LNA Control and Antenna Integration on u-blox NEO-M9N

LNA_EN Pin Function and Control

The **LNA_EN pin** on the NEO-M9N is an **output control line for an external LNA or active antenna**. It is **active-high** (driven high when enabling an external LNA/antenna) and is **controlled internally by the receiver's firmware**, not by user software or a direct GPIO input [1]. In normal operation, when the GNSS receiver is running and "needs GNSS signal," the module will drive LNA_EN high to turn on external RF front-end components [1]. This behavior can depend on power state: for example, in low-power or duty-cycle modes the module may de-assert LNA_EN when the RF signal is not needed, and assert it during active tracking periods [3]. The **NEO-M9N's internal software automatically manages LNA_EN** based on its power mode and an integrated antenna supervisor (e.g. it will switch off if an overcurrent/short is detected on the antenna feed) [3].

External Control: Because LNA_EN is an output from the module, it **cannot be directly controlled by a host MCU**. You do not toggle this pin manually; instead, you design the circuit to use this pin as a control signal for external RF hardware. For example, if using an external LNA chip that has an enable pin, connect LNA_EN to that enable. If using an active antenna (which typically has no enable pin and is powered via the coax), you might use LNA_EN to drive a P-channel MOSFET or a switch that connects the bias voltage – this allows the module to remove power from the active antenna when it's not in use (for power saving or fault conditions). In practice, many designs simply tie the active antenna bias (VCC_RF) on continuously; using LNA_EN to gate the power is optional but can be beneficial for power savings or to leverage the antenna supervision features.

Summary: In short, **LNA_EN is automatically handled by the GNSS receiver**. It goes high when the receiver is on and acquiring/tracking, and it can go low in sleep modes or if an antenna fault is detected [3]. There is no UBX configuration message to manually force LNA_EN – you rely on the module's power mode settings to influence it. If LNA_EN is not used in the design (e.g. passive antenna scenario), you can leave it unconnected. If it is used, design the circuit so that a high on LNA_EN enables the external LNA or antenna circuitry.

Internal LNA and Whether It Can Be Disabled

The NEO-M9N module includes an **internal Low Noise Amplifier (LNA)** in the RF signal chain, along with a pre-LNA SAW filter for out-of-band rejection [1]. This internal LNA is part of the module's front-end and is critical for achieving the specified sensitivity, especially with passive antennas [1]. **There is no documented method to disable the internal LNA via hardware pin or standard software configuration** – it is always active when the receiver

RF section is on. The LNA_EN pin does **not** disable the internal LNA; it only controls external amplifiers as described above.

In effect, the internal LNA is **built-in and always "on" during normal operation**. The module does manage this internally (for instance, powering it down when the receiver is in a sleep state), but there's no API for the user to independently switch off the internal LNA while the receiver is active. The internal LNA does not have a dedicated enable pin exposed; it draws power from the module's internal RF supply (which is fed by VCC_RF – see below).

Why you generally wouldn't disable it: The internal LNA and SAW filter are designed to improve sensitivity and protect against interference [1]. Even if you use a high-gain active antenna, u-blox recommends leaving the internal LNA in place – it further amplifies the signal and improves the noise figure after the long cable run or remote antenna. The module is specified to handle a certain range of total gain. According to the datasheet, the maximum *external* gain (from an active antenna or external LNA) that the module can accommodate at RF_IN is about **30 dB** [2]. This implies that using, say, a 20–25 dB active antenna in combination with the internal LNA is acceptable and within the linear range. There is typically **no need to disable the internal LNA** when using active antennas, and in fact the internal LNA helps ensure the best possible performance in most cases.

Hypothetical disable scenarios: If one really needed to bypass or "disable" the internal LNA (for example, to avoid cascade gain because an external LNA is very high gain), the only way would be a hardware modification – essentially not powering the internal LNA. Since the internal LNA is tied into the VCC_RF supply, cutting off VCC_RF would also remove bias from the internal LNA. **However, this is not recommended**, as it will significantly degrade the receiver's noise figure and sensitivity (unless the external LNA completely takes over that role, which would require careful planning). In practice, you should design within the recommended external gain limits rather than attempt to turn off the internal amplifier.

