SKYWORKS®

Enhancing GNSS RF Signal Quality with Skyworks LNAs and FEMs

Skyworks' extensive portfolio of global navigation satellite system (GNSS) front-end modules (FEM) offers many options for engineers and developers who work on a broad range of wireless products and systems, such as mobile fitness and activity trackers, drones, asset trackers, and Internet of Things (IoT) applications. Our solutions leverage multiple wireless technologies, making them ideal for a wide range of applications that require different frequency ranges, data rates, small footprint, and extended battery life. The GNSS family of devices [1] are used in stand-alone and highly integrated applications.

GNSS/GPS Technology Standards

The popular GNSS standards are GPS, GLONASS, Galileo, BDS/Compass, QZSS, and IRNSS. The GNSS systems provide precise Positioning, Navigation, and Timing (PNT).

GPS is a global positioning system [2] that is owned and operated by the US Department of Defense, and provides 24+ satellites that enable comprehensive global navigation and positioning. GPS operates at center frequencies L1 at 1575.42, L2 at 1227.6, and L5 at 1176.45 MHz. For commercial use, L1 is the most popular, while for the past several years, a combination of the L1 signal and the L5 signal are used for PNT.

Galileo is the European Union 's [3] GNSS, and is operated by the European Space Agency (ESA). Galileo operates at center frequencies E1 at 1575.42, E6 at 1278.75, E5a at 1176.45, E5 at 1191.795, and E5b at 1207.14 MHz.

QZSS, the abbreviation for Quasi-Zenith Satellite System, operates as Japan's satellite positioning system. It consists [4] mainly of satellites in quasi-zenith orbits (QZO). QZSS uses center frequency signals L1 at 1575.42, L6 at 1278.75, L2 at 1227.60, and L5 at 1176.45 MHz.

Skyworks FEM broad classification as L1 and L5	Constellation	Signal name	Lower frequency (MHz)	Upper frequency (MHz)	Dominant signal bandwidth (MHz)	Center frequency (MHz)
L1: 1559-1606	GPS	L1C GPS-III	1573.42	1577.42	±2	1575.42
	GPS	L1C/A	1574.397	1576.443	±1.023	1575.42
	GPS	L1P	1565.19	1585.65	±10.23	1575.42
	Galileo	E1	1563.144	1587.696	±12.276	1575.42
	GLONASS	G1	1597.552	1605.886	±0.511	1598.0625 – 1605.375
	GLONASS	G1a CDMA	1595.995	1605.995	±5	1600.995
	Beidou	B1I	1559.052	1563.144	±2.046	1561.098
	Beidou	B1C	1559.052	1591.788	±16.368	1575.42
	QZSS	L1 C/A	1574.397	1576.443	±1.023	1575.42
	QZSS	L1 C	1573.42	1577.42	±2	1575.42
L5: 1164-1189	GPS	L5	1166.22	1186.68	±10.23	1176.45
	Galileo	E5a	1166.22	1186.68	±10.23	1176.45
	Beidou	B2a	1166.22	1186.68	±10.23	1176.45
	QZSS	L5	1166.22	1186.68	±10.23	1176.45
	IRNSS	L5	1164.45	1188.45	±12	1176.45

Table-1. Skyworks L1 and L5 family FEMs mapped to constellation and signals

GLONASS is the Russian satellite-based navigation system, Globalnaya Navigazionnaya Sputnikovaya Sistema [5], and operates at multiple center frequencies: G1a at 1600.995 MHz, G2 at 1248.06 MHz, and G3 at 1202.025 MHz.

BDS/Compass is the Chinese BeiDou navigation satellite (BDS), which is also known as Compass [6]. The navigation system is centered at B1 at 1575.42 MHz, B3 at 1268.52 MHz, and B2a at 1176.45 MHz, and B2b at 1207.14 MHz.

