By Ryan Taylor

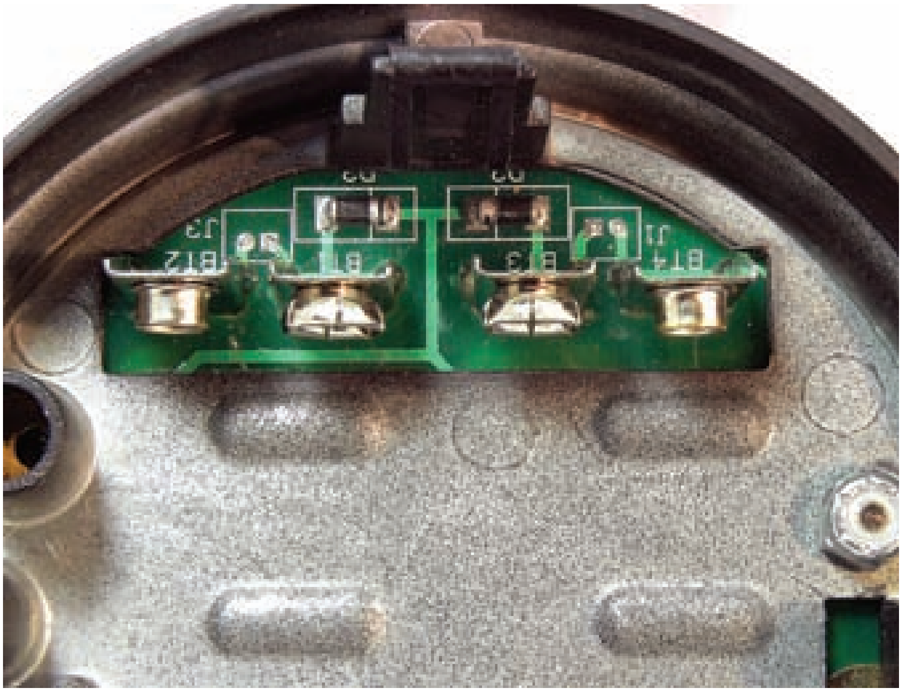

Figure 1. A close-up of two-battery keypad diodes.

Figure 2. A side view of two-battery keypad diodes.

Figure 3. Bypassing a two-battery keypad diodes.

S&G Keypad Diode Bypass

This surprisingly simple technique can boost the power of Sargent & Greenleaf electronic locks by 20%.

If you take a peek at the backside of any S&G keypad, you'll notice a small, black, cylindrical or rectangular component near the battery connection terminals *(see Figures 1, 2, 4, 7).* These components are diodes, and they protect the lock and keypad from reverse polarity when a battery or other power source is connected backward.

Diodes are a class of silicon-based electronic components (called rectifiers) that essentially act as one-way valves to electrical current, which makes them ideally suited for polarity protection. Since electricity can only flow one direction through a diode, placing one in-line with the battery power supply blocks all incoming electrical current from a reversed battery connection. This prevents lock damage while still allowing power to flow normally once the battery is reconnected in the proper direction.

There is, however, a downside to passing all incoming power through a diode: forward voltage drop, which is an inherent characteristic to all diode designs. If you were to equate the flow of electricity in a circuit to the flow of water through a network of pipes, a diode would be similar to a one-way check valve, and the electrical voltage of the system would be analogous to the water pressure in the pipes.

As water passes through the check valve, it naturally encounters some level of resistance to its flow, resulting in a slight loss of water pressure on the output side of the valve. This loss of pressure is similar to the forward voltage drop through a diode. As electrical current passes through the diode, its voltage is decreased, which reduces the power supplied to everything downstream of the diode.

In the case of S&G electronic locks, the diode used in the keypad, or pair of diodes on two-battery keypads, reduces the incoming voltage anywhere from 0.5V to 1.0V, depending on the load. This effect takes the supply voltage of fresh 9-volt battery, which typically measures at around 9.3 volts, down to 8.8 volts or less, which is similar to the voltage of a used battery *(Figure 10)*.

