Table 4-15 describes the ADC signals.

Table 4-15: ADC Pin Description

Pad #	Signal Name	I/O[a]	Description	I/O Type
C24	ADC1	AI	Analog to digital converter	1.8V (VGPIO)
C25	ADC0	AI	Analog to digital converter	1.8V (VGPIO)

a. Signal direction with respect to the module.

4.10 Clock Interface

The HL781x supports two digital clock output signals. These signals are disabled by default. To enable (or disable) these signals, use the AT+KHWIOCFG command. For details, refer to HL78xx AT Commands Interface Guide.

Note: To reduce noise and radiated spurious emission (RSE), disable the clock signals if they are not being used.

Table 4-16 describes the clock signals.

Table 4-16: Clock Interface Pin Description

Pad #	Signal Name	I/O[a]	Voltage Supply Domain	Description
C22	26M_CLKOUT	O	1.8V (VGPIO)	26 MHz Digital Clock output
C23	32K_CLKOUT	O	1.8V (VGPIO)	32.786 kHz Digital Clock output

a. Signal direction with respect to the module.

4.11 Debug Interfaces

The HL781x provides two 4-wire debug port interfaces (Diagnostic Interface, Modem Logs) that can be used with the AT interface for full debug capability.

Note: All UART signals operate at 1.8V. A voltage level shifter is required when connecting to a 3V3 domain.

UART interfaces are not active during Hibernate mode, so the host should ignore all activity on UART interfaces during Hibernate. If the module will enter Hibernate mode, Semtech recommends adding buffer circuits to ensure module I/Os are not driven high (i.e. >0.2V). To enable debug interfaces, refer to HL78xx AT Commands Interface Guide.

4.11.1 Diagnostic Interface

The Diagnostic interface is implemented over UART0. When the module begins to boot, UART0 is enabled at 115200 baud and writes an initial boot log.

Availability and behavior of UART0 after the initial boot log is written depends on the configured debug mode (using the AT command +SWITRACEMODE):

- Customer mode (AT+SWITRACEMODE=CUSTOMER)— UART0 is disabled after the initial boot log is written.

- Debug mode (AT+SWITRACEMODE=LOG or AT+SWITRACEMODE=SFPLOG)— UART0 remains enabled for logging. Unless configured differently using +SWITRACEMODE options, the default baud rate (921600) and default flow control (enabled) are used. With flow control enabled (4-wire logging), UART0_CTS is asserted. To receive logging data, the host must assert UART0_RTS, and then use UART0_RX/UART0_TX to receive/send data.
  With flow control disabled (2-wire logging), note that the host must be fast enough to capture all data streamed from the module so that log files are not corrupted.
- Boot mode for firmware upgrades (using SFT (Standalone File Tool))— UART0 remains enabled for 2-wire communication (flow control is disabled by default; UART0_CTS is not asserted, and UART0_RTS is ignored).

Note that Flow control may be enabled using AT+KBOOTCFG=1, but is not required for successful firmware upgrades.

For SFT details, refer to HL780x Firmware Update Methods Application Note.

Table 4-17: Diagnostic Interface Pin Description

Pad #	Signal Name[a]	Default State[b,c]	Active	I/O Type	Description
C55	UART0_RX	Output	—	1.8V (VGPIO)	Debug Receive Data
C56	UART0_TX	Input	—	1.8V (VGPIO)	Debug Transmit Data
C57	UART0_CTS	Output	L	1.8V (VGPIO)	Debug Clear to Send
C58	UART0_RTS	Input	L	1.8V (VGPIO)	Debug Request to Send

a. Signals are named with respect to the host device (i.e. DTE (Data Terminal Equipment) convention—PC view). For example, UART0_RX is the signal used by the host to receive data from the module.
b. Signal direction with respect to the module. For example, UART0_RX is an output from the module to the host.
c. Default states are for the module in Debug mode with flow control enabled.
In Debug and Boot modes, with flow control disabled, UART0_CTS and UART0_RTS are disabled.
In Customer mode, all signals are disabled.

Note: It is highly recommended to provide access through Test Points to this interface (required for customer platform debugging).

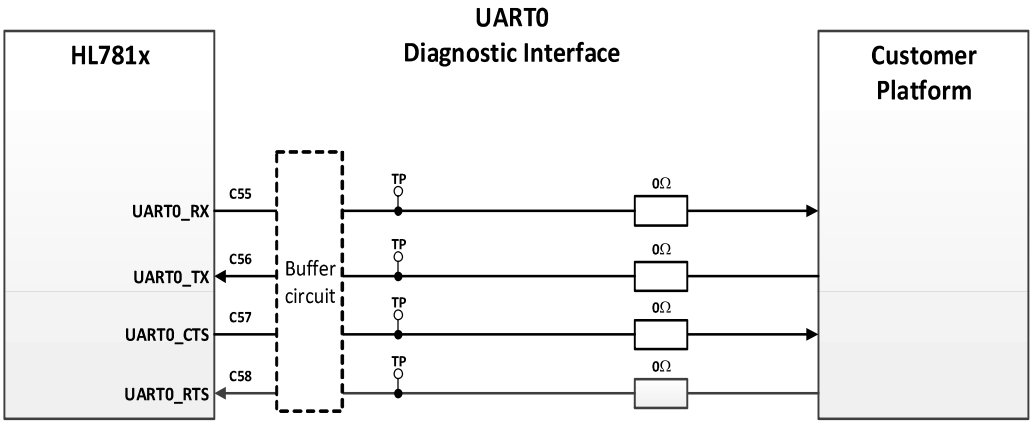


Figure 4-8: Diagnostic Interface connection example

4.11.2 Modem Logs Interface (MLI)

Table 4-18: Modem Logs Interface Pin Description

Pad #	Signal Name	I/O[a]	I/O Type	Description
C51	GPIO14	O	1.8V (VGPIO)	UART3_CTS[b]
C52	GPIO10	I	1.8V (VGPIO)	UART3_TX[b]
C53	GPIO11	I	1.8V (VGPIO)	UART3_RTS[b]
C54	GPIO15	O	1.8V (VGPIO)	UART3_RX[b]

a. Signal direction with respect to the module. For example, GPIO14 is an output from the module to the host.
b. Signals are named with respect to the host device (i.e. DTE (Data Terminal Equipment) convention—PC view). For example, UART3_RX is the signal used by the host to receive data from the module.

