Precision Timing Solutions

Electronic Detonators for Mining

Precision Timing in Detonators for Mining

Industrial detonators (also called blasting caps) are used to trigger an explosive device in applications such as mining, quarrying and civil engineering. Commercial explosives are made stable and safe to handle, so they will not explode if accidentally dropped, mishandled or exposed to fire. For this reason, they require a small initiating explosion to be set off. This is provided by a detonator.

Key Considerations

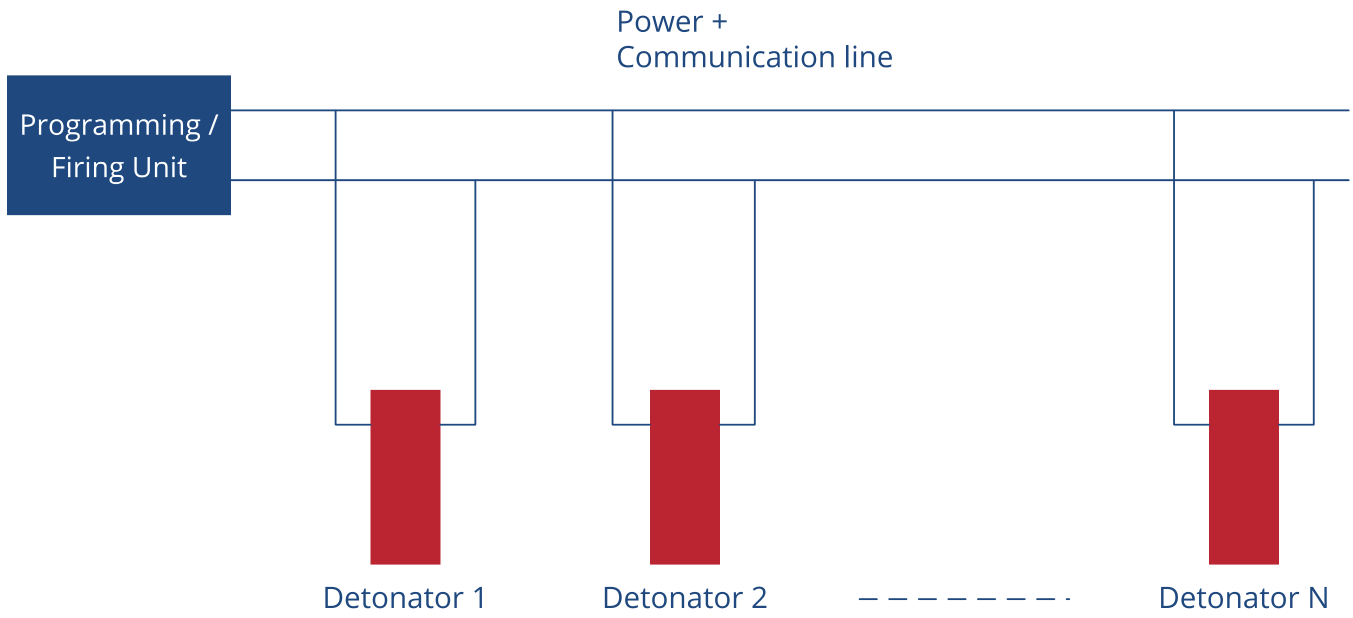
- Resilience to shock
- EMI resilience
- Timing accuracy
- Low power
- Small footprint

The timing accuracy of detonators used in the mining industry has a significant influence on the safety and effectiveness of blasting operations. A "detonation train" with precise timing is used to blast rock; lack of precise control can result in undesirable outcomes such as flyrock (rocks projected by the blast in an undesired direction), excessive ground vibration, uneven grade of rock as well as misfires or unintended firing [1].

