GAITRite Electronic Walkway Technical Reference

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CONTENTS

1.0 PRODUCT INFORMATION

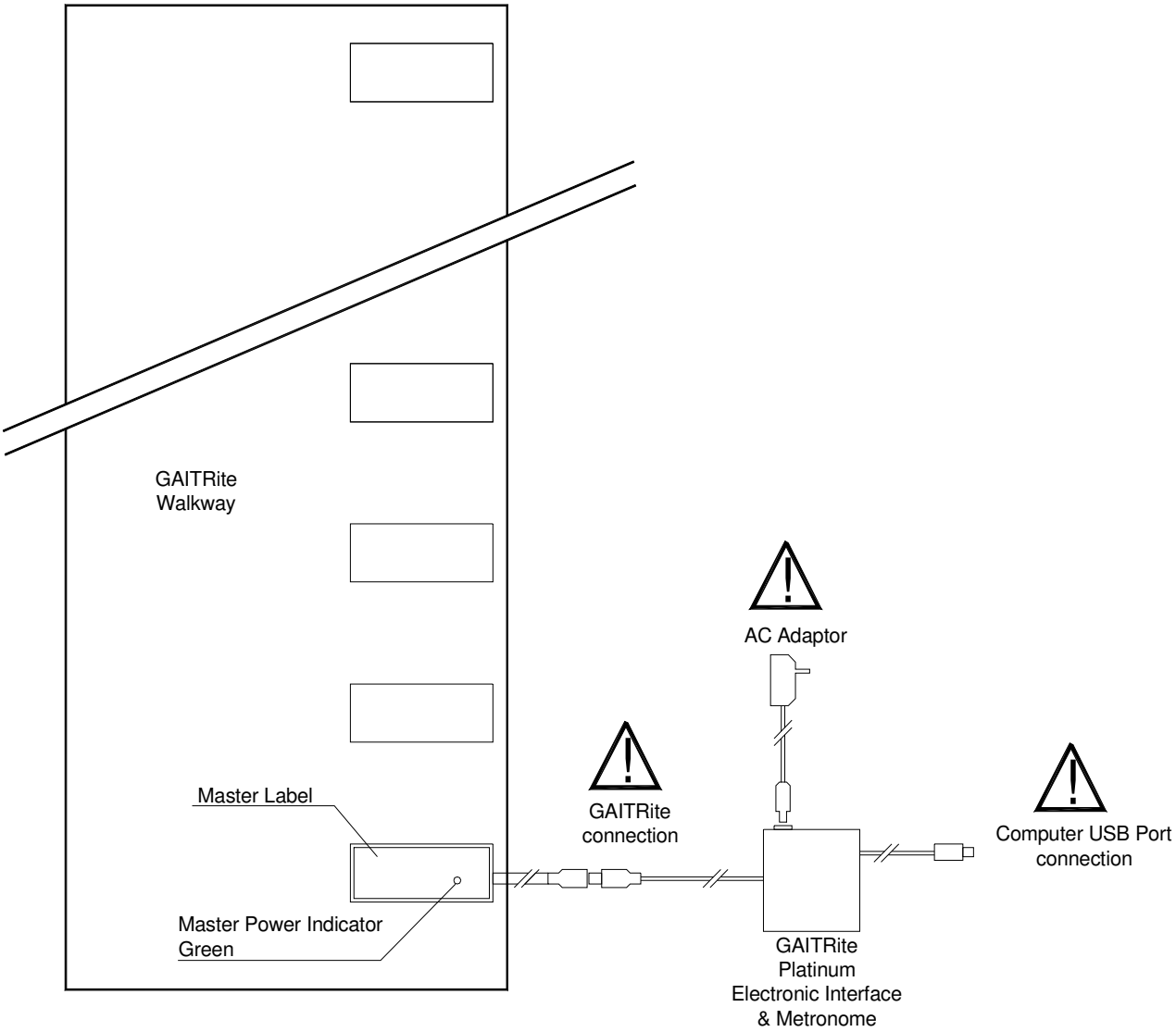
Product Name	The GAITRite Electronic Walkway
Manufacturer Name	CIR Systems Inc.
Address	8 John Walsh Blvd. Suite 429 Peekskill, N.Y 10566 USA
Country of Manufacture	United States
Certifications	ISO 13485:2003 CE

2.0 The GAITRite Walkway

2.1 Intended Use

The GAITRite System is an electronic walkway utilized to measure the temporal (timing) and spatial (two dimension geometric position) parameters of its pressure activated sensors. The GAITRite system's intent is to be utilized as a measuring device for the events occurring during biped and quadruped locomotion.

Inferred parameters are easily obtained by applying common physics and math formulas to the directly measured temporal and spatial data i.e calculate velocity, relationships between spatial and temporal events etc.



2.2 Safety Instructions

WARNING	• Make sure you have read and understood all the information listed in this document and the User's Manual. If you require additional information and/or training, please contact our Customer Service. • The company assumes that the user is trained in relevant professional fields or is familiar with the measurements provided by the GAITRite system. • The company assumes that you have read and understood the intended use of the GAITRite system and the safety instructions. • Before allowing subjects to ambulate across the GAITRite walkway, the subjects must be given adequate support, based on an assessment of their gait and balance abilities. • Barefoot testing is not recommended. If the protocol requires you to test barefoot, then you will have to setup your own quality procedure that follows the disinfection rules per our cleaning instructions and accounts for allergy/irritation produced, on the bare feet, from the walkway's top surface. • The GAITRite equipment should be installed and set up in the test area prior to the arrival of any Subjects. • Cables must be routed in a safe manner to avoid any risk of tripping Subjects and users. Adhesive tape can be utilized to affix cables on the floor. • For safety, prepare the subjects by pointing out the tripping hazards posed by the perimeter height of the walkway and the routed cables. • For safety, Subjects should stand on the "dead" area of the walkway before beginning a test, thus avoiding to trip at the entry point of the walkway. • The test area must be large enough for a fully unrolled walkway and also provide ample space at the beginning and end of the walkway for the Subjects to safely start and finish their walk. • When lifting, packing or relocating the GAITRite walkway, make sure that you observe proper lifting for heavy items, 60-120 Lbs. • The floor of the test area must be clean and completely dry prior to unrolling the walkway. • Before testing Subjects, make sure their shoes do not have points or sharp edges that can damage the surface of the walkway. • Do not use damaged or frayed GAITRite equipment.

2.3 Connecting the Walkway

To connect the GAITRite walkway follow these steps:

1. Make sure the computer is turned on
2. Unroll the electronic walkway
3. Utilize ESD cautionary procedures and connect the USB plug of the Interface Cable to an available USB port on the PC.
4. Utilize ESD cautionary procedures and connect the fire-wire connector, of the Interface Cable, to the GAITRite walkway.
5. Plug the AC Adaptor into a mains and connect the other end to the “Power Input” of the Interface Cable.

CAUTION **Do not use power adapters and/or cables other than those supplied with your GAITRite equipment.**

ESD CAUTION **The GAITRite walkway is considered an ESD (Electronic Discharge) sensitive device. Electrostatic discharge as high as 4000V readily accumulate on the human body and can discharge without detection. Although the GAITRite walkway features protection circuitry, permanent damage may occur when subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.**

2.4 Connection Problems

If the walkway is not working properly follow these steps to determine the area of the problem:

1. Check the power light on the Interface Module, if it is ON=lit go to step 2. If the light is not on check the wall outlet, if determined that it is working properly then contact our Customer service department.

2. Check the Green power light, located on the Master cover of the GAITRite Electronic Walkway, if it is not ON=lit then be sure the cables are securely attached. If you determined that all cables are secured then the problem is a failure of the Interface Cable contact our Customer service department.

2.5 Service Procedure

The GAITRite does not contain any serviceable parts. Please, contact our Technical Support department.

2.6 Cleaning Instructions

The walkway requires periodic cleaning in order to prevent a build up of dirt and contaminants. The correct cleaning procedures are:

WARNING	• Before cleaning ensure that the GAITRite equipment is disconnected from the mains (power outlets) and any peripheral devices. • The walkway may be cleaned with a damp cloth using any proprietary solution of mild detergent or disinfectant. Do not use solvents or abrasives. • Afterwards, moisten a clean cloth with clear, cold water and wipe the walkway surface. • Allow the walkway to dry completely before use. • Do not place the walkway near any flame or ignition sources, and do not drop lighted cigarettes/matches on or near the walkway.

2.7 Storage and transporting

For storage or transporting, the walkway must be properly rolled round the cardboard cylinder and placed in the storage container provided.

WARNING	• Always lay the container on its side. As indicated by the labels do not stand it on end. • Do not fold, crease or puncture the walkway, as this will void the warranty. • Never move the walkway without first rolling it up on the supplied drum. • If you decide to allow the walkway to permanently lay on the floor then make sure you provide adequate protection from rolling heavy equipment over the walkway. • If you decide to allow the walkway to permanently lay on the floor then make sure you provide adequate signs to warn the floor cleaning personnel to keep a distance while mopping the floors. • If you decide to allow the walkway to permanently lay on the floor then make sure you that the area will not flood during storms. If uncertain, please remove the AC Adapter from the mains, when the walkway is not in use.

2.8 Environmental Specifications for the GAITRite System

Condition	Specification
Storage & Transportation Temperature/Humidity	-29 to 50 degrees C (-20 to 122 degrees F) Relative humidity up to 80% (up to 31 degrees C) decreasing linearly to 50% at 40 degrees C
Operating Temperature/Humidity	10 to 40 degrees C (40 to 104 degrees F) Relative humidity up to 80% (up to 31 degrees C) decreasing linearly to 50% at 40 degrees C
General Use	**WARNING** **INDOOR USE ONLY.** Not suitable for wet locations.
Flammable Gases	**WARNING** **NOT SUITABLE FOR USE IN THE PRESENCE OF FLAMMABLE ANESTHETIC MIXTURE WITH AIR, OXYGEN, NITROUS OXIDE, WHERE SUCH GASES MAY ACCUMULATE IN CONCETRATION (CLOSED SPACE)**

2.9 Classification of the GAITRite System

Regulatory information	Classification/Specification
Classification According to Directive 93/42/EEC as amended by Directive 2007/47/EC	Class I, Annex V, Rule 1
Technical & Quality Assurance	IEC 60601-1 ISO 13485:2003
Classification of equipment per IEC 60601-1	Class II
Degree of Protection Against Electric Shock per IEC 60601-1	Type B
Degree of Protection Against Ingress of Water per IEC 60601-1	IPX0
Mode of operation per IEC 60601-1	Continuous
Electromagnetic Compatibility and Electromagnetic Emissions Compliance (see attached tests)	EN 60601-1-2:2002 EN 61000-3-2:2000 EN 61000-3-3:1995
Country of Manufacture	USA

2.10 GAITRite Walkway Technical Specifications

Parameter	Walkway Specification
Walkway Overall Dimensions (for 10 pad walkway)	35.25” x 276” x .125” (.250” height of electronics box) 90cm x 700 cm x 3.2 mm (6 mm height of electronics box) Custom lengths are available.
Active Area (for 10 pad walkway)	24” (±.015) x 240” (±.15”) (60.96cm x 609.6cm)
Spatial Resolution	.5” (1.27cm)
Spatial Resolution Accuracy	±.5” (±1.27cm)
Sample Rate	60, 80, 100, 120,180, 240Hz
Temporal Accuracy	±1 sample
Quality Test Method	Each Walkway is placed over existing walkway previously calibrated and compared against 3D Video System. The Ambulation Time Velocity between the two systems are compared. Expected Ambulation time within 1 sample rate Expected Ambulation Velocity within ±2%
Walkway-to-Walkway Spatial Accuracy	±.5” (±1.27cm)
Walkway-to-Walkway Temporal Accuracy	±1 sample
Walkway-to-Walkway Switching Level Accuracy	±.5 switching level
Walkway Top Cover	Flame retardant, anti-slip vinyl
Walkway Bottom Cover	Open cell neoprene rubber
Internal Materials	Uncoated polyesters

2.11 GAITRite Electrical Ratings

Mains power quality should be that of a typical commercial or hospital environment. If the user of the Gaitrite Walkway System requires continued operation during power mains interruptions, it is recommended that the Gaitrite Walkway System be powered from an uninterruptible power supply or battery. Certifications for the specified AC Adaptor can be furnished upon request.

