INTRUDER ALARM SYSTEMS: THE STATE OF THE ART

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This paper presents a detailed description of today's state of the art intruder alarm systems and detectors. It focuses on the several applied technologies, including the transmission and reception of alarm messages and commands trough GSM/GPRS and TCP/IP, and compares them. Several concepts, useful rules and techniques are proposed, concerning the project of intruder alarm systems for domestic, commercial and industrial use, in homes, shops, large buildings, and production facilities.

Keywords: **alarm systems, intrusion detectors, communicator modules**

1. Introduction

Today, the project, installation and use of security alarm systems for intrusion prevention is massively present in our own homes and work facilities.
A simple intruder alarm system consists of a control panel (with rechargeable battery power backup, and internal or external keypads), several perimeter and interior intrusion detectors, and at least, one external sounder:

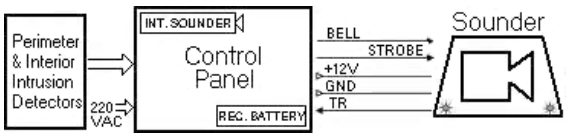

Figure 1- a conventional intruder alarm system.

Typical electrical signals associated with the conventional intruder alarm system are:

Table 1- electrical signals of an intruder alarm system.

Signal	*Function*	*Source*	*Enabled*
BELL	Sounder Bell	Output	+12V↴ 0V
STR	Sounder Strobe	Output	+12V↴ 0V
VBAT	Power (+12V)	Power	All
GND	Ground (0V)	Power	All
TR	Sounder Tamper Return	Input	0V→Open

The BELL signal is the first output signal from the alarm control panel, and is used for triggering the alarm sounder devices.
The STROBE signal is the second output from the alarm control panel, and will enable the flash lamps from the external sounder.
VBAT and GND are the power source terminals for the alarm control and the external sounder. Power is always +12V.
TR ("Tamper Return") is the external sounder output signal, indicating an opened sound cover tamper.
The installation of a conventional alarm system could not be sufficient to prevent intrusion, since burglars and becoming more and more sophisticated, and can easily thwart conventional alarm systems. So, it is very important to choose the right system and the right detectors for all the places to watch out.
Let's first describe the different types of intruder alarm systems that are nowadays commercially available:

2. Intruder alarm systems

An intruder alarm system can be first classified as a:

- Hardwired system;
- Wireless system;
- Hybrid system.

The best secure intruder alarm systems are always hardwired systems, because wireless systems will need additional battery power backup and, even with Anti-Jamming protection, still can be affected by radio-frequency interferences, although its detectors are usually brand specific.
Wireless systems are mainly used when there is not pre-wiring and they operate at 433MHz or 868MHz.
Hybrid alarm systems allow simultaneously the installation of hardwired and wireless detectors, being the most versatile of all.

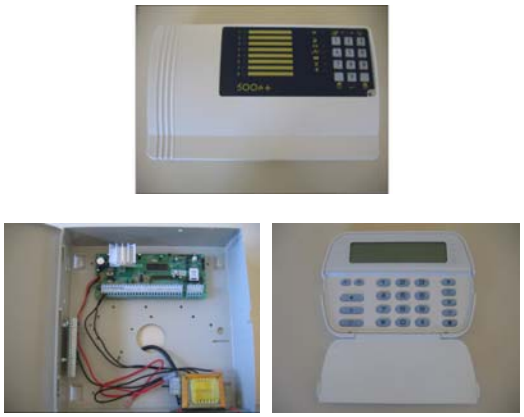

Figure 2- wireless and hybrid alarm controls (Scantronic 500r+ [1], DSC Power864+Keypad [2]).

2.1 Intrusion detectors

Commercial available intrusion detectors are:

- PIR (Passive Infrared motion detectors);
- PET (Pet Immune motion detectors);
- Dual Technology motion detectors;
- Magnetic contact;
- Acoustic Glass Break detectors;
- Vibration/Chock sensors;
- Others.

These detectors can be further divided as perimeter and interior devices. All are extremely important, concerning the project of "burglar-proof" alarm systems.

2.1.1 PIR (Passive Infrared motion detectors)

PIR detectors are nowadays the most used sensors for intruder detection. Its cost and power consuming is considerably low, and the installation is quick and easy (both for walls, corners or ceilings), and without the need to even remove the printed circuit board inside.

Figure 3- PIR motion detector (DSC Bravo 2).

This sensor is +12V powered and has a silent normally close or normally open output. It also comes with a cover tamper protection output, for detecting inside coverage removal, also normally opened or normally closed. Wireless versions of PIR detectors can easily transmit up to 30 meters (and much more in open field).
A PIR motion detector uses a special Fresnel lens. A Fresnel lens is quite thinner than a conventional lens, being able to pass more infrared light, at the expense of reducing its imaging quality.
This kind of lens reduces the amount of material required when compared to a conventional spherical lens, by breaking the lens into a set of concentric annular sections, named Fresnel zones.

