Energy, Efficiency, & Noise in Audio Cables

MIT® Technologies—as related to Imaging
A Technical Overview

MIT Interfaces are well-known for their ability to reproduce accurate sonic images. This ability results from three key MIT technologies — Input Terminator technology, Output Terminator technology, and CVT Coupler technology.

MIT's patented interface technologies involve the use of numerous electrical component parts that are not found in ordinary cables. The housings that hold these additional parts give MIT Interfaces a distinctive appearance that is a first clue to their superior performance. Unlike ordinary cables, MIT's application of these technologies also requires MIT Interfaces to be correctly oriented in the audio system. This paper describes these key MIT technologies and discusses the sonic benefits that they deliver to any audio system.

The most dramatic sonic results of MIT's Interface technologies are the size and quality of the imaging and soundstaging that these technologies produce. While audiophiles may debate many aspects of an audio system's performance, there is nearly uniform agreement that systems employing MIT Interfaces are able to reproduce recorded music with the largest and most accurate soundstages possible — they reproduce with ease the room cues, micro-details, and subtle overtones that are missing with other cable systems.

This ability to create a natural image is a result of the action of three major MIT technologies: **Output Terminator technology, Input Terminator technology**, and **CVT Coupler technology**. Each technology plays a separate and vital role in an audio system's ability to deliver stable, believable imaging and to create a realistic soundstage. These technologies are used singly or in combination in the three MIT Interface Series.

ENERGY AND EFFICIENCY— KEYS TO OVERALL SOUND QUALITY

Understanding the importance of MIT Interface technologies requires knowing something about how electrical energy is moved from one component to the next in an audio system. Energy is the ability to do work, while power is a measure of how much work is done in a given amount of time.

Musical signals, in electrical form, are complex combinations of voltages and currents, with each signal frequency having its own voltage and current. As these voltages and currents travel from one component to the next through an interconnecting cable or speaker cable, they are briefly stored in the cable as Energy. The voltages are stored in the cable's capacitances and the currents are stored in the cable's inductances. Combined, the stored voltages and currents form what MIT calls the **Final Energy Component**. MIT has discovered that the larger the Final Energy Component, the better the sound quality of a cable.

MIT®

When the time relationships between the voltages and currents of each frequency (called their phases) are correct, all of the stored energy is transported in phase from the cable to the component or speaker. MIT calls this energy transportation **Efficiency**. When all of the voltages and currents of a signal have their correct phase relationships, Efficiency is 100%, and the stored energy is delivered as in-phase power. MIT has found that the higher the Efficiency, the better and more accurate the sound quality of a cable.

Input Terminator Technology — Key to the Size and Shape of the SoundStage, and to Overall Tonality and Dynamics

MIT's Input Terminator technology stores electrical (musical) energy in a linear and predictable manner. The quality of this energy storage directly controls the quality of the reproduced soundstage and the tonality of the musical presentation.

The MIT Input Terminator technology controls the ability to store energy in a linear relationship to frequency and also controls the amount of energy stored. MIT has found that energy storage directly affects the size and shape of the reproduced soundstage and the overall tonality and dynamics of the presentation.

Soundstage and Image The outer boundaries of the reproduced image in all three axes is defined as the soundstage. The soundstage should not be confused with the image, which is the ability to reproduce a specific event in space. Rather, the soundstage defines the space that the event — the image — takes place in. Seen this way, the soundstage encompasses the acoustic characteristics of the hall in which the event was recorded. Accurately reproducing the event space in the listening room is essential to the High End listening experience.

The soundstage is defined as the outer boundaries of the recreated space in which the recorded event takes place. The ability to correctly place a specific acoustic event within the soundstage is called imaging.

MIT views the soundstage as a geometric solid that is produced in the listener's room. In addition, the boundaries of the soundstage should take on the characteristics of the event's original boundaries. For example, if the event was recorded at Carnegie Hall, then the boundaries of the soundstage should have the same acoustical characteristics as Carnegie Hall. That is, the apparent reflections, natural reverberation, and decay of sound energy in the environment of Carnegie Hall should be accurately recreated in the listener's room. Listeners should feel as if they have been transported to Carnegie Hall.

Reproducing the environmental nuances of the room in which a recording is made is one of the most difficult tasks in High End audio. Doing this places high demands upon the accurate handling of energy within all of the system components, including it's interfaces.