Note: To enable use of the UART3 interface for customer platform debugging, it is highly recommended to provide access through Test Points to these 4 GPIOs.

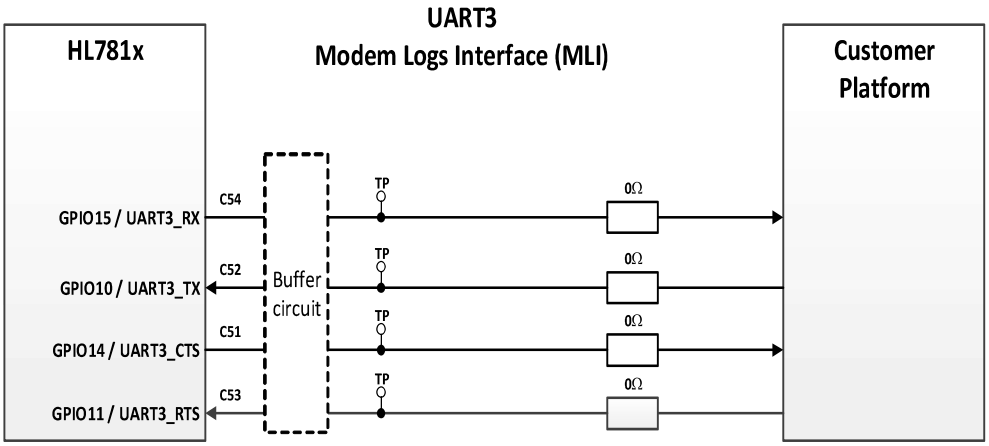


Figure 4-9: Modem Logs Interface connection example

4.12 Wake Up Signal (WAKEUP)

The WAKEUP hardware control signal is used to wake the module from low power modes (Sleep, Lite Hibernate, Hibernate, OFF) by driving the signal high to 1.8V.

The module will not enter or return to low power mode while the WAKEUP signal is high. Table 4-19 and Table 4-20 describe the WAKEUP signal.

Table 4-19: WAKEUP Pin Description

Pad #	Signal Name	I/O[a]	I/O Type	Description
C44	WAKEUP[b]	I	1.8V	Wakes the module up from low power mode

a. Signal direction with respect to the module.
b. Signal provided by host. Signal does not need to be buffered, and can be directly connected to the module.

Table 4-20: WAKEUP Electrical Characteristics

Parameter	Minimum	Typical	Maximum	Unit
V_{IL}	–	–	0.3	V
V_{IH}	1.2	–	–	V
Wakeup assertion time[a]	100	–	–	µs
Internal PD	–	100K	–	?

a. Assertion time—Time required to keep WAKEUP at high level to ensure module can wake up successfully.

4.12.1 Wakeup from Low Power Modes

This section describes the module's signal behaviors when waking from the low power modes defined in Table 3-5.

4.12.2 Wakeup from OFF Mode

Figure 4-10 and Table 4-21 describe signal behavior when WAKEUP is used to wake the module from OFF mode.

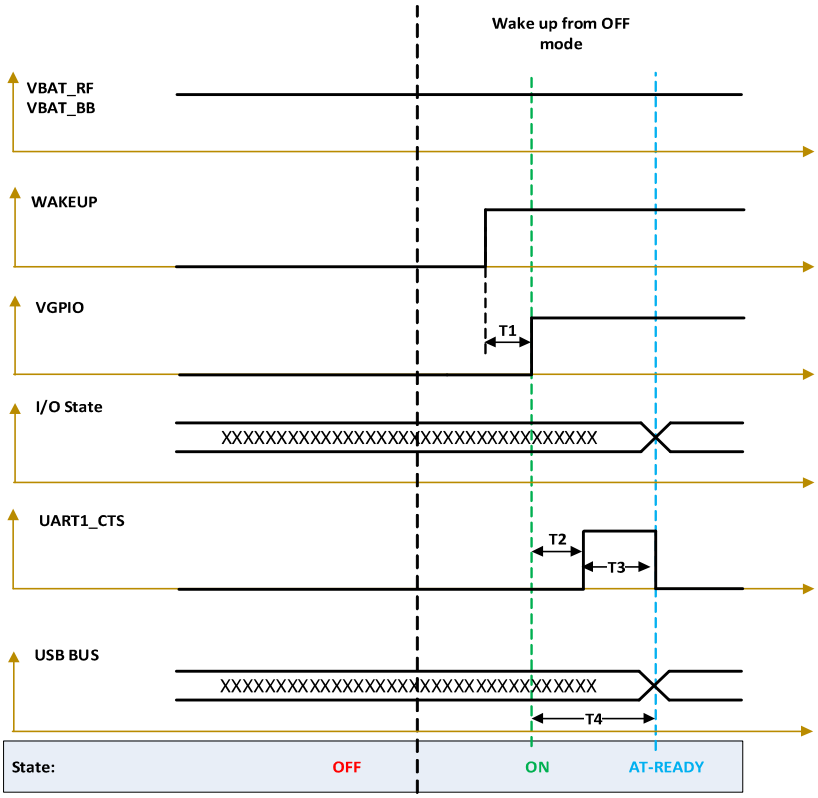


Figure 4-10: Wake up from OFF Mode

Table 4-21: WAKEUP Timing (from OFF Mode)

Parameter	Min	Typ	Max[a]	Unit
T1: Delay between WAKEUP and VGPIO	–	–	1	ms
T2: Delay between VGPIO and UART1_CTS	–	–	20	µs
T3: Delay	–	–	10	s
T4: Delay between VGPIO and USB enumeration	–	–	$T2_{max} + T3_{max}$	s

a. Measurements taken with HL78xx Development Kit

4.12.3 Wakeup from Lite Hibernate Mode

Figure 4-11 and Table 4-22describe the module's signal behaviors when WAKEUP is used to wake the module from Lite Hibernate mode.

