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RF DURESS ALARMS:
Market Survey and Preliminary Characterization

Bruce L. Draper

Sandia Laboratories

SF 2900 Q(7-73)

SAND79-0575
UNLIMITED RELEASE
PRINTED MAY 1979

RF DURESS ALARMS

Market Survey and Preliminary Characterization

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ABSTRACT

This report represents the first phase of the duress alarm studies. Presented here are the results of an extensive market survey and some preliminary observations on the effectiveness of many system components.

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INTRODUCTION

The purpose of this first phase of the duress alarm study is to identify and characterize all commercially available equipment which would enable a patrolling guard to initiate, at least semi-covertly, an alarm. Most of the information compiled so far can be found in the tables at the end of this section. Many characteristics such as transmitter size, output power and battery lifetime are self explanatory. Others, such as alarm format and antenna performance are discussed in the following text.

The tables are divided into three main groups:

a) Medium power/medium range alarm systems. This category represents the main thrust of the study. A particular collection of equipment can not be regarded as a complete system unless it contains transmitters, encoders (for transmitter identification purposes), a receiver, and decoders. (See Tables I and II.)

b) Low power/low range alarm systems. Because of their low range (often less than 30 meters) these alarms have a limited number of stand-alone applications. However, these units could be used by guards to activate their car transceivers from a short distance away. (See Table III.)

c) Decoders. If the proper precautions are taken and minor modifications are performed, these decoders may be used in conjunction with ordinary tone encoded hand-held transceivers to create an effective duress alarm system. (See Table IV.)

Most of the information presented here has been gleaned from the literature supplied by the various manufacturers, most of which were contacted in response to listings in the International Association of Chiefs of Police (IACP) Police Buyers' Guide (October 1977 issue of Police Chief). Only one system has undergone limited testing at Sandia Laboratories—the A.I.D. system consisting of the TX-2113 transmitter, RX-2000 receiver, and Alarm II printer.

TRANSMITTERS

Activation

The method of initiating an alarm transmission varies greatly from one unit to another. Overt activation may be accomplished through the use of miniature push buttons, pressure pads, pull rings, or momentary contact toggle switches. Some models offer accessory switch jacks to facilitate covert activation through the use of devices such as boot or holster switches. At least one model uses mercury tilt switches to automatically activate the transmitter if the wearer falls for any reason.

In our limited experience the miniature push buttons used on transmitters such as the A.I.D. Model TX-2113 have been found to be unsatisfactory for our application. In order to send an alarm the user must first locate a small, raised guard ring (1 cm diameter) surrounding the switch on the top of the case. Once this has been accomplished, the switch shaft (~3mm diameter) must be depressed far enough to start the alarm transmission. In several preliminary tests it was found that electrical switch closure did not always accompany what was thought to be proper activation by the user. In fact, probability of proper operation fell somewhat short of 0.75. A better quality switch would presumably increase reliability but operation would continue to suffer because of the small push button size and awkward layout--a condition which is aggravated when the transmitter is worn in its leather case.

Both of these problems may be eliminated through the use of large area pressure sensitive pads, such as found on the Kel T-12MDJ transmitter (formerly manufactured by Bell and Howell). Although no tests have been run with these units. operation would seem to be easier than with those transmitters using miniature switches.

General Electric has approached the problem from another direction. The GE-STAR alarm transmission can be initiated by pulling a metal ring on the top of the transceiver/encoder. The ring is large enough to be easily grasped.

Several of the commercial duress alarms may be ordered with a jack mounted on the case to allow the use of many types of covert switches to activate the transmitter. Two examples, very reliable boot and holster switches, are being developed at Sandia Laboratories. The switch assembly is comfortable, operation is completely covert, and false alarm rate has been zero in tests conducted to date. More rigorous field testing will begin in the near future.

The A.I.D. transmitters offer another interesting feature--the "Deadman Alarm™." Three mercury tilt switches are oriented in such a manner that at least one of them closes when the unit is tilted off the vertical by approximately 45 degrees or more. The switch assembly may initiate an alarm transmission only if the contacts are closed for five seconds. This nearly eliminates the false alarms associated with normal user movements. External switches may also be wired into this delay circuit. False alarm rates with this and all other types of switches seem to be extremely low.