The walls of Carnegie Hall are physical boundaries to the acoustical energy within the hall. Reproducing the acoustic energy fingerprint of a hall requires the precise storage and transportation of electrical energy within the audio system, and especially through the system's cabling.

Ordinary cables store more energy at high frequencies than at midrange or bass frequencies. This causes an audible emphasis of high frequencies that makes music sound "bright" and "over-articulated."

▶ A fundamental discovery at MIT is that ordinary cables store energy in a non-linear manner with respect to frequency. This flaw manifests itself in three ways:

Audible emphasis At those frequencies where more energy is being stored, a tonal emphasis occurs. This emphasis occurs event-wide. For example, if a cable stores more energy at 1 kHz and above than at frequencies below 1 kHz, all information in the recording over 1 kHz, including room details, will be emphasized over information below 1 kHz. Audiophiles describe this defect as "poor tonality."

Because ordinary cables store less energy at midrange and bass frequencies than at high frequencies, they result in poor bass dynamics and a lack of bass "weight."

Poor dynamics At those frequencies where more energy is stored, a dynamic emphasis occurs. This emphasis also occurs event-wide. For example, if a cable stores more energy at 1 kHz and above than it does at frequencies below 1 kHz, all information in the recording over 1 kHz, including room details, will possess greater dynamic range than information below 1 kHz. Audiophiles describe this as "loss of weight" or "loss of impact" in the de-emphasized frequency range, or else as an "over-articulation" in the emphasized frequency range.

The non-linear energy storage of ordinary cables causes them to distort the size and shape of the soundstage. This makes the treble region appear to be located forward and up, while the bass region appears to be low and away from the listener.

Distortion of the size and shape of the soundstage As mentioned earlier, the soundstage boundaries should take on the size, shape, and characteristics of the event hall. However, when there is frequency-dependent, non-linear energy storage occurring in a system, the event space becomes distorted. At frequencies where there is more energy storage, musical information will seem to the listener to be elevated in space and "thrown" forward towards the listener. Conversely, frequencies having relatively less energy storage appear to be lowered in space and "pushed" to the rear. Audiophiles describe this distorted presentation as having the sopranos and strings artificially located overhead, while the bass instruments are located on the floor, far away. Overall, the presentation appears to be confined to a skewed plane, which runs from the stage's back floor, up and overhead.

MIT's Input Terminator technology eliminates unwanted audible emphasis and preserves natural tonality by increasing and linearizing energy storage throughout the audio spectrum.

The MIT Input Terminator technology greatly increases energy storage. This enables the audio system to recreate a larger and more accurate soundstage.

▶ MIT's Input Terminator technology corrects these defects by using a two-pronged approach to store energy in a linear and predictable manner:

Storing energy in a linear relationship to frequency A fundamental job of the Input Terminator is to eliminate the audible emphasis caused by the frequency-dependent, non-linear energy storage characteristics found in ordinary cables. The audible results of this improvement are much more natural tonality and more accurate reproduction of the original event hall's shape and size.

Storing a predictable amount of energy The size of the reproduced soundstage is directly related to the amount of energy stored. The ability to design Input Terminators that accurately control the amount of energy stored within the Interface enables MIT Interface-equipped audio systems to reproduce accurate soundstages. This design ability allows MIT to use this technology in different product series with consistent and predictable results.

OUTPUT TERMINATOR TECHNOLOGY — KEY TO EFFICIENCY, SOUNDSTAGE DEFINITION AND IMAGE SPECIFICITY

MIT's Output Terminator technology transports the energy stored by the Input Terminator as in-phase power. This increases the audio system's ability to fully utilize the musical energy. The percentage of energy transported as in-phase power is called Efficiency.

MIT's Output Terminator technology controls the ability to deliver energy as in-phase power. In order for speakers and other devices to fully use the musical signal energy, it must be transported accurately and efficiently. MIT quantifies how well energy is transported through a cable as Efficiency.

MIT defines "imaging" as the ability of a system to recreate a specific sound event, such as an instrument, with its proper location in space. High Efficiency is crucial to achieving an accurate image. For example, in a situation where a system is reproducing an instrument that is recorded dead-center, the major difference between left and right channel information is in the room cues — the reverberation, apparent reflections and acoustic decay — that place the instrument within the soundstage; the tonal content of both channels is essentially the same.

