INTREPID™

MicroPoint Cable

A New Fence Sensor Technology

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Part 1 - INTREPID™ MicroPoint™ Technology

INTREPID MicroPoint is a new microphonic cable sensor technology which has been developed at Southwest Microwave, Inc. It is unique in that it not only detects cable disturbances but it also locates the disturbance. The ability to locate a disturbance along a 200 meter length of cable is used to provide a number of unique features:

- Sensitivity Leveling - a calibrated sensitivity setting for each meter of cable
- Free Format Zoning - software controlled zones
- Point Impact Discrimination - dramatic reduction of false alarms by looking at the spatial signature of the disturbance.
- MicroPoint Detection and Assessment - the ability to "assess" a specific short section of cable and the ability to locate specific causes of false alarms

State of the art Digital Signal Processing (DSP) using temporal and spatial filtering is used to reduce false alarms.

Power and data are also distributed around the perimeter on the MicroPoint cable. The peer to peer data communications is by means of a FSK protocol called ICOM. In addition to reporting alarms this network provides the ability to upload and download software to the microprocessors on the perimeter. The maintenance and diagnostic tools that this provides are unprecedented in perimeter security systems. These can even be used remotely over standard telephone lines using modems. High efficiency DC to DC converter circuits are used to create a power distribution network which is also superimposed on the MicroPoint cable. The cost savings of not having to install additional power and data wiring and cable are very significant.

Background & Introduction

Microphonic cable sensors have been used in outdoor fence protection for many years. Some of the most common technologies used in microphonic cable sensors are: Electret effect, Inductive coupling, Capacitive coupling, Triboelectric effect and Piezoelectric effect. In general, products based upon these technologies tend to have false and nuisance alarms due to wind and rain. The condition of the fence is a key factor in determining their performance. These sensors are in widespread use throughout the world in commercial, industrial, corrections, military and nuclear sites.

All the products based on these older technologies are “Block Sensors”. These sensors determine if a target is present within a “Zone” which is defined by the start and end of a length of transducer cable. Setting one threshold per zone is always a compromise between acceptable Probability of Detection (Pd) at the least sensitive spots and False Alarm Rate (FAR) at the most sensitive spots. In general, the longer the zone length the more false and nuisance alarms. Since there are only one or two zones per processor the cost of such systems is largely determined by the number of processors.

INTREPID MicroPoint is based on a whole new concept in microphonic cable transducers. This patented technology is unique among microphonic cable sensors in that it not only detects the presence of an intruder, it pinpoints the exact location of the intruder. This ability to locate the intruder along the length of the transducer allows one to perform spatial filtering in addition to the traditional temporal filtering. All of the recent
feature recognition DSP techniques become more effective because they operate on the local disturbance as opposed to the response from the entire length of cable.

**MicroPoint Cable**

Key to the MicroPoint sensor is its unique cable transducer which is shown in cross section on the left. The center conductor and the braided outer conductor form a normal coaxial cable. During the extrusion of the dielectric surrounding the center conductor keyways are formed in the dielectric material. Small sense wires are inserted into the keyways as a thin insulating sheath is applied to the core formed by the dielectric and the center conductor. A tough outer jacket is then extruded over the braid to complete the cable fabrication.

Because the sense wires fit loosely in the keyways they are free to move relative to the body of the cable in response to motion of the cable. More correctly the inertia of the sense wires tries to hold them stationary as the cable moves in response to a disturbance. It is the relative motion of the sense wires in terms of the center and outer coaxial conductors which is detected and located.

The standard MicroPoint MC100 cable is designed to attach directly to the fabric of a chain link fence. In higher security applications this cable can be installed in a flex conduit which is attached to the fence fabric.

Radio frequency energy is transmitted down the coaxial cable formed by the center conductor and the braided outer conductor. Energy is coupled into the transmission lines formed by the sense wires and the braided outer conductor. The amount of energy which is coupled is altered by the motion of the sense wires in the keyways. A portion of the coupled energy propagates back to the start of the cable. The two sense wires are transformer coupled to the receiver so as to provide common mode rejection of noise. The receiver uses the return delay time to locate the reflection from the moving sense wires. This is analogous to a radar inside the cable which detects and locates the motion of the sense wire.

The received signal is sampled into 120 range bins corresponding to 3.3 meter (21 feet) lengths of cable along the entire 400 meters (1310 feet) of cable connected to a Processor Module. The response in each of these range bins is processed in the microprocessor. Spatial filters discriminate against distributed disturbances caused by rain, wind or nearby vehicular traffic. Temporal filtering is used to select the band of...
response frequencies of interest. The DSP recognizes features that are unique to a person cutting the fence fabric or climbing on the fence.