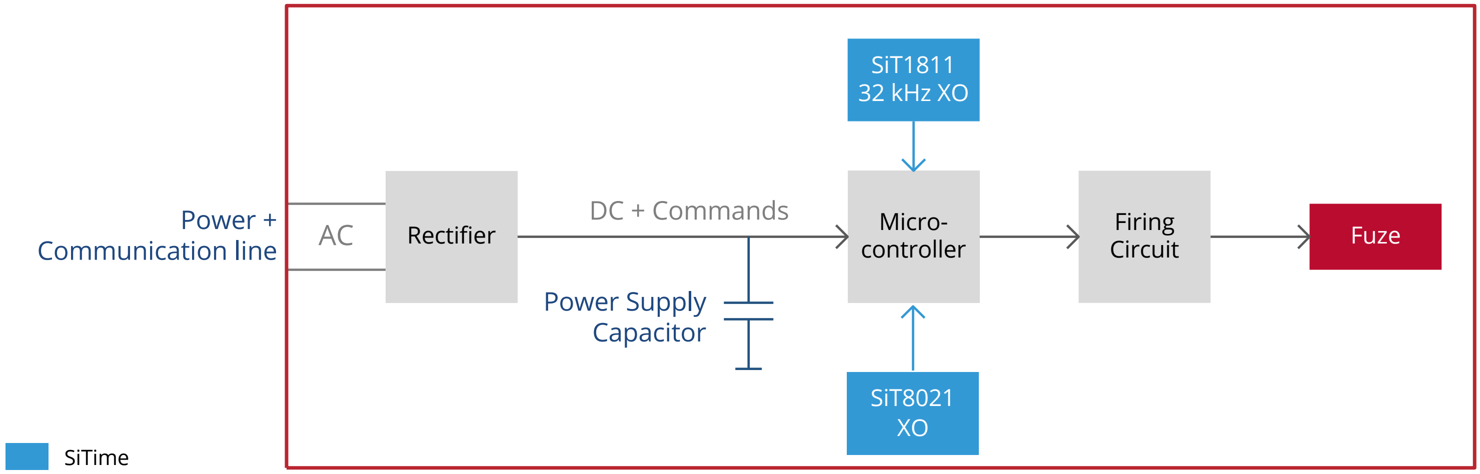
Block Diagram – Wired Detonators

Individual wired detonators are usually connected in parallel, via a differential line, to a programming and firing unit. The line provides both power as well as individual commands – such as delay programming, arming, disarming and firing – to the detonators. The firing order is programmed into the detonators by adjusting a time delay from the start of the sequence, to the moment the individual detonator fuses. All detonators are triggered simultaneously; the individual delay of each detonator executes the blast pattern.

Resilience and reliability are key parameters for detonators. They must be designed to avoid misfires and unintended firing under the harshest of conditions: shock from nearby explosions, ground vibration, gas or water intrusion, temperature extremes, etc. EMI interference is a common reason for unintended firing, which can be caused by lightning, static electricity, nearby radiofrequency transmitters, or stray currents from defective equipment.