Antennas

There are several types of antennas which are commonly used with duress alarm transmitters. There appears to be no configuration which is clearly best. Trade-offs must be made regarding efficiency, visibility, and convenience. Only a few manufacturers offer a choice of several antennas for use with their transmitters.

Built-in antennas such as tuned ferrite loops and printed circuit loops have the advantage of being completely concealed. Because of their small size, however, their radiation efficiency is low; signals received from this type of antenna may be from 3 to 10 dB below those from a quarter wave ($\frac{1}{4}\lambda$) whip, depending on design. This decrease in signal strength could prove disastrous when working under weak signal (fringe area) conditions.

Shown in Figures 1 through 3 are radiation patterns of the A.I.D. TX-2113 which uses an internal printed circuit board loop antenna. The loop is approximately 1.5 x 9 cm ($\frac{1}{20}\lambda$ in length and $\frac{1}{8}\lambda$ total circumference). In Figure 1 it can be seen that the effect of the body is to decrease the signal strength an average of 5 to 10 dB but the pattern remains essentially omnidirectional.

Comparison of figures 1 and 2, plotted under the same conditions except that oppositely polarized receiving antennas were used, reveals two important facts. First, the transmitting antenna has a polarization coinciding with the orientation of the rectangular PC loop's long axis (vertical, in these two cases). Secondly, the proximity of the human body may create deep nulls in the radiation patterns in some directions while enhancing transmission in others. Consideration of Figures 1 through 3 leads to the general conclusion that in order to insure reception of an alarm transmission, it is highly desirable to have a receiver antenna system that includes both vertically and horizontally polarized antennas.

The choice of an antenna may be a compromise between comfort and efficiency. Telescoping rods or whips are more efficient radiators than small loops but can be very awkward when the transmitter is belt worn. Short, flexible, helically wound antennas are slightly less efficient than quarter wavelength rods but are much more convenient to use with the duress alarms studied so far. Wire antennas, taped to the wearer's body, may also be used in many cases. An antenna which may allow omnidirectional coverage is one which is an integral part of (i.e., woven into) a belt. More detailed study of all of these antenna systems is planned for the near future.

Range is a strong function of transmitter antenna efficiency, output power, height and gain of the receiving antenna, and propagation conditions. When used in a system with a 6 dB gain receiving antenna at a height of 60 feet, VHF and UHF transmitters with output power near one watt could be expected to provide reliable communications at distances up to five miles over flat terrain. It is highly recommended that each prospective user survey the propagation conditions of his particular environment before choosing any RF duress alarm system.

Type of Transmission

An alarm system might be useless if it were impossible to identify which transmitter is activated and/or from which area the alarm originates. Transmitter identification can take several forms:

a) Tone encoding--single tone, multitone sequential, or dual tone (simultaneous transmission).

b) Digital encoding--Frequency Shift Keying (FSK) or Audio Frequency Shift Keying (AFSK). This type of transmission is usually shorter than one which is tone encoded and may be more reliable. Both tone encoding and digital encoding may be added to most standard hand-held transceivers (Wilson, E. F. Johnson, Aerotron, Motorola, G.E., Repco, IEC, etc.) to make them useful as duress alarms. However, precautions should be taken to ensure that the receiver section *is muted after an alarm transmission.*

c) Voice. In several special applications and in many low cost systems, a prerecorded message may be transmitted. This method eliminates the need for decoding equipment at the receiver but is not as reliable as encoding schemes.

It is often advantageous to send the identification codes more than once in order to increase the probability of alarm reception. Some of the transmitters, such as the A.I.D. TX-2113, may be programmed to send the alarm from one to four times. Others may continue to transmit alarm sequences until reset.

In those transmitters which use some type of encoding it may be beneficial also to allow for voice transmissions following the alarm sequence. Details concerning the nature of the emergency situation could then be rapidly relayed to the control station. Of course, this is straightforward in transceiver units such as the GE-STAR and in transmitters which utilize tone encoding. The A.I.D. TX-2113 has a microphone which is activated after completion of the alarm sequence but transmitted audio quality is poor, and vibrations of the plastic case tend to mask vocal information transmission. Units which use FSK may not be capable of voice modulation.

Even if voice transmissions are not made it is almost a necessity that the transmitter carrier remain on after the initial alarm has been sent in order to facilitate direction finding, tracking, and to insure base reception and recognition. An alarm code which is repeated indefinitely would serve the same purpose.