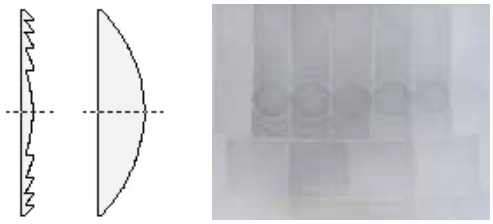

Figure 4- cross sections of a Fresnel lens (photo) and a conventional lens.

For each of these zones, the (overall) lens thickness is reduced, chopping the surface of a standard lens into several surfaces with the same curvature.
The maximum detection range for the PIR motion detector varies between 12 and 23 meters (with long range lens), usually spreads with a 90º aperture (can reach 360º with several IR elements), and with four or more layer detection levels.
The Fresnel pigmented lens provides a large number of detecting layer beams (usually more than 60), along with protective shielding, for blocking out white light.
An additional layer (named zero layer, look down layer or creep zone) can be also provided to sweep the areas immediate bellow the sensor.
PIR motion detectors sweeps all layer beams for fast temperature changes due to the movement of the human body, that emits infrared radiation, and have an internal microchip or thermistor that will adjust the device for slow temperature changes. This way, as a room cools down and warms up during an armed alarm period the PIR detector will not send a false alarm.

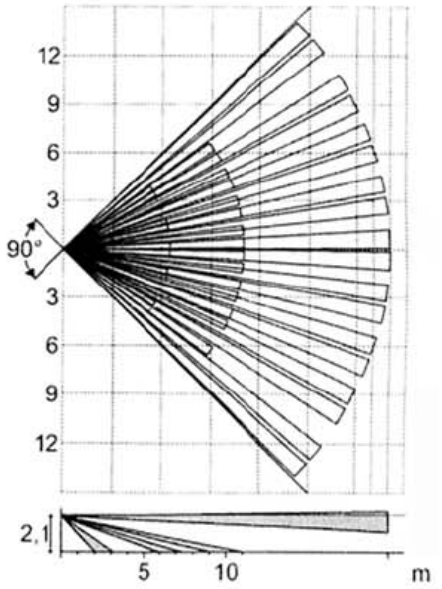

Figure 5- typical covered area for a twin-element PIR detector. (Courtesy from Afroluso [3]).

Some PIR motion detectors allow manual sensitivity adjusting, and others have also "smart" Digital Signal Processing for real-time settling the catch threshold, usually dependent from the speed that the burglar crosses the layer beams.
The PIR motion detectors have also temperature compensation and are usually anti-white light (above 9000 LUX). Although its good immunity to white light, they should not be installed pointing directly to windows and other sun-light entry sources.
Unfortunately, this kind of motion detector can sometimes trigger false alarms, usually in covered areas with air flows (opened windows or air conditioning), once they detect variations of heat by

the form of infrared radiation. To attenuate this problem, some PIR detectors have two independent alarm outputs for first and second detection, making a sequentially alarm confirmation. Another good solution to prevent false alarms is to use a PIR detector with twin PIR elements, as shown in figure 5 (one of the main thinks with PIR elements to keep in mind is that we never should touch these).
Also, as PIR sensitivity is reduced when the ambient temperature approaches the body temperature, it is possible for a bugler to sufficiently mask himself ("cloak") from the PIR motion detector, using camouflage techniques, so that the detector does not identify him, because it eventually could not sense his infrared radiation.

2.1.2 PET (Pet Immune motion detectors)

Before PET immune technology, a pet owner had to either confine his pet from the protected area or bypass the correspondent motion detector.
To solve this problem, it was developed a special passive infrared detector (named PET immune detector), that could distinguish from two different layer beams, that are offset from each other.
So, a PET immune detector is essentially made by two PIR motion detectors, specially developed to (both) detect simultaneously a high and low layer pre-assigned beam. As pets under a certain amount of weight are not large enough to hit both beams, the PET motion detector does not really feel them.
The multi-level signal processing used by this detector will allow only the detection of the infrared energy originated by humans or other very large animals.

Figure 6- a PET immune motion detector (DSC Bravo 6).

