

GLONASS CDMA signals Now on L1, L2

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G LONASS satellites traditionally use L1 and L2 frequency division multiple access (FDMA) signals. FDMA is characterized by a different transmit frequency for each satellite. Newer satellite generations also transmit an L3 code division multiple access (CDMA) signal. CDMA uses the same frequency but different ranging codes for individual satellites. The first GLONASS K2 satellite, with the space vehicle number R803, was launched in August 2023. It extends the range of CDMA signals to the L1 and L2 bands.

Frequency spectra of R803, including these new signals, are shown in **Figures 1 and 2**. They were measured with the 30 m high-gain antenna of the German Space Operations Center (GSOC) in Weilheim, Germany, on Jan. 17, 2024. The largest and sharpest peak in the L1 band at 1,598.625 MHz originates from the 0.5 MHz binary phase-shift keying (BPSK) FDMA signal. The center peak of the L1 CDMA signal is located at 1,600.995 MHz. It is related to the L1 open service signal consisting of a data component (L1OCd) and a pilot component (L1OCp). L1OCd and L1OCp are combined by time-division multiplexing. The peaks that are ± 5 MHz away from the L1 CDMA center frequency are introduced by the binary offset carrier (BOC) modulation of the secured L1SC signal. Prominent L1SC side lobes are visible ± 15 , ± 25 and ± 35 MHz offset from the center frequency. A quadrature phase-shift keying (QPSK) modulation is used to combine the L1OC and L1SC signals. The local minimum between 1,610 MHz and 1,614 MHz is caused by a notch filter onboard the satellite to protect radio astronomical observations of the Hydroxyl spectral

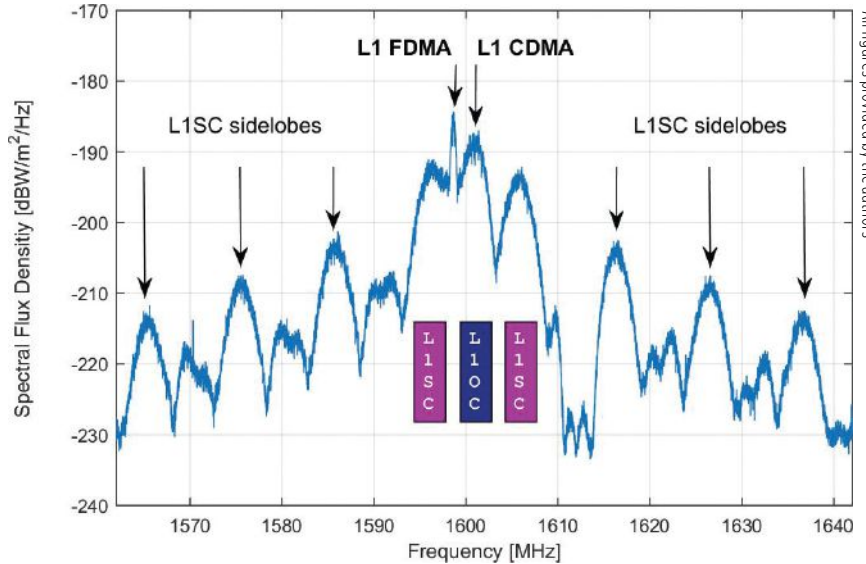


FIGURE 1. GLONASS K2 spectrum of the L1 frequency band. The different components of the L1 CDMA signal are indicated by colored boxes. L1SC: secured signal. L1OC: open service signal.

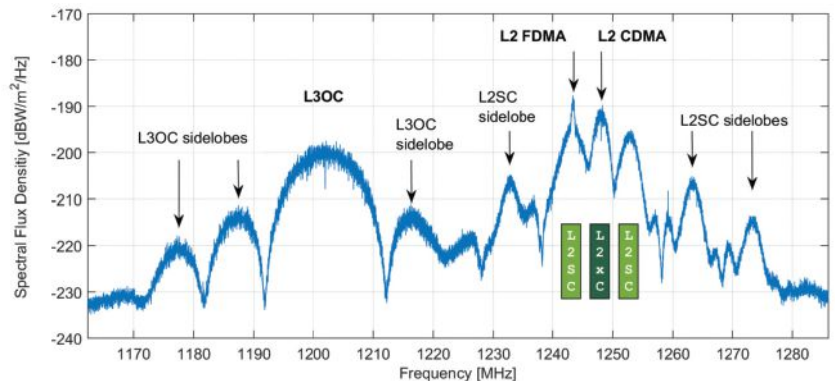


FIGURE 2. GLONASS K2 spectrum of the L2 and L3 frequency bands. The different components of the L2 CDMA signal are indicated by colored boxes. L2SC: secured signal. L2x stands for the time multiplexed L2OCp and L2 CSI signal.

line at 1,612 MHz.

