FX51D Hall Sensor Datasheet

Rotational Knob with FX51D (Master)

FX51D (Master)
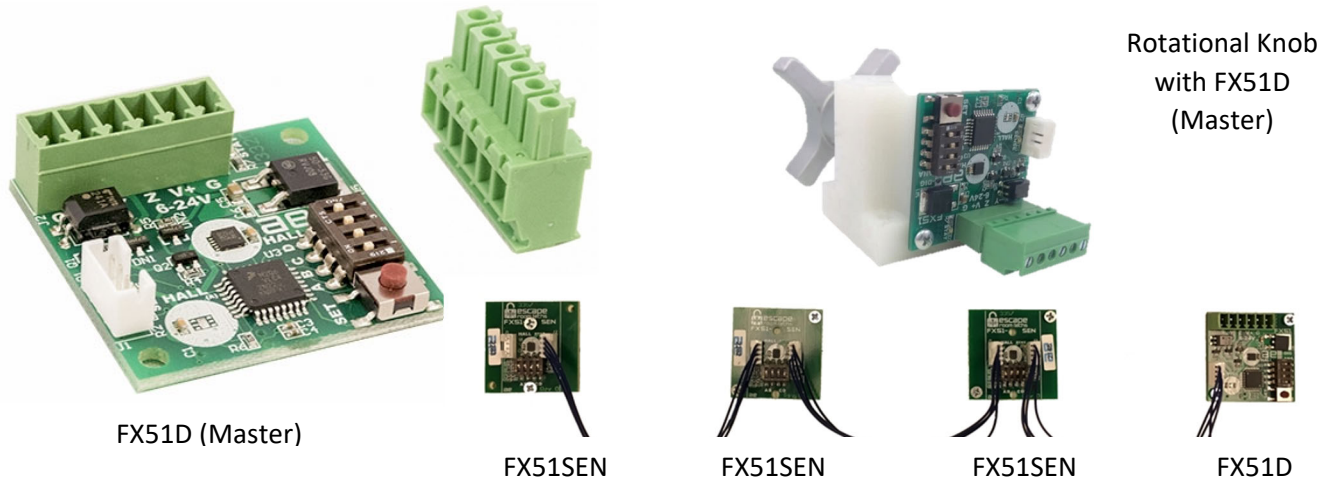
FX51SEN   FX51SEN   FX51SEN   FX51D

3x FX51 Sensor with 1 FX51D Master (rotational or placement)

Quick Start

If you purchased a kit, it will come prewired and preconfigured. If you have a prewired kit, power it up and test it before installing into your prop to test and become familiar with it.

STEP 1

Wire and place the sensors Two to Nine Sensor Puzzle (Rotational / Positional)) temporarily where you want them to go. For placement detection, magnets should be between 1/2" and 1 1/4" away from the sensor (standard 1/2" magnet). Rotational knob sensors do not have this condition.

Note, the output control is solid state (no clicking) and will not tolerate cheap maglocks which do not have proper internal protection. Purchase the MOV with the kit if you do not know for sure.

If you have FX51 Sensors, ensure they are addressed properly. Use this table: FX51SEN Addressing and Mode Selection

Power the FX51D (master). The red STAT light may blink then stay on. Remove all magnets (N/A for rotation/knobs). Turn all switches off and press the set button. This will reset the FX51D and calibrate it. The single master FX51D is in bipolar mode. Any magnet will trigger the output.

Step 2

What kind of game do you want to run?

- Single sensor for rotational position detection
-
-
-
-

Single sensor for rotational position detection

Position the knob/shaft to the solve position. Set the FX51D switches to off-on-on-off (0110) and press set. The STAT light will blink. As the knob/shaft is rotated, the SENSE light will turn on when the in the position it was taught. See detailed instructions below for more options.

Single sensor for position or placement detection

The FX51D is currently in Bipolar mode. Any magnet pole will trigger it. To set the FX51D to trigger on a specific magnetic pole (Unipolar) or trigger on a specific pole and strength/distance (Gated), follow these instructions. Position the prop with the magnet/prop over the sensor.

Detect single prop placement, any magnet

This is the default mode where calibration takes place (steps above).

Detect single prop placement, specific magnetic pole

For Unipolar Mode, set the FX51D switches to off-off-on-off (0010) and press set. It will only trigger with a North pole (one blink of the STAT light) or South pole (two blinks of the STAT light). Press set to toggle between modes.

Detect specific prop placements specific magnetic pole and strength

For Gated Mode, set the FX51D switches to off-on-off-off (0100) and press set. It will only trigger when this magnet is positioned at this distance from the sensor.

Set of knobs with sensors for rotation detection

This mode will require ALL sensors/shafts to have the correct rotation for the entire prop to be solved.

Position the knobs to the solve position. Set the FX51D switches to off-on-on-off (0110) and press set. The SENSE light will come on showing that the knobs are in the solved position. See detailed instructions below for more options.