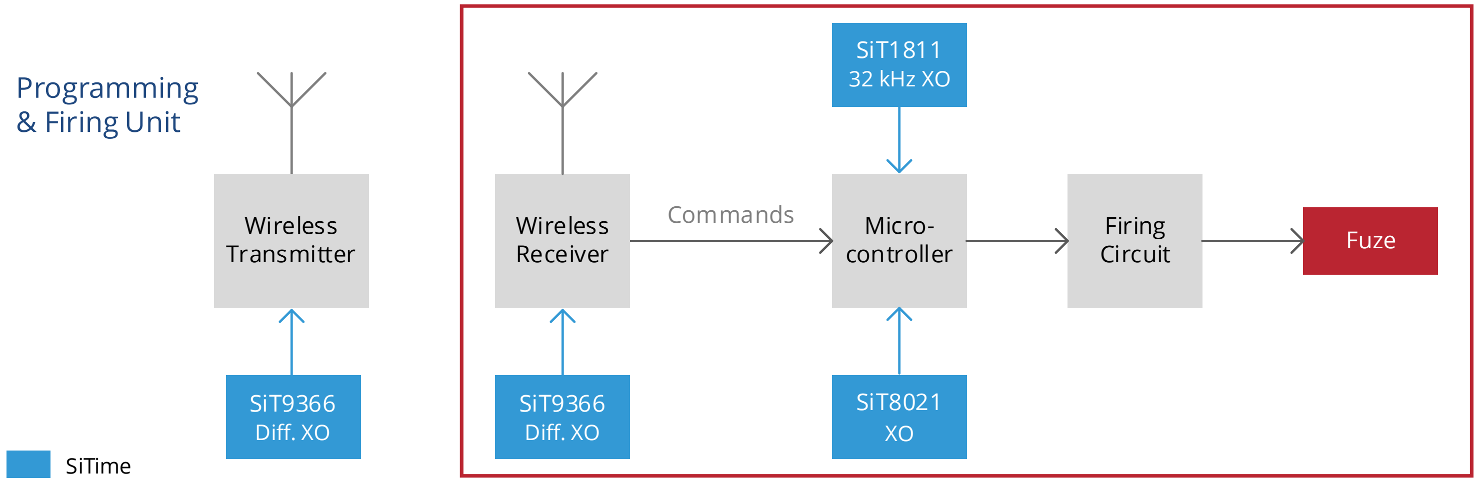


Once the firing sequence is initiated and explosions start, detonators are likely to be disconnected from the power + communication line. For this reason, they feature an internal power supply capacitor which keeps them running until the fuse is triggered. The timing until the fuse is fired is managed by a microcontroller, using a reliable timing source such as the SiT1811 32.768 kHz oscillator.



Block Diagram – Wireless Detonators

Wireless detonators follow a similar operating principle as wired detonators. They are battery-powered and replace the power + communication line by radio transmission. Several techniques exist to create wireless transmitters and receivers; some of them rely on a clock source. A high-stability, low-jitter clock source such as the SiT9366 enables more reliable transmission, lower error rate, and less interference.
The SiT1811 32.768 kHz oscillator is an ideal clock source for the Real-Time-Clock (RTC) function of any microcontroller. Its low power consumption (490 nA typ.) and high stability (< ±20 ppm) enable longer standby times of the system without the need to re-sync the RTC to a network, which consumes power. The SiT1603 low power can be used for general-purpose clocking, for instance to the microcontroller's main clock.



References
[1] Chambers C., Hookham S., Clay M. (2017). EU type certification of non-standard Electronic Initiations Systems used in blasting at mines and quarries.

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SiTime MEMS Oscillators Advantages

- **Resilience to shock and vibration** ensures the detonators keeps working despite nearby explosions.
- **EMI Resilience** minimizes the risk of wrong timing, misfiring or unintended firing.
- **Frequency accuracy and stability over temperature** range ensures perfect blast timing regardless of operating conditions.
- **Low Power** maximizes the operating time on the power supply capacitor or battery; alternatively, it enables using a smaller, lower cost capacitor or battery.
- **Hermeticity of the MEMS resonators** ensures the timing component is and not subject to performance degradation or failure in the presence of external contaminants.
- **Small form factor** enables building smaller detonators.
- **Programmable, low jitter differential oscillators** are a perfect clock source for wireless receivers.

Featured Devices

Type	Product	Frequency	Key Features	Key Values
MHz oscillator	SiT8021	1 to 26 MHz	• -40°C to +85°C • ±50 ppm stability • 1.5 x 0.8 CSP package	• High reliability • EMI resilience • Low power • Small footprint • Excellent frequency stability • MEMS reliability
32.768 kHz oscillator	SiT1811	32.768 kHz	• ±20, ±50 ppm stability • 1.14 to 3.3 V supply • 490 nA typ. current consumption (no load) • Up to -40°C to +105°C • 1.2 x 1.1 mm QFN	
Differential oscillator	SiT9366 SiT9367	SiT9366: 1 to 220 MHz SiT9367: 220 to 725 MHz	• Low jitter 0.23 ps RMS[1] • LVPECL, LVDS, HCSL • 2.5 to 3.3 V • -40°C to 105°C • 3.2 x 2.5 mm package	• Meets demanding jitter requirements • Small PCB footprint, easier layout • Easy design due to flexibility • MEMS reliability

[1] 12 kHz to 20 MHz integration range

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