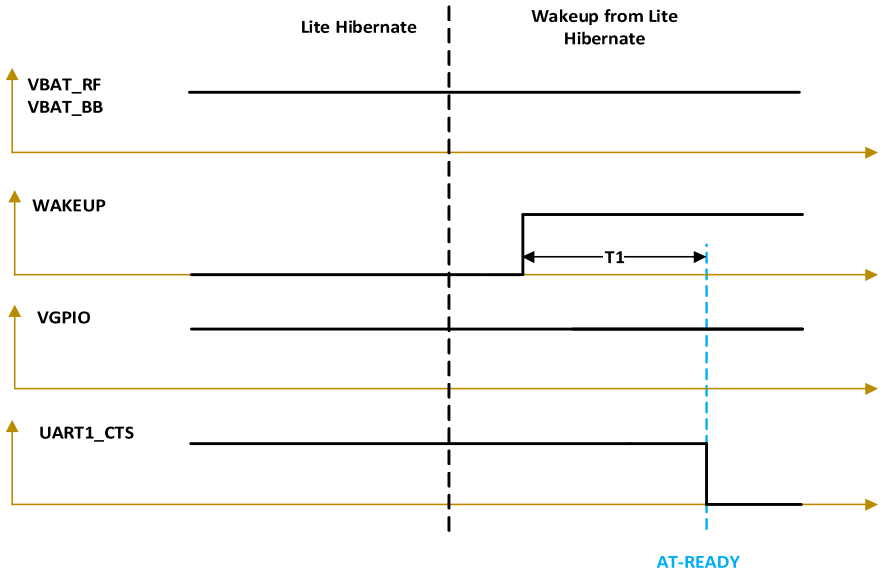


Figure 4-11: Wake up from Lite Hibernate Mode

Table 4-22: WAKEUP Timing (from Lite Hibernate Mode)

Parameter	Min	Typ	Max[a]	Unit
T1: Delay between WAKEUP and AT-READY	–	1	80	ms

a. Measurements taken with HL78xx Development Kit

4.12.4 Wakeup from Hibernate Mode

Figure 4-12 and Table 4-23 describe the module's signal behaviors when WAKEUP is used to wake the module from Hibernate mode.

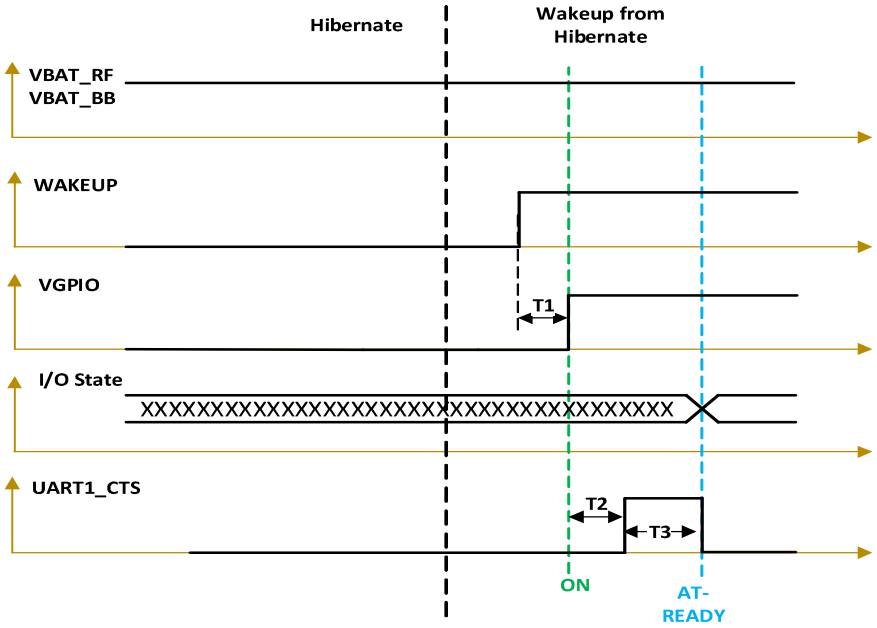


Figure 4-12: Wake up from Hibernate Mode

Table 4-23: WAKEUP Timing (from Hibernate Mode)

Parameter	Min	Typ	Max[a]	Unit
T1: Delay between WAKEUP and VGPIO	–	–	1	ms
T2: Delay between VGPIO and UART1_CTS high	–	–	20	µs
T3: UART1_CTS high to AT-READY	–	–	80	ms

a. Measurements taken with HL78xx Development Kit

4.13 RF Interface

The RF interface of the Semtech HL781x provides a single RF antenna connection for the transmission/reception of RF signals. Contact Semtech technical support for assistance in integrating the HL781x on applications with embedded antennas.

4.13.1 RF Antenna Connection

A 50Ω RF track (with maximum VSWR 1.1:1, and 0.5 dB loss) is recommended to connect the module's RF_MAIN to standard RF antenna connectors (e.g. SMA, U.FL, etc). Table 4-24 describes the module's RF interface.

Table 4-24: RF Main Pin Description

Pad #	RF Signal	Impedance	VSWR Rx (max)	VSWR Tx (max)
C48	GND	–	–	–
C49	RF_MAIN	50Ω	2.5:1	2.5:1
C50	GND	–	–	–

4.13.2 LTE RF Interface

4.13.2.1 Maximum Output Power

The HL781x module's LTE maximum transmitter output power for all bands in normal operation conditions (25°C) is specified in Table 4-25.