Set of sensors for placement detection

This mode will require ALL sensors have valid magnets in place for the entire prop to be solved. To set all devices to Unipolar (trigger on a single magnetic pole) or Gated (trigger on a specific pole and distance), follow these instructions. Position the props with the magnet over the devices.

Detect multiple prop placements, any magnet

The FX51D is currently in Bipolar mode as well as all the sensors set to linear modes (not rotational). Any magnet pole will trigger each sensor.

Detect specific multiple prop placements, different magnetic poles and strengths

For Gated Mode, set the FX51D switches to off-on-off-off (0100) and press set. It will only trigger when this magnet is positioned at this distance from the sensor.

Detect multiple prop placements, specific magnetic poles

For Unipolar Mode, set the FX51D switches to off-off-on-off (0010) and press set. It will only trigger with a North pole (one blink of the STAT light) or South pole (two blinks of the STAT light). Press set to toggle between modes.

See detailed instructions below for more options.

Sensors for use with the Bad ASS Controller

When the sensors are connected directly to a Bad ASS Controller, they become fully programable. Check out the manual here: http://manuals.escaperoomtechs.com/games/fx51array/ Call or write for details.

Step 3

Next Steps

Now that you have the setup properly detecting your props and knobs, set the output mode. If the output of this prop is going to another digital device like a BAC or PLC or controller light a PicoBoo, the default output trigger (active high) is probably acceptable. If you are controlling a maglock, where when the prop is solved, you want to turn something off, set the output to active low (on-off-off-off) then press set.

After you've performed the basic configuration of your system. Disconnect power and properly mount the devices with #4 screws and/or VHB tape. Check out details below for connecting the output (maglock, lights, etc.) and additional output options.

Table of Contents

Overview

The FX51D is a hall sensor controller capable of detecting rotation and 3D positioning of magnets. Features include onboard switch / button configuration, diagnostic lights, and output protection.

Diagnostic Lights

The SENSE light illuminates when the solid-state X-Y output switch is closed. Additionally, this light will flash to indicate magnetic field strength errors.

The STAT light is used to display error codes as well as to acknowledge the successful receipt of a command. A table of all possible flash codes is in the section **Flash Codes**.
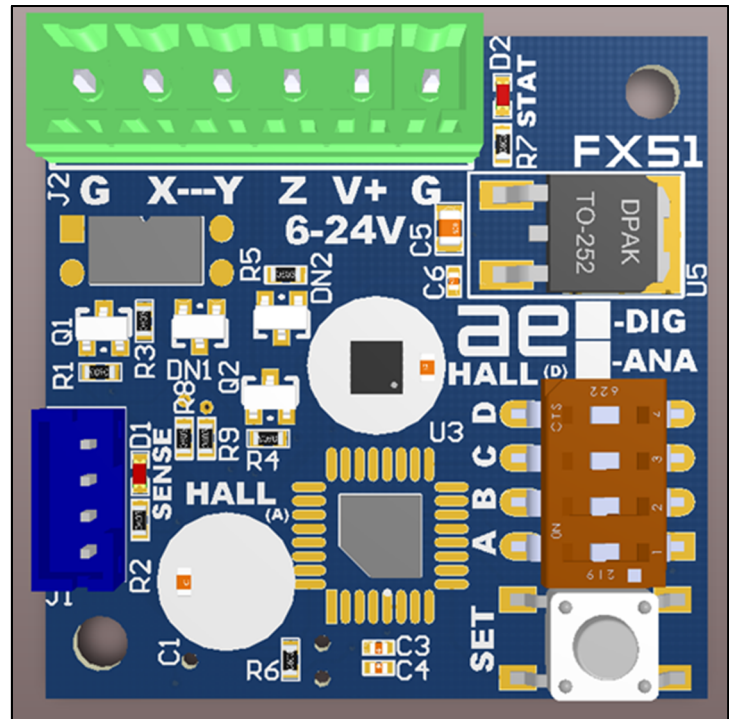
Magnet Considerations

Ring style magnets are not recommended for gated modes as they can produce inconsistent field strengths!

Magnets should be selected to provide a stable reading. Having too strong of a magnet or placing magnets too close (< ¾ " depending) to the sensor can cause saturation (> +/- 1000 gauss), causing erratic performance. For gated mode it is important that the magnet fields do not have overlapping strengths. For more information see sections **Magnetic Specifications** and **Example Offsets for Gated Mode**.

Installation

It is recommended to use double backed tape to test fit the sensor. Once the final mounting position has been determined, use small, #4 screws through the mounting holes.

