A key ingredient of the shale revolution and the advance of horizontal completions has been the use of electric wireline services for plug and perforating operations. It is very well established that in certain reservoirs, cemented liners and stage completions are the best method for achieving optimum production. To fracture the formations and to produce the well fluids, the well casings/liners have to be perforated and plugs set between stages to effectively stimulate the formations. In the early days of horizontal drilling and completions, perforating guns were conveyed on tractors, or tubing conveyed. This was time consuming and expensive. When the technique for pump-down wireline deployment was introduced, well completion efficiency improved dramatically. For a pump-down plug and perforating operation a series of perforating guns are stacked and a setting tool with a plug is attached to the bottom of the string. The assembly is lowered into the well on electric wireline and when the string will no longer fall by gravity, pumps are engaged and fluid is pumped into the well. The friction of the fluid slides the gun/plug assembly along the horizontal wellbore. When the assembly has been pumped below the stage interval to be stimulated, the plug is set and the perforating assembly is pulled along the wellbore and individual guns are detonated at the intended depth need to stimulate the reservoir. The wireline assembly is pulled from the well, the stage is stimulated and the process is repeated for each of the horizontal stages to be completed.

The technology to selectively set plugs and perforate has been employed by the wireline services industry for many decades. The selective detonation of a setting tool to set the plug and individually detonate each gun in series (select-fire), required the use of diodes and switches in the gun/setting tool assembly. These diodes and switches allow the wireline operator to send current to each of the components in the assembly, the setting tools are stroked, and the guns are fired individually, from the bottom up with a pressure seal maintained for the unfired components. The switches used by the industry over the past four or five decades for select-fire perforating are pressure switches. These switches are positioned between the guns in the assembly. The switches are wired to pass positive (red) or negative (green) current and are alternated from the bottom up. The first gun/setting tool is fired with either positive or negative current and then polarity is alternated to fire the next gun in the string. These switches utilize the pressure created in the perforating event to arm the next gun in the string. The pressure pulse causes a plunger within the switch to shift, arming the next gun. This technique has been enhanced and refined over many years, but continued to suffer deficiencies for both safety and reliability.

When pressure switches are used for select-fire perforating, the guns can be detonated by inadvertent voltage/current. In the event that stray voltage, at a higher enough level and the correct polarity, is applied to the wireline, guns can be fired where they are not desired to be. An inadvertent perforating event down-hole can be costly. Perforating the wrong interval can require a lot of resources to repair, or a well could be lost or production sub-optimized. If the inadvertent detonation occurs at the surface, the results can be life threatening. Wireline companies have strict processes developed for safe and on-depth perforating, but regardless, accidents still happen. There have been multiple inadvertent surface detonations over the past few years and countless off-depth perforating events down-hole. The vast majority of these accidents resulted from human error. To prevent these incidents and provide the highest level of safety, a new switch technology has been developed. These new switches are electrically addressable and must be in direct communication with the surface system (and wireline operator) before they will pass current to the perforating gun and allow it to detonate. They are inherently safer to use for explosive operations, but it has also been proven that they are more reliable. Reliability is extremely important for pump-down plug and perforating operations, since there are usually large and expensive frac spreads standing by waiting for the wireline companies to perform so they can begin fracturing operations. This paper will discuss the new switch technology and present a case for quick adoption by the industry.