The L2 CDMA signal is composed of a signal for service information (L2 CSI) and the pilot open service navigation signal (L2OCp). As for L1, these two signals are time-division multiplexed and combined with the secured L2SC signal by QPSK. The left main lobe of the L2SC signals coincides with the L2 FDMA center

frequency of 1,243.375 MHz. Both, the L2 CSI, as well as the L2OCp signal, contribute to the peak at the L2 CDMA center frequency at 1,248.06 MHz. The L3 CDMA signal is composed of 10 MHz BPSK data (L3OCd) and pilot (L3OCp) components resulting in a broad peak at 1,202.025 MHz.

FDMA and CDMA signals of GLONASS R803 were tracked with

All figures provided by the authors

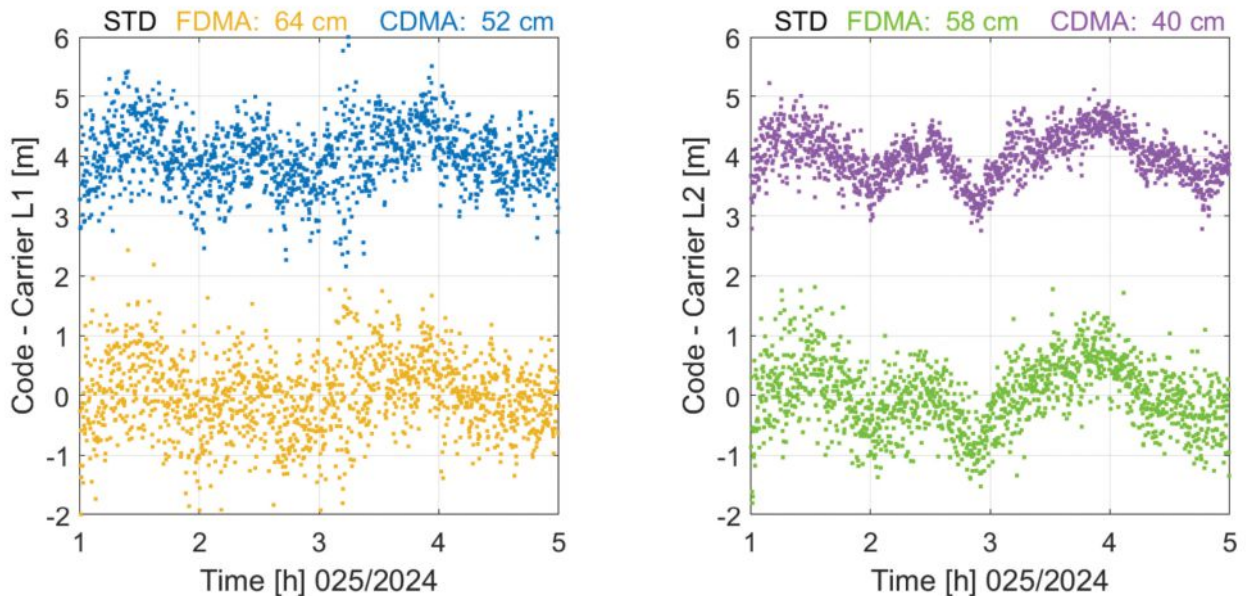


FIGURE 3. Code – carrier for GLONASS R803 FDMA and CDMA signals: L1 (left) and L2 (right). A second order polynomial has been removed and the CDMA signals are shifted by 4 m.

a JAVAD TRE_3S receiver with a prototype firmware located at GSOC in Oberpfaffenhofen, Germany. **Figure 3** shows the differences between pseudo range and carrier phase observations for the FDMA and CDMA signals in the L1 and L2 frequency bands. Long-term ionospheric effects were removed by a second-order polynomial. Thus, remaining effects include short-term ionospheric variations, multipath, and observation noise. The standard deviation of the code-carrier combination is, in general, at the half-meter level. Due to their advanced design, the CDMA signals show an improved performance by 18% for L1 and even 31% for L2 compared to the legacy FDMA signals.

Further launches of L1 and L2 CDMA-capable GLONASS K2 satellites are planned for the upcoming years. A constellation of at least 12 satellites is expected for 2030. To guarantee backwards compatibility, these satellites

will also transmit the L1 and L2 FDMA signals. Further improvements in positioning accuracy are expected due to improved satellite clocks and inter-satellite laser ranging. 🌐

FURTHER READING

Karutin, S. (2023), “GLONASS: The decade of transition to CDMA signals,” *GPS World*, Vol. 34, No. 12, pp. 39-41, gpsworld.com/glonass-the-decade-of-transition-to-cdma-signals/

Russian Space Systems (2016), *GLONASS Interface Control Document: Code Division Multiple Access Open Service Navigation Signal in L1 frequency band*. Russian Rocket and Space Engineering and Information Systems Corporation, Joint Stock Company.

Russian Space Systems (2016), *GLONASS Interface Control*

Document: Code Division Multiple Access Open Service Navigation Signal in L2 frequency band. Russian Rocket and Space Engineering and Information Systems Corporation, Joint Stock Company.

MANUFACTURERS

GNSS data used in this article were collected with a JAVAD (www.javadgnss.com) TRE_3S receiver. The spectral overviews were captured with a Rohde & Schwarz (www.rohde-schwarz.com) FSQ26 signal analyzer.

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