Table 4-25: HL7810/HL7812 Conducted Tx Max Output Power Tolerances - LTE[a]

LTE Bands	Min	Typ	Max	Units	Notes
All bands	21.5[b]	23	24.5	dBm	Power class 3

a. Under normal operating conditions (25°C)
b. Additional power reduction is applied to the lowest and highest supported channels for each band — see Table 1-1 footnote "a" for supported Tx channel ranges. (e.g. applies to B2 channels 18602 and 19198)

Table 4-26: HL7810/HL7812 Conducted Tx Max Output Power Tolerances – NB-NTN[a]

RF Band	Min	Typ	Max	Max Units	Notes
NB-NTN B23/255/256	21.5	23	24.5	dBm	Power class 3

a. Under normal operating conditions (25°C)

4.13.2.2 Rx Sensitivity

The module's LTE receiver sensitivity is specified in the following tables.

Table 4-27: HL781x Typical Conducted Cat-M1 RX Sensitivity[a]

LTE Band	Typical Reference Sensitivity Level @ 95% of Maximum Throughput		
	@ +25°C (dBm)	@ Class A (dBm)	3GPP Limit (dBm)[b]
B1	-104	-102.5	-102.3
B2	-104	-103	-100.3
B3	-105	-103.5	-99.3
B4	-104	-102.5	-102.3
B5	-105	-104	-100.8
B8	-105	-103	-99.8
B12	-105	-103.5	-99.3
B13	-105	-104	-99.3
B18	-105	-104	-100.3
B19	-105	-104	-102.3
B20	-105	-104	-99.8
B25	-105	-103	-100.3
B26	-105	-104.5	-100.3[c]
B28	-105	-104	-100.8
B66	-104	-102.5	-102.3[c]
B85	-105	-104	-102.3

a. Test conditions per 3GPP TS 36.521-1 v13: Bandwidth: 5MHz on Reference Measurement Channel.
b. Displayed limits derived from 3GPP TS 36.521-1 V16.3.0, Table 7.3EA-2, adjusted by +0.7 dB for measurement uncertainty.
c. Band not defined by 3GPP therefore no associated limit.

Table 4-28: HL781x Typical Conducted NB1/NB2 RX Sensitivity[a]

LTE Band	Typical Reference Sensitivity Level @ 95% of Maximum Throughput		
	@ +25°C (dBm)	@ Class A (dBm)	3GPP Limit (dBm)[b]
B1	-113	-111.5	-107.5
B2	-113.5	-112.1	-107.5
B3	-114	-112.5	-107.5
B4	-113	-111.6	-107.5

Table 4-28: HL781x Typical Conducted NB1/NB2 RX Sensitivity[a] (Continued)

LTE Band	Typical Reference Sensitivity Level @ 95% of Maximum Throughput		
	@ +25°C (dBm)	@ Class A (dBm)	3GPP Limit (dBm)[b]
B5	-113.5	-112.3	-107.5
B8	-113	-111.8	-107.5
B12	-112.5	-111.2	-107.5
B13	-113	-111.8	-107.5
B18	-113.5	-112.2	-107.5
B19	-113.5	-112.2	-107.5
B20	-113	-111.7	-107.5
B25	-113	-111.7	-107.5
B26	-113.8	-112.5	-107.5
B28	-113	-111.7	-107.5
B66	-113	-111.5	-107.5
B85	-113.5	-112.5	-107.5

a. Test conditions per 3GPP TS 36.521-1 v13: on DL Reference Measurement Channel defined
b. Displayed limits derived from 3GPP TS 36.521-1 V16.3.0, Table 7.3F.1.3-1, adjusted by +0.7 dB for measurement uncertainty

Table 4-29: HL781x Typical Conducted NB-NTN RX Sensitivity[a]

RF Band	Typical Reference Sensitivity Level @ 95% of Maximum Throughput	
	@ +25°C (dBm)	3GPP Limit (dBm)
NB-NTN B23	-113	-107.5[b]
NB-NTN B255	-113	-108.2[c]
NB-NTN B256	-113	-108.2[c]

a. For B23: Test conditions per 3GPP TS 36.521-1 v18.4: on DL Reference Measurement Channel defined
For B255/B256: Test conditions per 3GPP TS 36.102 v18.5: on DL Reference Measurement Channel defined
b. Displayed limits derived from 3GPP TS 36.521-1 v18.4, Table 7.3F.1.5-1, adjusted by +0.7 dB for measurement uncertainty.
c. 3GPP TS 36.102 v18.5 Table 7.3B-1

4.13.3 2G RF Interface (HL7812 only)

The HL7812 module is a GPRS only device (no EGPRS support) supporting GSM multi-slot class 10 (4 DL/2UL max (5 slots)).

4.13.3.1 Tx Output Power

The module's 2G maximum transmitter output power is specified in Table 4-30.

Table 4-30: HL7812 Conducted Tx Max Output Power Tolerances - 2G[a,b]

RF Band	Min	Typ	Max	Units	Notes
GSM 850	31.5	32.5	33.5	dBm	GMSK mode (Class 4; 2 W, 33 dBm)
E-GSM 900	31.5	32.5	33.5	dBm	GMSK mode (Class 4; 2 W, 33 dBm)
DCS 1800	28.5	29.5	30.5	dBm	GMSK mode (Class 1; 1 W, 30 dBm)
PCS 1900	28.5	29.5	30.5	dBm	GMSK mode (Class 1; 1 W, 30 dBm)

a. Stated power tolerances satisfy 3GPP TS 51.010-1 requirements for normal (25°C) and Class A (extreme) conditions.
b. Stated power tolerances for input voltage of 3.7V.

4.13.3.2 Rx Sensitivity

The module's GPRS receiver sensitivity is specified in Table 4-31.

Table 4-31: Typical Conducted RX Sensitivity - GPRS Bands[a]

GPRS Band	Parameters	Typical Reference Sensitivity Level @ 95% of Maximum Throughput		
		@ +25°C (dBm)	@ Class A (dBm)	Standard Limit (dBm)
GSM 850	10% BLER; GMSK CS1	-110	-108	-102
E-GSM 900	10% BLER; GMSK CS1	-110	-108	-102
DCS 1800	10% BLER; GMSK CS1	-112	-110	-102
PCS 1900	10% BLER; GMSK CS1	-112	-110	-102

a. Stated sensitivity values satisfy 3GPP TS 51.010-1 requirements for normal (25°C) and Class A (extreme) conditions

4.14 TX Burst Indicator (TX_ON)

The HL781x provides the TX_ON signal for TX activity indication.