The Detection Process

The detection process is illustrated in Figure 1. The transmitted pulse propagates down the cable at a velocity which is determined by the dielectric constant of the core material. Matched load impedances are provided at the ends of the cable to terminate the pulse with minimal reflection. As the pulse propagates along the cable, signal is reflected back to the receiver on the sense wires much like in a directional coupled. The signal received in the normal “as built” rest position of the cable is referred to as the cable clutter. It is directly analogous to the clutter caused by fixed objects like buildings in standard radar. Digital processing means are used to remove the clutter and only “look at” the changes in the response caused by motion of the sensor cable. When the fence fabric is cut or a person climbs on the fence the impact causes the sense wires to vibrate in their keyways and it is this vibration that is detected.

MicroPoint Sensor

Figure 1 illustrates how the cable response is digitized into range cells and subsequently processed to detect and locate disturbances caused by intruders. There are 60 range bins per 200 meter (656 feet) length of MicroPoint cable. The system scans the 200 meters of cable “A” on the left then the 200 meters of cable “B” on the right. A proprietary coded pulse is used to be able to detect the very minute reflections caused by the motion of the sense wires. The reconstructed shape of this coded pulse is used to locate the target within subcell. There are 180 subcells in a 200 meter length of cable which corresponds to a subcell length of 1.1 meters (42 inches).

One of the major problems with older microphonic cable sensors used on chain link fences is their susceptibility to false alarms during high winds or heavy rain conditions. The localized disturbance caused by an intruder is compared to the noise which is accumulated over the entire length of cable. In the MicroPoint sensor the intruder
response is compared to noise accumulated over the cell in which the intruder is located. This provides MicroPoint with a significant improvement in Signal to Noise Ratio (SNR) over all existing microphonic cable sensors. This improved SNR translates in to a lower False Alarm Rate (FAR) and a higher Probability of Detection (Pd).

The proprietary coded pulse used in MicroPoint is designed to have no DC component and to have 99% of its energy in the 3 to 15 MHz band. This facilitates the superposition of the FSK data communications and power on the same cable. Frequency multiplexing is used to isolate the FSK signals from the code detection pulse train.

**Sensitivity Leveling**

One of the main causes of false alarms in traditional microphonic cable sensors is the non-uniformity of the fence fabric. There is a different response on a tight panel than on a loose panel. In many cases this means that the fence must be tensioned to overcome this problem. This is a costly proposition.

The precise location information obtained with MicroPoint sensor is used to effectively set a different gain setting for every meter (3ft) of cable based upon a “calibration walk”. During calibration a MicroPointer is dragged along the fence fabric over the entire length of cable transducer. The response to this uniform stimulus is recorded for every subcell (1.1m) and used to set the gain profile thereby ensuring uniform sensitivity. This process is referred to as Sensitivity Leveling. The cost saving of working with the fence fabric in its present condition can not be over emphasized. In addition it dramatically reduces the time to install the sensor. Transportable applications of the sensor are now feasible.

**Free Format Zoning**

Knowing where the disturbance is located along the length of the cable transducer allows the installer to create any number of zones on the perimeter independent of the number of processors. No longer is the number of processors directly related to the number of zones. The zones are identified during installation by tapping on the fence at the zone boundaries. Since the zone boundaries are controlled in software the installer can easily add zones or move the zone boundaries to optimize the system performance without having to add any hardware or move any cable. With other sensors one must remove the sensor cable and re-install it and the processors and all the power and data wiring to change zones. (It is like removing the sensor and starting again.) With the MicroPoint sensor, zones are altered from a PC keyboard and it can even be done without going to the site using a modem connection over standard telephone lines.

**MicroPoint Detection and Assessment**

MicroPoint tells the operator precisely (within 3 meters - 10 feet) where the intrusion has been detected. This precise location information is very useful in many ways. It allows one to switch a CCTV camera to the exact location on the perimeter to assess the nature of the alarm. It allows one to dispatch a response force to the precise location. It allows one to quickly and easily identify and correct causes of nuisance alarms. (For example, all microphonic cable sensors will detect a loose top rail that rattles during windy conditions but with MicroPoint one knows exactly which panel top rail not just that something is causing alarms somewhere on the 100meter zone.) The cost and performance benefits associated with knowing the precise location of an alarm are significant.
Performance Optimization

When the site map is created Display Segments are assigned. These are basically straight line segments of the perimeter that appear on the Graphic Map with added key points at each module and Zone Boundary on the perimeter. Display Segments can be either Active or Inactive. A Display Segment assigned to lead-in cable or across a driveway are normally set Inactive. (There is no need to splice in inactive cable like other older sensors - just assign the Display Segment inactive using a PC.) When using the Map Monitor the operator can “Access” any Display Segment to temporarily turn off alarms from that particular segment of cable. Zones are defined as groups of Display Segments and relays can be assigned to groups of Zones.