Rating	Specification
WARNING **UTILIZE ONLY THE AC ADAPTOR SUPPLIED WITH YOUR EQUIPMENT.**	
AC Adapter Input Voltage	100-240V- .8-.4 A
AC Adapter Output Voltage	9 VDC 3.0A

2.12 Electromagnetic compatibility

The GAITRite System has been tested and found to comply with the limits for medical devices in IEC 60601-1-2. These are designed to provide reasonable protection against harmful interference in a typical medical installation. In the event of interference, power devices from separate mains supplies and/or increase physical distance between devices. Contact CIR Systems Inc. Customer Service if have any questions.

2.13 Electromagnetic Emissions-Guidance and manufacturer's declaration

WARNING **The Gaitrite Walkway System is intended for use in the electromagnetic environment specified below. The customer or the user of the Gaitrite Walkway System should assure that it is used in such an environment.**

Emissions Test	Compliance	Electromagnetic environment – guidance
RF Emissions CISPR 11	Group 2	The Gaitrite Walkway System must emit electromagnetic energy in order to perform its intended function. Nearby electronic equipment may be effected.
RF Emissions CISPR 11	Class A	The Gaitrite Walkway System is suitable for use in all establishments other than domestic and those directly connected to the public low voltage power supply network that supplies buildings used for domestic purposes
Harmonic emissions IEC61000-3-2	Class B	
Voltage fluctuations /flicker emissions	Complies	

Immunity test	IEC60601 test level	Compliance level	Electromagnetic environment – guidance

Electrostatic discharge (ESD) IEC 61000-4-2	±6kV Contact ±8kV Air	Complies	Floors should be wood, concrete, or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%
Radiated RF IEC 61000-4-3	3 V/m 80MHz to 2.5GHz	Complies	Field strengths outside the shielded location from fixed RF transmitters, as determined by an electromagnetic sit survey, should be less than 3 V/m. Interference may occur in the vicinity of equipment marked with the following symbol: 
Conducted RF IEC 61000-4-6	3Vrms 150kHz to 80MHz	Complies	
Electrical fast transient IEC 61000-4-4	±2kV power line ±1kV I/O lines	Complies	Mains power quality should be that of a typical commercial or hospital environment.
Surge IEC 61000-4-5	±1kV differential ±2kV common	Complies	
Voltage dips, short interrupts and voltage variations on power supply input lines IEC 61000-4-11	>95% dip 0.5 cycle 60% dip 5 cycles 70% dip 25 cycles 95% dip 5 sec.	Complies	Mains power quality should be that of a typical commercial or hospital environment. If the user of the Gaitrite Walkway System requires continued operation during power mains interruptions, it is recommended that the Gaitrite Walkway System be powered from an uninterruptible power supply or battery.

2.14 Walkway Disposal

Disposal of the walkway should be done according to the requirements of the local authorities. The materials included in the walkway are listed in the “GAITRite Materials Specifications” section of this document. Local Authorities may require separation of the electronic devices and recycling during disposal.

3.0 The GAITRite Platinum Interface

This document describes the use and specifications for the GAITRite Interface Module. The Interface Module is not an accessory; it is an integral part of the GAITRite System. It supplies power to the GAITRite walkway, provides the communications cabling between the GAITRite walkway and the host personal computer and provides means to interface and synchronize with external systems.

3.1 Interface Utilities

The GAITRite Interface Module includes standard utilities which are hard-wired, always enabled, and available to communicate with all GAITRite software modules and versions of the GAITRite Electronic Walkway. The standard utilities are:

- Power Input connection;
- Cable to connect to host Computer;
- Cable to connect to the GAITRite walkway; and
- Status indicator.

The GAITRite Interface Module includes optional utilities. Optional utilities must be purchased separately and are enabled from the GAITRite Software. The optional utilities are:

- SYNC OUTPUT interface;
- SYNC INPUT interface;
- METRONOME;
- XBEE RF peripheral Interface;
- Food carrying tray equipped with XBEE RF Inclinometer; and
- Coffee Cup equipped with XBEE RF Inclinometer.

Each utility/connection will be examined separately.

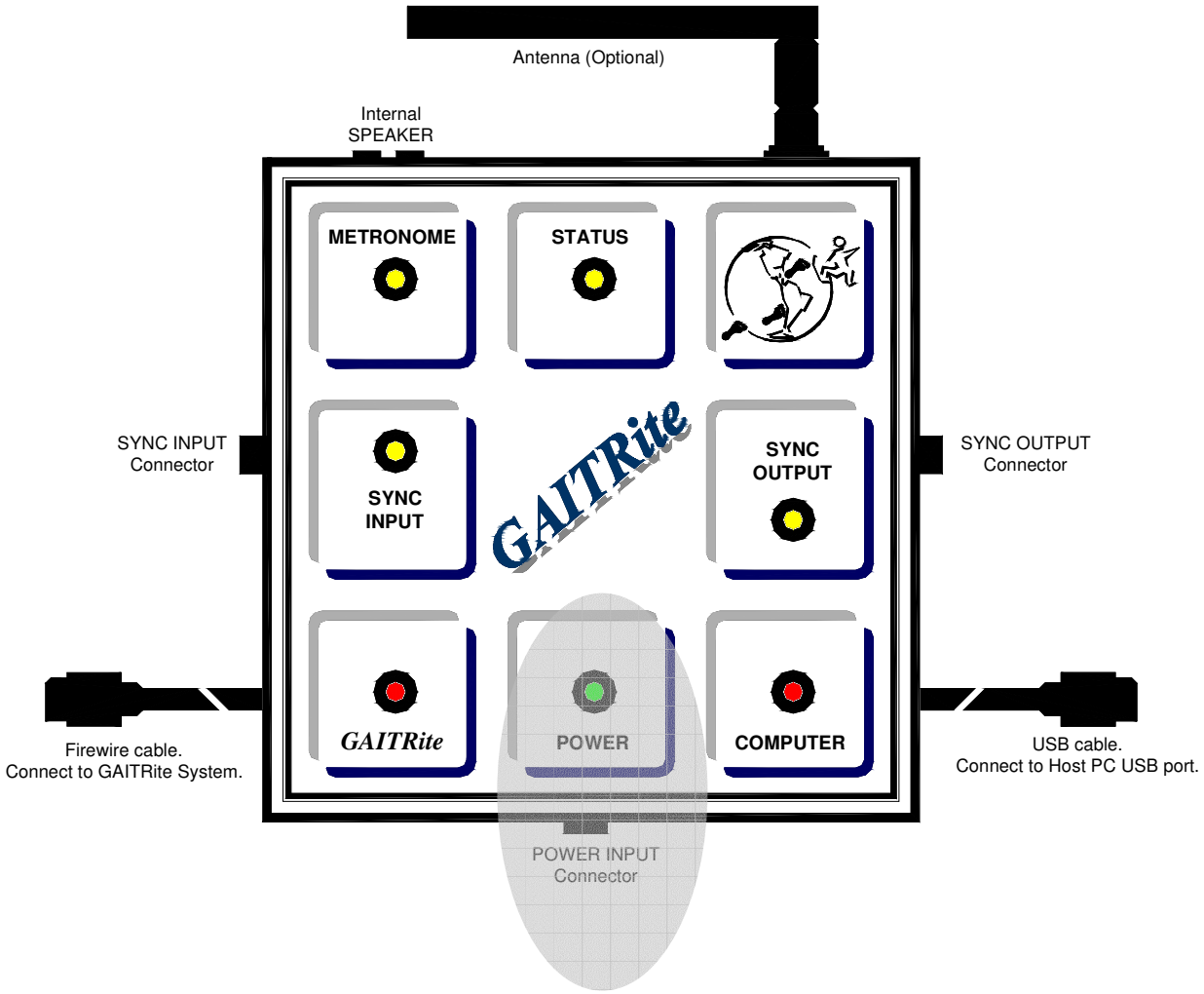
3.2 Power Input Connection

This input connection is designed to accept an external transformer. The AC Adaptor provides power to the Interface Module and to the GAITRite walkway and was selected with very specific characteristics.

WARNING **Do not use power adapters and/or cables other than those supplied with your GAITRite equipment.**

If AC Adaptor failure is suspected, please call our Technical Support Department for a replacement.

To apply power, first connect the AC plug of the external transformer to the AC wall outlet (mains) and then insert the other end, 2.1 mm plug, to the Interface Module Power Input connector. When these connections are done correctly the green light marked "POWER" will be lit (ON) and power is available for the GAITRite Interface Module and the GAITRite electronic walkway. Specifications and certifications for the specified AC Adaptor can be furnished upon request.



3.3 Computer Connection

ESD CAUTION

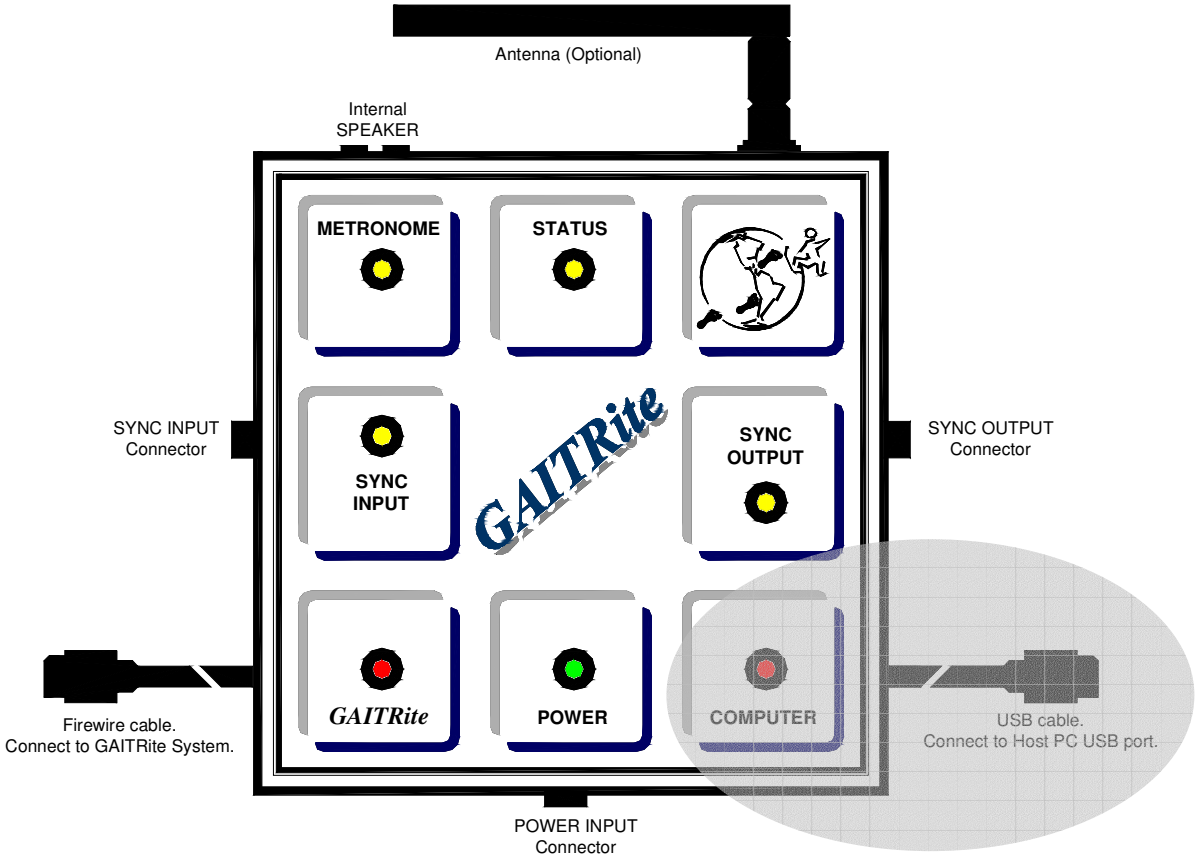
The GAITRite walkway is considered an ESD (Electronic Discharge) sensitive device. Electrostatic discharge as high as 4000V readily accumulate on the human body and can discharge without detection. Although the GAITRite walkway features protection circuitry, permanent damage may occur when subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

A cable, six feet long, has one end hard-wired with the GAITRite Interface Module; the other end has a USB connector ready to plug to a standard USB 2.0 port of a host computer.

Note

An extension cable can be utilized to extend the range of this connection. The total length of this connection should not exceed 12 feet.

With power applied to the GAITRite Interface Module connect this cable to the USB port of your GAITRite computer. The red light associated with this connection, marked “COMPUTER”, will be not lit (OFF) if the computer has successfully communicated with GAITRite Interface Module. The red light will be lit (ON) if the computer can not successfully communicate with the GAITRite Interface Module.