IRNSS is the Indian Regional Navigation Satellite System. IRNSS [7] also uses the operational name Navigation with Indian Constellation (NavIC), and operates in the single-frequency L5 position from 1164.45 to 1188.45 MHz, centered on 1176.45 MHz.

Skyworks supplies front-end modules (FEMs) and low noise amplifiers (LNAs) for L1 bands (1559-1606 MHz), and L5 bands (1164-1189 MHz) to support multiple GNSS family standards. Table-1 lists multiple constellations and band frequencies that use Skyworks FEMs. The simplest GNSS FEM support is built with a stand-alone LNA with a matching network. Enhanced features include an optimized combination with pre-filter (Pre-F), LNA, post-filter (Post-F), input and output-side impedance matching, and long-term evolution (LTE) band-13 (B13) filtering.

As more applications are using Ligado networks spectrum [1526-1536 MHz, which has a 23 MHz separation from the lower GNSS band edge at 1559 MHz] desensitizing of GNSS is occurring. To counter this, Skyworks GNSS FEMs provide better than 90 dB rejection in that specific Ligado-adjacent band. As more applications use the spectrum adjacent to the 1559-1606 MHz band, a FEM that includes filters and matching will become the de-facto solution for future proofing the product. Skyworks products incorporate this type of filtering, while including additional features that enhance GNSS positioning.

Key features of Skyworks GNSS RF front-end modules:

- Frequency bands that support multiple GNSS standards that span across L1 and L5 frequencies

- LNA gain combinations in the range of 14-20 dB

- Noise figure (NF) as low as 0.6 dB

- Configurations with Pre-filter, LNA, Post-filter, band rejection filters, and various matching networks

- Linearity across wide input ranges

- Supply voltage range capability from 1.1 to 3.6 V

- Control of LNA in active and standby modes

- Active current of 1 mA, and leakage current of 0.1 µA to 1 µA in low-power FEMs

- Miniature packaged parts with some parts supplied in shielded packages
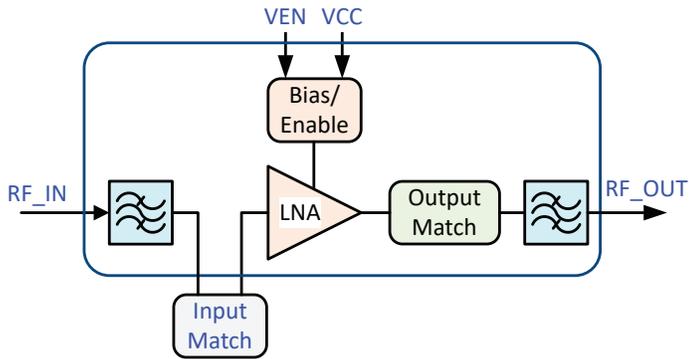
Table-2 highlights various Skyworks GNSS FEM devices and their key features. Individual data sheets for the GNSS devices are linked and provide additional information on the various parameters, such as linearity characteristics, leakage currents, and switching time.