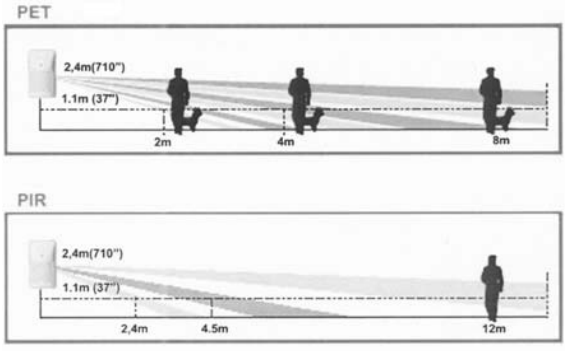

Figure 7- PET and PIR high and low layers. (Courtesy from Afroluso).

A PET immune motion detector is powered with +12V, and has also two normally closed (or opened) silent contacts, for intruder detection and for cover tamper protection. A smaller look down layer range (when exists) also allows pet immunity.
New PET immune motion detectors bring along also the Variable PET Threshold technology (VPT), for an adaptative threshold adjust, in order to avoid false alarms.
It is not recommended the use of PET immune motion detectors for zones with two or more pets since they can hit both beams. A PET immune motion detector will also easily trigger the alarm in presence of a free flying bird, even small, if it passes nearby the detector.

2.1.3 Dual Technology motion detectors

Dual Technology motion detectors are the technology newest sensors for increasing catch performance. It incorporates a PIR sensor and a special microwave detector operating at 10.525 GHz.
Conventional PIR detectors can generate false alarms when sensing heat flows, in situations when air flows occur due to open windows or air conditioners. Also, they might not work when directly pointed to the sun light.
Microwave detectors work differently, sensing the reflections of the emitted signal. This technology is most often Doppler and looks for the air movement that occurs when an intruder walks into an area, turning air to move as his body mass pushes it along. Because the air moving speed is much less than the light speed, and considering v_r the speed in the observer direction, and λ as the wavelength, the Doppler Effect will translate the following equation:

$$\frac{\Delta\lambda}{\lambda} = \frac{v_r}{c} \qquad (1)$$

Using dual technology detectors (both PIR and microwave) catch performance will increase, and we can further avoid typical PIR false alarms, because the triggering signals will be effectively double checked with the microwave detectors.
AND mode will maximize interference immunity, and the OR mode can be used in situations when might occur the blocking of one of the detecting signals.
In the dual technology detector both the sensitivity of PIR and microwave sensors can be independently adjusted. Its cost will naturally be higher, as a price to pay for higher precision.
These devices are recommended for installation in harsh environments such as garage or sun-rooms. For example, in a garage a car can be a source of heat flow, even when it is stopped!
Dual technology detectors are not commonly adopted in wireless alarm systems, because its power consumption will be considerable higher than the wireless PIR detectors. Also, they can be of detriment to users of pacemakers (very important). Ultrasound,

along with PIR dual technology motion detectors can be a nice alterative solution (without pets).
Dual technology detectors are +12V powered and have two NO or NC output terminals for detection and cover tamper protection.
This type of detectors allows switching from short to long distance detection, by an internal jumper, and can use Anti-Crosstalk Anti-Collision Technology that prevents false alarms from microwave interference, in a situation when several of these detectors operate face to face or adjacent in the same area.

Figure 8- Dual-Technology sensor (OPTEX MX-40QZ).

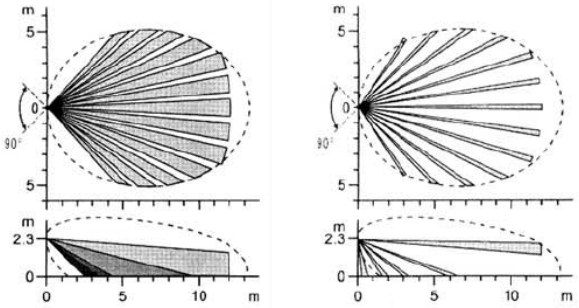

Figure 9- typical Dual Technology (PIR double element) range diagram. (Courtesy from Afroluso).

Recent Dual Technology motion detectors can also have Anti-Cloak Technology (ATC) [4] to thwart even the most camouflaged burglars. A moving, cloaked intruder will emit a weak IR signal that has some characteristic pattern. ACT applies recognition algorithms that disregard the signal strength and focuses on its shape. Once verifying that it matches with the signal of an intruder (and if microwave detection is on), ACT immediately switches to microwave triggering mode, for a certain time period. The same also happens when the temperature in the detecting zone is very close to the human body temperature.
Quad Element PIR Technology is another great technological breakthrough, and can really improve intruder catch and considerably reduce false alarms, because it will in fact use two PIR channels or twin-elements with separate lenses that will distinguish more effectively between humans and other infrared sources. Dual technology Quad Element PIR motion detectors can also use more end-of-line resistors, and some recent Dual Technology versions already have PET immunity.
The cutting-edge Sway Recognition Technology takes two microwave signals to recognize objects that constantly move without traveling, like for example moving blinds.
Grenline Technology is also very important, because this Dual Technology detector will disable its microwave sensor when the entire building or zone is occupied. There is no need to send constantly high frequency microwave signals to environment areas occupied by humans or animals, and the global power consumption is decreased.
The Dual Technology motion detector also can use Anti-Fluorescent Signal Processing, to avoid fluorescent light flashes, and Anti-Masking, by using an active infrared channel located behind the lens to protect against spraying and covering burglar techniques, and even can incorporate an optional integrated digital video camera.