Programming

There is a set of switches (A B C D) and a SET button in the lower right side of the circuit board. Set the DIP switches to the desired configuration specified in the table below and press SET. The STAT light will blink once to acknowledge the change has been committed. Note that when setting unipolar mode, the STAT light will flicker once for North pole sensing and twice for South pole sensing. Press SET repeatedly to toggle the selected pole.
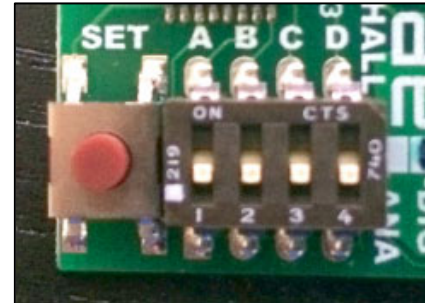
Switch Configuration Table

Mode	Config		Section
Switch A	Switch B & Switch C	Switch D	
1 – Output	1 1 – Lights	1 – Light Toggle	Toggle , Press and hold for debug status
		0 – PWM Output	PWM Output Modes
	1 0 – Set / Clear	1 – Set	Set
		0 – Clear	Clear
	0 1 – Pulse	1 – Positive Pulse	Pulse High
		0 – Negative Pulse	Pulse Low
	0 0 – Active	1 – Active High	Active High
		0 – Active Low	Active Low
0 – Sense	1 1 – Rotate (Local / Networked)	1 – Custom (2°-178° radius)	Rotation Mode, Rotational Learning (Custom Radius)
		0 – Low Thresh (15° radius)	Rotation Mode, Rotational Learning (Default Radius)
	1 0 – Gated (Local / Networked)	1 – High Thresh (30%)	Gated Mode, Gated Learning
		0 – Low Thresh (20%)	Gated Mode, Gated Learning
	0 1 – Unipolar* (Local / Networked)	1 – High Thresh (30%)	Unipolar Mode
		0 – Low Thresh (20%)	Unipolar Mode
	0 0 – Bipolar*, ** (Local / Networked)	1 – High Thresh (30%)	Bipolar Mode
		0 – Low Thresh (20%)	Bipolar Mode
Press SET to Program			Programming

* These modes calibrate the hall sensor when SET.

** Bipolar mode also resets the output mode to Active High and resets all parameters.

Calibration

If you are using FX51SEN (slave) boards, they should be connected for this step. Due to background magnetic fields, the sensor(s) must first be calibrated. This allows the sensor(s) to determine a true baseline and give more accurate readings when detecting a prop piece. To calibrate the sensor(s),

remove any nearby magnets, set the FX51D (master) switches to and press SET. The STAT light will blink once to acknowledge a successful calibration.

Sensing Modes

When the 'A' switch is in the 0 or 'Off' position, the rest of the switches are used to set the sensing mode. Refer to the **Switch Configuration Table**. There are 4 sensing modes for the FX51D. Set the DIP switch to the desired mode and press SET to program.

Bipolar Mode
(Networked or Standalone)

Bipolar mode refers to the sensor triggering on both North **and** South poles. When this mode is set, there **should not** be a magnet near the sensor as the hall sensor will be calibrated. See the **Calibration** section. This mode has a high and low threshold configuration.
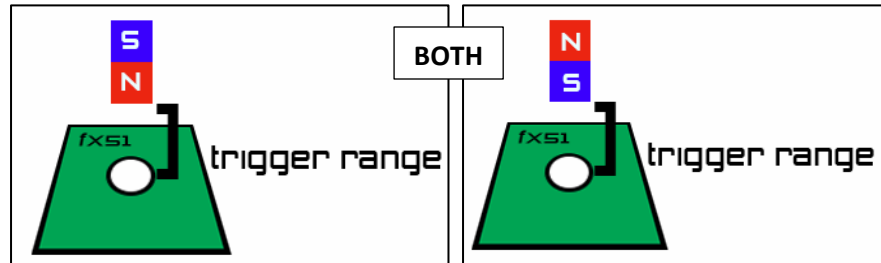
Low Threshold

Using magnet A, the low threshold configuration triggers at about 1.25"
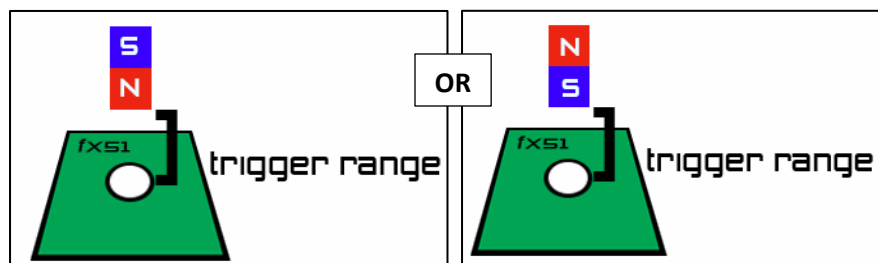
High Threshold

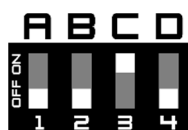Using magnet A, the high threshold configuration triggers at about 2.75".

