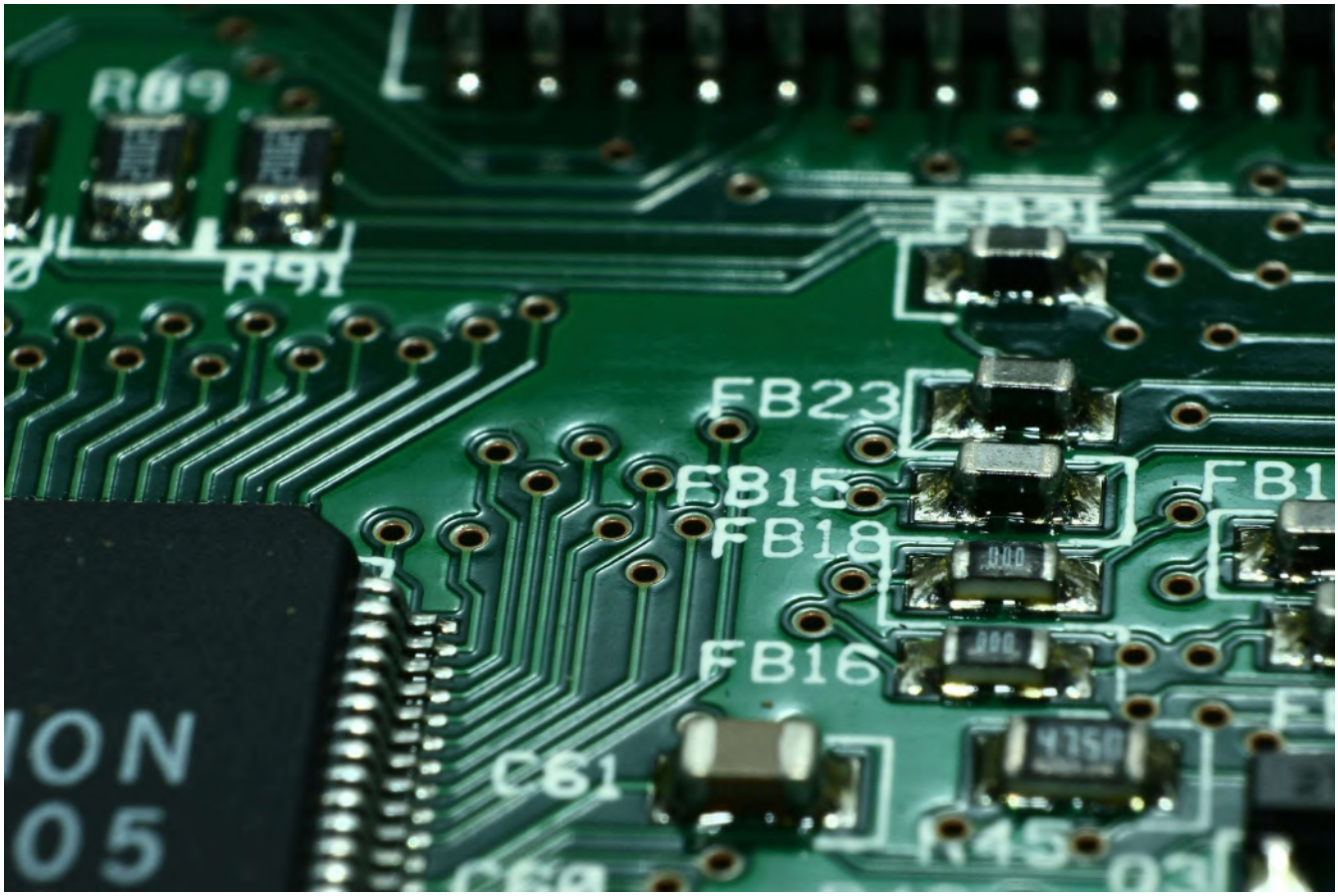

Maxwell Technology: An Introduction

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The high accuracy, availability and integrity of Trimble's precision positioning solutions is derived from a set of hardware and software innovations that are collectively known as Maxwell™ 7 Technology. At the core of the technology is the Maxwell™ 7 baseband GNSS ASIC (application-specific integrated circuit). This is the 7th generation ASIC in the Maxwell family and has been designed to maximize the quality of observables derived from all signals transmitted from all navigation constellations. Complementing the Maxwell™ 7 GNSS ASIC is Trimble's custom designed RF ASIC (one for each band). This chip converts the analog L-band and S-Band GNSS signals into digital inputs to the Maxwell™ 7 ASIC. The measurement observables are finally delivered to the companion

processor subsystem (CPU, RAM, Flash,) to compute position and attitude at rates up to 100Hz. We shall now review the real-world advantages of Maxwell™ 7 Technology and how it improves application productivity.