2.1.4 Magnetic contact

These sensors are usually used for detection of opening or closing doors and windows. They have a moving (the magnet) and a fix part (the magnetic field detector), that it will detect the magnetic field generated by the magnet (Hall Effect).
This detector works with a very small embedded micro relay that closes or opens when exposed to a magnetic field. The Magnet is mounted aligned with the mark moulded into the side of the detector, up to a 10 mm gap.

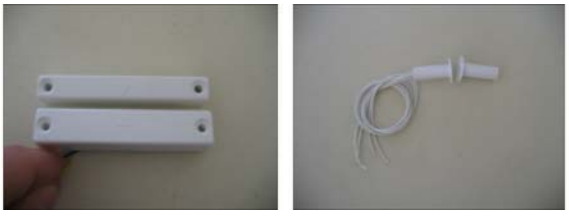

Figure 10- magnetic contact detector, and magnet (conventional and embedded versions).

Figure 11- wireless Magnetic contact detector, and magnet.

The great advantage is that these sensors do not need to be powered at all. In fact, the simple presence of the magnetic field is enough to trigger the embedded relay from the fixed detector, needing only a two-wire alarm cable for the installation.
A smaller embedded version can also be found in the security industry market, making its visual detection more difficult to intruders.

2.1.5 Acoustic Glass Break detectors

Acoustic Glass Break detectors add important 24-hour perimeter protection by detecting potential burglars, and while them are still outside.
Acoustic Glass Break detectors use an internal omni-directional microphone and a digital signal microprocessor along with DAS (Digital-Sound-Analysis) technology, to detect typical sound patterns of glass breakage, protecting all glass types and thickness (plate, laminated, tempered and wired), yet disregarding non-framed glass breakage and other sources of false alarms.
These flexible fixed part detectors can be surface, corner, flush, or even swivel-mounted on any wall or ceiling. The maximum range varies up to 9m, in straight line, measured from the microphone to the farthest glass window.
Simplified testing is provided trough a special audio tester. Some Acoustic Glass Break detectors have even an automatic dead microphone supervision test, by continuously listening environmental sound.
Identically they are +12V powered and have for detection and cover tamper protection, two normally open (NO) or normally closed (NC) output terminals.
The main problem with the acoustic devices is that an intruder can still achieve to force to open a window without needing to break the glass. So this perimeter acoustic sensor should be installed along with other interior intrusion detection devices. That is why some PIR motion detector versions can have already built-in an Acoustic Glass Break detector.

Figure 12- acoustic Glass Break detector (SENTROL ShatterPro II).

2.1.6 Vibration/Chock sensors

Vibration/Chock sensors are indeed a good alternative for Acoustic Glass Break detectors, by sensing the vibration on a window even before it breaks. These don't sense sound, but vibrations, usually by the use of an encapsulated internal piezo-electric sensor, or a CMOS micro-accelerometer.
Vibration/Shock sensors provide a reliable perimeter protection whenever there is a burglar attempt to smash, force, saw or drill through a door, window, wall or roof. These detectors can be mounted vertically or horizontally on frame or glass.
Some models came also with magnetic contacts for an extra double protection on opening windows and doors, saving installation costs and time.
As well as the other intrusion detectors they are +12V powered, and have NC or NO output detection terminals, and also a NC or NO terminal outputs for cover tamper protection.
Usually these detectors bring a latching led indicator (remotely reset). Sensivity can also be adjusted by an internal potentiometer. A Double Knock optional feature will avoid false alarms.
Vibration/Chock sensors are also present in the ATM Machine Industry, for vandal-acts prevention.

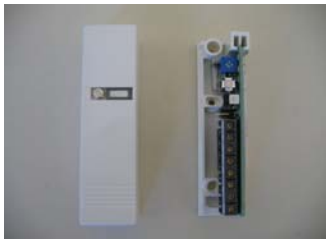

Figure 13- vibration/chock sensor (Viper GLX).