Conclusion: The **internal LNA cannot be toggled via any external control in normal operation**. It's always on (when the module is on), ensuring the receiver meets its sensitivity specs with passive antennas. With active antennas or external LNAs, plan the gain budget such that the internal LNA does not saturate (staying within the ~30 dB external gain recommendation) [2]. The NEO-M9N's internal LNA and filters are an integral part of its performance and generally should be left enabled.

VCC_RF Output – Behavior and Usage for Active Antennas

VCC_RF on the NEO-M9N is a dedicated output pin that provides a **filtered DC supply voltage for an external RF device** (such as an active antenna's LNA or an external LNA module). Essentially, this pin is the power source you can use to feed the active antenna through a bias-T. Key characteristics of VCC_RF:

- It is typically at (or just below) the module's main VCC level (approximately VCC – 0.1 V according to the datasheet) [2]. So if you power the NEO-M9N at 3.3 V, VCC_RF will supply ~3.2–3.3 V, suitable for a 3.3 V active antenna (check that the antenna's required bias voltage matches – if the antenna needs 5 V, you **must use an external supply instead** [1]).

- It can source up to **50 mA** of current [2], which is plenty for typical active GNSS antennas (these often draw ~10–20 mA). This output is short-circuit protected only by passive components (and possibly an internal limiter); in the design, u-blox recommends a series resistor to limit current in case of a short [1].

- **Always on:** VCC_RF is powered whenever the module is powered. There isn't a software command to turn off VCC_RF independently. **In other words, as long as the NEO-M9N VCC is applied, the VCC_RF pin provides voltage**. It does not automatically shut off when the GNSS is in standby (the voltage rail stays up, though the LNA_EN signal might go low – but that by itself doesn't cut power). So, if you connect VCC_RF straight to the active antenna, the antenna's LNA will be fed continuously.

Given that VCC_RF is always on, if you want to **conserve power** by turning off an active antenna when the GNSS receiver is not in use, you would need to implement an external switch (again, potentially using LNA_EN or another MCU control to gate the VCC_RF supply to the antenna). The NEO-M9N does *support* this use case in concept: LNA_EN goes low when the receiver is in backup mode or shut down, so you can use that signal to cut off the bias via a transistor. But by default, if you just tie VCC_RF through an inductor to the antenna, that bias is continuously present.

Is VCC_RF suitable for active antennas? – Yes. The NEO-M9N is explicitly designed to support active antennas, and VCC_RF is the convenient on-board supply for them [1]. It is filtered and intended for low-noise antenna powering. Just ensure the voltage is compatible and budget the extra current. For instance, the integration manual notes that using an active antenna or external LNA will add about 5–20 mA typical to the power consumption, which must be supplied via VCC_RF and the main supply [1]. Also, **use the recommended bias-T circuit** (inductor and capacitor) so that the RF signal and DC power share the antenna line properly without interference [1].

In summary, **VCC_RF is always on when the module is on, and it is designed to power an active antenna's internal LNA directly**. It can source the needed current (up to 50 mA), but you should include protections (like a current-limiting resistor and ESD protection) in the antenna bias circuit to guard against short-circuits or ESD hits on the antenna line [1]. If the active antenna requires a different voltage or you want to cut power in certain modes, plan to use an external regulated supply or a switching circuit accordingly [1].

Supported Antenna Configurations (Passive vs Active)

The u-blox NEO-M9N is very flexible and can work with both passive and active antennas. The internal LNA+filter network ensures it performs well even with a passive antenna, but it also supports adding external gain for remote or low-signal scenarios [1]. Let's break down the scenarios:

- **A) Passive Antenna:** Yes, the NEO-M9N works out-of-the-box with a passive antenna. In fact, it is designed with an internal LNA and SAW filter specifically so that a quality passive antenna can be used without external amplification [1]. A passive antenna can be connected directly to the RF_IN pin (no bias voltage needed). The integration manual shows a simple passive antenna connection (with the possibility of an optional matching network or ESD protection, but no bias-T since no DC power is required) [1]. Many NEO-M9N breakout boards and modules use passive chip or patch antennas taking advantage of the module's built-in LNA.