Note: This signal is currently available for LTE Cat-M1. Support for LTE Cat-NB1 (HL7810 /HL7812) and 2G (HL7812) will be available in a future firmware release.

Table 4-32: TX_ON Pin Description

Pad #	Signal Name	I/O[a]	I/O Type	Description
C60	TX_ON	O	1.8V (VGPIO)	High during Tx activity

a. Signal direction with respect to the module

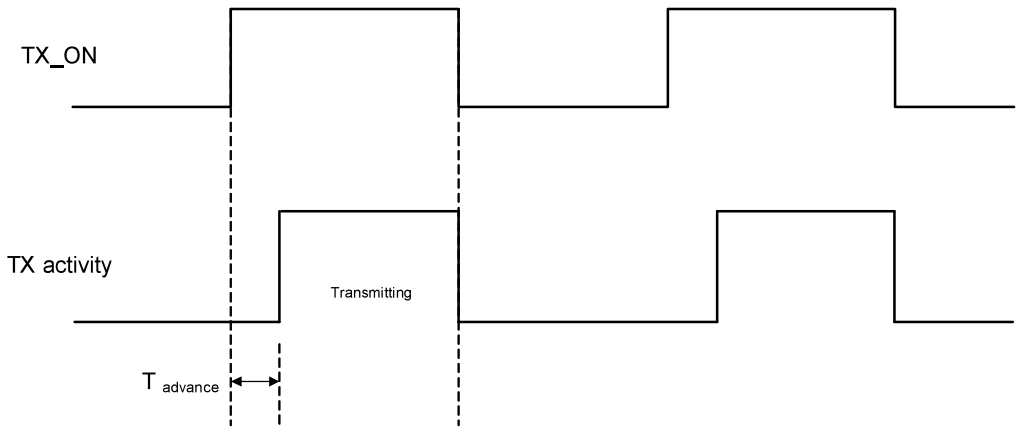


Figure 4-13: TX_ON State High during TX Activity

To enable/disable this feature, use the AT+KHWIOCFG command. For details, refer to HL78xx AT Commands Interface Guide.

Table 4-33: TX_ON Characteristics

Parameter	Typical
$T_{advance}$	30 µs

4.15 Tx/Rx Activity Indicator; External RF Voltage Control

The HL781x provides the VBAT_PA_EN signal for RF activity (Tx/Rx) indication.

Depending on customer requirements, it can be also be used to select the module VBAT_RF power source during RF activity, and support antenna switching.

To enable/disable this feature, use the AT+KHWIOCFG command. For details, refer to HL78xx AT Commands Interface Guide.

Table 4-30, Figure 4-11 and Table 4-31 describe the VBAT_PA_EN signal.

Table 4-34: VBAT_PA_EN Pin Description

Pad #	Signal Name	I/O[a]	I/O Type	Description
C41	GPIO8	I/O	1.8V (VGPIO)	High during Tx/Rx activity
	VBAT_PA_EN	O		

a. Signal direction with respect to the module

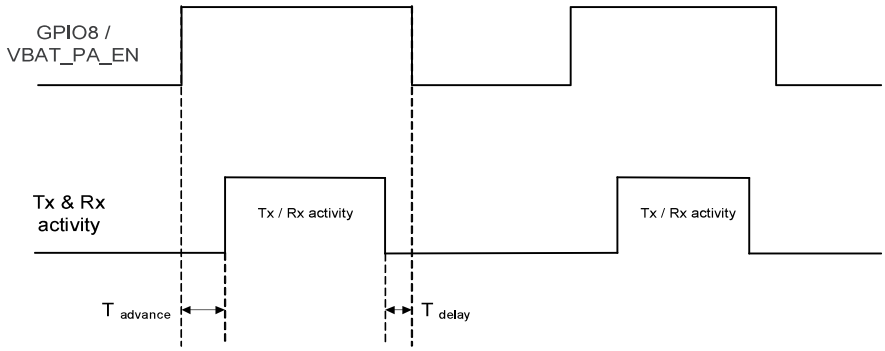


Figure 4-14: VBAT_PA_EN State during Tx/Rx Activity

Table 4-35: VBAT_PA_EN Characteristics (TBC)

Parameter	Min	Max
$T_{advance}$	0.4 ms	5 ms
T_{delay}	10 µs	20 µs

4.16 GNSS

The HL781x's GNSS implementation supports GPS L1 and GLONASS G1 operation.

Note: The GNSS receiver and LTE/GSM receiver share the same RF resources, therefore GNSS can only be used when the module is not actively connected on LTE/GSM. An example of a suitable implementation of GNSS in an end product would be the use of GNSS positioning for asset management applications where infrequent and no real-time position updates are required.

Table 4-36 describes the GNSS antenna specifications. Note that the HL781x does not support an active GPS/GNSS antenna.

Table 4-36: GNSS Antenna Specifications

Characteristics		Value	Unit
Frequency	GPS L1	1563–1587	MHz
	GLONASS G1	1593–1610	MHz
RF Impedance (RF_GNSS pad)		50	W
VSWR max		2:1	–

4.16.1 GNSS Performance

Table 4-37 summarizes the HL781x module's GNSS performance characteristics.

Table 4-37: GNSS Performance

Parameters	Conditions	Typical Value
Sensitivity	Cold Start	-145.8 dBm
	Hot Start	-152 dBm
	Tracking	-161 dBm
Time To First Fix (TTFF)	Cold start, Input power -130 dBm	39s
	Hot start, Input power -130 dBm	1s
2D Position Error	Input power -130 dBm	1.29 m

5: Mechanical Drawings

For tolerances, refer to Table 1-2 and Table 1-3.