There are a number of Control Parameters that are set to optimize performance. There are seven Control Parameters that are set for each processor. These include a calibration factor which effectively lets the installer raise or lower the threshold over the entire 400 meters of cable attached to the processor. Using a PC any Control Segments (groups of subcells) can be set with a unique Detection Window, Detection Level and Incremental Threshold. The Incremental Threshold is adjusted to raise or lower the threshold over the particular Control Segment. A Detection Level of 1, 2, 3 or 4 is selected on a Control Segment basis. If Level 1 is selected an Alarm is generated for every Event that meets or exceeds the Alarm Threshold. For levels 2, 3 or 4 there must be that many Events at the same location within the Detection Window whose average score exceeds the Alarm Threshold to create an alarm.

While the Detection Level setting sounds similar to that of a Count Setting on conventional microphonic cable sensors it has two major differences. The multiple Events must occur at the same location - not just anywhere along the length of cable and the score is based on the average response level not just count. This makes Detection Level setting much more effective in eliminating nuisance alarms.

The fact that Control Segments can be assigned using the PC either on site or remotely over a modem gives the service person the ability to optimize the sensor performance quickly and easily. The Histogram Displays provided in the Installation and Service Software pinpoint problem areas and provide guidance as to the corrective action required to reduce the nuisance alarm rate while preserving the desired probability of detection.

The fact that one can apply different settings for different locations on the cable is very unique to MicroPoint. Clearly the intruder has no way of knowing how the Control Parameters are set for any part of the cable. Conventional sensors only allow for one adjustment for an entire length of cable at a time.
Integrated Power & Data

Most conventional perimeter security sensors require power and data wiring to each processor on the perimeter. The acquisition and installation of these wires can be as costly as the security system that it supports.

In MicroPoint cable DC power is provided over the coaxial cable to all units on the perimeter. High efficiency DC to DC converters are used at each module to compensate for the resistive losses in the cable. Applying power to a single point on the perimeter makes it much easier to provide battery backup without the complexity of having batteries outdoors. When the system is installed in a “closed” configuration the power grid is redundant. Since power flows both ways around the perimeter in a “closed” loop system a cable can be cut and power continues to flow to all processors on the perimeter. By using DC power it is easy to add power at various point on large perimeters without need for synchronization.

The FSK data communications operates at 150 to 200 kHz over the coaxial sensor cable. It is a peer to peer communications network. These FSK data are converted into RS232 or RS422 data to communicate with a PC directly or over a modem to a PC. In this way the PC can monitor the real time performance of any processor on the perimeter. All adjustments to setup the system or to optimize the sensor performance are made using a PC and the Installation and Service software provided with the system. There are no knobs to adjust or switches to set at each processor as with older technologies.

Power and Data to Auxiliary Sensors

In many cases it is desirable to add additional sensors on the perimeter to accommodate particular situations such as gateways or areas without fences. The power and data network described previously is also available to integrate these auxiliary sensors into the INTREPID system. Power and data ports are made available at the modules on the perimeter to provide 12 volts DC output as well as to collect alarm contacts. This removes the need for additional power and data wiring to these auxiliary sensors and the alarm data is integrated into a single display.

The Role of the PC

INTREPID has been designed to make maximum use of PC technology to install and maintain the hardware. This includes Windows® based software to install the product as well as to maintain and service the product. Graphic Map display software is available to show the precise location of alarms as they occur. Alarm reporting software is available to monitor the system performance including the operator responses to alarms.

Part 2 - INTREPID™ MicroPoint™ the Components

INTREPID MicroPoint is a very modular system. It is designed to adapt to the particular requirements of each site. One thing that Southwest Microwave has learned from its many years of experience in the outdoor perimeter market is that every site and customer requirement is different. While this is obviously true of the physical dimensions and environmental conditions that exist at each site it is also true of the threat and response philosophy.
In addition to the components described below you will also require other items such as computer, a modem and power supply to complete the system.

**Major Hardware Components**

**Processor Module (PM)**

The PM is the main module in the MicroPoint system. It controls up to 400 meters (1,310 feet) of cable providing intrusion detection and location. It is housed in a weather proof plastic enclosure that is fastened to the fence fabric. All cables enter the enclosure from the bottom.