- **B) Active Antenna (with its own LNA) – Internal LNA ON:** Yes, the NEO-M9N can work with an active antenna that has an internal LNA, *with* the module's internal LNA still enabled (which is the normal state). In this configuration, you effectively have a cascade of the antenna's LNA followed by the module's LNA. This is a common scenario and is supported. The key considerations are to provide the DC bias to the active antenna (via VCC_RF or other supply through a bias-T), and to ensure the total gain isn't excessive. As noted, u-blox allows up to ~30 dB of external gain at the input [2]. Most active GNSS antennas provide around 20–28 dB gain, which combined with the module's own LNA (noise figure ~3.5 dB, gain on the order of ~15–20 dB) will improve the overall signal quality without saturation. In other words, **having both the antenna's LNA and the internal LNA active is not only acceptable, it is the typical configuration for active antenna setups**. The internal LNA will further amplify the signal and overcome any cable losses. The integration manual explicitly recommends active antennas for cases where passive ones don't suffice and shows how to bias them, implying the internal LNA remains in use [1].

- **C) Active Antenna – Internal LNA OFF:** *Can* it work if the internal LNA were off? In theory, yes – an active antenna provides gain, so the receiver could still get enough signal even if its own LNA were not powered. However, as discussed, the internal LNA is not intended to be disabled during normal operation. There is no official configuration where you deliberately turn off the internal LNA while using an active antenna. So, **this scenario would only occur in unusual circumstances**, such as if you powered an active antenna from an external supply and somehow the module's internal LNA were unpowered (which would require a custom hardware modification). The NEO-M9N RF input path does have an internal DC block and matching network, so an active antenna's RF output would still be coupled into the receiver even if the internal LNA were off [1] – but with higher noise figure. If the active antenna's gain is high enough, the receiver *could* still make use of the signal. For example, a 25 dB active antenna alone could drive the receiver's mixer, likely with some degradation in C/N0 compared to having the internal LNA on. In short, **yes, the receiver will "work" with an active antenna even if the internal LNA contributed no gain – but this is not a standard or recommended configuration**.

To put it plainly: **You typically do not need or want to disable the internal LNA when using an active antenna**. The module is designed to accommodate both. All three cases (pure passive, active+internal, or hypothetically active-alone) result in the GPS signals reaching the receiver. Case (C) is hypothetical since internal LNA off is not a user-controlled option – if for some reason the internal LNA failed or was off, an active antenna can provide some level of reception, though not optimal. Cases (A) and (B) are fully supported by u-blox with guidance in the documentation [1].

For best results, follow u-blox's recommendations: use a good passive antenna for short antenna runs, or use an active antenna/external LNA for long cable runs or weak signal environments, **without any need to disable the module's own LNA**. Ensure any active antenna's gain is within the allowed range, and use LNA_EN/VCC_RF as needed to properly power and control it.

Configuration: u-center vs. Microcontroller (UART)

No special configuration is required to *use* a passive or active antenna on the NEO-M9N – the hardware will work as described above by default. You do **not have to send any UBX or other commands to "enable" the bias-T or LNA** – simply implementing the circuit (bias network, etc.) is enough. The module's default behavior (LNA_EN control, etc.) will handle the rest.

That said, the NEO-M9N is highly configurable via u-blox's UBX protocol. All configuration that can be done in u-center (which is u-blox's PC software) can also be done by a microcontroller through the UART (or I²C/SPI) interface by sending the appropriate UBX configuration messages. In other words, **you do not need a PC or USB to configure the module** – a microcontroller (like the Raspberry Pi RP2040 mentioned) can send the same configuration commands over UART.

Some relevant configurations or considerations:

- The **antenna supervisor** features (if you want to detect antenna open/short conditions) are typically configured via the UBX-CFG-ANT message on older u-blox modules. On the M9N, the documentation indicates an antenna supervisor is available [4], but the integration manual doesn't call out a specific user configuration for it – it seems largely automatic. If you did want to adjust thresholds or behavior, you would use UBX commands (from the microcontroller) to do so. This can be done over UART.