RECEIVERS/DECODERS

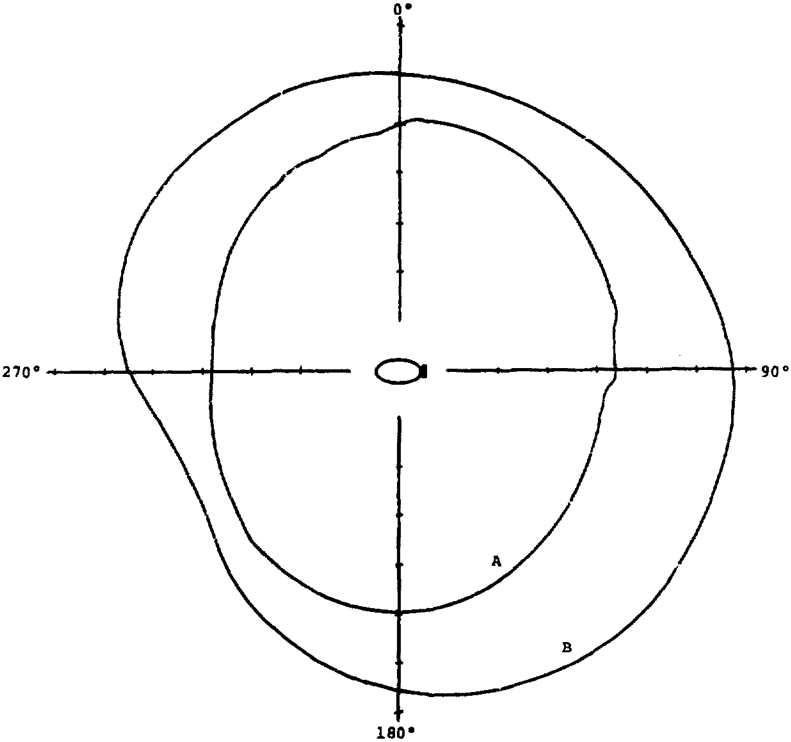
Most of the systems in group "a" on page 1 utilize receiver/decoder combinations which are basically alike. The variations which do exist concern the number of codes that can be accommodated and the number of frequencies which can be scanned for alarms. When an alarm code is received, it is usually displayed with LEDs and an audible alarm is sounded. Printers are also available *on some systems to provide a permanent* record of alarm codes, times and dates. Group "b" receivers typically are capable only of receiving standard FM transmissions. In fact, quite often the central receiver is the main communications receiver for the police or guard force. Smaller, less sophisticated "intermediate" receivers are used in these systems; the low range transmitter, which the guard carries when he is away from his vehicle, activates this intermediate receiver which may turn on a tape player or other device to transmit an alarm over the mobile transceiver.

DIRECTION FINDING

The ability to determine the area from which an alarm has been sent could be very important if the guards are on a "roving" patrol. If voice transmission is impossible, then electronic direction finding techniques may be necessary. (If the patrolling is done by some known route, simple logistics could be used to help locate the alarm site.)

Although many such systems are commercially available, only one, the A.I.D. Bird Dog, has been tested in this study. By detecting phase differences in the received signal between two $\frac{1}{4}\lambda$ whips mounted $\frac{1}{4}\lambda$ apart on a rotating platform, this unit can determine the transmitter bearing to within a few degrees. By using three of these systems it is then possible to locate the transmitter very accurately through triangulation.

Position location by positive electronic means rather than logistic extrapolation or voice communications seems highly desirable. However, logistic factors might be used to a great advantage in combination with a primary electronic location system, especially in resolving potential errors caused by multipath propagation.



Fiqure 1

A.I.D. TX2113 Radiation Pattern, 169.6 MHz

Receiver antenna is vertically polarized.

Curve A: Subject is standing facing 0° with transmitter worn on the right hip.

Curve B: Transmitter only.

Axes are marked in increments of 5 dB.