Unipolar Mode
(Networked or Standalone)

Unipolar mode refers to the sensor triggering on either North **or** South poles, not both. When this mode is set, there **should not** be a magnet near the sensor as the hall sensor will be calibrated. See the **Calibration** section. When configuring unipolar mode, pressing the SET button will alternate between triggering of the North pole (one off-flash) and the South pole (two off-flashes). This mode has a high and low threshold configuration.
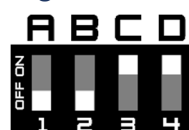
Low Threshold

Using magnet A, the low threshold configuration triggers at about 1.25"
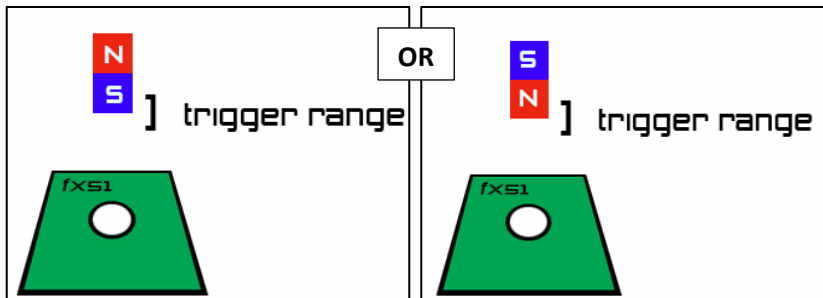
High Threshold

Using magnet A, the high threshold configuration triggers at about 2.75".

4

Gated Mode
(Networked or Standalone)

Gated mode is used to train the device to trigger in only a very narrow range and only on one pole. This can be used to discriminate between different prop pieces. When this mode is selected, a magnet **should** be present at the desired trigger point. The module will automatically detect the distance and pole of the present magnet. Before using this mode, be sure to calibrate the hall sensor at least once by setting either unipolar or bipolar mode.

For gated mode, low threshold uses a narrow range (±20%) of magnetic strength to trigger, and high threshold uses a wider range (±30%) of magnetic strength to trigger. While this setting can be engineered for your solution, the most practical method is to experiment with your props to ensure each puzzle piece only triggers the correct sensor (no overlap in field strengths). For precalculated offsets see section **Example Offsets for Gated Mode**.

Low Threshold

The low threshold configuration triggers at about ±20% of the detected magnetic field strength.

See **Gated Learning**

High Threshold

The high threshold configuration triggers at about ±30% of the detected magnetic field strength.

See **Gated Learning**

Rotation Mode
(Networked or Standalone)

Rotation mode detects the absolute rotation of a magnet and can be used for sensing knob or wheel positions. When this mode is SET, a magnet should be present at the desired trigger angle. The sensitivity setting for the rotation mode is measured in degrees. In low angle mode, the trigger range will be +/- 15° around the learned position. In high angle mode, the trigger range is user defined by adjusting the angle of the magnet to a new position.

Low Threshold
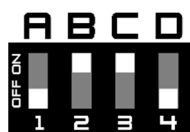
The low threshold configuration triggers at a ±15° radius from the center point.

See **Rotational Learning (Default Radius)**

High Threshold

The high threshold configuration triggers at a user defined radius between ±2-178°from the center point.

See **Rotational Learning (Custom Radius)**

Output Modes

The FX51 is capable of 6 output modes and has a primary solid-state relay output which can drive maglocks and other loads (up to 2A, 24V) directly.

Set the FX51D's configuration switch to the desired output mode below and press SET.

Active High (default)

The primary output is closed when triggered, otherwise open.

Active Low

The primary output is open when triggered, otherwise closed.

Pulse High

The primary output closes for ½ second when triggered, then opens.

Pulse Low

The primary output opens for ½ second when triggered, then closes.

Set

Primary output starts open. When triggered the output will close until reset.
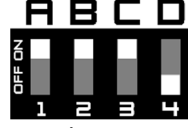
Clear

Primary output starts closed. When triggered the output will open until reset.

Toggle Lights

Toggles light output in case the lights are visible through the prop. Keep the switch set to this configuration to prevent accidental mode changes if SET is inadvertently pressed. Holding the SET button for 2 seconds will display the configuration of the FX51D.

PWM Output

Toggles PWM mode. Each button press will cycle through OFF, RANGE, VELOCITY modes. With PWM off, the output mode behaves as configured otherwise (Active High/Low, Pulse, Set, Clear). See PWM Output Modes for more details.

PWM Output Modes

With these modes it is possible to get position and speed information out of a FX51D directly via a PWM output signal. In RANGE PWM, at zero speed, the output will vary from 10% to 90% depending on the position of the shaft. This can be scaled to any range using the custom range options above. In VELOCITY PWM, at zero speed, the output is at 50% and will vary from 10% to 90% depending on the speed and direction of rotation.

NOTE: PWM Modes are only valid for a single FX51D without sensor boards.