3.4 GAITRite Connection

ESD CAUTION

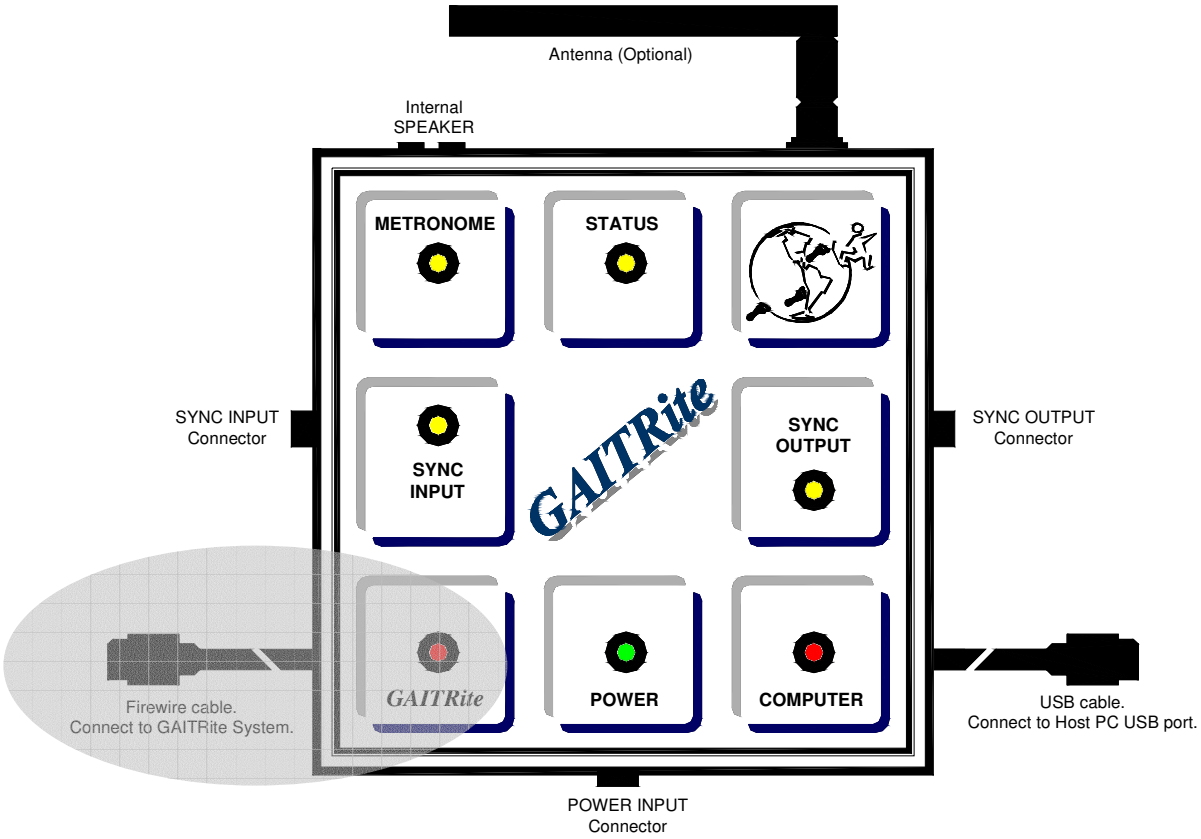
The GAITRite walkway is considered an ESD (Electronic Discharge) sensitive device. Electrostatic discharge as high as 4000V readily accumulate on the human body and can discharge without detection. Although the GAITRite walkway features protection circuitry, permanent damage may occur when subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

A cable, nine feet long, has one end hard-wired with the GAITRite Interface Module; the other end has a "Firewire" connector ready to plug to a Platinum Gaitrite System.

Note

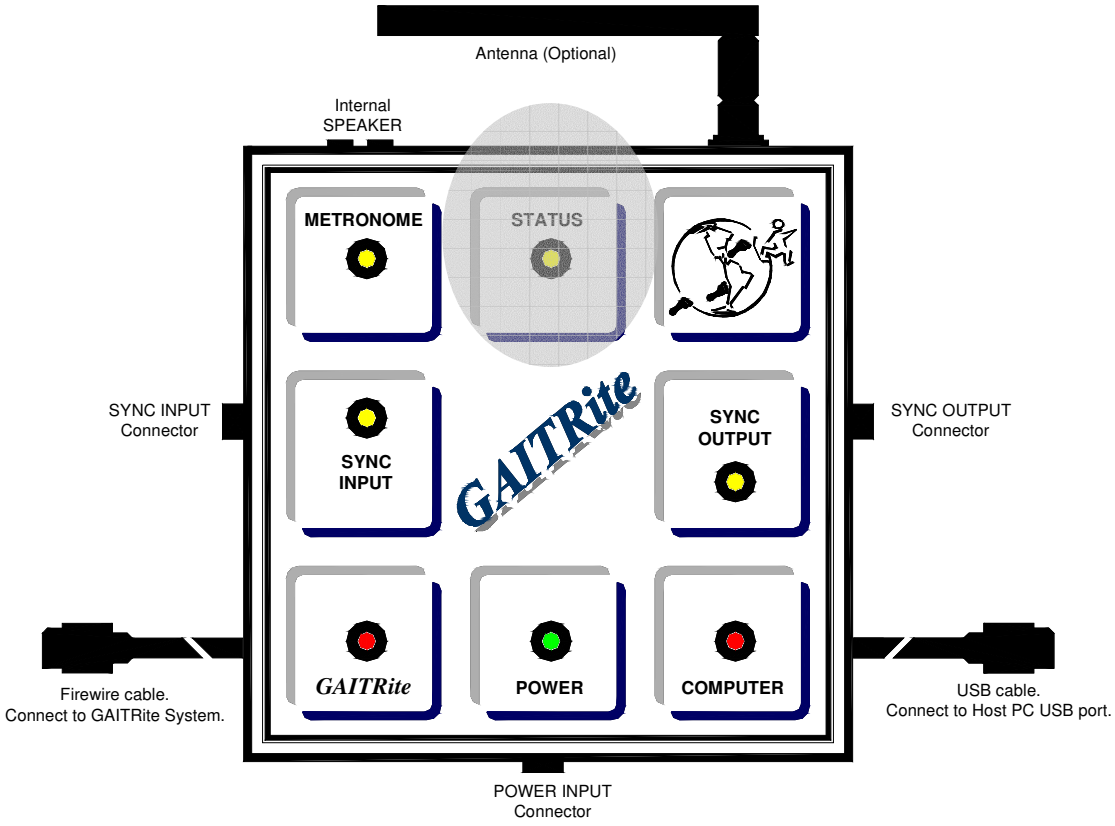
An approved extension cable can be utilized to extend the range of this connection. The total length should not exceed 48 feet. Approved cables are available from our Technical Support Department.

With power applied to the GAITRite Interface Module connect this cable to the walkway. The red light associated with this connection, marked "GAITRite", indicates the status of the connection between the Interface Module and the walkway. The light will not be lit (OFF) if the connection is successful. The light will be lit (ON) if the connector is not plugged into the walkway or the Interface Module can not communicate with the walkway.



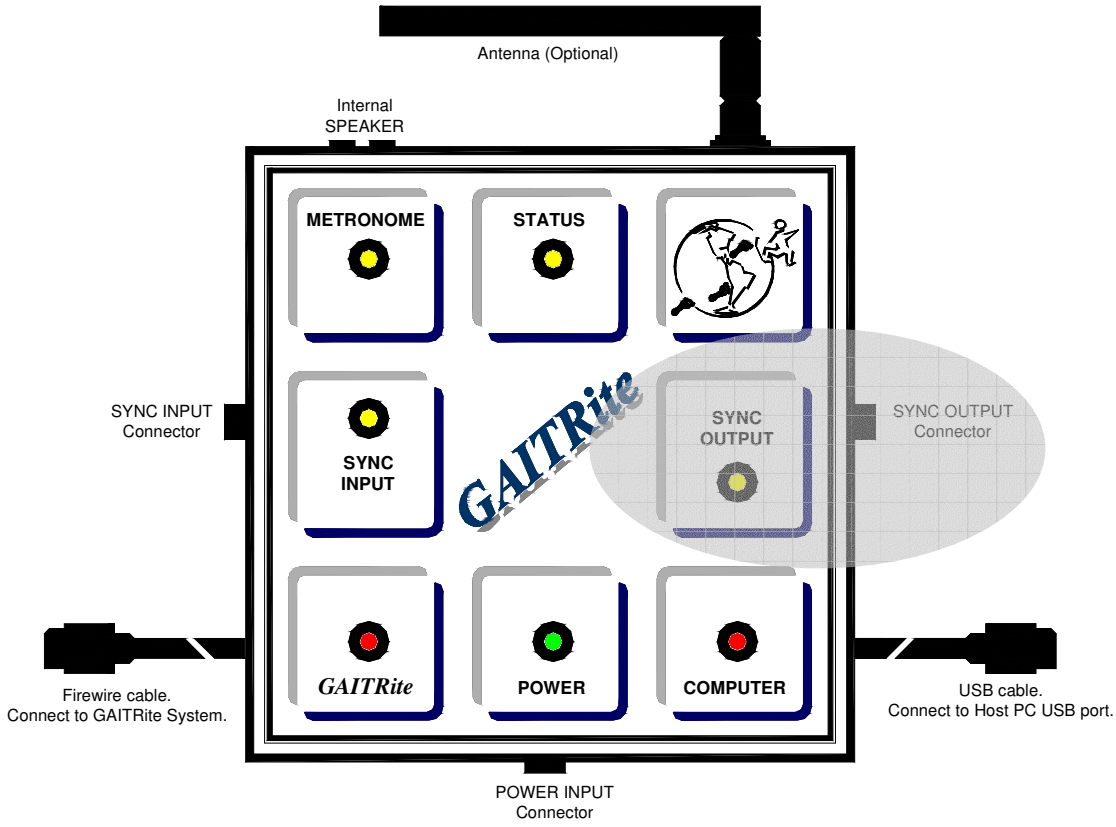
3.5 Status Indicator

A yellow light, marked “STATUS”, is utilized to display errors. It blinks when a problem is encountered. The blinking rate and the number of blinks are utilized by our Technical Support Department to identify the problem. You are encouraged to call our Technical Support Department if you observe a blinking status light after you start a test.



3.6 SYNC Output Connection

The SYNC OUTPUT connection is utilized to synchronize external systems with the GAITRite walkway such as Electromyography equipment etc.



3.6.1 SYNC Output Light

A Yellow light, marked “SYNC OUTPUT” is employed as a visual indicator for the functions associated with this connection.

Lit (ON)= signal at connector output is logic level high
Not Lit (OFF)= signal at connector output is logic level low (Default)

3.6.2 SYNC Output Software Controls

Logic transitions for the SYNC OUTPUT signal can be selected from a list included in the GAITRite Software. The options are shown below:

Signal at SYNC OUTPUT connector	Description
Default Start with SYNCOUT low. During the first scan change SYNCOUT form Low-to-High. At end of test change SYNCOUT back to low.	When this option is selected SYNCOUT starts at level low, SYNCOUT light=OFF. During the first scan the SYNCOUT signal changes state to level high, the light turns ON. It continues on this state until an end of test; the SYNCOUT signal will go back to level low and the light will turn OFF.
Start with SYNCOUT high. During the first scan change SYNCOUT form High-to-Low. At end of test change SYNCOUT back to high.	When this option is selected the SYNCOUT starts at level high, SYNCOUT light=ON. During the first scan the SYNCOUT signal changes state to level low, the light turns OFF, not lit. It continues on this state until an end of test; the SYNCOUT signal will go back to level high and the light will turn ON.
Start with SYNCOUT low. Upon detecting first sensor activity change SYNCOUT form Low-to-High. At end of test change SYNCOUT back to low.	When this option is selected SYNCOUT starts at level low, SYNCOUT light=OFF. The SYNCOUT will remain low until the first sensor change is detected: during this scan the SYNCOUT signal will change state to level high, the light will turn ON and will continue on this state until an end of test: the output signal will go back to level low and the light will turn OFF.
Start with SYNCOUT high. Upon detecting first sensor activity change SYNCOUT form High-to-Low. At end of test change SYNCOUT back to high.	When this option is selected SYNCOUT starts at level high, SYNCOUT light=ON. The SYNCOUT will remain high until the first sensor change is detected: during this scan the SYNCOUT signal will change state to level low, the light will turn OFF and will continue on this state until an end of test: the output signal will go back to level high and the light will turn ON.