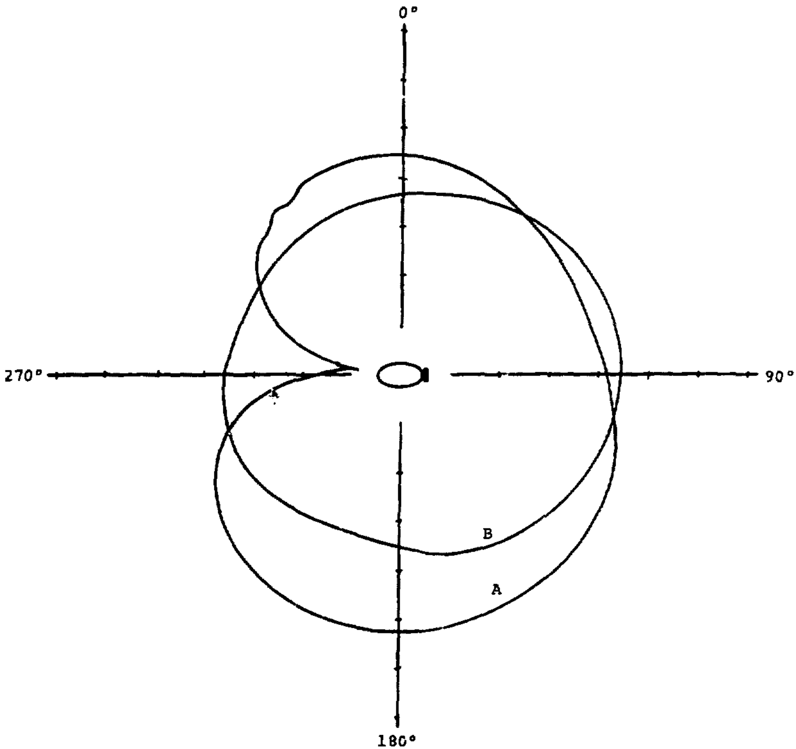


Figure 2

A.I.D. TX2113 Radiation Pattern, 169.6 MHz

Receiver antenna is horizontally polarized.

Curve A: Subject is standing facing 0° with transmitter worn on the right hip.

Curve B: Transmitter only.

Axes are marked in increments of 5 dB.

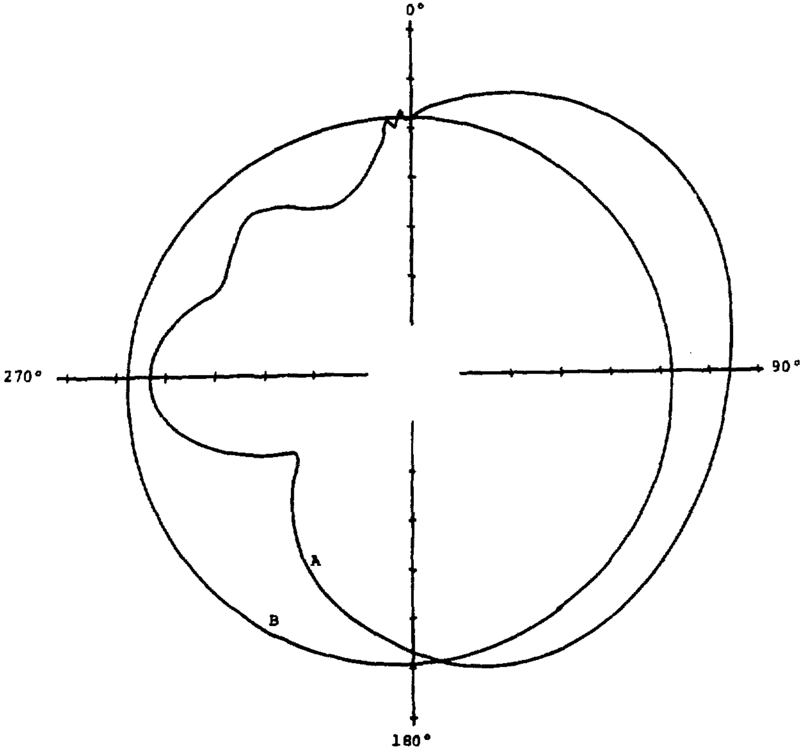


Figure 3

A.I.D. TX2113 Radiation Pattern, 169.6 MHz

Receiver antenna is horizontally polarized.

Curve A: Subject is in a prone position, face down, with head pointed toward 0°. Transmitter is worn on right hip.

Curve B: Transmitter only.

Axes are marked in increments of 5 dB.