2.1.7 Others

There are may other types of detectors also used for preventing intrusion and steeling.
The Outdoor PIR and Dual Technology motion detectors (commonly named WatchOUT detectors) are being used more and more as an important additional perimeter motion detector. With a hood, it provides protection from rain, snow, sun, hail, and even birds, being also Pet immune. 360º ceiling PIR and Dual Technology motion detectors are also very common for protection in large industrial facilities.
Volumetric ultra-sound intrusion detectors are also used to prevent vehicle intrusion and steel. The volumetric detectors use the sonar principle, emitting and receiving ultra-sounds, and they are most applied to detect small volumes, like the vehicle interiors.
Many alarm control panels can also incorporate custom smoke and flood detectors, easily adding additional 24-hour fire warning and flood protection capabilities to a pre-existing intruder alarm system (keep in mind that the main goal of an intruder alarm system is, above of all, to protect people).
There are several types of smoke detectors (all +12V powered). The most common are the photoelectric smoke detectors, which use optical reflection principles to detect smoke, thus allowing 360° detection. Ionization detectors are mostly used to detect flames rather than smoke. A combination of both photoelectric and ionization detectors might be the best solution in fire prevention.

Figure 14- photoelectric smoke detector (System Sensor ECO1003), and relay base.

2.2 The External Alarm Sounder

The external alarm sounder choice is another key element for all alarm systems. The power sound capability of an external sounder is measured in dB (a good sounder should be able to deliver above 100dB). The sounder input signals are BELL and STROBE. These terminals can also came in differential mode (BELL+, BELL-, STROBE+ and STROBE-). The supplier usually provides the current sounder demand for a trigger occurrence.
External sounder autonomy is granted by the capacity (Ampere-Hour) of its internal rechargeable battery, along with the use of an internal auto-recharging circuit. A good external sounder must allow the attachment of a vandal-proof double skin metal cover:

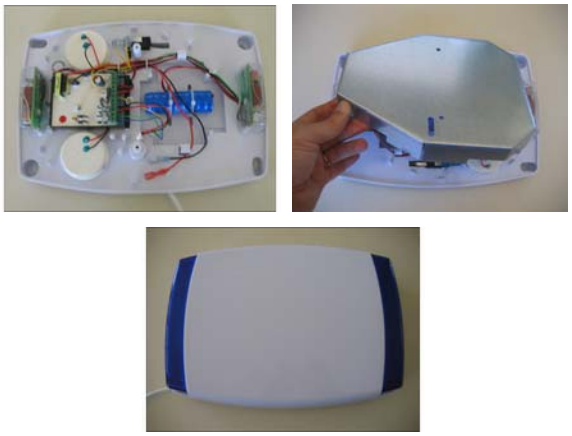

Figure 15- external sounder (SENTROL SIR001).

One should always choose twin-piezo speakers for low power consumption and a double protection, a UV-treated weatherproof Polycarbonate coverage, and an internal sounder PCB with long-life status/presence led indicators. Also, a SAB/SCB mode selectable is highly recommended. This allows to power the sounder directly from the control panel, or alternatively, from the sounder battery.
A standard control panel can wire two or more alarm sounders, as shown above. TR ("Tamper Return") turns out a "serial" terminal. Keep in mind however that the control panel must allow sufficient total current output for the added sounders that are going to be installed (if not, a "dummy" sounder can simulate a real one, and really cheat burglars).

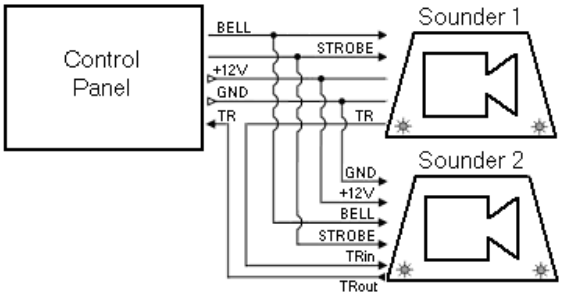

Figure 16- two external sounder wire-diagram circuit.

A ground "Tamper Return" (TR) shunt is provided in the control panel for silence the sounder during installation and tests. Never install an active sounder because an accidental trigger may cause serious hear injury.
External and internal alarm sounders can also be wireless, when extreme mounting conditions allow difficult cable installation. In return, some additional ongoing diagnostic measurements must be performed.
Every sounder should be checked (at lest) in a two year period. Diagnostics include measurements of the speaker current, sounder input current and voltage, battery voltage, and finally, a battery load test should be also performed.
Recent state of the art sounders include low power and long lifetime Surface Light Technology (SLT) strobes, replacing the traditional Halogen/Xenon lamps mounted in most strobes, along with adjustable flash rate and strobe time. Also, they can be anti-foam attack, and allow automatic internal battery shut-down, for full discharge prevention.