- If you wanted to adjust power management (e.g. use Power Save Mode so that the LNA_EN only goes high at intervals), you can configure that via UBX-CFG-PMS or similar messages – again via UART from an MCU or via u-center on USB, whichever is convenient. No difference in capability.

- **TXREADY (if relevant):** The TX_READY feature (discussed more below) is configured by a UBX message (CFG-TXREADY) and can equally be set via microcontroller. In general, **u-center is just a convenient GUI that sends UBX commands over USB**. Any host that can send those commands (MCU over UART, etc.) can achieve the same configuration. So you do not need to rely on u-center in production – you can have the microcontroller set up the module at startup by sending the proper UBX config commands over the UART.

In summary, **all necessary configuration or control of the NEO-M9N can be done via the UART interface from an MCU**. There's no requirement to use the USB/u-center, except for initial experimentation. In many designs, the module is simply left at default settings with perhaps minor tweaks done by the MCU at runtime.

(One note: if you plan to use the USB interface concurrently with an MCU on UART, remember to set the D_SEL pin properly (open/high for UART enable) [2]. Typically, you use one or the other interface at a time.)

Summary of u-blox Support Thread Insights

Thread 1 – "Right way to enable/disable active antenna on M8N/M9N": This u-blox forum thread discussed how to properly use the active antenna control features on NEO-M8N/NEO-M9N. The key points from the thread were:

- **Automatic Control:** The u-blox modules will **automatically control LNA_EN**; there is no manual "antenna on/off" command you need to send. The NEO's firmware handles when to drive LNA_EN high or low (for instance, toggling with power-save mode or if a short circuit is detected on the antenna line) [3]. Users were sometimes unsure if they needed to enable anything in software – the answer is that **if you've connected VCC_RF and LNA_EN as recommended, the module will do it all internally**.

- **Hardware Implementation:** The correct approach is to implement the bias-T and antenna enable as shown in the Hardware Integration Manual (HIM). In the thread, the user had followed the HIM recommendation of using **VCC_RF + LNA_EN to drive their active antenna** (e.g. feeding VCC_RF through an inductor to the antenna and using LNA_EN to gate a supply) and wanted to confirm that was the right method. The advice from u-blox was that this is indeed the intended design. Essentially, **tie the active antenna's bias to VCC_RF and use a current-limiting resistor; if you want the module to cut power, insert a switch controlled by LNA_EN**.

- **No Software "switch":** The thread clarified that there isn't a specific UBX message to "enable active antenna" – once the hardware is wired, the module knows when to power it. However, if the module's antenna supervisor is enabled (it usually is by default on these modules), it will monitor the current. If an over-current (short) is detected, the module can internally pull LNA_EN low to protect itself [3]. The module can also signal an antenna fault status via UBX or NMEA messages (on older modules this was in UBX-MON-HW status flags, likely similar in M9).

- **M8N vs M9N:** The thread likely also mentioned that both the older M8N and newer M9N use the same principle for active antenna control. The exact pin might be named ANT_ON on some modules, but for NEO-M9N it's LNA_EN – functionally serving as ANT_ON. The answer applied to both, meaning if you had an M8N or M9N, the approach to active antennas is the same: use the bias-T, use the control pin if desired, no special software toggling required.

Overall, the **“right way” is to use the built-in supply (VCC_RF) and control line (LNA_EN) as provided, rather than, say, powering the antenna from an always-on 3.3 V and ignoring LNA_EN**. This ensures the module can manage power to the antenna, and that you benefit from short-circuit protection and power-save features. The takeaway from the support discussion is that the u-blox design is largely plug-and-play for active antennas if you follow the reference design, with the module handling the rest.