In High End audio, driving the speakers with great accuracy is essential because the information that creates a great High End presentation is contained in signals where the differences between left and right channels are very small. The challenge in reproducing these small interchannel differences is revealed by specialized test equipment. When a musical signal is viewed on an oscilloscope, one sees that the information of the room cues — location, reverberation and decay — is very small in amplitude compared to the tonal information. Therefore, efficiently transporting this low-level information is crucial to achieving proper imaging.

Poor Efficiency causes poor imaging and a poor definition of the soundstage boundaries.

The low Efficiency of ordinary cables produces noise that prevents the audio system from imaging accurately.

The non-linearity of the Efficiency of ordinary cables with respect to frequency distorts the boundaries of the soundstage.

Poor Efficiency manifests itself in two majors ways:

Lack of precise imaging Poor Efficiency is the result of power not being delivered 100% in-phase. The out-of-phase components manifest themselves as noise. This noise obscures and contaminates the original signal, hiding detail. Furthermore, this noise is released from the cable at random times, causing the reproduced image to shift in space for a short time, blurring the image focus.

Indefinite soundstage boundary As well as preventing an audio system from producing specific images, poor Efficiency can cause the outer boundaries of the soundstage to appear undefined and even to change size with the loudness of the music. The noise associated with poor Efficiency causes a masking of the outer edges of the soundstage, blurring the definite physical dimensions of the event space.

Furthermore, frequency-dependent, non-linear Efficiency often causes the apparent loudness to be non-linear, as well. For example, a cable that is more efficient in the upper treble often is more efficient at higher loudness levels, too. Audiophiles perceive that the upper treble registers not only appear higher in space, but the event space at that frequency appears wider, as well.

MIT's patented Output Terminator technology increases and linearizes Efficiency with respect to frequency. This produces an accurate image that is correctly located within a natural soundstage — another MIT Interface hallmark.

MIT's Output Terminator technology reduces noise, especially at low frequencies. This results in the distinctive bass weight for which MIT Interfaces are famous.

▶ MIT's Output Terminator technology corrects these flaws by using a two-pronged approach:

Higher Efficiency A major job of the Output Terminator technology is to reduce noise by increasing Efficiency. By reducing the noise caused by out-of-phase power, MIT Output Terminator technology significantly reduces overall noise, particularly in the low frequencies, where ordinary cables are the least efficient. Higher Efficiency means less noise, and less noise means more precise imaging. The Efficiency increase produced by MIT's Output Terminators is responsible for the distinctive bass weight often associated with MIT products.

More linear Efficiency with respect to frequency In addition to having higher Efficiency, it is extremely important that the Efficiency be as linear as possible throughout the audible frequency spectrum. Linear Efficiency translates directly into correct placement of the image within the soundstage, as well as preserving the natural boundaries of the soundstage. The ability to design Output Terminators that accurately and predictably maintain high Efficiency enables MIT to use this technology successfully in each of its product series.

CVT Coupler Technology — Key to Lowest Noise Floor and Best Focus

The significantly reduced noise of MIT's patented CVT Coupler technology was a breakthrough in audio cable technology.

The unpredictable high-frequency behavior of ordinary cables injects noise into the audio signals. This phenomenon, discovered by MIT, raises the system noise floor and prevents correct image focus.

One of the first technologies developed by MIT was the CVT Coupler. A passive network installed at the input of the cable, the CVT Coupler controls the cable's behavior in the frequency ranges that lie above the audio spectrum and below the cut-off frequency of the amplifier. Early research by MIT showed that audio cables behaved very erratically just above the audio range and that this behavior was responsible for injecting noise down into the audible frequency range. By shunting unwanted noise to ground, MIT's CVT Coupler technology greatly reduces the noise floor of the system. This MIT technology was responsible for a quantum leap forward in audio cable performance.

- Ordinary cables have noise problems in the upper frequency range that manifest themselves in two ways:

  Higher noise floor Ordinary cables inject random, spurious noise into audio signals, effectively raising the noise floor. This added noise masks both the silence between passages and the lower-level musical detail.

  Poor image focus The noise injected by ordinary cables often masks detail in a random manner, making image focusing imprecise and vague. While some image specificity does occur, the noise prevents overall precise, life-like, stable image focus in the soundstage, and the goal of image specificity, regardless of the surrounding performance levels, is nearly impossible to achieve.

The MIT CVT Coupler technology controls high frequency behavior. This reduces noise and enables the audio system to precisely focus images on a noise-free background.