FX51SEN Networking

FX51D   FX51SEN   FX51SEN   FX51SEN
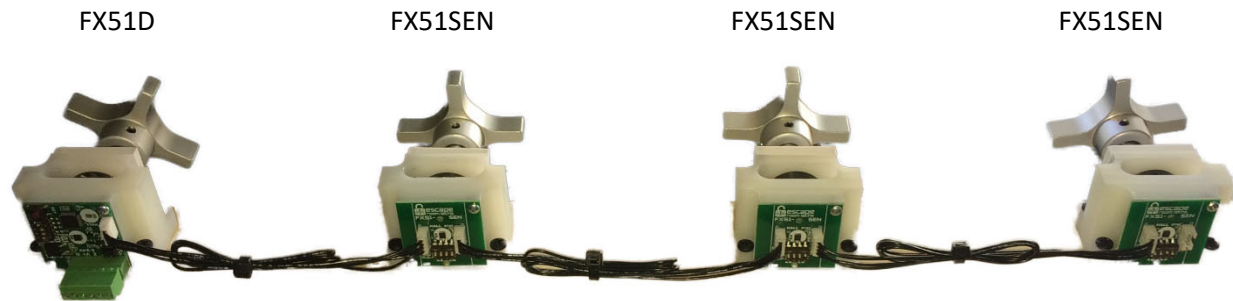

Wiring

The FX51D can support up to 16 additional sensors via a connection at J1. It is designed to connect to the FX51SEN sensor board module. They have in and out connections which facilitate easy chaining. It should be noted that the total wire lengths of the boards and extension wires should not exceed 3 ft. Consult Escape Room Techs for specifics and the availability of other length connection wires and network repeaters.

To connect FX51SEN boards to your FX51D, use the provided jumpers to connect all the boards together in a chain, starting with J1 on the FX51D, then to the first FX51SEN. The FX51SEN has two identical connectors (J1 and J2) for chaining. It does not matter which is the in or which is the out.

FX51SEN Addressing and Mode Selection

The switches on the FX51SEN are the address selection switches. The A switch also serves an additional purpose. It is used to determine if the sensor is in the linear mode (switch on) or in rotational mode (switch off). Linear modes are Gated, Unipolar, and Bipolar. Every FX51SEN must have a unique address. This means that there is a maximum of 8 rotational + 8 linear FX51SEN sensor boards in a system, plus the FX51D sensor for a total of 17 sensors.

Rotational Addressing

Component	ABCD Switch	I²C Address
FX51SEN (1)	(Rotate)	0x65
FX51SEN (2)	(Rotate)	0x6D
FX51SEN (3)	(Rotate)	0x61
FX51SEN (4)	(Rotate)	0x69
FX51SEN (5)	(Rotate)	0x67
FX51SEN (6)	(Rotate)	0x6F
FX51SEN (7)	(Rotate)	0x63
FX51SEN (8)	(Rotate)	0x6B

Gated, Unipolar, Bipolar Addressing

Component	ABCD Switch	I²C Address
FX51SEN (1)	(Linear)	0x64
FX51SEN (2)	(Linear)	0x6C
FX51SEN (3)	(Linear)	0x60
FX51SEN (4)	(Linear)	0x68
FX51SEN (5)	(Linear)	0x66
FX51SEN (6)	(Linear)	0x6E
FX51SEN (7)	(Linear)	0x62
FX51SEN (8)	(Linear)	0x6A

Learning

Note that it is possible to mix gated and sensing modes!

Gated Learning

Before learning gated mode, the sensors should be calibrated as outlined in the **Calibration** step. Wire the sensors as described in **PWM Output Modes**

With these modes it is possible to get position and speed information out of a FX51D directly via a PWM output signal. In RANGE PWM, at zero speed, the output will vary from 10% to 90% depending on the position of the shaft. This can be scaled to any range using the custom range options above. In VELOCITY PWM, at zero speed, the output is at 50% and will vary from 10% to 90% depending on the speed and direction of rotation.

NOTE: PWM Modes are only valid for a single FX51D without sensor boards.

FX51SEN Networking, and make sure to set the FX51-SEN addresses to available addresses outlined in the **Gated,** Unipolar, Bipolar Addressing table.

Next set the FX51D to ![dip]for low threshold gated sensing or ![dip]for high threshold gated sensing. Place the prop pieces with embedded magnets in their desired locations, and press SET. The settings will save, and the FX51D's switch will close (output on). Removing or swapping any of the pieces should unsolve the puzzle and the output will turn off. At this point you may set one of the other **Output Modes**.
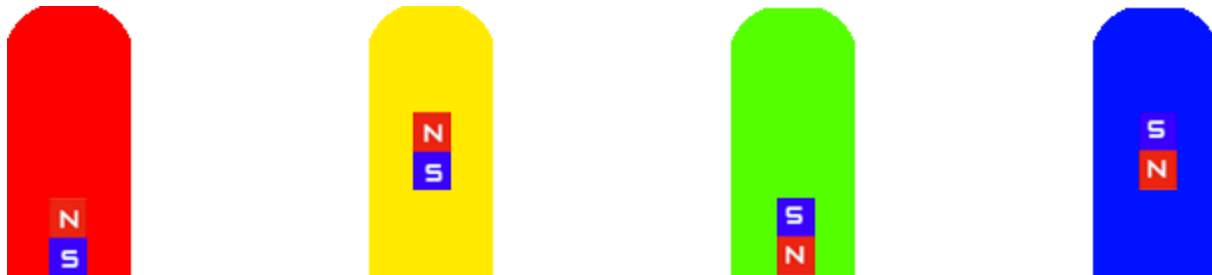
Rotational Learning (Default Radius)