Thread 2 – “Configuring TXREADY on NEO-M9N”: This thread was about using the TX_READY feature on the NEO-M9N. TX_READY is an optional signal that indicates when there are bytes ready to transmit on a given interface (often used for I^2C/SPI to alert the host instead of constant polling). The user in the thread was trying to configure a pin for TX_READY per the documentation but was encountering difficulties. Key findings were:

- **Documentation Gaps:** The integration manual and protocol docs describe a CFG-TXREADY message and say that TX_READY can be mapped to a “free” PIO (Programmable IO) on the receiver [1]. However, the documentation was a bit **unclear on which PIOs are actually available on the NEO-M9N** for this purpose. The thread highlighted that the NEO-M9N module, in its 24-pin package, doesn’t have obvious spare pins for a TX_READY output. All the external pins are largely occupied (UART, I2C/SPI, timepulse, etc.), and the ones labeled “Reserved” are not normally usable by customers.

- **Outcome:** The consensus was that **TX_READY is not practically supported on the NEO-M9N module**, despite the feature existing in firmware. The support responses indicated that it’s a known issue that the documentation mentions TX_READY, but on certain modules (like NEO-M9N) there is no easy way to output it because no extra PIO is exposed to the user. In other words, the feature is there in theory (and can be configured via UBX), but **there’s no readily available pin on the NEO-M9N hardware to output the TX_READY signal**. This was confirmed by u-blox staff, noting that the question had come up for other chips as well, implying a documentation oversight.

- **Workaround:** If an application truly needed TX_READY, one would have to sacrifice another pin’s function (for example, repurpose the TIMEPULSE pin or a reserved pin if possible) by reconfiguring that PIO for TX_READY. However, this may not be feasible or documented. The thread likely concluded that on NEO-M9N, **it’s best to assume TX_READY cannot be used** (since it’s “disabled by default and remains effectively unusable on this module”). Instead, typical flow control or polling methods should be used for UART/I2C. This aligns with the integration manual hint that for USB it doesn’t work and it’s primarily meant for I2C/SPI in high-throughput applications [1]. Given the limitations, most designs do not use TX_READY on NEO modules.

In summary, the second thread's takeaway is: *Don't count on using TX_READY on the NEO-M9N.* The feature exists in the software and can be configured via UBX commands, but the hardware pins on the NEO form factor don't readily support it, and the documentation is sparse on how to actually wire it up. The user was advised of this limitation.

Hardware Design (Supporting Both Passive & Active Antennas)

Designing a board for NEO-M9N that can accommodate either a passive or active antenna requires a bit of foresight in the RF front-end. Here are **technical recommendations and considerations**:

- **Include a Bias-T Network:** If there is any chance an **active antenna** will be used, implement the bias tee circuit on the RF input. This typically consists of an inductor (choke) to feed DC to the antenna line, and a capacitor to block DC from entering the receiver input. In u-blox's reference, they use e.g. **L1 = 27 nH** in series from VCC_RF to the RF_IN node, and **C1 = 100 nF** from that VCC_RF line to ground to filter noise [1]. The RF_IN pin itself already has an internal DC block capacitor in the M9N, but for other designs or extra safety, they show an optional **C2 (for DC block)** and an optional matching network (L2/C3) if needed to match 50 Ω [1]. A **10 Ω resistor (R1)** in series with the VCC_RF bias line is highly recommended as a **current limiter** – this protects the inductor and internal LNA in case the antenna port is shorted or an active antenna draws excessive current [1].

- **ESD Protection:** The antenna connector is a major entry point for ESD strikes. Use a dedicated RF ESD protection diode or a gas discharge tube at the antenna input. Place it right where the antenna connects, before it reaches the module. This will shunt high-voltage transients to ground and protect the GNSS front end [1].

- **Antenna Placement and Grounding:** Whether passive or active, the antenna performance is heavily affected by ground plane size and placement. For a patch or chip antenna on board, follow the datasheet guidelines for ground plane area. For an external antenna via connector, ensure the connector's ground is solidly tied into the PCB ground. **Provide a good ground plane** under the NEO-M9N and the RF trace. Keep noise sources (digital lines, switching regulators) away from the RF circuitry to prevent interference [1].