Since supply voltage has a direct effect on numerous aspects of lock performance, eliminating the forward voltage drop through the keypad diode(s) can be a powerful servicing and troubleshooting tool on Sargent & Greenleaf electronic locks.

A Simple Solution

A quick and simple technique to accomplish this is placing a small alligator clip *(Figure 9)* onto the keypad diode(s) *(Figures 3, 5, 6, 9)* to allow incoming battery current to bypass the diode entirely and flow freely to lock and keypad without any reduction of voltage.

This significant boost in supply voltage is clearly demonstrated in *Figures 10 and 11,* with the help of a digital multimeter used to display the voltage measurements at the lock with a fresh 9-volt battery installed in the keypad. The readings shown in *Figure 10* are taken with the standard two-battery S&G keypad, while *Figure 11* shows the new voltage levels with an alligator clip used to bypass the keypad diode.

The amount of increase in supply voltage through bypassing the keypad diode(s) depends both on the load and the type of keypad. The diode's forward voltage drop increases relative to the amount of current flowing through it. At low current levels, such as when entering a code, the forward voltage drop could be as little as half a volt. However, when the lock attempts to open, the current draw spikes and the voltage drop through the diode can approach 1.0 volts.

This reveals one of the beauties of bypassing the keypad diode: It boosts the supply voltage even more as the load increases, providing the biggest power boost when you

Figure 4. A single-battery keypad diode.

Figure 5. Bypassing a single-battery keypad diode.

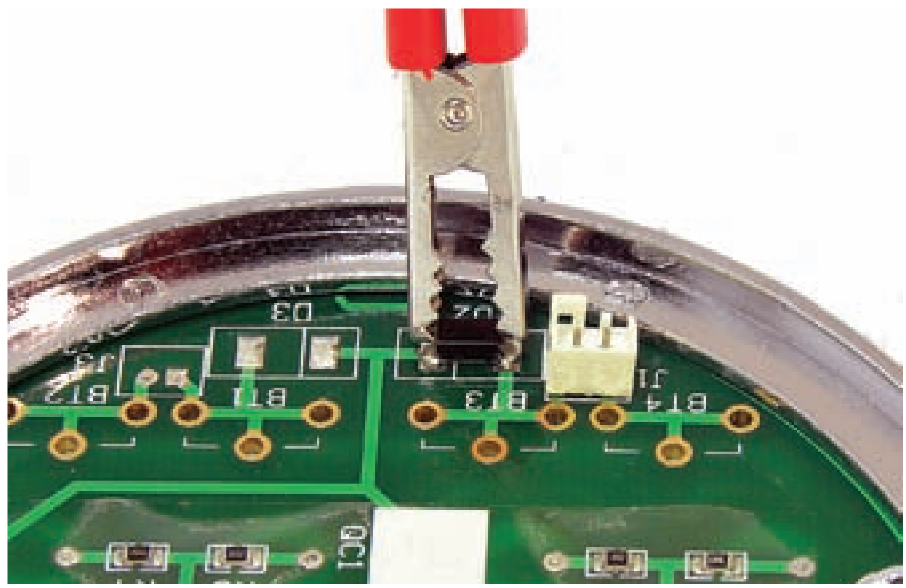

Figure 6. A close-up of a single-battery keypad diode bypass.

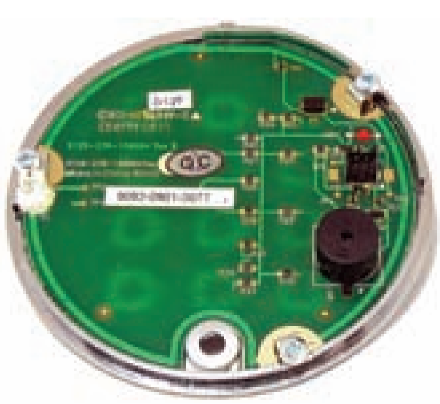

Figure 7. A low-profile keypad Schottky diode.