3.6.3 SYNC Output Port Electrical Characteristics

The SYNC OUTPUT signal has the following electrical characteristics:

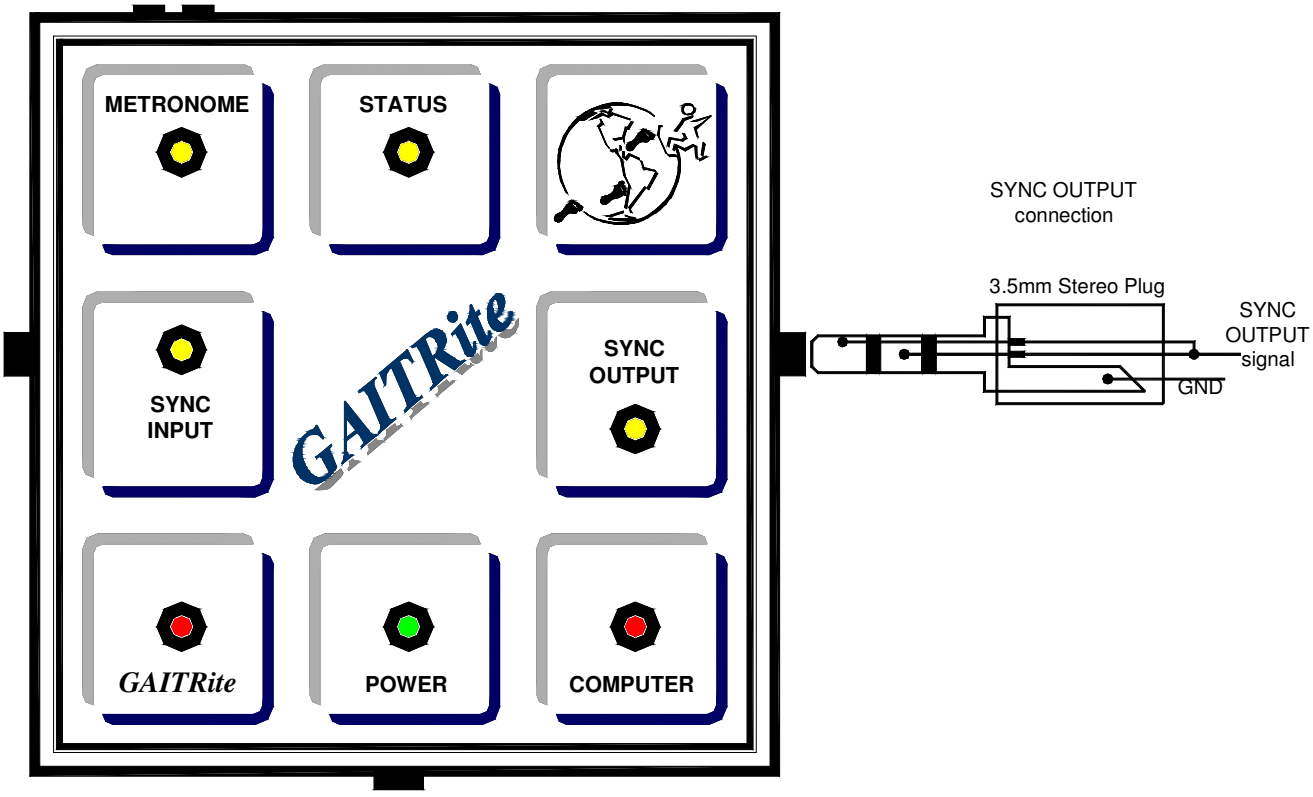
Output Voltage Low: .1V@.5ma, .5V@15ma

Output Voltage High: +5V@.5ma, +4V@15ma

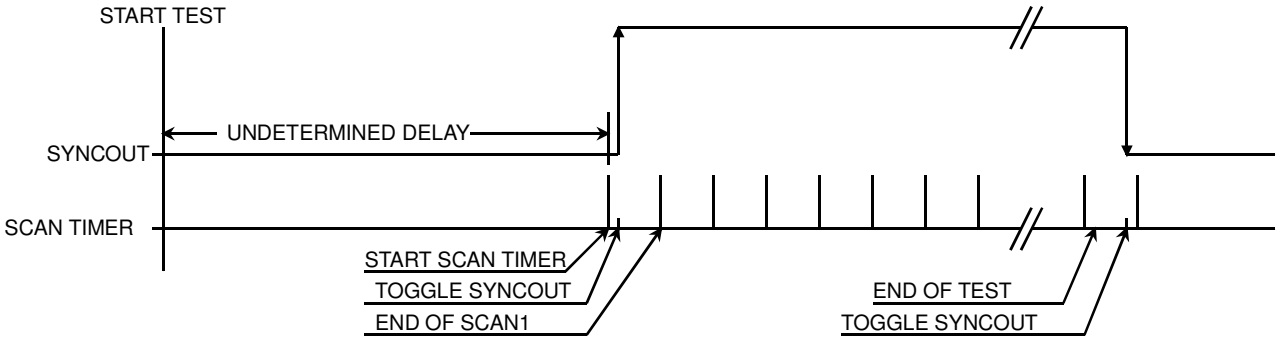
ESD protected to ±15KV

Connector: 3.5mm Stereo Jack

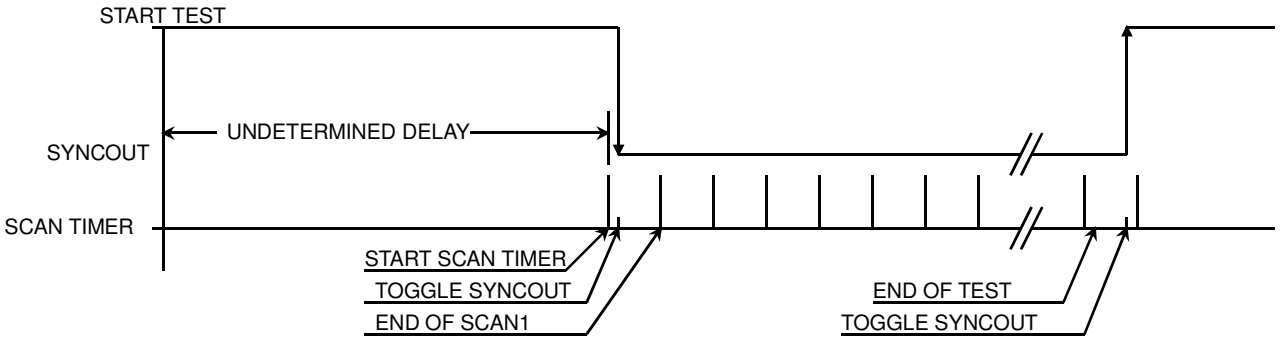
The diagram below provides a detailed view of the connections required at the SYNC OUTPUT connector. Users can make their own interface cable to use between two systems or our company can provide you one. Please, call our Technical Support Department.



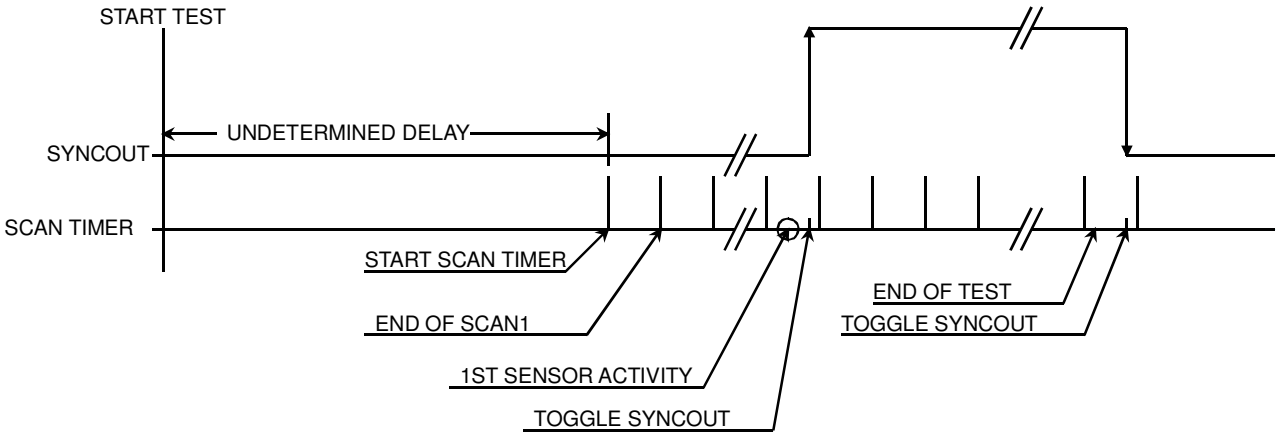
3.6.4 SYNC Output Timing Diagrams



SYNCOUT low-to-high(default) , trigger on first scan.



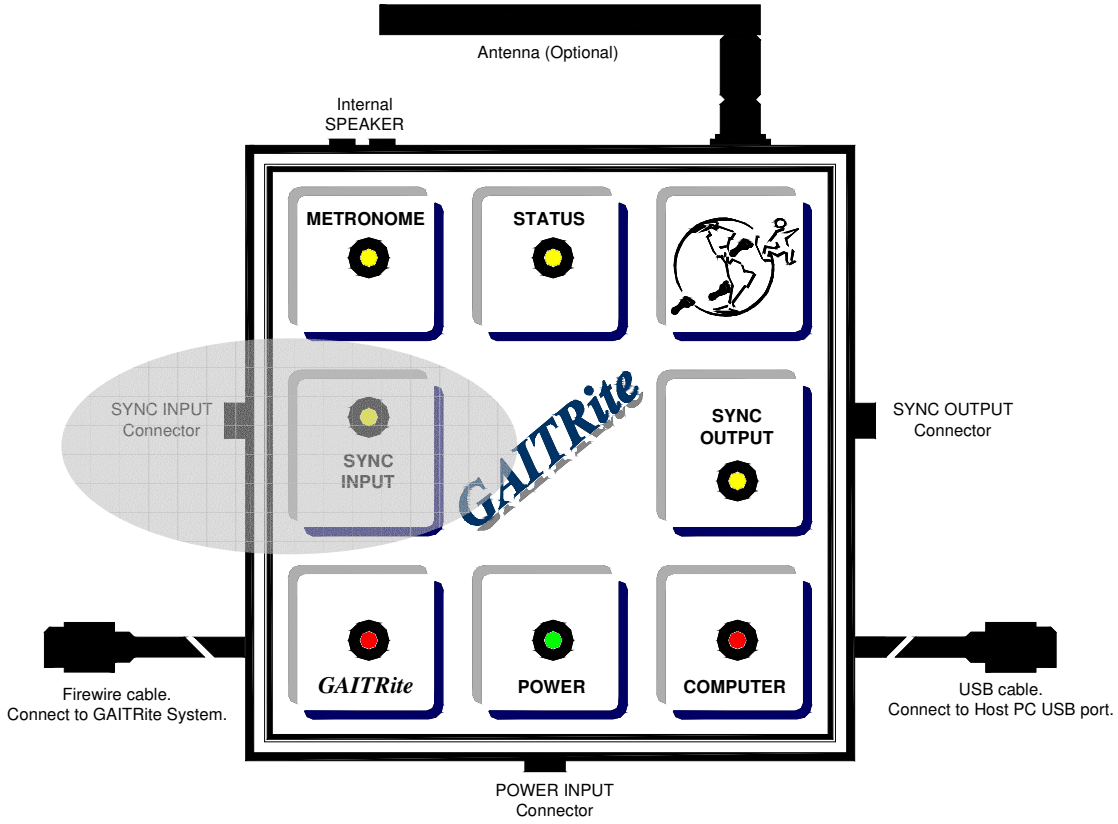
SYNCOUThigh-to-low , trigger on first scan.



SYNCOUT low-to-high , trigger on first active sensor.

3.7 SYNC Input Connection

The SYNC INPUT connection is utilized to capture the logic state of an external signal identified as an event by the GAITRite system. Events are inserted in the data stream of the GAITRite walkway as they occur (in real time). Later these events will appear as time marks in the temporal parameters review.



3.7.1 SYNC Input Light

A Yellow light, marked “SYNC INPUT” is employed as a visual indicator for the functions associated with this connection.

