Technology Overview

IntelliSense®

FG-1025 Family
Glassbreak Detectors
Technical Note
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Overview

This Technical Note is intended to explain in detail the technical advancement of the new FG-1025 family of glassbreak detectors over the previous FG-730 family of products. Further, it is intended to highlight the benefits of those enhancements to the customer. This Technical Note is not confidential, and can therefore be provided to customers who have a technical interest in our new FG-1025 family of glassbreak detectors.

Market Demand

The FlexGuard® FG-730 is the world’s best selling acoustic glassbreak detector, with well over one million detectors installed worldwide. This popularity was achieved due to the detector’s excellent glass break detection and false alarm immunity.

However, since the introduction of the FG-730, the market for glassbreak detectors has changed. The market now demands detectors without sensitivity adjustments for ease of installation, detectors which detect even the most minimal quiet breaks, and detectors with outstanding false alarm immunity. Our new FG-1025 family meets these requirements.

Theory of Operation

Using a dual channel design, the FG-730 uses two technologies: listening for the acoustic sound of glass breaking, and sensing the “flex” pressure generated when glass breaks. Signals are compared to set thresholds in the detector, and the detector alarms if the thresholds are crossed. The significant technical breakthrough of the FG-730 was sensing the flex, thus the name FlexGuard.

The FG-1025 family is based on the same flex/audio principle of dual technology sensing, but with far more signal processing using an on-board microcontroller.

FlexGuard Signal Processing Design

FG-1025

FG-1025R

FG-1025Z
The FG-730 family of FlexGuard products are all analog devices. They route the signal from the microphone through a series of discrete (individual) components on the circuit board. The signal passes through circuitry gates which compare the signal to fixed threshold settings to see if the amplitude (intensity) of the signal is greater than the threshold. The three threshold settings are:

- **Flex level threshold:** Does the signal exceed a fixed level for the flex?
- **Audio level threshold:** Does the signal exceed a fixed level for the audio?
- **Time coincidence:** Are the two thresholds both crossed within a time window of less than 200 milliseconds?

If these three set conditions occur, then the detector alarms.

**FG-1025 Signal Processing Design**

FG-1025 glassbreak processing is an order of magnitude beyond the FlexGuard. The heart of the FG-1025 family is a Motorola 68HC05 microcontroller. Using four on-board A to D converters, the microcontroller converts the analog signal into a digital datastream. Only the FG-1025 family uses an advanced microcontroller, providing 2,112 bytes of ROM, 128 bytes of RAM, an internal clock, and 21 lines of input/output all on-board.

The FG-1025 family is more computer than detector. It uses 1,019 lines of assembly language computer code, each one a separate instruction for processing the digitized signal from the microphone. This software program is executed within the central processor unit (CPU). The custom software is permanently burned into the microcontroller’s ROM at the Motorola factory, virtually eliminating the possibility of memory loss. The FG-1025 family is the only glassbreak to use factory-installed masked ROM microcontrollers. Other detectors on the market use OTP (EPROM) alterable memory, which can be subject to memory loss.

The FG-1025’s digitized signal is compared against eight thresholds:

- **Flex level threshold:** Does the signal exceed a level for the flex?
- **Audio level threshold:** Does the signal exceed a level for the audio?
- **Time coincidence:** Are the two thresholds both crossed within the time window?
- **Flex/audio ratio:** Is the ratio consistent with glass breaking?
- **Attack threshold:** Does the signal match an attack profile?
- **Flex duration:** Does the duration match a glass break profile?
- **Audio duration:** Does the duration match a glass break profile?
- **Microphone overload:** Does the signal represent a true glass break attack instead of microphone overload?

If these eight conditions occur, then the detector alarms.
Detector Intelligence Through Digital Signal Processing

The FG-730 is a “dumb” detector in that the signal is compared against three fixed thresholds. The thresholds remain the same regardless of conditions because the thresholds are built out of discrete components on the circuit board.