Figure 8. Bypassing a low-profile keypad Schottky diode.

need it the most. The keypad diode bypass trick works on every model of S&G keypad, including the two-battery versions *(Figures 12, 13, 14, 19),* single-battery models *(Figure 15)* and the new low-profile keypads *(Figures 16-18).* The voltage increase is slightly less on the new low-profile models due to their use of a low-power loss, high-efficiency Schottky diode for polarity protection *(Figure 7)* that provides a lower forward voltage drop that ranges from 0.2V to 0.5V.

Figure 9. Alligator clips.

More Motor Torque

One of the key benefits to boosting the supply voltage by bypassing the keypad diode on the 6120 series of motor locks *(Figure 19)* is an increase in motor torque, which translates into stronger bolt retraction. Due to multiple different issues — bolt side pressure, drive nut damage, attached linkage, etc. — the lock bolt can sometimes stall and not retract fully into the lock case, which results in a lockout.

Bypassing the keypad diode(s) gives the motor an extra boost to help it overcome these issues (think of it as bolting an alligator clip supercharger on to the motor in your vintage '98 S&G 6120!). The increase in supply voltage to the motor has a direct and dramatic impact on the strength of bolt retraction by increasing it nearly 20% on average, as shown in the first two bolt force tests *(see Tables 1 and 2).*

TABLE 1

Test No. 1 Results

Bolt Force Measurements (grams)	Normal	Diode Bypass
	3545	4485
	3495	4955
	4300	4600
	4720	4975
	3370	4905
	4185	5410
	4655	4860
	4305	4960
	4200	5020
	4205	4935
Averages:	**4098**	**4911**

Average Increase (g): 813

Average Increase (%): 19.8%

Figure 10. A normal voltage measurement.

Figure 11. Voltage measurement with a diode bypass.

Figure 12. An old-style two-battery keypad.

Figure 13. A new-style two-battery keypad.

A Battery of Tests

To gauge the relative strength of bolt retraction with different power sources and setups, a custom testing jig was constructed using a digital scale attached to an S&G 6120 lock with a modified bolt *(Figure 23).* Although rather crude in construction, this setup proved an extremely effective means by which to measure the relative strengths of different bolt retractions, and it delivered consistently accurate and repeatable measurements.

The digital scale was originally designed to measure weight, and it therefore displayed results in grams. Although the gram is technically a unit for measuring mass, not force, for the purposes of this article, I'll refer to grams as a measurement of the overall strength and force of bolt retraction.

Test 1. Bolt retraction strength, single battery
Battery: Duracell Procell
Battery Voltage: 9.41v
Testing Procedure: Lock cycled open/close 20 times, recording bolt force measurements. Alligator clipped used to bypass keypad diode on every other cycle. Results averaged to compare strength with and without diode bypass. *(See Table 1 for results.)*

Test 2. Bolt retraction strength, multiple batteries
Testing Procedure: Same procedures as Test No. 1 repeated for several new 9-volt batteries. Results averaged to compare strength with and without diode bypass. *(See Table 2 for results.)*

The same principle behind boosting the supply voltage to increase motor torque on the 6120 series of locks also applies to S&G's other electronic locks, including the new motor-blocking Titan series *(Figures 20 and 21)* and the solenoid based Z02/Z03 Rotarybolt *(Figure 22)* and D-Drive models. In each case, bypassing the keypad diode(s) will result in either stronger motor engagement or more powerful solenoid retraction.

Bypassing the keypad diode(s) can also be used to boost the performance of an already low or marginal battery enough to program, troubleshoot or open the lock. One of the more remarkable characteristics of bypassing the keypad diode(s) is its impact on the strength of bolt retraction relative to the condition of the battery. Amazingly, the lower the voltage of the battery, the more boost bypassing the diode provides *(see Table 3)*. This means it supplies the biggest power boost to the batteries that need it the most.

Using an alligator clip to increase the supply voltage of a low battery can also be used to overcome low battery warnings and the open the lock. S&G 6120 locks will start to emit a lower-pitch beep on button presses whenever the battery drops to approximately 7.7 volts. This feature serves as a friendly reminder to the user to change their batteries as soon as possible while still allowing the lock to be opened. However, once the battery voltage reaches 7.0 volts, the lock will emit a long sequence of error beeps anytime the "#" button is pressed.