Track all available GNSS Signals

Over the last 20 years we have seen major changes in the world of satellite navigation. We have moved from relying on the GPS constellation to now including satellites from GLONASS, BeiDou, Galileo, QZSS and NavIC constellations. This has allowed us to operate in environments where the direct signal from the satellites is regularly blocked. Today we regularly have more than 40 satellites available in the sky. In addition to the number of satellites we also have more signals transmitted by each satellite. In the past we typically used two signals from each satellite (dual-frequency) for centimeter positioning in real time. Receivers using Maxwell™ 7 technology utilize up to three signals (triple frequency) from each satellite. All these measurements result in increased availability of positioning and less project downtime. More measurements also improve the integrity of the solution, allowing identification and elimination of erroneous signals. Additional channels are dedicated to tracking geostationary satellites transmitting GNSS corrections from SBAS or Trimble's RTX and OmniSTAR services.

Stronger Tracking of Signals

GNSS receivers track very low-power signals transmitted from satellites. This tracking is made even more difficult in challenging environments such as urban canyons, high dynamics and regions experiencing high ionospheric activity. Maxwell™ 7 technology utilizes advanced phase and frequency tracking on all frequencies to deliver stronger signals with the ability to quickly transition back to multi-frequency phase measurements once a satellite returns in view. Multi-frequency measurements are essential for both RTK and RTX positioning engines to deliver centimeter accuracy without long periods of initialization.

Reduced Size and Power

Both the Maxwell™ 7 baseband and RF ASIC are smaller than the previous generation even though the number of physical correlators and channels has increased. This has allowed Trimble to develop smaller products or increase functionality within the same physical footprint. For example, we can now develop heading receivers with dual antenna inputs in the same footprint as single antenna receivers from the past. The ASIC's are also significantly lower in power consumption resulting in a 15% overall reduction in the

total receiver's power requirement. For products operating on batteries this is a welcome addition and the reduction in heat generated adds to the longevity of the product, extending the replacement lifecycle.

Advanced Multipath Mitigation with Everest Plus™

With the introduction of Maxwell™ 7 Technology Trimble has significantly improved the multipath mitigation performance with a patent pending technique known as Everest Plus. A separate technical bulletin "**Trimble Maxwell™ 7 Technology – Advanced Multipath Mitigation with Everest™ Plus**" provides an overview of how Trimble receivers provide this improvement.

Interference Detection with Onboard RF Spectrum Analysis

GNSS users and developers face the challenge of unwanted signals interfering with the low-power signals transmitted from satellites. This can disrupt productivity or slow development of new products. With the introduction of Maxwell™ 7 Technology, Trimble has added the ability to monitor and analyze the signals received in each of the GNSS frequency bands using the receiver's graphical user interface. A separate technical bulletin "**Trimble Maxwell™ 7 Technology – Interference Detection with Onboard RF Spectrum Analysis**" provides an overview of how this onboard Spectrum Analyzer feature helps users identify interference on the bench or post-mission and take steps to remove.

Protection against Spoofing Attacks

With the introduction of Maxwell™ 7 Technology, Trimble has added several technical innovations that improve the protection from the increasing threat of false GNSS signals. These false or spoofed signals could potentially result in a receiver calculating positions in error by many kilometers. This is not to be confused with jamming, which also disrupts positioning by transmitting strong undesired signals that overload the GNSS receiver's RF or signal processing. However, in the jamming scenario, while the receiver has difficulty calculating a position, it will generally not be in the wrong location. A separate technical bulletin "**Trimble Maxwell™ 7 Technology – Protection Against GNSS Spoofing**" provides an overview of how Trimble receivers provide this improvement.

« Protection Against GNSS Spoofing