The default radius is 15° which is useful for 12 position puzzles. Wire the sensors as described inPWM Output **Modes**

With these modes it is possible to get position and speed information out of a FX51D directly via a PWM output signal. In RANGE PWM, at zero speed, the output will vary from 10% to 90% depending on the position of the shaft. This can be scaled to any range using the custom range options above. In VELOCITY PWM, at zero speed, the output is at 50% and will vary from 10% to 90% depending on the speed and direction of rotation.

NOTE: PWM Modes are only valid for a single FX51D without sensor boards.

FX51SEN Networking, and make sure to set their addresses as described in the **Rotational Addressing** table.

Place your prop pieces with embedded magnets in their desired orientation.

Set the FX51D to and press SET. The settings will save, and the FX51D's switch will close (output on). Removing or rotating any of the pieces beyond 15° will unsolve the puzzle and the output will turn off. At this point you may set one of the other **Output Modes**.

Rotational Learning (Custom Radius)

If a custom threshold is desired, follow the steps in **Rotational Learning (Default Radius)**. This will initially set a center point with a 15° radius.

Next adjust the prop pieces to their desired outer limit. Set the FX51-D to ⬛ and press SET. If adjustments are necessary, this step may be repeated. The new thresholds will be saved. Thresholds are unique to each sensor, which means different sensors can have wider or narrower ranges.

Examples

Simple Mag Lock Controller

This example shows how to use a single FX51D as a simple maglock controller. Calibrate the sensor as described in the **Calibration** section. Then set one of the **Sensing Modes**. Next you want to set the output mode. Here you want power to the maglock to start then either cut it off for a pulse (to let a spring door open) or forever (for something you want to stay unlocked). If a pulse mode is desired, use output mode **Pulse Low**. If a permanent off mode is desired, use output mode **Clear**. Set the switches to the desired output mode and press the SET button.

When using a 12V or 24V maglock drawing less than 2A, the FX51's solid-state relay can drive it directly.

Recommended maglock: http://www.seco-larm.com/E-941SA-80Q
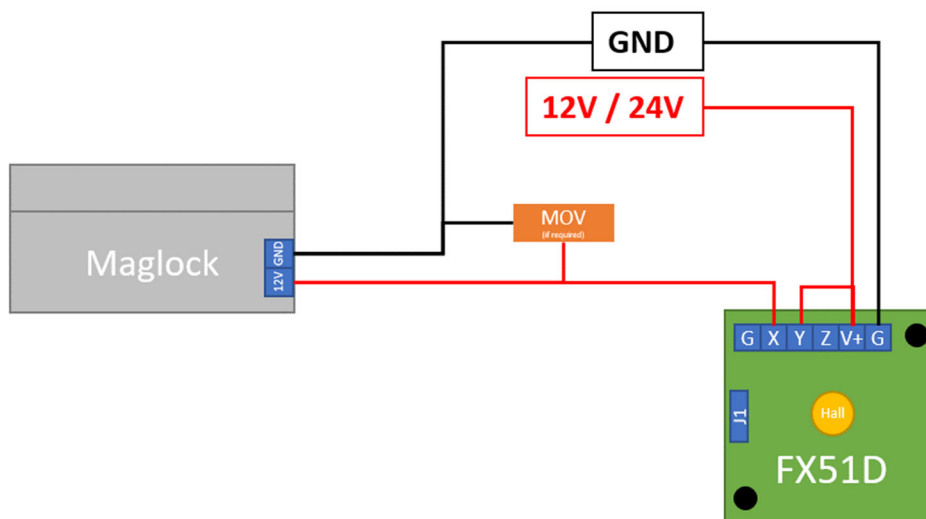
Two to Nine Sensor Puzzle (Rotational / Positional)

This example shows how to pair an FX51D with up to eight FX51SEN boards. Wire the setup according to the diagram below and apply power. Configure the FX51-SEN boards as outlined in the **FX51SEN Addressing and Mode Selection** section. Then calibrate the sensor as described in the **Calibration** section. Then Next, position the prop pieces in the desired solved state. Finally, set the FX51D to either **Gated Mode,** or **Rotation Mode**. The FX51D will store the desired solution. For more information see the **Learning** section.

When using a 12V or 24V maglock drawing less than 2A, the FX51's solid-state relay can drive it directly.