3. Hardwired alarm circuit configuration

In all hardwired commercial alarm systems each protected zone (at least, usually eight) is implemented with a closed loop circuit, where a fixed controlled current flows. The first protected zones are usually door entry zones, for manual or remote entry/exit pre-time arming and disarming.
Several intruder alarm configurations are available. Usually are called single NC, single NO, EOLR and DEOLR loop circuits.

3.1 Single NC and single NO circuits

Multiple normally closed (NC) and normally open (NO) detectors can be serial or parallel installed:

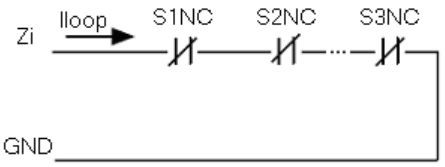

Figure 17- single NC alarm circuit configuration.

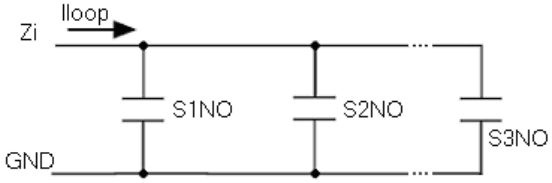

Figure 18- single NO alarm circuit configuration.

All detectors belong to a single loop zone. If some detector triggers, the loop circuit opens (Iloop=0A, due to SnNC detectors), or closes (Iloop=I_{Max}, due to SnNO detectors). The Output detector tamper terminals are usually serial wired with the output

trigger detection terminals, and for this configuration cannot be distinguished.
In this No-End-of-Line-Resistor settling, normally open and normally closed detectors can not be mixed. Also, NO configuration can be a problem, as the control panel will not detect a wire cut. A possible solution lies in the use of an End-of-Line resistor.

3.2 EOLR (End-of-Line-Resistor) circuit

What makes End-of-Line-Resistors (EOL) so important is that they can supervise the wires. When properly placed in the circuit, EOL resistors prevent wire tampering. The burglar who shorts loop wires together hides the EOL resistor from the control panel, letting the control panel know that something is going on.
The proper placement of an EOL resistor is at the last switch, on the detection circuit. We should never mount EOL resistors at the control panel, because in this case, it will act as if it has no EOL resistors. The EOL resistor value is provided by the control panel manufacturer (typically 5.6KΩ). EOLR circuits can (also) now be single NC, single NO or both mixed:

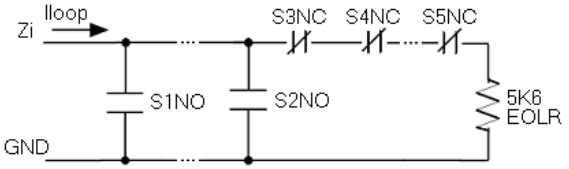

Figure 19- a mixed EOLR NC and NO alarm circuit configuration.

Table 2- mixed EOLR NC and NO alarm condition.

Loop Resistance	*Alarm Condition*
REOLR	Standby
∞	SnNC intruder detect or broken wire
0Ω	SnNO intruder detect, or loop shorted

3.3 DEOLR (Double-End-of-Line-Resistor) circuit

Double-End-of-Line-Resistor allows distinguishing between an opened cover tamper and from a trigger detector motion condition.
The tamper output normally closed detector terminal must be serial wired with the (normally closed) detector terminal, as shown below, and only one NC contact can be wired to each zone.

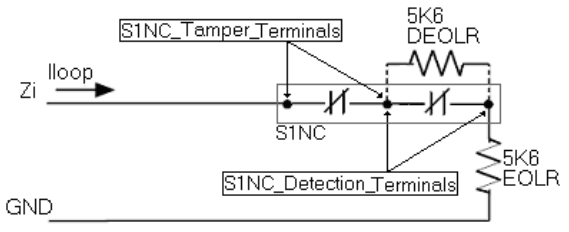

Figure 20- DEOLR NC alarm circuit configuration.

Recent control panel models allow programmed supervision for a single or double End-of-Line-Resistor.

Table 3- DEOLR NC alarm condition.

Loop Resistance	*Alarm Condition*
REOLR	Standby
∞	Opened cover tamper or broken wire
0Ω	Loop shorted
2.REOLR	S1NC intruder detect

DEOLR normally open circuits are not very often used, because a wire cut at the (NO) terminal detector output will not be sensed by the control panel.

4 Intruder alarm functions

Another key issue is the possibility for the control panel to execute several other important on-demand tasks, rather than just arming or disarming protected zones, at the end of the exit/entry programmed delays.

4.1 "Panic" alert

A control panel or a remote control should allow the activation of a simple "Panic" alarm witch will alert other family members, friends, or the Police in case of an emergency. Panic alarm can trigger or not the external and internal sounder. Sometimes it is better to only remotely alert others (by GSM/GPRS or IP, for example), to catch the intruder by surprise.