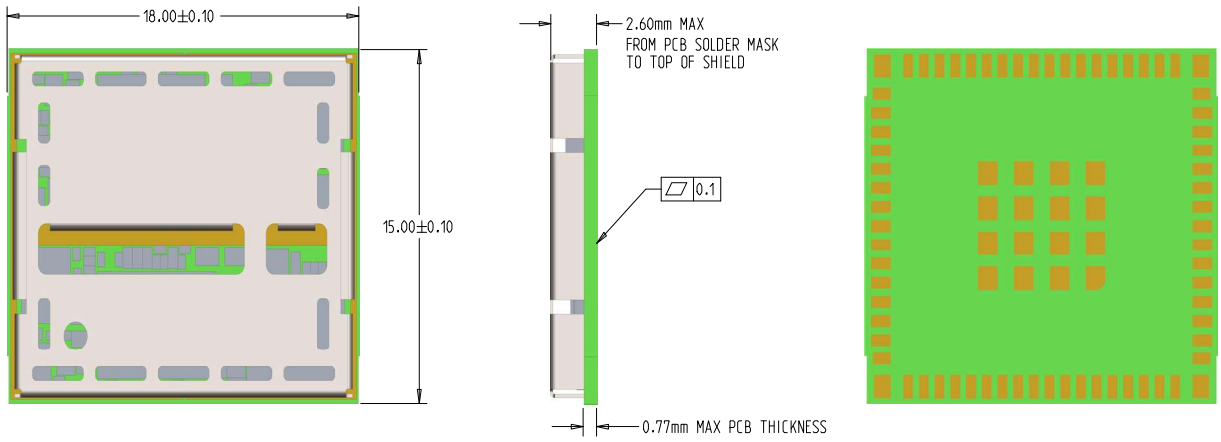


Figure 5-1: Mechanical Drawing

Note: The HL7812 shield displayed. The HL7810 shield does not have center cutouts.