Part number	Frequency (MHz)	Configuration with Pre-Filter (Pre-F), LNA, Post-filter (Post-F), and Fully Matched networks	Distinct features	Gain (dB)	NF (dB)	Vdd (V)	Idd (mA)	Package (mm x mm x mm)
SKY55950-11	1559-1606	Pre-F + LNA + Match + Post-F	94 dBc rejection in Ligado 1627-1629 MHz band	16.0	1.90	1.5-3.6	1.0	2.5 x 2.5 x 0.56
SKY55951-11	1559-1606	L1: Match + LNA + Match + Post-F	LTE B13 notch in L1	17.0	1.4 (L1)	1.5-3.3	1.0	2.0 x 1.6 x 0.7
	1164-1189	L5: Match + LNA + Match + Post-F	Independent L5	18.0	1.2 (L5)		1.9	
SKY65605-21	1559-1606	Input Match + LNA	gain 19 dB, low 0.6 dB NF	19.0	0.60	1.8-2.85	3.6	0.7 x 1.1 x 0.55
SKY65611-11	1559-1606	LNA + Match		16.5	0.65	1.5-3.0	3.5	1.1 x 0.9 x 0.45
SKY65624-682LF	1559-1606	LNA + Match		17.0	0.65	1.5-3.6	4.0	0.8 x 0.8 x 0.32
SKY65723-11	1559-1606	Pre-F(2) + Match + LNA + Match	LTE B13 notch	17.0	1.80	1.62-3.6	4.0	1.7 x 2.3 x 0.7
SKY65723-81	1559-1606	Pre-F + Match + LNA + Match		16.5	1.50	1.62-3.6	4.0	1.7 x 2.3 x 0.7
SKY65724-11	1559-1606	Pre-F + Match + LNA + Match		16.0	1.80	1.62-3.6	3.8	1.1 x 1.5 x 0.65
SKY65725-11	1559-1606	Pre-F + Match + LNA + Match	LTE B13 notch, Shielded package	16.5	1.80	1.1-2.85	4.5	1.6 x 1.6 x 0.75
SKY65725-81	1559-1606	Pre-F + Match + LNA + Match	Shielded Package	16.0	1.50	1.8	3.5	1.6 x 1.6 x 0.8
SKY65728-11	1164-1189	Pre-F + Match + LNA (L5) + Match	L5 band, Shielded package	16.0	1.60	1.1-2.85	3.9	1.6 x 1.6 x 0.7
SKY65943-11	1559-1606	Pre-F + LNA + Match + Post-F		16.0	1.70	1.62-3.3	2.9	2.5 x 2.5 x 0.65

Table-2. Skyworks highlighted GNSS FEM and LNA parts

The combination of L1 and L5 frequencies provide benefits from failover from jamming and spoof, improved sensitivity and ionospheric corrections, multipath mitigation, and reduced interference. The L1 and L5 frequency combination also reduces acquisition time through L1, and improved accuracy from L5. The same GNSS FEM devices that use L1, L5, and an L1+L5 combo directly support augmented GNSS (AGNSS) and augmented GPS (AGPS). GNSS LNA and supporting filters are made available as an add-on hardware block inside IoT and Cellular FEMs. Functional hardware block diagrams for the devices listed in Table-2 are shown in Figure-1. Refer to the Skyworks GNSS devices main page here for hardware features, datasheets, and technical documents.
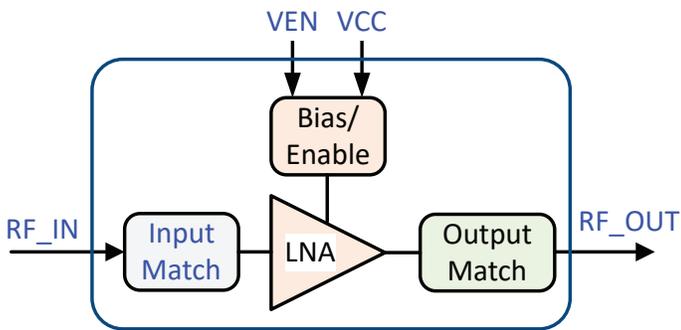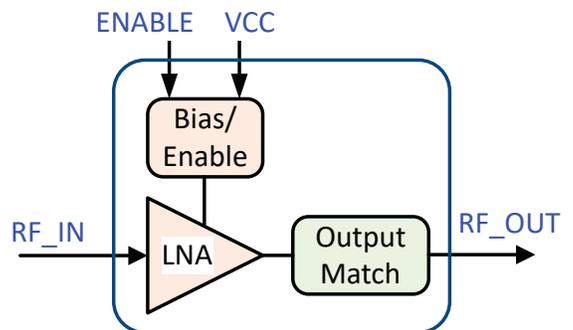
SKY55950–11, SKY65943–11