Lit (ON)= signal at connector input is logic level low
Not Lit (OFF)= signal at connector input is logic level high (Default)

3.7.2 SYNC Input Software Controls

The functionality of the SYNC INPUT port is configured and enabled from your GAITRite Software. The SYNC input port can be configured for the following:

FUNCTION	ADDITIONAL HARDWARE REQUIRED	RESULTS
Mark Event	GAITRite Event Switch with wires or wireless	When the switch gets pressed, the yellow light will go ON and a mark will be placed on the current frame of the GAITRite data. When the switch gets released, default state, the yellow light will go OFF and another mark will be placed on the current frame of the GAITRite data.
Mark Event with audible tone	GAITRite Event Switch with wires or wireless	When the switch gets pressed, the yellow light will go ON, a mark will be placed on the current frame of the GAITRite data and an audible tone will be generated by the GAITRite Interface Module. When the switch gets released, normal state, the yellow light will go OFF and another mark will be placed on the current frame of the GAITRite data without generating an audible tone.
External System Trigger	External system compatible with the electrical characteristics of the Sync Input Port detailed below.	To synchronize the GAITRite System with an external system the signal of the external system must meet the electrical characteristics described below. On every logical transition (signal edge) of the signal at the SYNC INPUT, the GAITRite walkway will insert a mark in the GAITRite data stream. Upon review of the temporal parameters you can use the inserted marks to align the GAITRite walkway data with the data of the external system.

3.7.3 SYNC Input Electrical Characteristics

The SYNC INPUT signal includes an internal a pull-up resistor (2.2KOhm), and has the following electrical characteristics:

Input Low Voltage: .3V

Input High Voltage: 2.0V

Max. Input Voltage: +5V

Delay from trigger: ±1 frame of sampling rate

External signal must be able to sink 4 ma

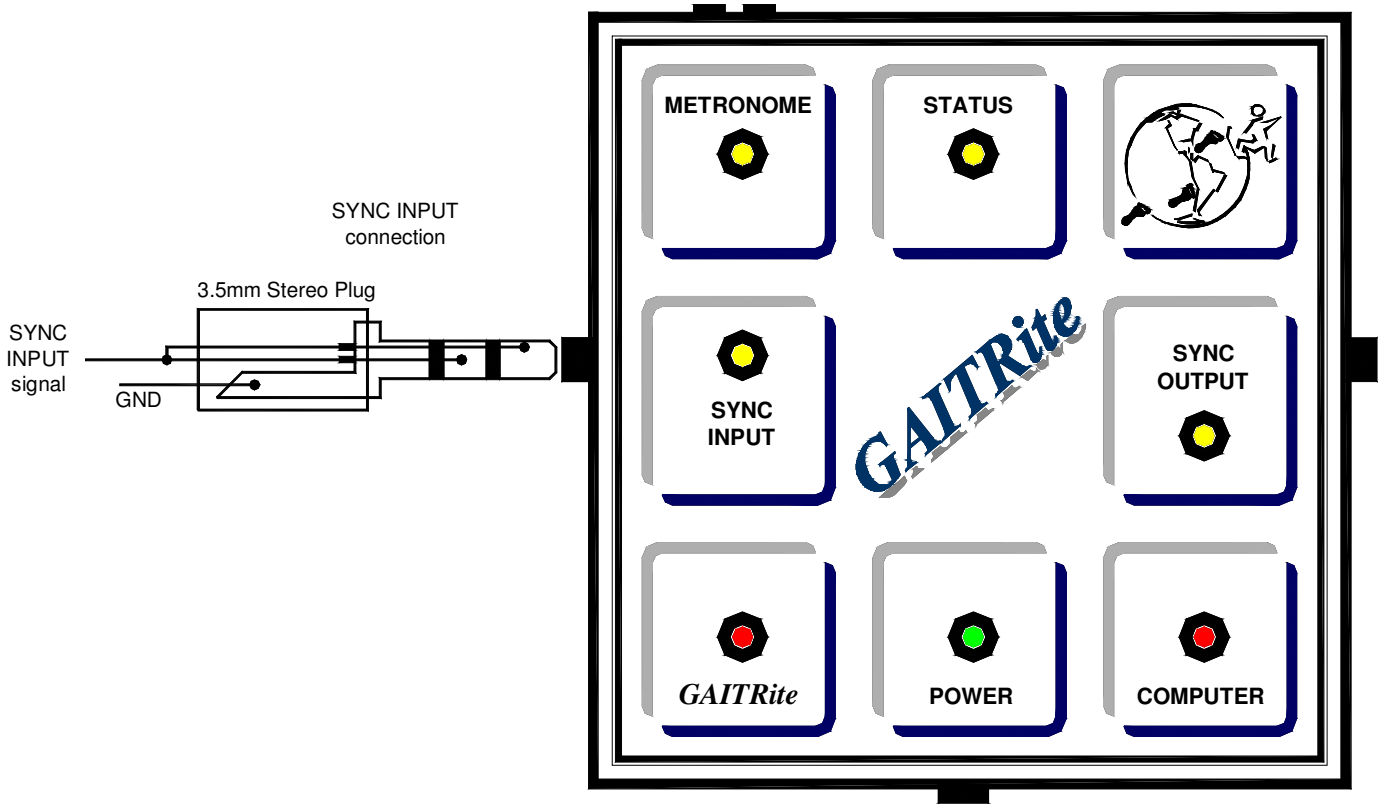
Minimum time low state: 18 msecs

Minimum time high state: 18 msecs

Max. Input Frequency: 30Hz

ESD protected to ±15KV

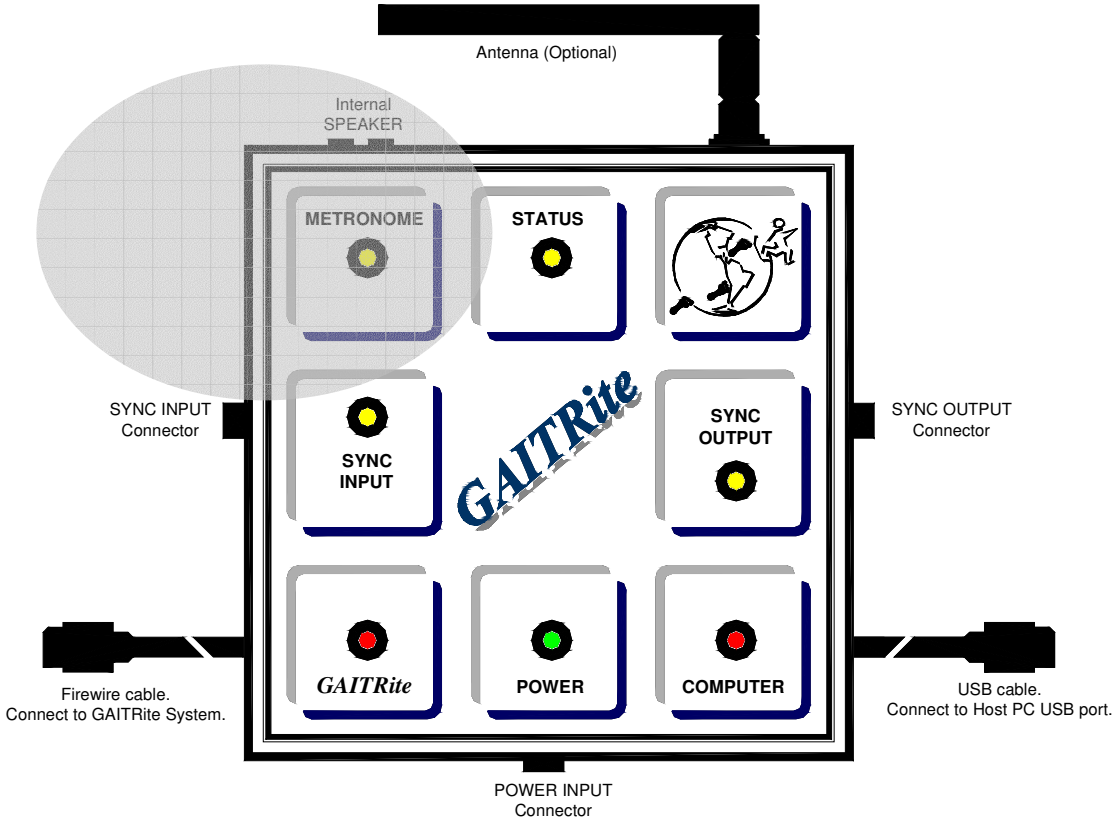
The diagram below provides a detailed view of the connections required at the SYNC INPUT connector. Users can make their own interface cable to use between two systems or our company can provide you one. Please, call our Technical Support Department.



3.8 Metronome

The Metronome function of the GAITRite Interface Module provides an audible tone at pre-selected rates (beats/minute). A yellow light labeled “METRONOME” is associated with this function and blinks at the rate (beats/minute). The audible tone is generated by an internal speaker located above the metronome yellow light. Please avoid covering this area of the Interface Module enclosure.

You can enable the metronome and select the beat rate through the GAITRite Software. By default the metronome function is disabled.



4.0 GAITRite MEASUREMENTS & DEFINITIONS

Encapsulated within the electronic walkway are sensor pads. Each sensor pad has an active area of 24 inches square (61cm square) and contains 2,304 sensors arranged in (48x48) grid pattern. The sensors are placed on .5 inch (1.27cm) centers. Multiple sensor pads are connected to form the desired length of the walkway.

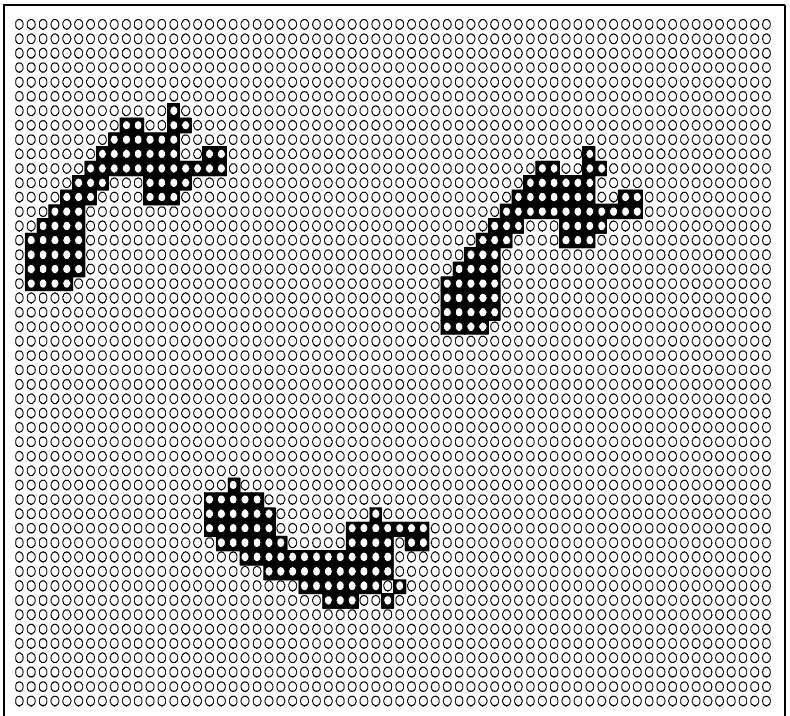


Figure 1

As the subject ambulates across the walkway, the pressure exerted by the feet onto the walkway activates the sensors. The walkway does not only sense the geometry of the activating objects but also the relative arrangement between them in a two dimensional space. In addition, the walkway senses the vertical component of the relative pressure exerted by the objects. What makes the walkway valuable for gait analysis are the special algorithms build into the system. The algorithms isolate the objects and identify them as footprints.

4.1 FOOTPRINT ANALYSIS

The software utilizes special algorithms to automatically group sensors and form footprints. Once a footprint has been formed it will be divided and the following areas will be identified:

1. Identify a quadrilateral that encloses the footprint;
2. Identify the heel, mid and toe areas of the footprint;
3. Identify the centroid, geometric center, of each area; and
4. Divide each quadrilateral into four equal quadrilaterals.

Each area will be examined separately.

4.1.1 Identify the quadrilateral

The method for defining the quadrilateral of a footprint was first developed by Shores[1] and later improved upon by Lisa Selby-Silverstein[2], while an automated improved version of the algorithm has been implemented by the GAITRite system. The following steps refer to Figure 3.

1. Identify the two most outer sensors on the medial side of the footprint, sensor 1 and sensor 3. Draw the medial line; the line that connects sensor 1 to sensor 3.

2. Identify the two most outer sensors on the lateral side of the footprint, sensor 5 and sensor 6. Draw the lateral line; the line that connects sensor 5 to sensor 6.

3. Identify the rear most outer sensor(s), sensor 2. From sensor 2 draw a line perpendicular to the medial line. The two lines intercept at point A. Extend the line to intercept the lateral side at point L.

4. Identify the front most outer sensor(s), sensor 4. From sensor 4 draw a line perpendicular to the medial line. The two lines intercept at point G. Extend the line to intercept the lateral side at point R.