Once in this state, the lock cannot be opened or programmed. The lock will not even properly respond to "*8#" and identify its model number (6120, 6123, Z02, etc). Once the battery has fallen to this level and refuses to open or operate, bypassing

Figure 14. An audit keypad.

Figure 15. A single-battery keypad.

Figure 16. A low-profile keypad (black tab).

Table 2
Test No. 2 Results

Battery	Battery Voltage	Normal	Diode Bypass	Increase (grams)	Increase (%)
Rayovac Heavy Duty	9.40	3112	3758	646	20.8%
Rayovac Alkaline	9.26	3185	3763	578	18.1%
Duracell Procell	9.41	4098	4911	813	19.8%
Duracell	9.57	4788	5455	667	13.9%
Thunderbolt Magnum Alk.	9.63	4180	4939	759	18.2%
UtiliTech Alkaline	9.56	4372	5144	772	17.7%
Averages:		**3956**	**4661**	**705**	**17.8%**

Figure 18. A low-profile keypad (yellow tab).

Figure 17. A low-profile keypad (blue tab).

Figure 19. An S&G 6120 with a two-battery keypad.

the keypad diode will increase the supply voltage enough to allow the lock to operate normally. This bypass trick will buy you an additional 0.5 volts cushion before the low battery warning is triggered — that's enough extra power for multiple openings and any programming that's required.

Bypassing the keypad diode(s) can also be used to overcome problems with damaged keypad cables. In situations where the flow of power between the lock and keypad is hindered due to damage to the keypad cable or its connectors, a boost in supply voltage can be enough to allow sufficient power to reach the lock.

Keypad Removal/ Bypass Instruction

Two-Battery Keypads *(Figures 12-14, 19).* These keypads require no disassembly to access the diodes. Simply pull the keypad off the keypad base just as you would when replacing the batteries. Once removed, locate the two diodes located directly above the battery terminals *(Figures 1 and 2).*

Carefully place an alligator clip across both diodes (or just single diode, if only one battery will be used) *(Figure 3).* Take care to avoid contacting the sides of the keypad or any other components with the alligator clip during installation or use *(Figure 3).* Once installed, the alligator clip is connected directly to the positive side of the battery while the metal of the keypad body is grounded to the negative side of the battery.

Contacting the two will result in a direct short that can create a rip in the fabric of space-time and quickly drain the battery. A business card placed between the alligator clip(s) and side of the keypad will help to avoid these potential issues. Remember, with the keypad diode(s) bypassed the lock is no longer protected against reverse polarity. Use caution when connecting batteries or applying power.

One-Battery Keypads *(Figure 15).* These keypads feature a single diode, which is

Table 3
Test No. 3 Results

Battery Condition vs Bolt Force (w/ Diode Bypass)

Battery	Battery Voltage	Normal	Diode Bypass	Increase (grams)	Increase (%)
Duracell	7.65	1023	2150	1127	110.1%
Duracell	8.24	2235	3110	875	39.1%
Duracell	8.90	3702	4645	943	25.5%
Duracell	9.25	3777	4692	915	24.2%
Duracell	9.41	4098	4911	813	19.8%
Duracell	9.57	4788	5455	667	13.9%

accessible by removing the screw located beneath the S&G sticker then removing the face of the keypad *(Figure 4)*. Simply place a single alligator clip across the square black diode on the back of the keypad *(Figures 5 and 6)*.

The diode may be covered with a thin, clear conformal coating that prevents the clip from making contact with the diodes terminals. In these cases simply squeeze the alligator clip and rock it slowly side to side until the teeth work through the coating. Remember, with the keypad diode bypassed, the lock is no longer protected against reverse polarity. Use caution when connecting batteries or applying power.