The Processor Board is a multi-layer circuit card with surface mount components. It is held in the enclosure by two simple clips. It incorporates a 16 bit microprocessor, a programmable logic array with over 3000 gates and 2 Meg of Flash memory. (Flash memory is non-volatile - it retains its memory even when the power is turned off.) The PM has no potentiometers or physical adjustments of any kind to set during production or in the field. Because all connections to the PM are with screw terminals there is no need for solder or heat shrink tubing in the field. The custom MC100 terminal blocks are equipped with a built-in striping tool that can not be lost or misplaced because it is an integral part of the terminal block. All input and output lines are protected against lightening. Reliability and ease of maintenance has been built into the design at every turn. The inside of the enclosure is coated to ensure that the PM meets all FCC and CE regulations governing computing devices.

There are 6 relay and 4 analog input ports per PM. There are 3 relay contact outputs. Up to 150 ma at 12 volts is available for auxiliary sensors. System power can be added at any PM on the perimeter.

**MicroPoint Cable (MC)**

MicroPoint Cable is not only the intrusion sensor but also provides DC power to all modules and auxiliary sensors as well as the data communication path for the built-in alarm/control multiplexing network. The cable comes in 50, 100 and 200 meter (164, 328 and 656 foot) lengths. The outer jacket is made of high density polyethylene so that it withstands normal wear and tear from years of use in an outdoor environment.

**Link Unit (LU)**

The LU is used to connect multiple Processor Modules together. It passes the power and data from one length of cable to another while terminating the detection process on each cable.

The are 4 relay input ports available on a LU. When an optional Power Converter Card (PCC) is added to a LU up to 150ma at 12 volts is available to power auxiliary sensors. System power can be added at any LU.
Termination Unit (TU)

The TU is used at the end of a system to terminate the MicroPoint Cable. It is housed in a plastic utility type box which is tie wrapped to the fence fabric.

Relay Module (RM)

The RM provides 6 relay outputs and has 6 relay and 4 analog inputs. It communicates to a PM over an RS485 twisted pair network. Up to 8 RM’s can be installed on a single RS485 line.

Supplemental Hardware Components

Power Converter Card (PCC)

A Power Converter Card is a DC to DC converter that accepts the 10 to 60 volts provided on the MicroPoint Cable and produces +5 VDC and +12 VDC to power the various modules and auxiliary sensors. A PCC is included in each PM and can be added to an LU or RM when required.

Network Interface Module (NIM)

A Network Interface Module is used to connect RS232, RS485 or RS422 lines to a MicroPoint system as well as to provide a real time clock and audio output. The NIM is a daughter card that plugs onto any PM.

RS232 Adapter (232A)

A 232A is a small plug in device which is used to connect an RS232 communication line to a Intrepid system. It can be used separately or in parallel with a NIM on a PM.

RS422/485 Adapter (422/485A)

A 422/485A is a small plug in device which is used to connect an RS485 or an RS422 communication line to a MicroPoint system. It can be used separately or in parallel with a NIM on a PM.

Software Modules

Site Manager is a Windows based software package that communicates with INTREPID modules to setup and manage a complete perimeter security system.

Basic Modules:

Drawing Tool

The Drawing Tool is used to draw a site plan and to locate all the INTREPID modules and auxiliary sensors. It is the first tool used in the installation process.
Installation \ Service Tool

The Installation \ Service Tool is used during installation of MicroPoint Cable and later for On-Site-Service or Remote-Service via telephone. This tool provides real time displays of the sensor operation as well as plots of historical data that provide guidance to the service person to quickly identify and remedy problems. A data file is stored once a system is installed and commissioned which is used as a base when service is required. For example, by comparing the current clutter to the stored clutter one can detect and locate cable problems. Comparing the current sensitivity to that recorded when the system was commissioned clearly identifies site changes that may have occurred such as a fence that has been deformed by being hit by a truck. The use of the Installation and Service Software replaces oscilloscopes, meters and strip chart recorders used by most other systems and it can be done from the comfort of the Service Persons office using modems and a telephone link to the site. The cost savings are obvious.

Optional Modules:

Map Monitor

The Map Monitor is a graphic site map, which displays exact intrusion location. It is used by the site security staff to Detect, Assess and Respond to perimeter intrusion alarms. With Map Monitor one would normally use a conventional desk top or tower PC with a three (3) button mouse. In this case one would normally remove the keyboard and have the Security Staff use the three-button mouse to control the system. The Supervisory Staff would plug in the keyboard, enter a password, view the alarm log and make limited changes to the map.

Site Manager supports modems and telephone or radio links. Use this to upload data and down load software via telephone. A Hayes compatible modem is required.

Alarm Activity Report

A report which provides a data log that is to be used by senior security staff to monitor and supervise the operation of the security system.

Component Limits

Each MicroPoint system is limited to 8 PMs, with up to 400 meters (1310 feet) of cable per PM and up to 8 RMs. Multiple MicroPoint systems can be combined to do larger sites.

Summary

Location, location, location is the key to this next generation perimeter security system.