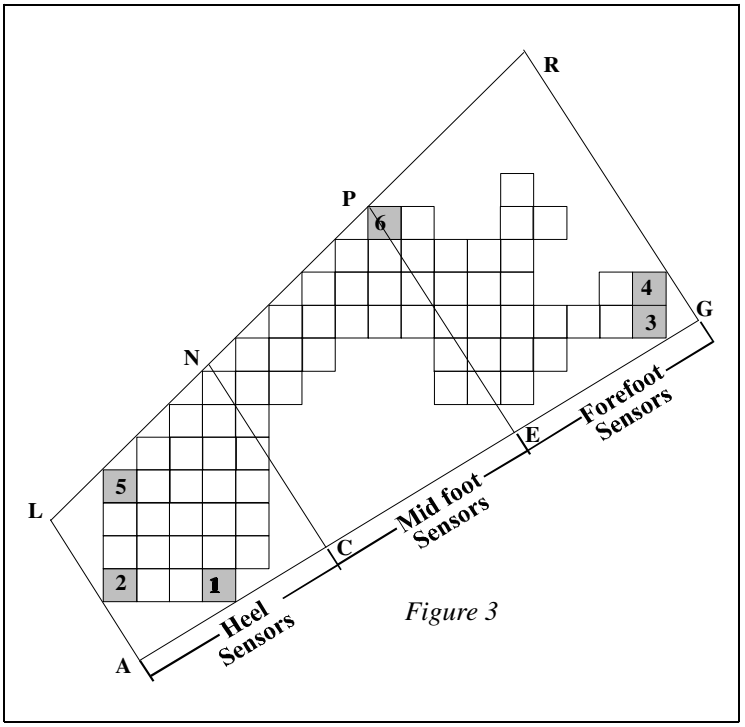


Figure 3

5. The formed quadrilateral (ALRG), in this case a trapezoid, encloses the footprint efficiently.

4.1.2 Identify Heel, Mid and Toe areas

Refer to Figure 3 and identify points (C) and (E); these two points divide the medial line (AG) into three equal spaces.
From point (C), draw a line perpendicular to the medial line and extended it in order to intercept the lateral line at point (N). Similarly, from point (E), draw a line perpendicular to the medial line and extended it in order to intercept the lateral line at point (P).
Quadrilateral (ALNC) contains the Heel area sensors, (CNPE) contains the mid foot area sensors and (EPRG) contains the toe area sensors.

1. Shores M. Footprint analysis in gait documentation: an instructional sheet format, Phys Ther 60:1163, 1980.
2. Silverstein LS: the effect of neutral position foot orthoses on gait of children with down syndrome. Doctoral Thesis. PA, 1993, Hahnemann University.

4.1.3 Identify the centroid

So far, the footprint was divided into three quadrilaterals with the intention of identifying the sensors for the heel, mid foot and toe areas.
Figure 4, illustrates the heel area quadrilateral (ALNC), in this case a trapezoid, and the sensors included in the heel area of the footprint.
Point (C1), the centroid, represents the center of the heel area. The centroid is the pivot point of the two dimensional sensor structure shown in gray.

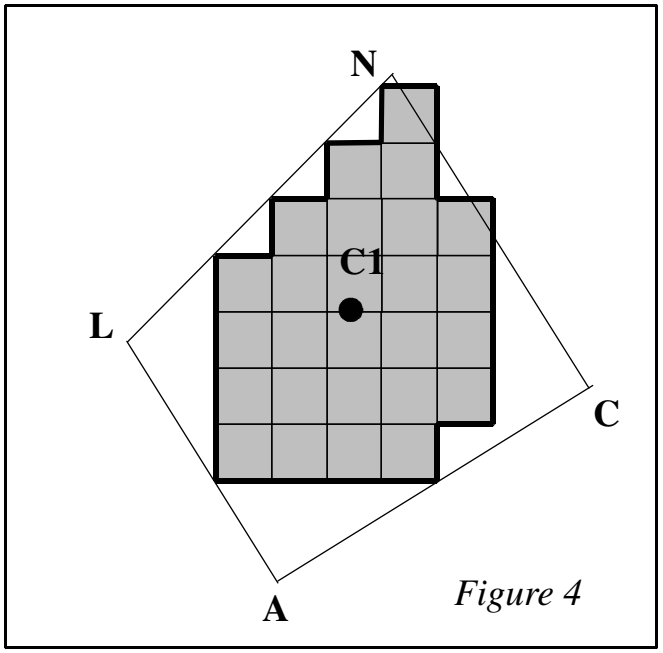


Figure 4

Figure 5, illustrates the toe area quadrilateral (EPRG), in this case a trapezoid, and the sensors included in the toe area of the footprint.
Point (C2), the centroid, represents the center of the toe area. The centroid is the pivot point of the two dimensional sensor structure shown in gray.

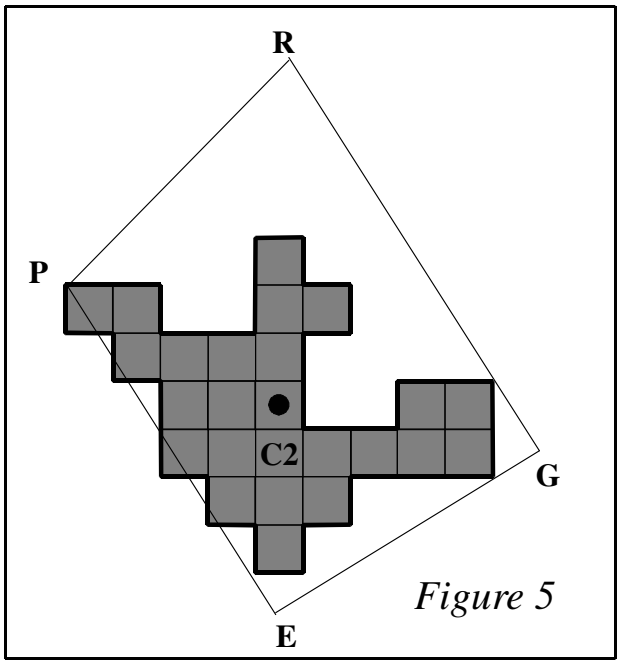


Figure 5

4.1.4 Identify the twelve quadrilaterals

As illustrated in Figure 6, in this specific footprint the quadrilaterals form trapezoids, but in other cases the quadrilaterals could form rectangles. Point (C1), the centroid of trapezoid (ALNC) represents the heel center of the footprint. Point (C2), the centroid of trapezoid (EPRG) represents the toe/metatarsal center point. This footprint is geometrically represented by twelve trapezoids; six medial and six lateral points. Quadrilaterals are formed in the two dimensional representation of the footprint in order to isolate the sensors and later perform calculations based on the isolated sensors of each quadrilateral.
The line that connects point C1 to point C2 is the midline of the footprint.

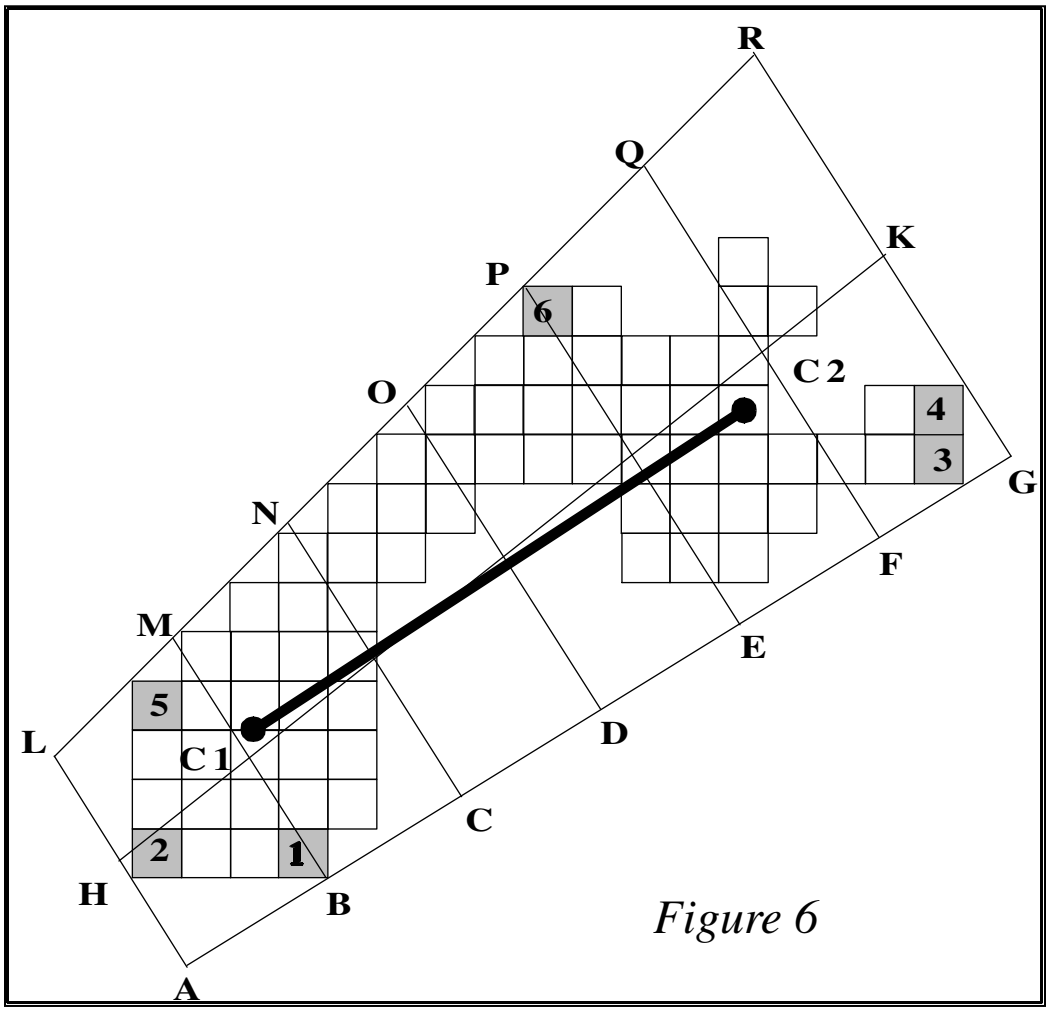


Figure 6

4.2 SPATIAL PARAMETERS & DEFINITIONS

The walkway does not only sense the geometry of the activating footprints but also the relative arrangement between them in a two dimensional space. Figure 7, illustrates three footprints.