	Frequency	Power Output (W)	Ant. Type	Activation	Jack for External Switch	Alarm Format	Voice Modulation Provisions	Continuous Carrier Following Alarm (Tracking)	Size, Weight	Case Material	Operating Temp. Range	Recommended Battery Type/ Life	Notes/ Special Features
AID TW-3113	Single Channel 136-174 MHz	1.5	Printed Circuit Loop	Small Pushbutton or Tilt Switch	Optional	Two-tone Sequential repeated 1-6 times (programmable)	Yes -- anytime after alarm	Yes	3.375" x 5.25" x 0.875" 7.87 oz w/o battery	High Impact Cycolac w/ Fiberglass	-10°C to +60°C	Two 9V Alkaline or Ni-Cad Pack. 45 min. (min.)	"Deadman" Switch: Transmitter is activated when tilted off vertical by 45° for 5 sec.
Communications [illegible]	Single Ch. 450-470 MHz	2.0	6" Flexible Helically-Wound Stub	Large Pushbuttons	Optional	13-bit Digital, repeated four times	No	No	4.75" x 3.00" x 1.625" 8 oz	Metal	-10°C to +60°C	Ni-Cad 15,000 Alarms	Transmitter number and one of three types of alarm may be transmitted.
G.E. [illegible]	138-174 MHz up to 6 Ch.	3.5	Telescoping Rod	Pull Ring	No	Phase Shift Keyed, 600 bps. Sent five times.	Yes -- following alarm (15 sec)	No	5.01" x 2.62" x 1.38"	Metal/ Plastic	-30°C to +60°C	Ni-Cad, Mercury or Alkaline up to 82 hr.	Transceiver
General Instrument	170 MHz	0.25	Flexible Wire	Ext. Switch	Yes	Dual-Tone Multi-Frequency Pairs	No	Alarm Sent Repeatedly	2.50" x 4.00" x 1.00"	Metal	-30°C to +70°C	9V Alkaline or Lithium	Other models available. Mode 1: Assurance mode, sends continuous ID. Mode 2: Alarm mode, faster pulse rate. Mode 1 may be disabled.
[illegible] T-12	1 or 2 Ch. 148-174 MHz	1.0	Flexible Wire	Pressure Pad	Yes	Two-Tone Sequential	No	No	2.25" x 4.875" x 0.75"	Stainless Steel	-30°C to +60°C	Mercury or Ni-Cad, up to 15,000 Alarms	
[illegible] TPT-1	2 Ch. 30-50 MHz 150-170 MHz	1.5	Flexible Wire	External	Yes	Dual-Tone Multi-frequency, repeated every 5 sec	Yes	Alarm Emitted every 6 sec.	2.00" x 6.5" x 1.5"	High Impact Plastic	-20°C to +60°C	Lithium or Ni-Cad. 15,000 Alarms	Up to three external switches can be used and coded separately.

TABLE I

Medium Power Duress Alarm Systems -- Transmitter Characteristics

	Sensitivity	Scanning Capabilities	No. of Codes Recognized	Code Display	Audible Alarm	Voice Reception Capability	Printer Option	Date/Time Display	Automatic Battery Switchover During Power Outage	Notes/ Special Features of the Complete System
AID RX-2000	0.08 µV for 0.90 Probability	2 Channels	100	LED	Yes	Yes	Yes	Yes, On Printer Only	Yes	
Communitronics 50050D	0.3 µV for 12 dB SINAD	No, Manual Selection of 5 Ch.	256	Annunciator Panel	Yes	No	Yes, Model 50089 Microprocessor Based	Yes, On Printer Only	Yes	If wearer does not report at preprogrammed intervals, an alarm is automatically sent.
G.E. GE-STAR	0.35 µV for 0.99 Probability	Up to 8 Ch.	2047	LED	Yes	Yes	No	Time Only	Optional	Part of a complete communications package.
General Instruments	No RF Section	No RF Section	10, May be Expanded	LED	Yes	No	Yes	Yes	Yes	Audio Decoders -- May be used with any RF receiver.
KEL TAC-II	0.15 µV	No, Manual Selection of 2 Ch.	100	Annunciator Panel	Yes	No	No	No	Yes	
VARDA DRR	0.25 µV	No, Manual Selection of 2 Ch.	10^6	LED	Yes	Yes	Yes	Yes, On Printer Only	Optional	Up to three external switches per transmitter may be used. Each transmits an identifying code.