4.2 Perimeter arming mode

Perimeter arming mode allows a homeowner to freely circulate at night inside his home, yet still being armed the control panel, continuously monitoring all house perimeter sensors, such as doors and windows detectors and only disregarding interior motion detectors.

4.3 Door Chime feature

Door Chime feature is often used in shops and homes, allowing a quick audible short sound, for example each time a client enters inside a store.

4.4 Remote and automatic arming/disarming

Remote control panel arming and disarming can be done in recent hardwired alarm controls with the aid of a single specific current loop (zone), previously programmed for that purpose. This feature is truly recommended when we want to arm and disarm a control panel with a mobile phone or a PDA.
Automatic arming and disarming uses the internal control panel real-time-clock and calendar. This programmable option is indeed a control panel must-

have, being extremely useful for protecting places with predefined working timetables.

4.5 "Videofied" feature

Some new PIR wireless motion detectors can also have an internal night-vision camera [5], sending by radiofrequency instant 10 second video frames (compressed MPEG) directly to a dedicated control panel, and from there to a central monitoring station. The 10 second image is only sent if the alarm triggers. Monitoring stations can effectively then check if it is (or not) a false alarm, and immediate call the Police.

5. Alarm remote monitoring and control

Remote monitoring and control of an intruder alarm system can be done using conventional telephone lines, or with the aid of GSM/GPRS/IP modules. Both can connect to a dedicated monitoring station, or directly to any person.

5.1 GSM/GPRS/IP Modules

There are two types of GSM/GPRS communicator modules: a low cost, one-way, that only receives status information from the control panel, and bidirectional modules, that are able to either receive information or to control (arm/disarm) the control panel. GSM/GPRS modules have a SIM (Subscriber Identity Module) and a "free" mobile operator contract. Many mobile operators inhibit the SIM card, if after a tree month period no messages or calls where made or received. To avoid this problem usually the GSM communicator module allows sending a message test, every week or month for example, avoiding the deactivation of the SIM card and also to check the system.
GSM/GPRS modules use entry channels normally enabled to the negative transition (from 12V to 0V), being able to be directly connected to the BELL or STROBE control panel outputs. Otherwise, we just might need to use a small relay to adapt entry channels. These modules can be programmed directly from a mobile phone or though PC/laptop USB port, pre-defining the mobile phone numbers and the alarm messages that can be simple SMS, or even voice messages.
New GSM alarm modules already have a pre-warning for the SIM credit expiration, alerting with a SMS message the alarm user.
GPRS is usually faster and more reliable than GSM. Unfortunately mobile operators are still demanding for a fixed pre-user-contract, with a higher cost than by simply charge any GSM mobile phone to sent SMS messages. IP modules also enable IP communication between the control panel and a central monitoring station (or even any PC/laptop/PDA/mobile phone with Internet access, even wireless). Secure communication is full SSL (Secure Sockets Layer). Some IP communicator modules connect directly to the existing control panel main telephone lines, transmitting in SIA, ContactID, or FastFormat protocols to an IP receiver station.

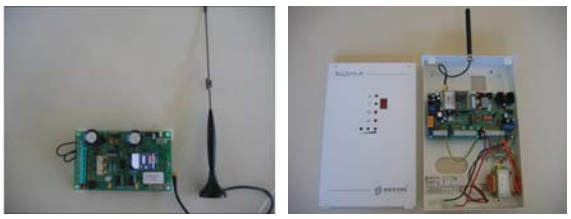

Figure 21- GSM Modules. S-20 (from ALWON [6]) and BGSM-A (from Bentel Security [7]).

5.2 Adding GSM/GPRS/IP modules to old alarm systems

Everyone that owns an older control panel alarm system can always adapt it to be able to send GSM/GPRS or IP alerts (some even to receive).
The BELL output must be wired to an input terminal of the GSM/GPRS/IP module (that can also be powered by the control panel itself). This simple operation will avoid the need for extra month fees and supervision alarm contracts with security companies. Control panel telephone line (if exist) can also be directly wired to a GSM/GPRS/IP module, and be used to send an alarm message.

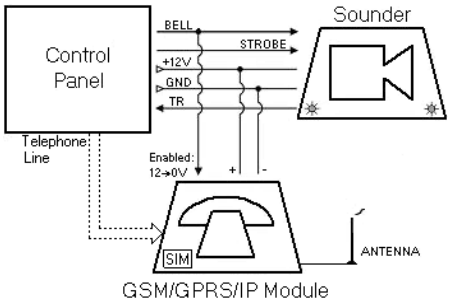

Figure 22- simple GSM/GPRS unidirectional module circuit to automatically send intruder alert messages.