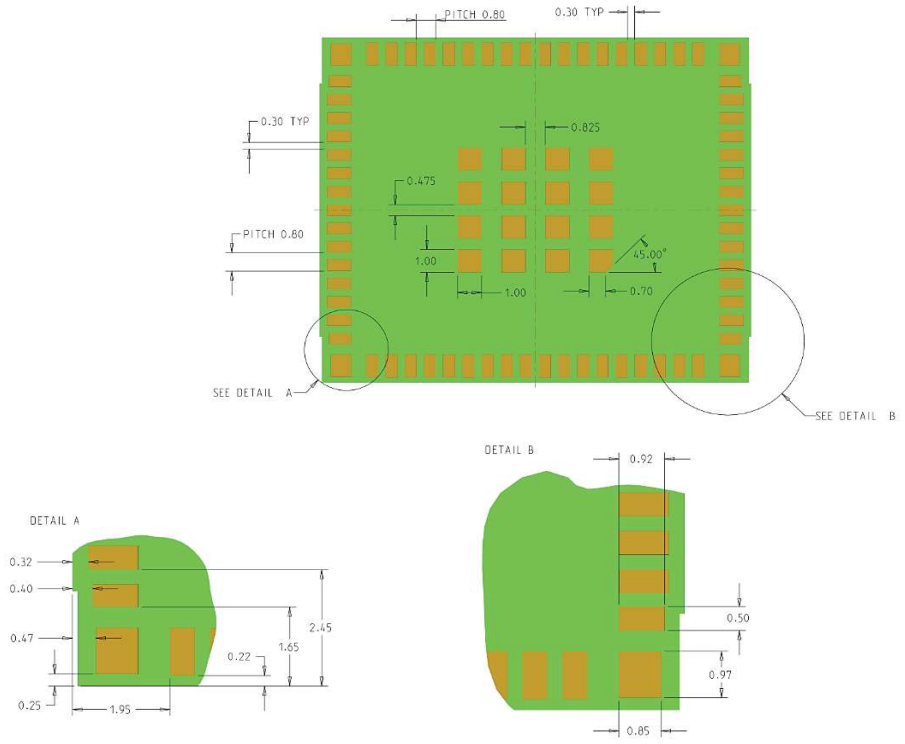


Figure 5-2: Dimensions Drawing

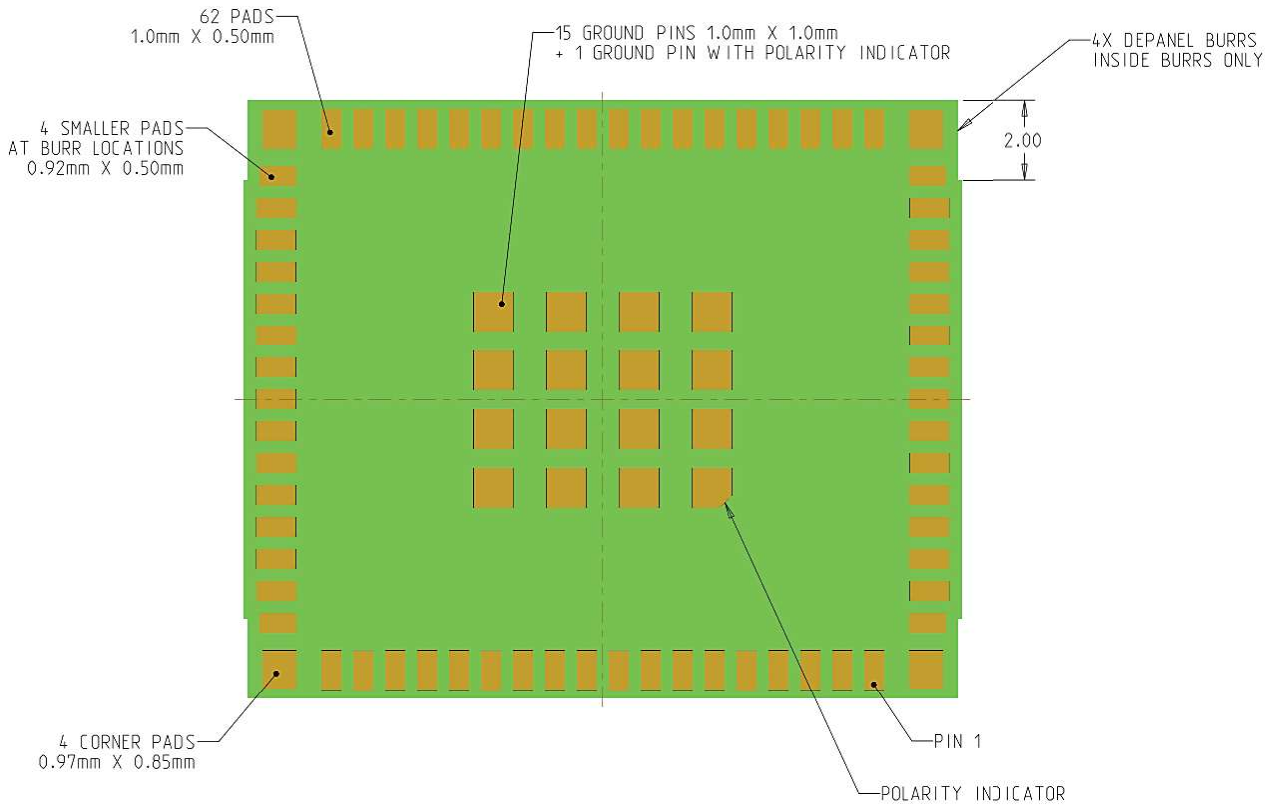


Figure 5-3: Footprint Drawing

6: Design Guidelines

6.1 Power Supply Design

When designing the power supply, make sure VBAT_BB/VBAT_RF meet the requirements listed in Table 3-2— Semtech recommends adding a 30% design margin, if possible.

Careful attention should be paid to the following:

- Power supply design— A low-ripple, low-noise source such as LDO, battery, or switching power supply (SMPS) is recommended.
- (HL7812 GSM Tx) Capacity to deliver high current peaks in a short time
  - VBAT_BB/VBAT_RF must support peak currents with an acceptable voltage drop that guarantees the minimum required VBAT_BB/VBAT_RF value.
- VBAT_BB/VBAT_RF signal voltage must never exceed the maximum value, otherwise the module may be severely damaged.
  - If necessary, add a voltage limiter to the module's power supply lines to ensure VBAT will never receive a voltage surge over 4.35V. There are a few protection options from a basic linear regulator to a voltage limiter, as simple as a Zener diode.
- ESD protection is recommended on VBAT_BB/VBAT_RF supply rails— Semtech recommends Diodes Inc part number D8V0L1B2LP3-7.
- Both over-voltage protection and ESD protection devices will increase platform current consumption.
- All ground pins (C30, C32, C37, C39, C48, C50, CG1–CG4, G1–G16) must be connected to the same net.

6.2 UIM1

UIM1 can operate at clock rates up to 5 MHz.

Most UIM1 signal lines do not require a buffer during Hibernate, and can be directly connected to the UIM card or holder. A buffer is required for UIM_DET1 if powered from the host (not required if powered from VGPIO).

Decoupling capacitor(s) must be added to UIM1_VCC and UIM1_DET, as close as possible to the UIM card. Decoupling capacitors for UIM1_CLK, UIM1_RST, and UIM1_DATA are recommended to be added as placeholders for potential EMC issues.

The two resistors (RCLK and RDAT) should be added as placeholders to compensate for potential layout issues. Both can be populated to slew the UIM1 signals, if required.

The UIM1_DATA trace should be routed away from the UIM1_CLK trace.

Keep the distance between the module and the UIM holder as short as possible.

Semtech recommends using the following ESD protection on the UIM1 interface:

- INFINEON ESD112-B1-02EL E6327— UIM1_CLK, UIM1_DATA, UIM1_RESET
- Diodes Inc D8V0L1B2LP3-7 — UIM1_VCC, UIM1_DET

Figure 6-1 illustrates the recommended implementation of a UIM interface

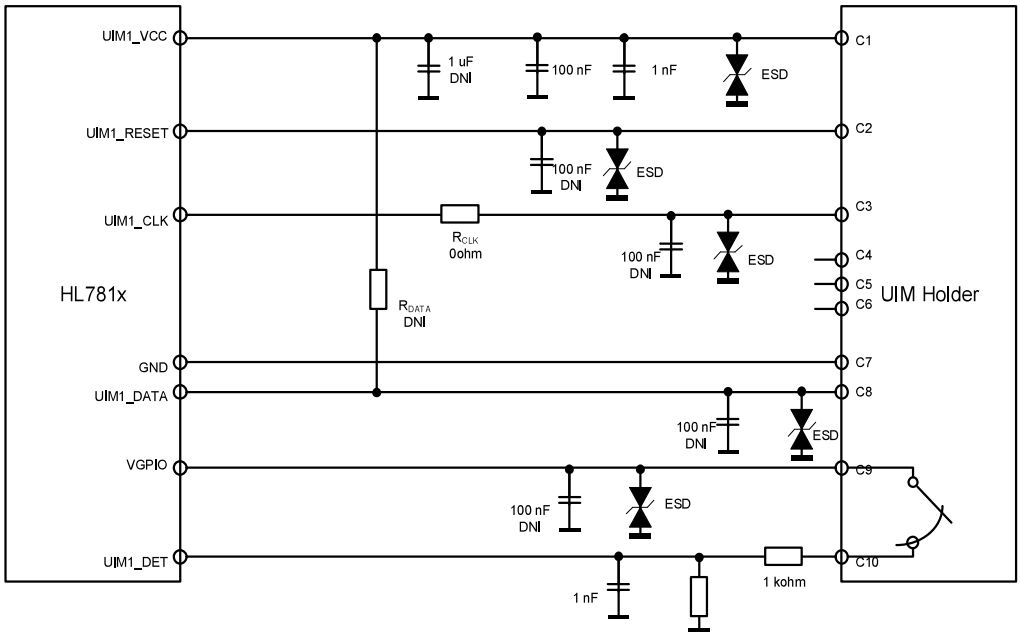


Figure 6-1: EMC and ESD Components Close to the USIM

6.3 USB Interface

The USB interfaces requires 90Ω differential pair routing to the host side.

For USB operation, USB_VBUS is a mandatory connection. The host must ensure USB_VBUS is provided before establishing USB communication.