Low-Profile Keypads *(Figures 16-18)*. These keypads feature a single Schottky diode, which is accessible by removing the screw located beneath the S&G sticker then prying off the face of the keypad *(Figure 7)*. Simply place a single alligator clip across the square black diode on the back of the keypad *(Figure 8)*.

The diode may be covered with a thin, clear conformal coating that prevents the clip from making contact with the diodes terminals. In these cases, simply squeeze the alligator clip and rock it slowly side to side until the teeth work through the coating. Remember, with the keypad diode bypassed the lock is no longer protected against reverse polarity. Use caution when connecting batteries or applying power. ◉

Ryan Taylor has been with Lockmasters Inc. since 2006. He is involved in safe, safe deposit and safe lock technical support, along with new product development. He is also an instructor for Lockmasters in combination lock manipulation, safe deposit lock servicing, and electronic safe lock servicing, and is the lead safe and safe lock instructor for PureAuto seminars.

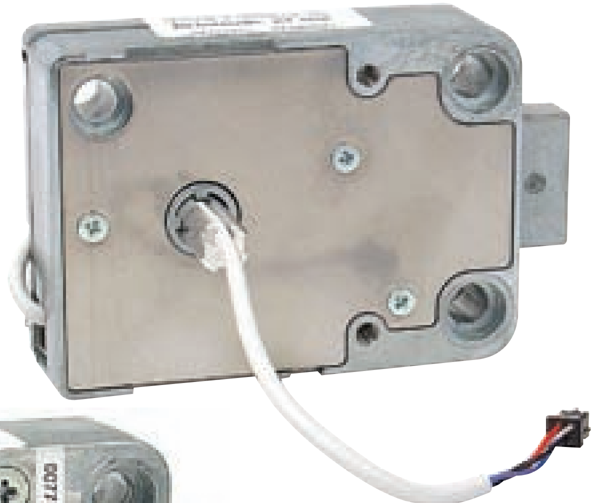

Figure 20. A Titan D-Drive.

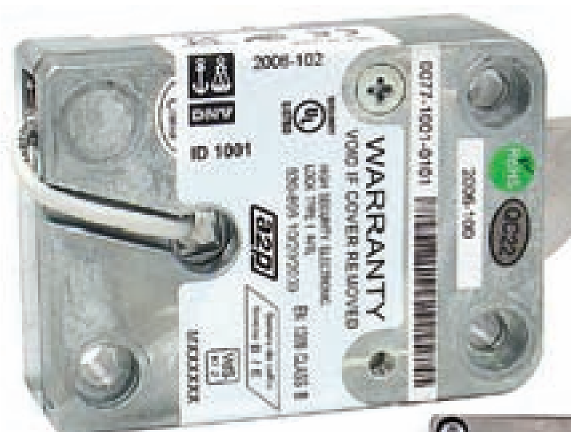

Figure 21. A Titan PivotBolt.

Figure 22. A Z02 RotaryBolt.

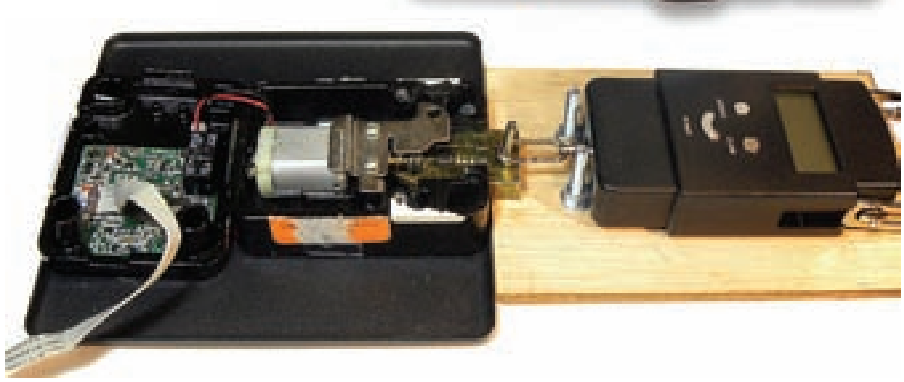

Figure 23. The bolt force testing jig.