A bidirectional module can be used if an old control panel with no telephone line has a programmed built-in arming loop or an input for arming and disarming:

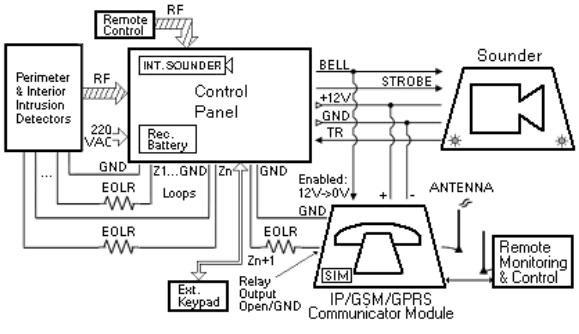

Figure 23- complete alarm circuit with a bidirectional communicator module (no telephone line allowed).

For all alarm owners who still have regular telephone line communicators, one might also consider switching to VoIP (Voice over Internet Protocol).

6. Basic intruder alarm system rules

To successfully conceive and install an intruder alarm system, it is necessary first to obtain the detailed map where the all system will be installed, with the zones to be protected. The alarm control panel choice has to be done considering the ratio cost/liability/time and also the esthetic outcome of a hardwired, wireless or hybrid solutions.
The definition of the protected zones must allow the establishment of the minimal number of loops and also of the total number of detectors, assuming a PIR/PET/Dual Technology motion detector solution per protected zone, and an additional number of perimeter detectors for doors, windows and in the outside. Apart from all that was already mentioned before, PIR and PET motion detectors installation should obey these basic following rules:

- The detector must be fixed approximately 2 meters from the floor (depends also on the module), and should always be identified with a stick number;

- The detector must be pointed in the opposite direction of light entries and windows, and never directly to sun light;

- A 90º detector must be preferentially mounted to a corner. A 360º detector should be mounted on the ceiling;

- Avoid mounting the detector in areas near air conditioning, heaters, ovens and fans, where it could detect air flows;

- When installing the detector, care should be taken to check if the manufacturer infrared and microwave radiation diagram fills the intended protected area;

- Avoid using wall swivels, that eventually could rotate, changing the detector position;

- A detector must preferentially point to frequent passage areas, such as door entries and corridors;

- Screw the detector only to fix parts, for example, to consistent walls;

- Avoid installing a detector near areas where exists vapor or high humidity that easily causes condensation;

- Avoid moving curtains and screens that can divide any infrared protected zone;

- Before mounting a detector, always read carefully the manufacturer installation manuals;

- Carefully check if all motion detectors are installed by performing always in the end a “walk test”.

For all acoustic glass break detectors, the following mounting procedures should be taken:

- The microphone of the detector should be pointed towards the direction of all windows, never more than 9 meters away (in straight line);

- Should be avoided to mount acoustic glass break detectors in kitchens, or close to audio speakers.

For magnetic contact sensors:

- Magnetic contact sensors should be hidden, and mainly used embedded magnetic switches;

- The magnet must always be attached to the moving part of a door or window;

- The distance between the magnet and the detector must be within the manufacturer limits (usually less than 10mm);

- In magnetic contact sensors only two-conductor alarm cables should be used;

- Where possible, mount the body of a magnetic detector close to the top of the non-moving frame of a door or window;

- Always align correctly the magnet with the existing marc on the detector;

- Magnetic contact sensors must not be fixed near metallic, magnetic structures, or high voltage cables, and nor near the floor.

Also, for PIR, PET and wireless magnetic contact detectors:

- Do not install wireless magnetic detectors near electrical engines and other electronic equipment that sends radiofrequency noise, such as automatic garage doors or automatic curtains;

- Do not install wireless detectors at difficult access places, because detector batteries some day will need to be replaced.

Finally, concerning the alarm control panel, one should install it in hidden places (inside a closet, for example) to prevent intruder vandal acts. Only keypads should be at visual site, and preferentially in frequent passage zones, like in front or house to garage door halls. If you chose to have only one keypad, it should be placed near the frequently used door. An additional Panic “distress code” should also be able to be programmed into the alarm control panel, “silently” letting know that someone might be in a hostage situation.

7. Conclusions

This paper outcome from the author's teaching experience in the three-week intensive High School "Intruder Alarm Systems Project and Installation" [8] Practical Courses.
The author hopes this "all-in-one-paper" can be useful for all those who want to start to plan and install state of the art intruder alarm systems in their homes, shops, large buildings and industrial facilities, or for any other protect areas.
The emergence of mobile and IP communications has changed the way we are able to view and control traditional security systems. Security Industry has an enormous world wide market, continuously growing, focusing (even) more and more that intruder alarm systems should be always designed and used to protect people first and property second.

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