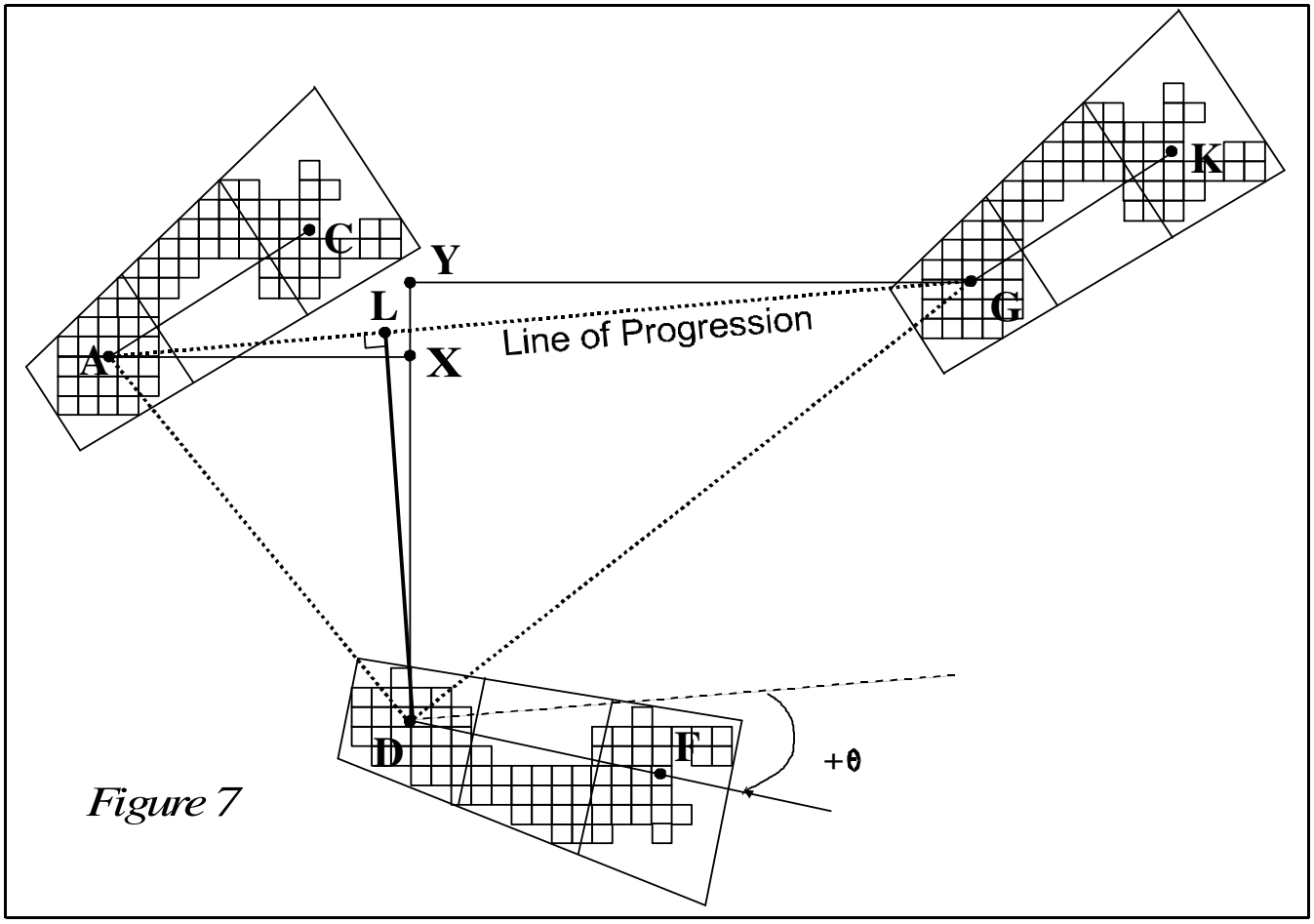


Figure 7

4.2.1 Heel Center

Points (A), (D) and (G) are the ***heel centers*** of each footprint.

4.2.2 Line of Progression

It is defined as the line connecting the heel centers of two consecutive footfalls of the same foot. Illustrated in Figure 7, the line of progression is formed by connecting point (A) to point (G).

4.2.3 Stride Length

It is measured on the line of progression between the heel points of two consecutive footprints of the same foot (left to left, right to right). In Figure 7, (AG) is the stride length of the left foot. The unit of measure is centimeters.

4.2.4 Step Length

It is measured along the line of progression, from the heel center of the current footprint to the heel center of the previous footprint on the opposite foot. In Figure 7, line (DL) is perpendicular to the line of progression (AG). The length of line (AL) is the ***step length*** of the right foot, while the length of line (LG) is the step length of the second left foot. The step length can be a negative value if the subject fails to bring the landing foot heel point forward of the stationary foot heel point. The unit of measure is centimeters.

4.2.5 H-H Base of Support or Base Width

It is the vertical distance from heel center of one footprint to the line of progression formed by two footprints of the opposite foot. In Figure 7, the height of the triangle (ADG) is (DL) which is the base width of the right foot. The unit of measure is centimeters.

4.2.6 Toe In / Toe Out

It is the angle between the line of progression and the midline of the footprint. In Figure 7, theta is the angle between the mid-line of the right footprint and the line of progression. Angle theta is zero if the geometric mid-line of the footprint is parallel to the line of progression; positive, toe-out, when the mid-line of the footprint is outside the line of progression and negative, toe-in, when inside the line of progression. The unit of measure is degrees.

4.2.7 Distance Traveled

It is measured on the horizontal axis from the heel center of the first footprint to the heel center of the last footprint. The unit of measure is centimeters.

4.2.8 Leg Length (LL)

It is measured in centimeters from the greater trocanter to the floor, bisecting the lateral Malleolus. Each leg should be measured separately. The unit of measure is centimeters.

4.2.9 Step/Extremity Ratio

It is defined as the Step Length divided by the Leg Length of the same leg. The result is an absolute number.

4.2.10 Step Width

It is measured from the midline midpoint of the current footprint to the midline midpoint of the previous footprint on the opposite foot. In Figure 8, distance (XY) is the right step width, while distance (YZ) is the left step width. The unit of measure is centimeters.

4.2.11 Stride width

It is the vertical distance from midline midpoint of one footprint to the line formed by midline midpoints of two footprints of the opposite foot. In Figure 8, the height of the triangle (XYZ) is (YP) which is the stride width of the right foot. The unit of measure is centimeters.

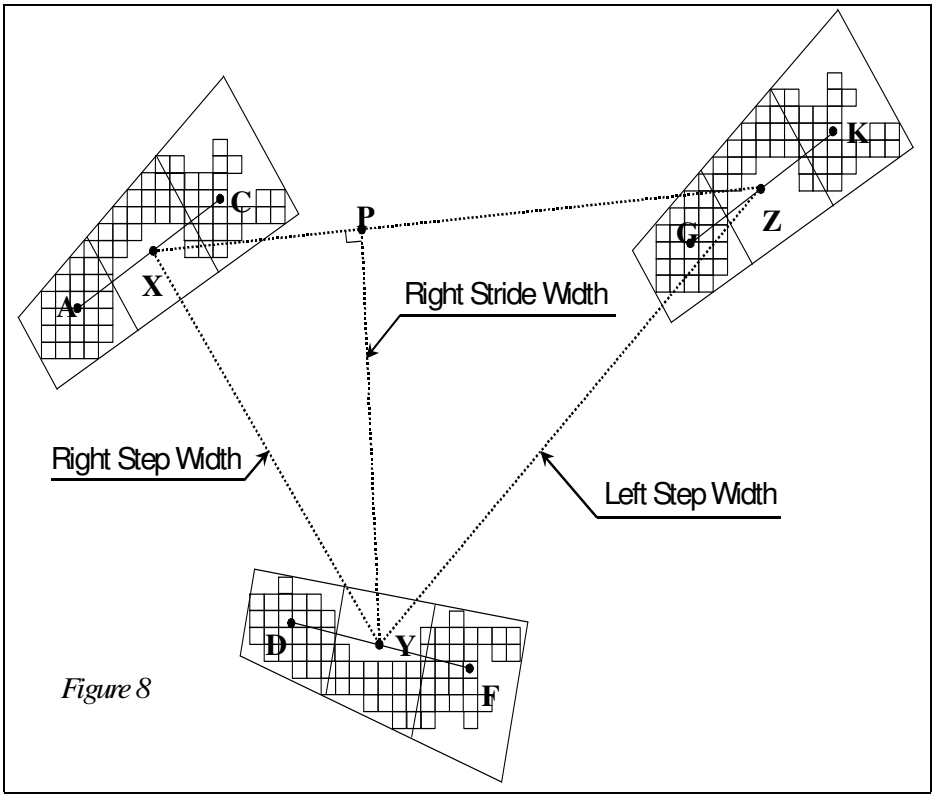


Figure 8

4.3 TEMPORAL DEFINITIONS

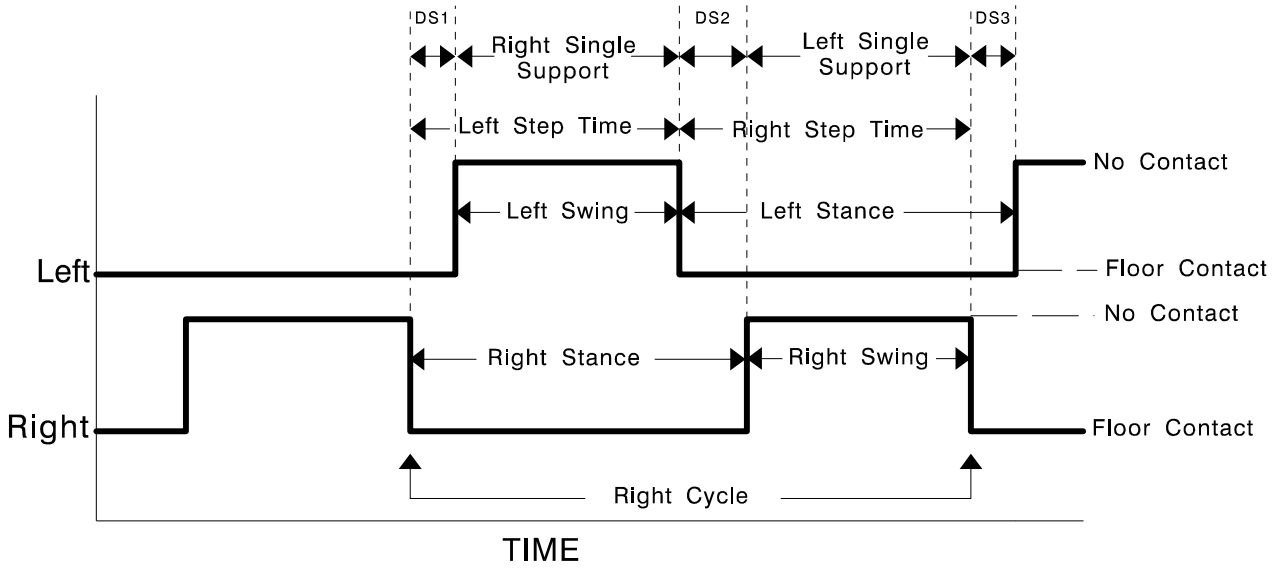


Figure 9

4.3.1 First Contact

It is the time that the first sensor appears in any quadrilateral. It is expressed in seconds (sec).

4.3.2 Heel Contact

It is the time that the first sensor appears in the heel quadrilateral of the foot. It is expressed in seconds (sec).

4.3.3 Last Contact

It is the time that the last sensor goes off in any quadrilateral. It is expressed in seconds (sec).

4.3.4 Toe Off

It is the time that the last sensor turns off in the forefoot quadrilateral of the foot. It is expressed in seconds (sec).

4.3.5 Step Time

It is the time elapsed from first contact of one foot to first contact of the opposite foot. It is measured in seconds (sec).

4.3.6 Stride Time

It is the time elapsed between the first contacts of two consecutive footfalls of the same foot. It is measured in seconds (sec).

4.3.7 Gait Cycle Time

It is the elapsed time between the first contacts of two consecutive footfalls of the same foot. It is measured in seconds (sec).

4.3.8 Ambulation Time

It is the time elapsed between first contact of the first and the last footfalls. It is measured in seconds (sec).

4.3.9 Velocity

It is obtained after dividing the Distance Traveled by the Ambulation time. It is expressed in centimeters per second (cm/sec)

.

4.3.10 Mean Normalized Velocity

It is obtained after dividing the Velocity by the Average Leg Length and it is expressed in leg length per second (LL/sec). The average Leg Length is computed (left leg length + right leg length)/2.

4.3.11 Stride Velocity

It is obtained after dividing the Stride Length by the Stride Time. It is expressed in centimeters per second (cm/sec).

4.3.12 Single Support and % Single Support

It is the time elapsed between the Last Contact of the current footfall to the First Contact of the next footfall of the same foot. Refer to Figure 9, Single Support time is equal to the **Swing Time** of the opposite foot. It is measured in seconds (sec) and expressed as a percent of the Gait Cycle time of the same foot.

4.3.13 Initial Double Support and %Initial Double Support

The two periods when both feet are on the floor, are called **initial double support** and **terminal double support**. Initial double support occurs from heel contact of one footfall to toe-off of the opposite footfall. It is measured in seconds (sec) and also expressed as a percent of the Gait Cycle time for the same foot. Refer to Figure 9, DS1 is the Initial Double Support for the right foot, while the DS3 is the Initial Double Support for the left foot.

4.3.14 Terminal Double Support and %Terminal Double Support

The two periods when both feet are on the floor, are called **initial double support** and **terminal double support**. Terminal double support occurs from opposite footfall heel strike to support footfall toe-off. It is measured in seconds (sec) and also expressed as a percent of the Gait Cycle time for the same foot. Refer to Figure 9, DS2 is the Terminal Double Support for the right foot.

4.3.15 Total Double Support and %Total Double Support

The two periods when both feet are on the floor, are called initial double support and terminal double support. Initial double support occurs from heel contact of one footfall to toe-off of the opposite footfall. Terminal double support occurs from opposite footfall heel strike to support footfall toe-off. Total double support is the sum of the initial double support added to the terminal double support. It is measured in seconds (sec) and also expressed as a percent of the Gait Cycle time for the same foot. Refer to Figure 9, the sum (DS1+DS2) is the Total Double Support for the right foot, while the sum (DS2+DS3) is the Total Double Support for the left foot.