Recommended maglock: http://www.seco-larm.com/E-941SA-80Q
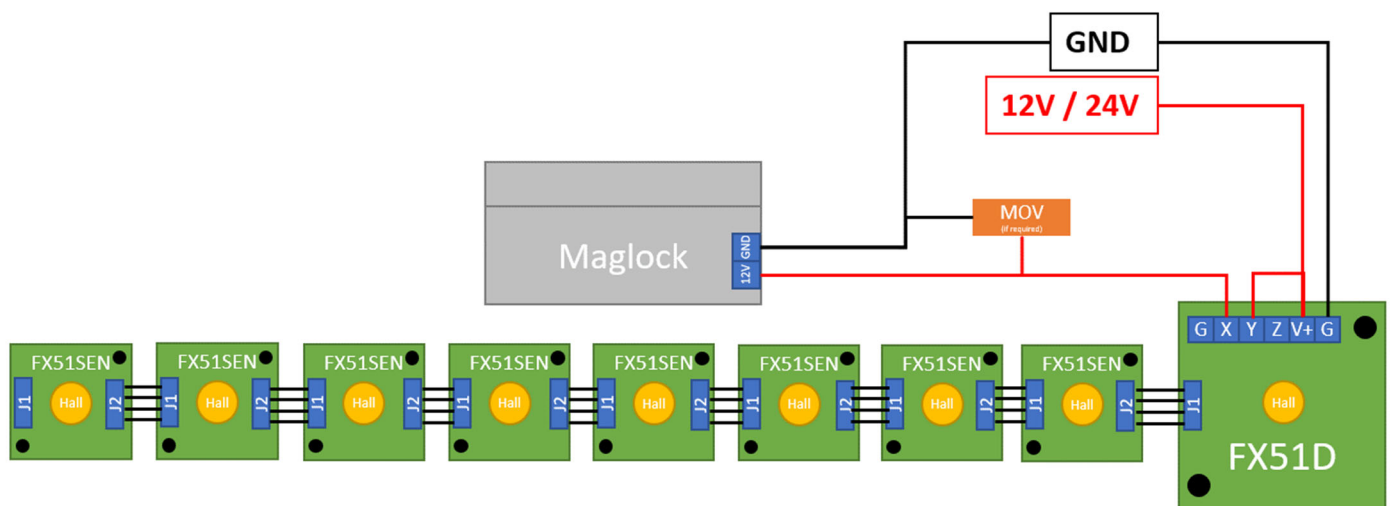
Example Offsets for Gated Mode

N52 ½" x ½" Magnets
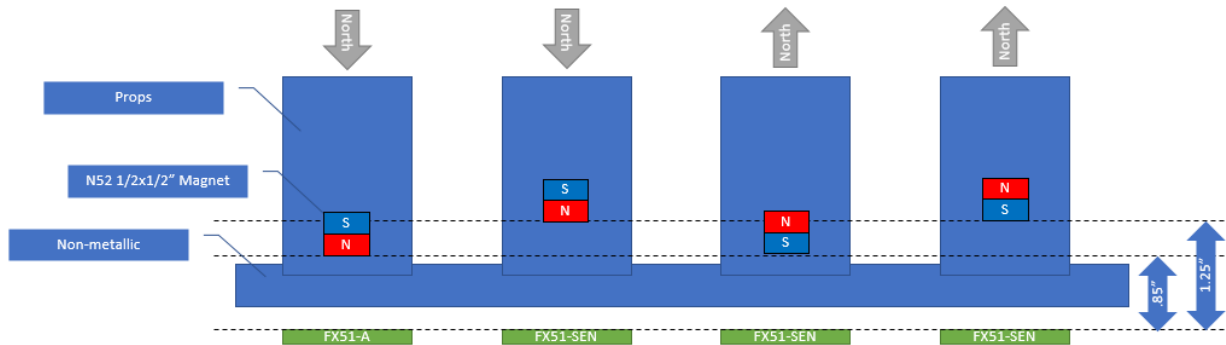
Magnet Size	Diameter		0.5	Magnet Type		14500	
	Axial		0.5				
				A	B	Tol	
				173	75	20.00%	
Distance	D from Center	D from surface A	Gauss A	Gauss B			
	0.55	0.80	200	200			
	0.6	0.85	173	173			
	0.65	0.90	152	152			
	0.7	0.95	133	133			
	0.75	1.00	118	118			
	0.8	1.05	105	105			
	0.85	1.10	93	93			
	0.9	1.15	84	84			
	0.95	1.20	75	75			
	1	1.25	68	68			
	1.05	1.30	62	62			
	1.1	1.35	56	56			
	1.15	1.40	51	51			
	1.2	1.45	47	47			
	1.25	1.50	43	43			
	1.3	1.55	39	39			

N52 ¼" x ¼" Magnets

North   North   North   North

Props

N52 1/4x1/4" Magnet

Non-metallic

S / N   S / N   N / S   N / S

FX51-A   FX51-SEN   FX51-SEN   FX51-SEN

5"   .9"