- MIT's CVT Coupler technology corrects these errors in the following ways:

  Lower noise floor The CVT Coupler lowers the apparent noise floor by shunting unwanted high-frequency noise to ground in a predictable, effective manner. Lowering the noise floor recovers inter-transient silence as well as low-level detail such as room cues. This is crucial for proper soundstaging.

  Precise focus Lowering the noise in both channels enables the two channels to work together correctly to prevent noise from masking low-level detail and inter-transient silences, and to keep images from "jittering around" within the sound stage. As a result, the audio system is able to reproduce superbly stable and focused images. Furthermore, the CVT Coupler technology improves the correct acoustic summation of the two channels, resulting in enhanced dynamic range. This means that stable focus is maintained over wide differences in performance loudness levels.

SYNERGISM

Because MIT's three technologies are each designed to do a specific job, they are able to work together, as a synergistic system.

While each of these MIT technologies is useful alone, they only achieve their full potential when utilized together, synergistically. The following describes the three MIT product families and the technologies they utilize, and briefly indicates the benefits gained:

In the MITerminator Series, the patented Output Terminator technology delivers better bass, better midrange and an enhanced ability to image when compared to ordinary cables, even "high-end" brands.

- MITERMINATOR SERIES — *OUTPUT TERMINATOR.* The MITerminator Series utilizes only the MIT Output Terminator technology. Compared to ordinary cables, the audible benefits are:

  Better bass sound Both higher Efficiency and higher energy at lower frequencies results in greatly increased bass weigh. Reduced noise at low frequencies also results in better imaging at lower frequencies, further adding to the perception of greater bass weight.

  Better midrange sound Most audio cables are highly inefficient below 1 kHz. All products in the MITerminator Series have greater than 50% Efficiency down to 120 Hz. This means that all of the musical information above 120 Hz is transported efficiently as in-phase power. This results in a cleaner and more articulate upper bass and midrange. Efficient transportation of music in the upper bass and midrange frequency region from 120Hz to 1kHz is crucial, because many of the fundamental frequencies of music are contained in this spectrum.

  Enhanced image The MITerminators' linearity of Efficiency with respect to frequency allows an audio system to reproduce images located in the full span between the speakers. Also, the reduction in noise provided by the Output Terminator networks provides a quieter background upon which to project the soundstage. The combination of linear Efficiency and noise

reduction results in an enhanced image that is far more natural and life-like than that produced by ordinary cables.

In the High End Series, the Output Terminator technology is teamed with the CVT Coupler technology to deliver greater bass extension than the MITerminator Series, with an expanded ability to image and focus.

▶ HIGH END SERIES (SERIES 2) — *OUTPUT TERMINATOR WITH CVT COUPLER.* This combination provides a significant step-up in performance compared to the fine MITerminator Series. This level of performance was previously available only in MIT's reference-level products:

Better bass sound More sophisticated Output Terminators provide efficient in-phase power transportation and greater energy storage down to 20 Hz, offering improved resolution of bass detail and greater bass weight.

Better midrange sound Higher and more linear Efficiency characteristics allow an audio system to resolve midrange articulation more cleanly and more quickly.

Expanded image The CVT Coupler, teamed with the Output Terminator, provides a significantly lower noise floor. This quieter background, as well as the precise focusing brought about by the CVT Coupler, allows for an expanded image that reaches out to the edges of the speakers, with added height and depth, as well — truly a High End image.

In the CVTerminator Reference Series, all three of MIT's technologies are employed to deliver no-compromise, Stable Image Technology performance. This full application of MIT's technologies results in the creation of the celebrated 2C3D Holographic soundstage.

▶ CVTERMINATOR REFERENCE SERIES — *INPUT TERMINATOR, OUTPUT TERMINATOR, AND CVT COUPLER.* The ultimate expression of MIT technologies, the CVTerminator Series offers performance and quality unmatched by any other wires or cables, regardless of selling price. The CVTerminator technology team provides:

True, neutral tonality The combined Input and Output Terminators provide for an effortless, noise-free storage and release of musical energy, removing any unnatural audible emphasis.

Unsurpassed Efficiency Teaming the Input Terminator with the most sophisticated Output Terminator ever developed by MIT yields more noise-free energy at lower frequencies than any other Interface. Furthermore, the Reference Series reproduces bass energy effortlessly down to 5 Hz, which is as low as our test equipment can measure. The result is life-like bass sound that is limited only by the audio system and the room. In addition, the upper bass and midrange regions are completely unrestrained, allowing for full transportation of all of the articulation and detail contained in the original recording.

