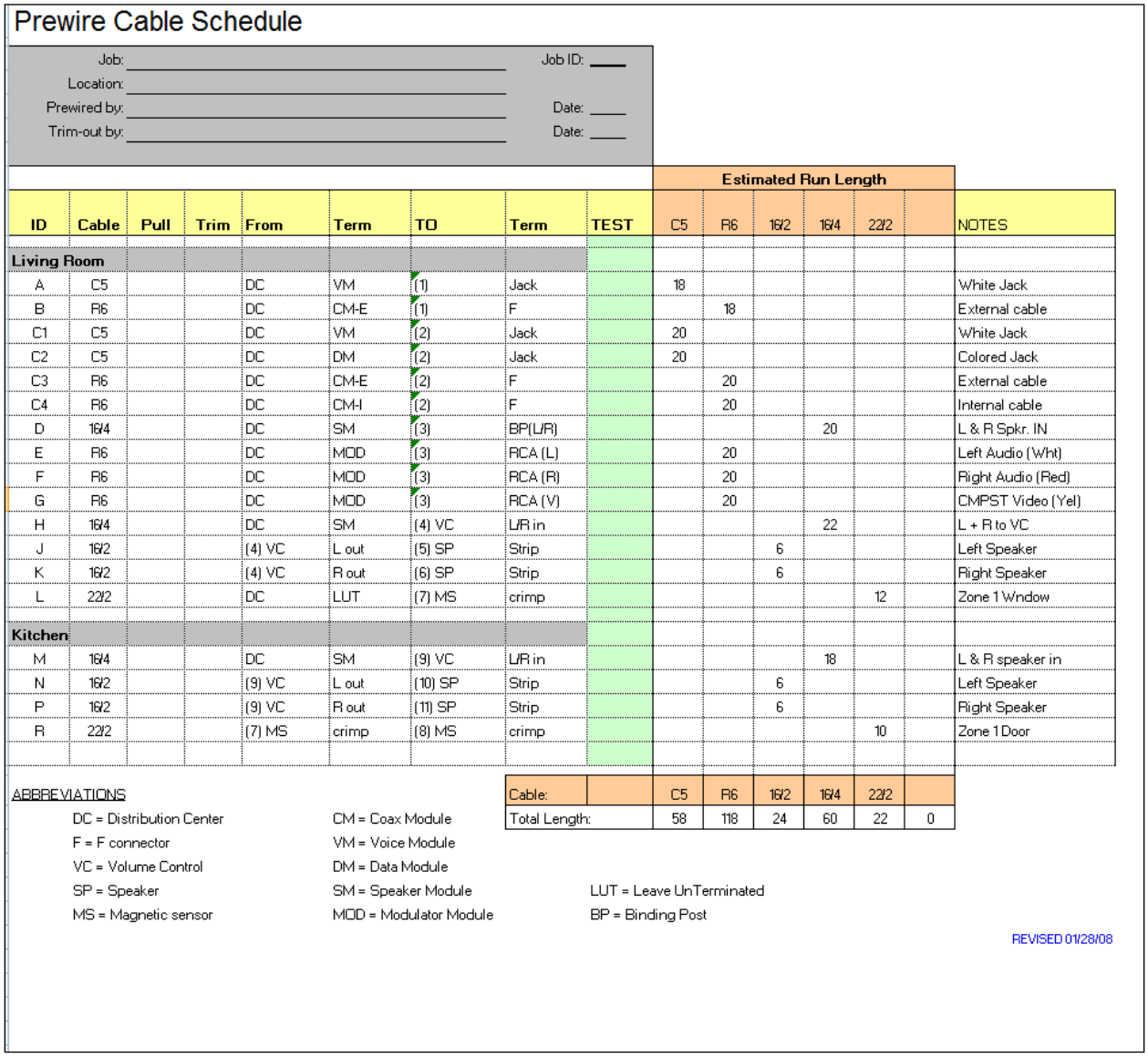


Figure 6: Sample Block Diagram



Prewire Cable Schedule

Job: _____ Job ID: ____
Location: _____
Prewired by: _____ Date: ____
Trim-out by: _____ Date: ____