The FG-1025 family of glassbreaks are “intelligent” detectors. The software uses proprietary mathematical formulas (algorithms) to process the signal and to adjust thresholds based on current conditions. False alarm rejection algorithms identify and reject whole classes of false alarm sounds. Glassbreak detection algorithms identify true glass break conditions for all glass types and attack profiles. Thresholds are adjusted up and down as warranted by data received at the detector. In sum, the FG-1025 family’s reliability is the best on the market because it performs 20 times more processing in the critical first 200 milliseconds of an event than that performed by the FG-730. Patents have been filed on the FG-1025 family and its digital signal processing.

The Latest Glassbreak Innovation - FG-1025Z

The newest member of the FG-1025 family of glassbreak detectors is the FG-1025Z. This is the first glassbreak detector that only listens for sounds coming from the glass. The FG-1025Z uses patented Time-of-Arrival (TOA) processing which is a giant leap forward in glass break detection and false alarm immunity for our industry. Using two microphones and TOA processing, the detector listens only for the sound of breaking glass arriving from the glass zone (front microphone), and ignores sounds arriving from elsewhere in the room—the excluded zone (back microphone). Other glassbreak detectors are space protection devices because they process sounds from the room interior, as well as sounds from the perimeter glass.
What Is Time Of Arrival (TOA)?

Time-Of-Arrival (TOA) is a method of processing sound to distinguish between true glass break attacks and false alarm sounds. Sounds are received by two microphones, 180° opposed, and processed differently depending on which microphone received the sound first. Sounds arriving first from the glass zone (front microphone), are processed to determine if a true glass break attack occurred. Sounds arriving first from the excluded zone (back microphone), are ignored as false alarm sounds. This innovative technology dramatically increases accuracy, reliability and false alarm immunity.

Additional FG-1025Z Enhanced Features

The FG-1025Z incorporates three additional enhancements: Remote LED Enable, Trouble Output, and Command Input. Focused on meeting worldwide compliance standards, the Remote LED Enable feature allows remote operation of the LEDs. The Trouble Output allows remote annunciations of any trouble conditions the detector may have. The Command Input feature allows local and remote activation of the detector’s self-test.

Solutions To Microphone Overload

Extremely loud glass break events, such as a bullet blowing out a huge window, can overload a glassbreak detector microphone causing a detector to false alarm or causing a detector to miss a detection, depending on the circumstances. The FG-930 was the world’s first detector to solve microphone overload. In a now patented process, a second microphone with a mechanical filter is able to filter out the overload, allowing the detector to respond normally to the glass break event, and to reject loud burst false alarms. The FG-730 does not have this feature, so its design treats these loud burst events as glass break events in order to maximize detection.

An even more ingenious solution is incorporated into the FG-1025 family. A digital filter inside the microcontroller catches and converts overload signals to normal signals, virtually eliminating burst related false alarms and significantly improving catch performance of previously “impossible to detect” glass break events.
Verification Of Proper Operation

The yellow flex LED on the FG-730 detectors will flash if a wall is struck. This provides some comfort to the end-user by providing visual feedback that the detector is still powered. Unfortunately, this test must be initiated by the end-user, and it is not an indication of the detector’s operational status, only that the LED still works.

The FG-1025 family uses the microcontroller to conduct a continuous self-test of the detector. It checks the ROM memory, RAM memory, controller logic, controller arithmetic, and the analog circuitry surrounding the microcontroller. In the unlikely event of damage or failure, the LEDs will begin to blink alternately in rapid succession to attract the attention of the end-user.

The end-user can also periodically test the detector’s power with a simple clap of the hands. The green LED blinks, exercising the circuitry and providing the end-user with visual confirmation. This simple test can be of great comfort to the end-user who wonders whether the detector is active, since real glass break events are infrequent, and since breaking real windows as a test is rarely practical.

- CONTINUOUS SELF-TESTS OF:
  - ROM memory
  - RAM memory
  - controller logic
  - controller arithmetic
  - analog circuitry surrounding the microcontroller

Activation Of Test Mode

At installation, the range of the FG-730 can be easily tested using the FG-700 or the FG-701 handheld glassbreak simulator. Following a flex signal initiated by the installer, the FG-700 or the FG-701 produces an audio signal realistic enough that in combination with the flex it trips the detector into alarm. This essentially is a false alarm which trips the detector.