- **Layout of RF Path:** The RF trace from the antenna connector (or on-board antenna feed) to the module's RF_IN pin should be a controlled-impedance 50 Ω trace. Place the bias-T inductor as close as possible to the antenna feed point to reduce the RF path going through the DC supply line. The filtering capacitor on VCC_RF should also be nearby. Essentially, maintain a short path for the RF and isolate the DC path with the choke. If you need a matching network (L2, C3) to match the specific antenna, place those components in a Pi or L configuration right at the RF_IN pin (or antenna feed) as needed [1]. The NEO-M9N already has internal matching suitable for 50 Ω, so additional matching might not be required unless the antenna impedance needs tweaking.

- **Passive vs Active Selection:** Design the circuit so that it **works with either antenna without hardware changes**. The bias-T does not hurt passive antenna operation – it simply won't have DC current flowing. (Just ensure the DC block capacitor C2 is in place if the internal one is not relied upon, so that the inductor doesn't load a passive antenna's RF – in M9N's case the internal DC block covers this). So you can have one unified RF input that supports passive antennas (with VCC_RF just providing no current) or active (drawing current). It may be wise to include a **jumper or zero-ohm resistor option to disconnect VCC_RF** in case you ever want to use an external supply for the antenna or if using a passive antenna and you want to completely eliminate any noise from that supply. By default, you'd populate it for active antenna support.

- **LNA_EN usage:** Bring out the LNA_EN pin in the design. If you anticipate only passive antennas, you can leave LNA_EN not connected (or perhaps use it to drive an LED if you want to indicate when the receiver is actively on – though be cautious loading it). If you do use active antennas or an external LNA, **use LNA_EN to the advantage**: for an external LNA chip, connect LNA_EN to its enable pin. For an active antenna, consider a P-channel MOSFET high-side switch or an RF switch that cuts off the bias line when LNA_EN is low. For example, LNA_EN could control a MOSFET that connects VCC_RF to the inductor. When LNA_EN is low (receiver off or in standby), the MOSFET is off, removing bias from the antenna; when LNA_EN goes high, bias is applied. This is not strictly required (you could simply tie the antenna to VCC_RF through the resistor/inductor and have it powered continuously), but implementing it means **power will be saved in backup mode**, and the module can remove power if it detects a short. If you use this, choose a MOSFET with low Rds_on and gate threshold such that it fully turns on at the logic level of LNA_EN (which is at VCC voltage level when high). Ensure the MOSFET doesn't add significant capacitance or leakage on the RF line when off.

- **Antenna Detection (optional):** The NEO-M9N's antenna supervisor can likely detect open or short conditions by measuring current draw on VCC_RF. If you want to make use of antenna status indications (e.g., get an alert if the antenna is unplugged or shorted), you typically need to enable and configure that via UBX (if not on by default). Check if the UBX-CFG-ANT or UBX-MON-HW messages show antenna status. In hardware, the current limiting resistor and the presence of a bias voltage are what allow detection (open = very low current, short = high current causing drop). The module may pull LNA_EN low on fault, but to be safe, you could also design a simple antenna detect circuit (like a voltage divider or an ADC measurement of the bias line) if needed. In most cases, the internal supervisor is sufficient.

- **Power Supply Considerations:** The active antenna will draw its current from VCC_RF, which ultimately comes from the main supply VCC. Make sure the regulator can supply this extra 10–20 mA on top of the module (~23 mA acquisition, ~ < 20 mA tracking typically). Also, decouple the VCC_RF line well (that 100 nF C1 and perhaps a 4.7 µF nearby) so that the active antenna's current pulses (if any) do not inject noise back into the module's supply. VCC_RF is filtered internally, but extra decoupling doesn’t hurt.

- **Testing both scenarios:** When the board is assembled, test with a passive antenna and measure acquisition performance (TTFF, C/N0 levels) to ensure the passive path is fine. Then test with an active antenna: verify that the active antenna gets the proper voltage at the antenna feed, and measure the current drawn through VCC_RF. It should match the antenna’s spec (e.g., 15 mA, and the LNA_EN should be high during operation). Check that no unwanted oscillations or noise are introduced (sometimes a high-gain LNA can oscillate if the bias network is not correct – the recommended network from u-blox is designed to prevent that). Also, if possible, simulate an antenna short (briefly) to see that the current limiter resistor and perhaps the module’s protection kick in without damage. The resistor will drop voltage if >150 mA flows, protecting the internal feed inductor [1].