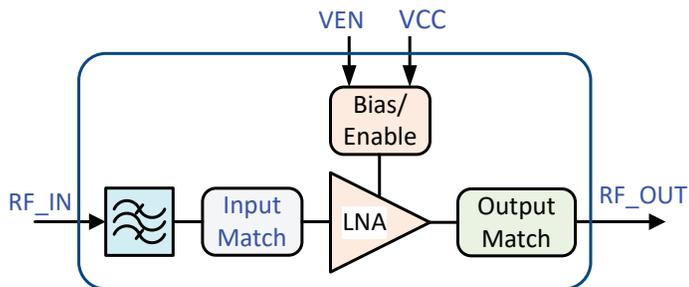RF_IN — [filter] — Input Match — LNA — Output Match — [filter] — RF_OUT

VEN, VCC → Bias/Enable → LNA

SKY55951–11 (L1 & L5)

EN_L1, VCC, EN_L5 → Bias/Enable

RFIN_L1 — Input Match + B13 notch — LNA — Output Match — [filter] — RFOUT_L1

RFIN_L5 — Input Match — LNA — Output Match — [filter] — RFOUT_L5

SKY65605–21

VEN, VCC → Bias/Enable → LNA

RF_IN — Input Match — LNA — Output Match — RF_OUT
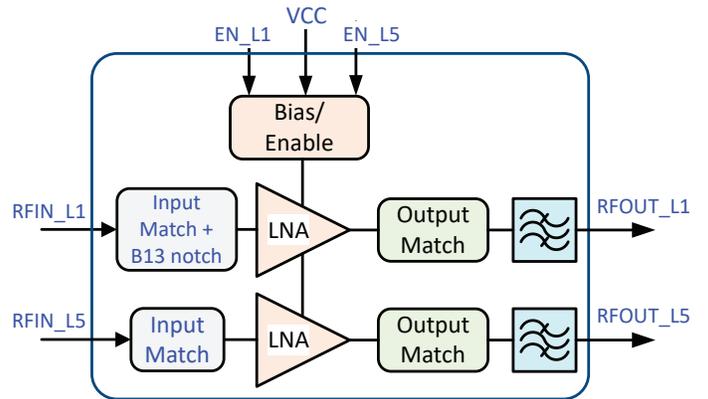
SKY65611–11, SKY65624–682

ENABLE, VCC → Bias/Enable → LNA

RF_IN — LNA — Output Match — RF_OUT

SKY65723–81, SKY65724–11, SKY65725–81, SKY65728–11 (L5 band)

VEN, VCC → Bias/Enable → LNA

RF_IN — [filter] — Input Match — LNA — Output Match — RF_OUT

SKY65723–11, SKY65725–11

VEN, VCC → Bias/Enable → LNA

RF_IN — [filter] — [filter] — Input Match — LNA — Output Match — RF_OUT
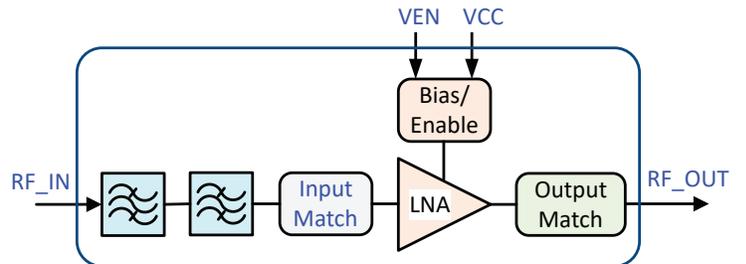
Figure-1. GNSS LNA/FEM hardware configurations

References

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5. GLONASS Applied Consumer Center [Russia] https://www.glonass-iac.ru/en/

6. BeiDou Navigation Satellite System [China] http://en.beidou.gov.cn/

7. IRNSS Programme [India] https://www.isro.gov.in/IRNSS_Programme.html

Skyworks | Nasdaq: SWKS | skyworksinc.com | sales@skyworksinc.com

USA: 949-231-3000 | Asia: 886-2-2735 0399 | Europe: 33 (0)1 43548540