The false alarm rejection algorithms in the FG-1025 family of detectors are too good to be fooled by the FG-700 or the FG-701 simulator. The detectors do not trip to this false alarm. These detectors must obviously still be range-tested, so a test mode is used. In test mode, the false alarm rejection algorithms are bypassed, while leaving the glass break detection algorithms in place. In this way, test mode provides a valid test of detector range.
Using Hand-held Testers To Confirm Detector Range

The old FG-700 tester can be used on the new FG-1025 family of glassbreak detectors. The installer opens the detector, shorts across the two pads with a screwdriver, and the detector goes into test mode for 10 minutes, after which it automatically reverts to normal mode. Once in test mode, the installer tests the detector’s range using the FG-700 Glassbreak Simulator.

An easier method is to use the new orange colored FG-701 tester. Rather than climbing a ladder, the installer puts any of the FG-1025 family into test mode by firing the tester at the detector from a distance of up to 10 feet (3 meters) away. The detector can then be tested for range. After 10 minutes the detector automatically reverts to normal mode. Also, the detector can be taken out of test mode by firing the tester at the detector.

The activation sound which places the FG-1025 into test mode is a sequence of seven short clicks. The time interval between each click is unique, and the detector listens for this unique pattern. One fear is that the detector might go into test mode on its own due to hearing a sound similar to the test mode activation sound. The consequence would be that false alarm immunity for the detector would be reduced for 10 minutes. Fortunately, this is very unlikely to occur due to the unique timing sequence between the seven clicks. Calculating for even worst-case noise conditions, the odds of a sound causing a false activation into test mode is one in two billion.

Improved Ease Of Installation

With over one million FG-730 detectors installed worldwide, we have received many suggestions on how to make a glassbreak detector easier to install. The FG-1025 family reflects these suggestions:

• No sensitivity adjustment, the detector is “lick and stick”
• A large, centered wiring hole for easy threading of wires
• Huge wiring space and 45 degree gate type terminal blocks for quick hookup
• Dip switches to eliminate the frustration of lost jumpers
• Inside plastic cover protects the electronics from accidental damage
• Terminal block positions and room for wiring EOL resistors
• A hinged cover which snaps off for easier access if needed
• 25 foot (7.6 m) range without adjustment covers almost any room
• No restriction on how close the detector can be mounted to the glass
• No restriction on where the detector can be mounted in the room
• Hidden LEDs for a beautiful appearance
Benefits Of The FG-1025 Family Of Glassbreak Detectors

1. The microcontroller’s false alarm rejection algorithms eliminate most known false alarm sources. Compared to the FG-730, which has excellent false alarm immunity, false alarm sources are reduced by two-thirds. Comprehensive tests show that the FG-1025 family has the best false alarm immunity on the market.

2. The microcontroller’s algorithms provide superior detection of breaking glass, including very challenging breaks such as quiet breaks. Compared to the FG-730, which has excellent glass break detection, the FG-1025’s detection of very challenging breaks is increased an additional 50%. Again, comprehensive tests show that the FG-1025 family has the best detection on the market.

3. The hand clap feature provides the end-user with peace of mind. The end-user can instantly check a magnetic contact by opening a door, or a motion detector by walking across the room, but no one wants to break a window to test the glassbreak detector. A simple hand clap will tell the end-user if the detector is active. Although the clap test is only a limited test, it does verify the detector is powered, the microphone is operational, and the microcontroller—the heart of the detector—is functioning and executing its program. If there was a problem, the LEDs would flash repeatedly indicating the microcontroller’s continuous self-test had found a problem.

4. Hiding the LEDs behind the cover provides for a more attractive appearance, and for about 10% of the installations, attractive products are what sells the end-user.

5. The new FG-1025Z only listens for sounds coming from the glass. Using two microphones and Time-Of-Arrival processing, the detector listens only for the sound of breaking glass arriving from the glass zone, and ignores sounds arriving from elsewhere in the room (excluded zone).

6. FG-1025 family detectors are a safer installation for the installer and the customer. The installer will not always know the exact type and thickness of the glass to be protected. FG-1025 family detectors have the industry’s widest specification for glass types and thicknesses, increasing the likelihood that the detector will perform as expected regardless of the glass installed in the room.

- Widest specification for glass types and thicknesses

Plate glass

Tempered glass

Laminated & coated glass

Wired glass

Sealed insulating glass