Schematic Reference: The u-blox Integration Manual provides an example schematic for an active antenna interface. In summary form, it shows: VCC_RF → (through R1 10 Ω) → node X. Node X connects to RF_IN through an inductor L1 (27 nH), and Node X is decoupled to ground with C1 (100 nF). This forms the bias-T: L1 injects DC into the RF line, C1 filters noise on the DC feed. The RF_IN side may have a coupling capacitor C2 (if needed) and matching network L2/C3 to ground (optional). **Figure below** (from u-blox) illustrates this setup [1]:

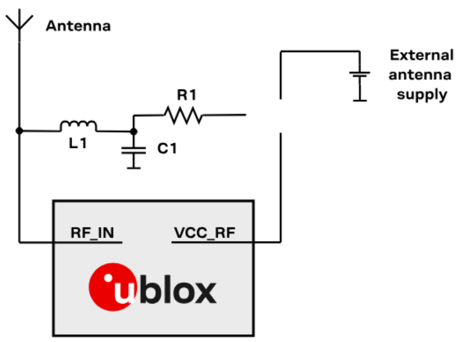

Figure 33: NEO-M9N active antenna example circuit (bias-T)

u-blox

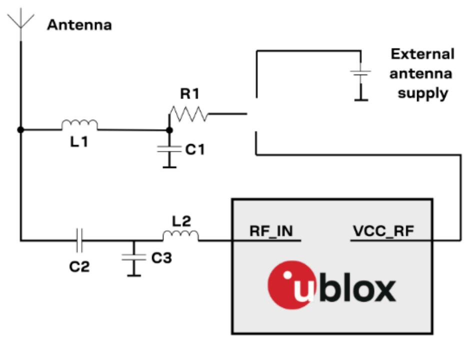

Figure 32: NEO-M9N active antenna example circuit (Bias-T)

Sparkfun

By following these guidelines, the board can seamlessly support **both passive and active antennas**. When a passive antenna is plugged in, it will simply feed the RF signal through, and no DC will flow (no harm done). When an active antenna is used, the bias-T will provide it power, and the GNSS module will benefit from the increased signal levels. No jumpers or different board versions are needed for each case – one design can accommodate both. Just be sure to adhere to the layout and component recommendations to maintain signal integrity and avoid interference in the sensitive RF path.

Lastly, always refer to the **NEO-M9N Integration Manual and Datasheet** for the definitive guidance. They contain schematics and explanations of the RF design (as we cited) that are invaluable in hardware design [1]. With the above approach, you’ll have a robust design ready for either antenna type and optimal GNSS performance.

References

1. **u-blox**. *NEO-M9N Integration Manual* (UBX-19014286 - R09), February 2024.
   Retrieved from: NEO-M9N Integration manual
   Document provides full hardware design recommendations, LNA behavior, antenna configuration, and example schematics.

2. **u-blox**. *NEO-M9N-00B Data Sheet* (UBX-19014285 - R07), March 2023.
   Retrieved from: NEO-M9N-00B Data sheet
   Includes pin definitions, electrical specifications, and signal performance data.

3. **u-blox Community Portal**. *Right way to enable/disable active antenna on M8N/M9N*.
   URL: https://portal.u-blox.com/s/question/0D52p0000AqfwpfCQA
   Community discussion about automatic LNA_EN control and best practices for active antenna biasing.
4. **u-blox Community Portal**. *NEO-M9N module*
   URL:https://www.u-blox.com/en/product/neo-m9n-module
   Community discussion about automatic LNA_EN control and best practices for active antenna biasing.

5. **u-blox Community Portal**. *Configuring TXREADY on NEO-M9N*.
   URL: https://portal.u-blox.com/s/question/0D52p00009qYXY5CAO
   Clarifies issues with TXREADY pin availability and limitations on the NEO-M9N hardware.

6. **u-blox**. *u-center GNSS Evaluation Software*.
   URL: https://www.u-blox.com/en/product/u-center
   Software used for configuring and monitoring u-blox GNSS modules over USB.