Magnet Size	Diameter	0.25	Magnet Type	14500		
	Axial	0.25				
			A	B	Tol	
			105	29	30.00%	
Distance	D from Center	D from surface A	Gauss A	Gauss B		
	0.35	0.48	133	133		
	0.4	0.53	105	105		
	0.45	0.58	84	84		
	0.5	0.63	68	68		
	0.55	0.68	56	56		
	0.6	0.73	47	47		
	0.65	0.78	39	39		
	0.7	0.83	33	33		
	0.75	0.88	29	29		
	0.8	0.93	25	25		
	0.85	0.98	21	21		
	0.9	1.03	19	19		
	0.95	1.08	16	16		
	1	1.13	15	15		
	1.05	1.18	13	13		
	1.1	1.23	12	12		
	1.15	1.28	10	10		
	1.2	1.33	9	9		
	1.25	1.38	8	8		
	1.3	1.43	8	8		

Flash Codes

Light	Flash Codes	Type	Description
STAT	Constant Blinking	Error	No sensors detected, I^{2}C bus is locked, memory error. Press the set button to acknowledge then cycle power.
STAT	4x Flash, 100x Slow Blinks, repeating forever, on power up.	Error	Configuration read failure – Contact Escape Room Techs.
STAT	5x Fast Blinks, on power up.	Warning	No configuration stored, loading defaults.
STAT	4x Fast, 100x Slow Blinks	Error	Configuration write failure. Try again and contact Escape Room Techs if the problem persists.
STAT	4x Fast Blinks	Error	On power up. Sensor(s) missing. The FX51D will assume the missing sensors are "solved" so that the puzzle may continue to work.
STAT	One Blink	Acknowledge	Indicates successful receipt of a command. Unipolar mode: Indicates North pole sensing.
STAT	Two Blinks	Acknowledge	Unipolar mode: Indicates South pole sensing.
SENSE	Blinking during positioning magnets	Feedback	When any device is saturated (magnet too close), the SENSE light will flash quickly. This is real time feedback.
SENSE	During learning in gated modes, 3x Fast Blinks	Feedback	When in learning mode, if a sensor is weak and not likely to be detected accurately again, the SENSE light will flash 3 times. Multiple sets of flashes indicate multiple sensors below threshold.
STAT	Blinking Pattern - Configuration Dump	Information	Set the switches to 1111 and press and hold SET. The blink pattern will output 5 sets of flashes in the following format after a long pause: 1. FX51SEN Sensor count +1 (1-17 blinks), does not includeincluding the FX51D. Subtract 1 from blinks for sensor count. 2. Firmware Version Letter

			A = 1 blink
			3. FX51D Sense mode
			1 blink: bipolar
			2 blinks: unipolar
			3 blinks: gate
			4 blinks: rotate
			4. FX51D Output mode
			1 blink: active high
			2 blinks: active low
			3 blinks: positive pulse
			4 blinks: negative pulse
			5 blinks: latch on
			6 blinks: latch off
			5. Sense mode for each FX51SEN (0-16) (short pause between sensors)
			2 blinks: gate/linear
			3 blinks: rotate

Specifications

Electrical Specifications

Input voltage	6 – 26V
Outputs	Primary: 1 Solid State Relay, 24V (max), 2A, TVS protected Secondary: 1 Transistor Output
Processor	NXP / Freescale ARM Cortex M0+
Gauss	+-1000G (gauss values above or below this will saturate the sensor)

Terminal Block J2

Pin ID	Use	Notes
G	Ground	
X	Solid State Relay Switch	These two pins are the contact for the solid-state switch.

Y	Solid State Relay Switch	**NOTE:** **Do not attempt to switch AC line (110V/220V AC) with this contact. Use a relay or other appropriate level switch.** **NOTE: Some electronics (such as motors and maglocks) can induce voltage spikes, use with caution. You can purchase a TVS with this device on the ordering page.** Recommended maglock: http://www.seco-larm.com/E-941SA-80Q
Z	Transistor Output: 200mA, 50V	RFU
V+	Input Power: 6 – 26VDC+	<23mA
G	Ground	

Magnetic Specifications

Name	Product ID	Specs
Magnet A	MAGNETL12N52CYL	**N52 ½" x ½" Linear / Rotary Magnet**
Magnet B	MAGNETR424N52	**N52 ¼" x ¼" Rotary Magnet**
Magnet D	MAGNETR834N52	**N52 ½" x ¼" Rotary Magnet**

Contact

Web: www.escaperoomtechs.com
Email: support@escaperoomtechs.com
Phone: 561-708-0007

References

Solid State Relay: Omron G3VM-41DY1(TR05)

https://www.digikey.com/product-detail/en/omron-electronics-inc-emc-div/G3VM-41DY1(TR05)/Z5418TR-ND/5799757

Terminal Blocks: Onshore Tech

Header - OSTOQ063250 https://www.digikey.com/products/en?keywords=OSTOQ063250

Terminals - OSTTS06315B https://www.digikey.com/products/en?keywords=OSTTS06315B

Errata

2019/03/12 - Fixed egregious wiring diagram error for maglocks, pages 9 and 10

2019/07/22 – Released Rev C with many new features.

2020/11/02