									Estimated Run Length						
ID	Cable	Pull	Trim	From	Term	TO	Term	TEST	C5	R6	18/2	18/4	22/2		NOTES
Living Room															
A	C5			DC	VM	(1)	Jack		18						White Jack
B	R6			DC	CM-E	(1)	F			18					External cable
C1	C5			DC	VM	(2)	Jack		20						White Jack
C2	C5			DC	DM	(2)	Jack		20						Colored Jack
C3	R6			DC	CM-E	(2)	F			20					External cable
C4	R6			DC	CM-I	(2)	F			20					Internal cable
D	18/4			DC	SM	(3)	BP(L/R)					20			L & R Spkr. IN
E	R6			DC	MOD	(3)	RCA (L)			20					Left Audio (Wht)
F	R6			DC	MOD	(3)	RCA (R)			20					Right Audio (Red)
G	R6			DC	MOD	(3)	RCA (V)			20					CMPST Video (Yel)
H	18/4			DC	SM	(4) VC	L/R in					22			L + R to VC
J	18/2			(4) VC	L out	(5) SP	Strip				6				Left Speaker
K	18/2			(4) VC	R out	(6) SP	Strip				6				Right Speaker
L	22/2			DC	LUT	(7) MS	crimp						12		Zone 1 Window
Kitchen															
M	18/4			DC	SM	(9) VC	L/R in					18			L & R speaker in
N	18/2			(9) VC	L out	(10) SP	Strip				6				Left Speaker
P	18/2			(9) VC	R out	(11) SP	Strip				6				Right Speaker
R	22/2			(7) MS	crimp	(8) MS	crimp						10		Zone 1 Door

Cable:		C5	R6	18/2	18/4	22/2	
Total Length:		58	118	24	60	22	0

ABBREVIATIONS

DC = Distribution Center
F = F connector
VC = Volume Control
SP = Speaker
MS = Magnetic sensor
CM = Coax Module
VM = Voice Module
DM = Data Module
SM = Speaker Module
MOD = Modulator Module
LUT = Leave UnTerminated
BP = Binding Post

REVISED 01/28/08

Figure 7: Sample Cable Schedule

Equipment List

Job: _____ Job ID: _____

Location: _____

Prepared by: _____ Date: _____

		Voice/Data/RF				Video	Audio						
		OUTLETS						Speakers					
LOCATION	ID	Voice	Data	Coax EXT	Coax INT	VID	LINE	WALL	CEILING	Binding Posts	V/C	IR	Other / Notes
LOCATION	**1**	1		1									1G co-locate, 2-port insert
North Wall	**7**												Mag. Window sensor
East Wall	**3**									L/R			2G, 4-port insert (BP)
East Wall	**3**					CMPST	L, R						4-port insert (3 RCA for L/R/V) Use Red, White, & Yellow
East Wall	**4**										VC		1G
East Wall	**5**							Left					5" In-Wall Speaker
East Wall	**6**							Right					5" In-Wall Speaker
West Wall	**2**	1	1	1	1								1G, 4-port wall plate
South Wall	**8**												Mag. Door sensor RETRO
South Wall	**9**										VC		1G, RETRO
South Wall	**10**							Left					5" In-Wall Speaker RETRO
South Wall	**11**							Right					5" In-Wall Speaker RETRO

REVISED 1/28/08

Figure 8: Sample Equipment Schedule

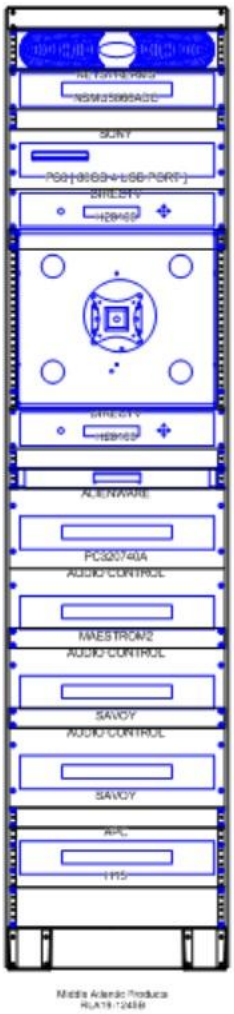


Figure 9: Sample Rack Elevation

ANNEX B: Sample Scope Document

Victorian Village Home Theater Scope Definition Document

Project Name: Victorian Village Home Theater Project

Project Manager: Amy

Project Sponsor: Bob and Vicki Client

Date Prepared: 2010

Prepared by: Amy

Project Concept

Problem/opportunity: single room, current TV not useful or visually appealing, not meeting needs.

Client needs: High performance luxury item needed.

Project priorities: Keeping integrity of Victorian layout while meeting the needs of the client (does not want to see the equipment), having a level of perfomance that meets the expense.

Project Objective

Who? Single family home (client).

What? High performance single room home theater.

Why? Client wants to improve home entertainment experience.

Rough time frame: Hard deadline. Project needs to be complete in 6 months.

Budget projection: $xx,xxx.xx

Change Control Process

Request for change: No current requests

Analysis of impact: Will use risk matrix and change control process to document and analyze.

Approval procedure: Client sign-off required on all changes.

CEA Document Improvement Proposal

If in the review or use of this document, a potential change is made evident for safety, health or technical reasons, please email your reason/rationale for the recommended change to standards@ce.org.

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Technology & Standards Department
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CEDIA CUSTOM ELECTRONIC DESIGN & INSTALLATION ASSOCIATION

CEA Consumer Electronics Association