TABLE II

Medium Power Duress Alarm Systems -- Receiver/Decoder Characteristics

	DESCRIPTION
Criminalistics Crisys	Pocket-sized transmitter with panic button actuates fixed 8 or 25 W transmitting encoder up to 1,000 feet away. Alarm code (Binary Coded Decimal Format) sent in UHF or VHF range to central decoder, displayed with LEDs.
F. C. Mason Eng. SSC/RA-2	Pocket-sized 300 MHz transmitter with panic button actuates a voice transmitter from up to 200 feet away. Prerecorded message is then transmitted on 30-50 MHz, 150-174 MHz, or 450-470 MHz bands (cassette tape recorder provided).
Gard Duty	Pocket-sized, 300-325 MHz, digitally encoded transmitter with panic button has a 100-foot range. Matching receiver closes a relay when the signal is decoded. Relay closure may be used to sound an alarm or to initiate transmission over mobile radio, etc.
Linear D22/D67	Hand-held transmitter (290-325 MHz) using pulse width encoding may activate receiver from up to 100 feet away. Alarm reception closes a relay which may be used to sound an alarm or to activate mobile or fixed transmitters.
Motorola Exec-Com	Personal Alarm Transmitter (1 W, 150-174 MHz) activates the Alarm Receiver Decoder located in car. Alarm code is then transmitted via Motorola's MODAT system (includes high power mobile data/voice transceivers and centralized data receivers/decoders).
Secode PPB-22/LB-4	Pocket-sized transmitter with panic button activates a fixed remote alarm transmitter from distances up to 100 feet. An alarm code (FSK) is then relayed to a central receiver and displayed either with LEDs or on an annunciator panel. Operates in HF, VHF, or UHF bands.
Stuart Safety Systems APEL	Belt-worn 100 mW transmitter with a range of up to 100 yards activates a tape recorder/mobile radio combination. Prerecorded message is then transmitted over normal communications channels. Transmitter also contains a tilt switch for automatic activation.
Transcience PT1/SCR	Hand-held panic button (240-320 MHz, 200-foot range) initiates relay closure on control receiver. Relay circuit may control audible alarms, high power transmitters, etc.

TABLE III

Low Power Duress Alarm Systems

	Sensitivity	Frequency	Code Display	Number of Alarm Codes Recognized	Audible Alarm	Date/Time Display	Automatic Battery Switchover During Power Outage	Voice Capability (Receive)	Working Code
NAPCO DD-470	No RF Section	No RF Section	LED	1,000	Yes	LEDs on Optional Printer, DD471	Optional	No	Standard ASCII AFSK
Plectron DD200 Series	Activation by 0.3 µV signal	Single Channel: 25-54 MHz 148-174 MHz 450-470 MHz	Annunciator panel	Up to 100	Yes	No	Optional	No	Two Tone Sequential

TABLE IV

Decoders

MANUFACTURERS

AID Technical Systems Division
1400 N.W. 62nd Street
Fort Lauderdale, FL 33307
(305) 776-5000

Communitronics, Ltd.
1324 Motor Parkway
Hauppauge, NY 11787
(516) 234-0099

Criminalistics, Inc.
13830 N.W. 27th Ave.
Miami, FL 33054
(305) 688-0822

F. G. Mason Engineering, Inc.
1700 Post Road
Fairfield, CT 06430
(203) 255-3461

Gard Duty
Minatronics Corp.
3030 Liberty Ave.
Pittsburgh, PA 15201
(412) 281-5050

General Electric Co.
Mobile Radio Department
P. O. Box 4197
Lynchburg, VA 24502
(804) 846-7311

General Instruments Corp.
1745 Jefferson Davis Hwy.
Suite 406, Crystal Square #4
Arlington, VA 22202
(703) 892-5655

Kel Corporation
37 Washington Street
Melrose, MA 02176
(617) 662-2222

Linear Corporation
347 S. Glasgow Avenue
P. O. Box 6019
Inglewood, CA 90301
(213) 649-0222

Motorola Communications & Electronics, Inc.
1301 E. Algonquin Road
Shaumburg, IL 60196
(312) 576-6630

NAPCO Security Systems, Inc.
6 Di Tomas Court
Copiague, NY 11726
(516) 842-9400

Plectron Corporation
Overton, NE 68863
(308) 987-2416

Secode Electronics
625 Good-Latimer
Dallas, TX 75226
(214) 742-7231

Stuart Safety Systems
1901 Avenue of the Stars
Suite 605
Century City, CA 90067
(213) 552-2226

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17 Irving Avenue
Stamford, CT 06902
(800) 243-3494

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Action Group
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