2C3D imaging All three MIT technologies together create the most stunning result of all: The 2C3D Holographic soundstage. When the pinpoint imaging of the CVT Coupler is added to the noise-free storage and transportation of the Input and Output Terminators, the result is Stable Image Technology (SIT). SIT is the technology combination that MIT uses to enable a superior system to project a noise-free, three-dimensional soundstage and to place images within it that stay fixed regardless of the intensity of the program material.

Each Series of MIT Interfaces provides huge audible benefits over any ordinary speaker and interconnecting cables. The synergism of MIT's key technologies also means that the High End Series offers substantial sonic improvements over the MITerminator Series, and that the CVTerminator Reference Series offers still higher sound quality compared to the High End Series.

Just as each succeeding MIT Interface Series offers an expansion of the use of key technologies to improve sound quality over the previous Series, so too does MIT's design predictability and scalability let Interface products within each Series offer improved performance from one to the next. This means that there are MIT Interfaces to suit every audio system, every budget, and every level of desire for audio reproduction quality.

Zip— Ordinary cables, such as the 12-gauge "zip cord" shown here, are unable to create realistic, life-like soundstages and cannot correctly place instruments or voices within them. As shown, the soundstage is small and constricted. The image is unfocused and unclear, and lacks appropriate size and definition.

High End Cable— Even so-called "audiophile" cables fail to create a believable sense of the space in which the recording took place. Although the image is larger than that of ordinary 12-gauge cable, it remains unfocused and lacks clarity and detail. Ordinary "audiophile" cables cannot provide the weight, clarity and dimensionality on which the proper reproduction of music depends.

Imagine two graphic artists trying to verbally describe a color that is somewhere between orange and red. Mere words can not describe the infinite shades between orange and red that exist. To solve this predicament, artists refer to a standard color chart, which enables them to effectively and quickly communicate about the color to resolve their problem.

Effectively communicating the sonic qualities of audio systems can be even more challenging, because there is no standard audio "color chart." What is meant by comparative statements such as "better soundstage" or "more life-like image"?

Because of these difficulties, MIT has developed test and measurement techniques to quantify how and why audio cables sound different from one another, with the goal of presenting graphic results that allow comparison of the sonic benefits of different audio cables visually, the way colors can be compared.

The results are shown in the following illustrations. Based on MIT's test and measurement analysis, these graphic renderings visually represent how a soundstage and image might appear if one could see an audio system's reproduction.

The illustrations point out two critical areas of High End audio system performance: Soundstaging and imaging. As explained previously, the soundstage is defined by the three-dimensional boundary limits of the system's presentation, while the image is the reproduction and localization of a specific acoustic event, such as a voice or instrument, occurring within the soundstage.

In MIT's comparative system, the soundstage is represented by a three-dimensional solid indicating the boundaries of the system's presentation, while the image is represented by a musical note indicating an acoustic event.

MIT MITerminator Series— MIT's affordable MITerminator Interfaces generate a large, believable soundstage which has plenty of room for life-like images to develop within. The image itself is accurately located, and has the dimensionality and clarity necessary to be called "High End." The MITerminator interfaces readily outperform "audiophile" cables and interconnects costing far more.

MIT High End Series— MIT's High End Series Interfaces create room-filling soundstages that transport the listener into the space in which the original performance took place. The compelling size, focus, clarity and dimensionality of the image assure that every voice and instrument has its appropriate place and weight in the soundstage. This ability to faithfully reproduce musical sounds is the reason for High End audio, and for MIT's dedication to designing and manufacturing the world's finest interfaces.

Thanks to these graphic representations, the qualities of audio cables are readily compared by the relative sizes and shapes of their soundstages and by the relative sizes, shapes, and clarity of the musical notes. The larger the soundstage graphic, the more unconstricted and life-like the presentation. **The larger, more three-dimensional, and clearer the note, the more accurate and life-like the location and presentation of acoustic images within the soundstage.**

MIT®

MUSIC INTERFACE TECHNOLOGIES™
Products are manufactured & sold by CVTL, Inc.
4130 Cutrus Ave., Suite 9 • Rocklin, CA 95677
TEL: (916) 625-0129 • FAX: (916) 625-0149