4.3.16 Stance Time and % Stance

The **stance phase** is the weight bearing portion of each gait cycle. It is initiated by heel contact and ends with toe off of the same foot. It is the time elapsed between the First Contact and the Last Contact of two consecutive footfalls on the same foot. It is also presented as a percentage of the Gait Cycle time.

4.3.17 Contact phase

It begins with heel strike and continues until about 22% of the stance phase. Forefoot loading terminates contact phase.

4.3.18 Midstance phase or Foot Flat

It begins with the first sign of forefoot loading. The end of midstance is heel-lift of the support limb. This occurs at about 50% of the stance.

4.3.19 Propulsive phase

This is the final 50% of the stance phase. It begins heel lift until toe off.

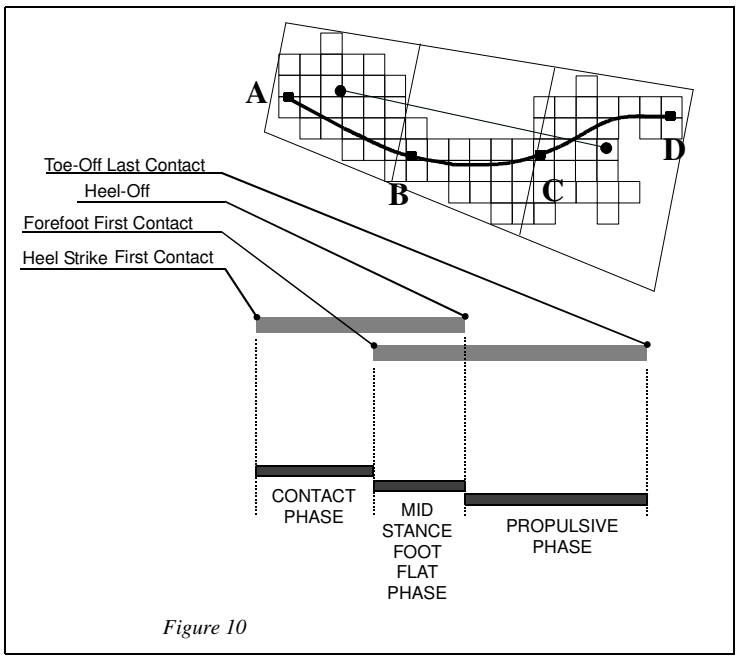


Figure 10

4.3.20 Swing Time and %Swing

It is initiated with toe off and ends with heel strike. It is the time elapsed between the Last Contact of the current footfall to the First Contact of the next footfall on the same foot. It is expressed in seconds (sec) and it is also presented as a percent of the Gait Cycle of the same foot. The Swing Time is equal to the Single Support time of the opposite foot.

4.4 SWITHING LEVELS

The GAITRite walkway's unique and patented sensor avoids false peripheral activation. Each sensor has been constructed with two flexible elements riding on a pivot point. When pressure is applied to the sensor both elements must flex around the pivot point to initiate activation, otherwise the pivot point will toggle the sensor in either side without activation. After activation, the sensor begins to change its value linearly with the vertical component of pressure exerted upon it.

The walkway contains thousands of sensors, therefore calibration of each and every sensor is not impossible but cost prohibitive. Pressure values are normalized and expressed as a percent of the maximum pressure and then divided into levels. Currently there are seven switching levels, illustrated in Table 1.

Color	Switching level
Dark Gray	1=lowest
Light Gray	2
Cyan	3
Yellow	4
Magenta	5
Red	6
Blue	7=highest

Table 1. Switching Levels, Color Assignment.

The walkway does not only sense the geometry of the activating footprints but also the relative arrangement between them in a two dimensional plane and the relative vertical component of pressure exerted by each footprint.

The pressure is represented by a switching level. As discussed earlier, the division of the footprint produces us with twelve sections; six sections are located in the medial side of the footprint and six in the lateral. Each section contains a number of activated sensors enclosed within a trapezoid. The GAITRite algorithms utilize the sectional division to identify the activated sensors included within each quadrilateral and then perform calculations to objectively describe the behavior of the section.

As illustrated in Figure 11, medial trapezoid (AHIB) includes the following sensors: 1,2,3,4,6 and 7. Lateral trapezoid (HLMI) includes the sensors: 5,10,11,15 and 16. A sensor can be claimed by only one trapezoid and not shared by others. Sensor 4, has most of its surface area within trapezoid (AHIB) and will be claimed only by this trapezoid. If the surface area of a sensor is equally divided among two or more quadrilaterals, i.e. sensor 12, then the sensor will be claimed by the first trapezoid in the algorithm. The results of the switching parameters are presented in the format illustrated in Table 2.

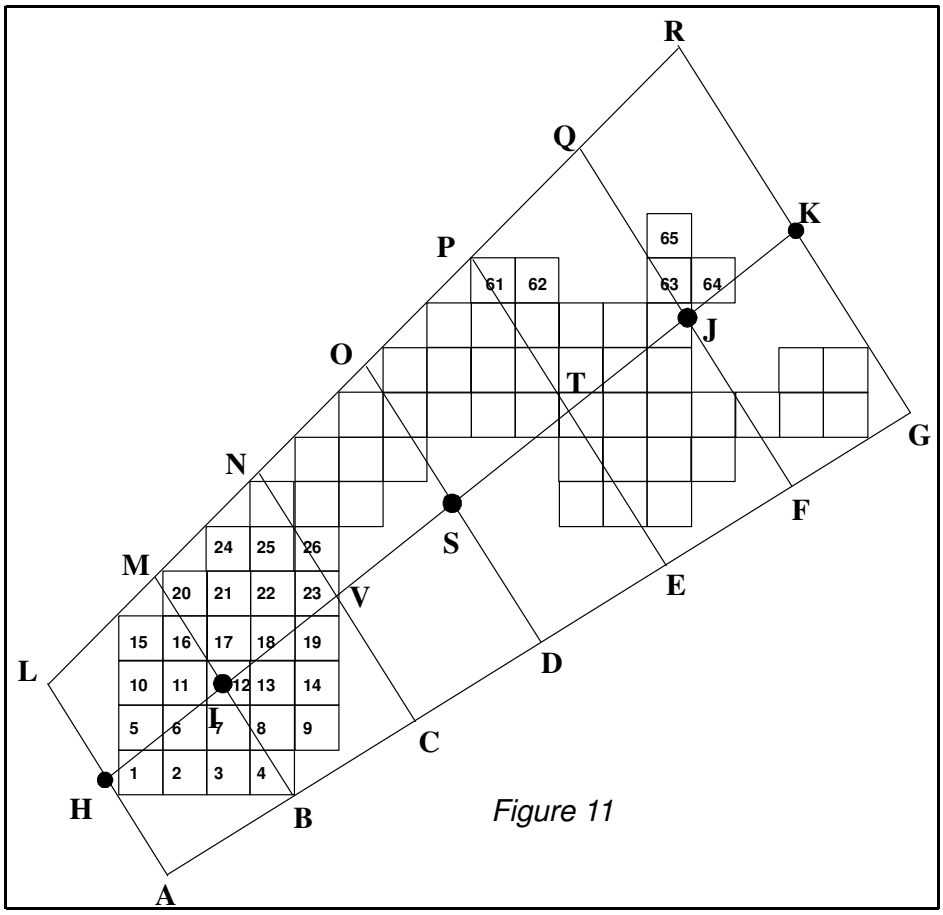


Figure 11

4.5 Switching Level Parameters

1. **P*t** for a section, is the sectional integrated pressure over time expressed as a percent of the overall integrated pressure over time. The overall P*t can be found by summing the P*t of each sensor, sectional P*t can be found by summing the P*t of the sensors included in the particular section also expressed as a percent of the overall P*t. As illustrated in Figure 12, P*t for sensor 1 is the total area under the curve calculated by:
2. (P*t)s1=(.020-.010)*1+(.030-.020)*2+ .....+(.070-.060)*6+.....+(.140-.130)*1

3. **Peak Time** for a section is the first time point that one or more sensors within a section was at the maximum switching level. Assume that a section included only the two sensors, illustrated in Figure 12; the peak time is at .060 seconds. Time count begins from first contact of the footprint.

4. **Area** of a section is expressed in centimeters squared (cm^2) and represents the sum of the active sensor areas within a section. Each sensor has an area of .5 in x .5 in or (1.27 cm x 1.27 cm).

5. **Peak P**(ressure**)** for a section, is the maximum sectional switching level expressed as a percent of the overall maximum switching level. Sectional switching level occurs at the peak time of the section. Assume that a section included only the two sensors illustrated in Figure 12, then peak time is at .060 seconds and a peak switching level of 6, then expressed as a percent of the overall maximum switching level.

	<(H	**<(I**	**<(V**	**<(S**	**<(T**	**<(J**
P*t						
Peak						
Area						
Peak P						
	<(A	**<(B**	**<(C**	**<(D**	**<(E**	**<(F**
<P*t>						
<Peak						
<Area>						
<Peak P>						

Table 2. Switching Levels by Section.

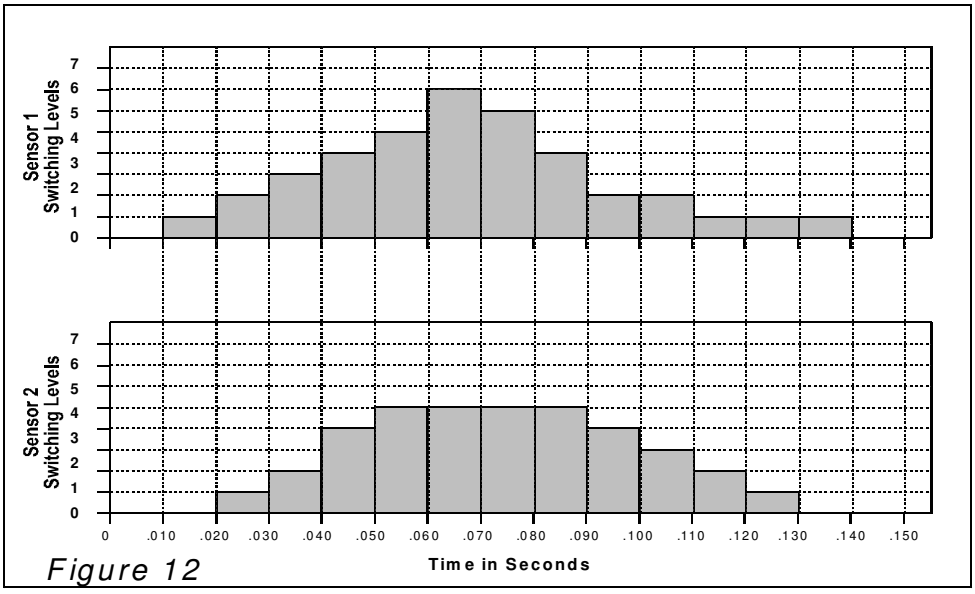


Figure 12

5.0 WARRANTY INFORMATION

5.1 Software

The software is licensed to the end user for use with the GAITRite System. It may be installed on any number of computers, within the purchasing organization, for this application without any additional fee. Copies of the software may not be resold. No transfer of copyright is granted or implied by this agreement.

5.2 License Key

As shipped the software can run basic functions. In order to access advanced functions, a license key, generated based on your purchase information, is sent separately via carrier or email.

5.3 Software Updates

To obtain the latest software release, please visit www.gaitrite.com/

5.4 WARRANTY

This product is warranted for 12 (twelve) months from date of shipment, for manufacturing defects and/or component failures. Defective equipment will be replaced or repaired at the discretion of CIR Systems Inc. Warranty will be voided by the limitations listed in this document.

5.5 PROOF OF WARRANTY

Please retain your invoice/delivery note as proof of warranty.

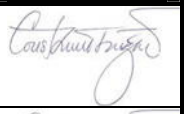
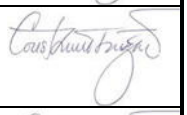
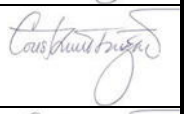
5.6 EXTENDED WARRANTY

Extended warranty may be purchased separately by conducting our sales office.

5.7 SALES AND SERVICE

CIR Systems Inc.
8 John Walsh Blvd.
Suite 429
Peekskill NY 10566
Phone:914.734.8178
FAX: 914.734.8179

6.0 DOCUMENT UPDATES

Revision Level	Revision Date	DCO/ECO Number	Description of Revision	Revision Author
DRAFT	01/22/2003		Draft	
A	04/22/2003		Initial Release	
B	06/22/2008		Results of independent laboratory testing	
C	02/11/2010		ISO 14971:2007 risk analysis