When the USB interface is externally accessible, ESD protection is required on the USB_VBUS, USB_D+ and USB_D- signals.

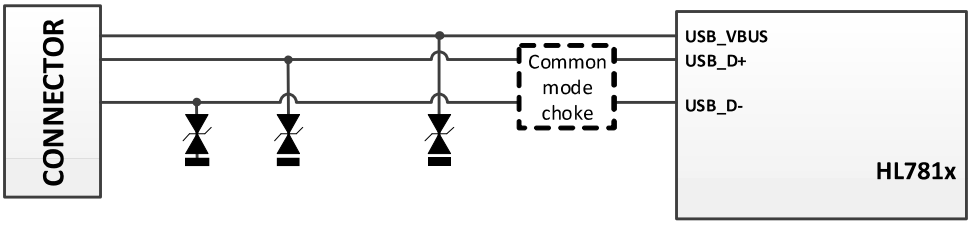


Figure 6-2: ESD Suppressors for USB FS

Semtech recommends using the following for ESD and EMI protection:

- ESD diodes— INNOCHIPS ULCE0505A015FR for USB data lines, and Diodes Inc D8V0L1B2LP3-7 for USB_VBUS
- Optional common mode choke for EMI protection, depending on customer requirements— Panasonic EXC24CG900U

6.4 ESD Protection for I/Os

ESD protection is highly recommended where module signals (GPIO, UART, H/W control, Indication, ADC, Clock) are externally accessible and potentially subjected to ESD by the user. Semtech recommends using Diodes Inc D8V0L1B2LP3-7.

6.5 Hibernate—Isolation Requirements

While the module is in Hibernate mode, the host platform (MCU) interfaces can remain powered.

Important: *To prevent these signals from back-powering the module, the host platform should make sure to isolate them—the signals should not be driven high (e.g. > 0.2 V).*

To ensure the host platform does not back-power the module:

- The host can add a buffer circuit to isolate module I/O during Hibernate. Semtech recommends using VGPIO to tristate I/O signals.
- The MCU can tristate any I/O that does not have an external PU/PD.

Note: A buffer is not required in Lite Hibernate mode.

If adding a buffer circuit, consider the signal type:

- Bidirectional (Input/Output) signals— For module I/O signals (e.g. GPIOs), an analog switch that can tri-state both the output and the input can be used (e.g. Texas Instruments TMUX1511). As shown in Figure 6-3, I/O signals connected to the buffer will be tri-stated.
- Directional (Input) signals— For module inputs (e.g. UART1_TX), a logic buffer with output tri-state mode can be used (e.g. Texas Instruments SN74LVC1G126). As shown in Figure 6-4, the signal is controlled and, when disabled, the output signal is tri-stated.

Note: Parts and usage descriptions above are intended as examples to assist the host platform designer in developing an appropriate solution for the platform. Selection and use of specific parts is the responsibility of the host platform designer.

Control of the buffer circuit is based on the status of VGPIO— for details, see VGPIO Monitoring and Buffer Control.

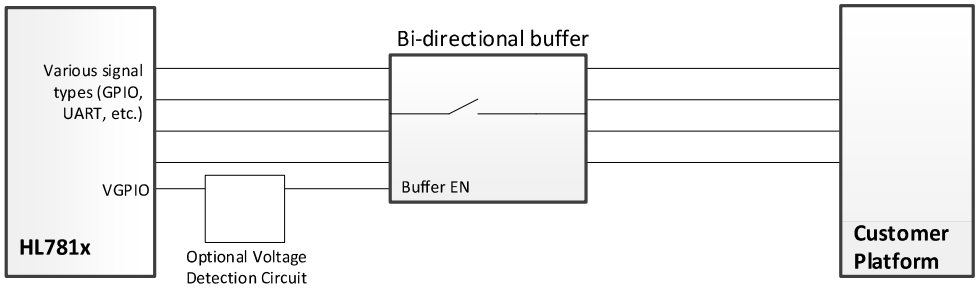


Figure 6-3: Example-Buffer - Bidirectional Signal

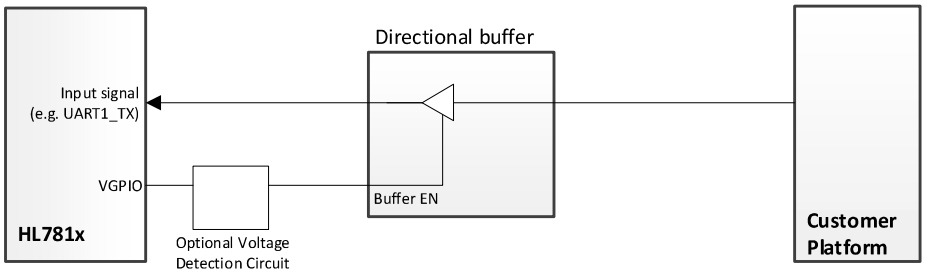


Figure 6-4: Example-Buffer - Directional Signal

6.5.1 VGPIO Monitoring and Buffer Control

Because the host platform can remain powered in Hibernate and Reset states, the host platform must react quickly, when VGPIO transitions low, to ensure signals do not back- power the module.

The host platform can monitor VGPIO to determine the HL781x module's current operating mode— for details, see VGPIO.

To ensure faster detection of VGPIO transitions, Semtech recommends adding an optional voltage detection circuit (as shown in Figure 6-3 and Figure 6-4) to monitor and detect the transition low, and then control (enable/disable) the associated buffer circuit.

Note: VGPIO can be used to directly connect to the buffer enable signal but the host platform must ensure that all host outputs are not driven high (i.e. > 0.2 V) before the module enters Hibernate mode.

6.6 Radio Frequency Integration

The HL781x is equipped with an external antenna.

6.6.1 Antenna Matching Circuit

A 50Ω line matching circuit between the module, the customer's board and the RF antenna is required as shown in Figure 6-5.

Because matching is dependent on the customer's platform, values marked as 'TBD' for the recommended components must be determined by the customer.

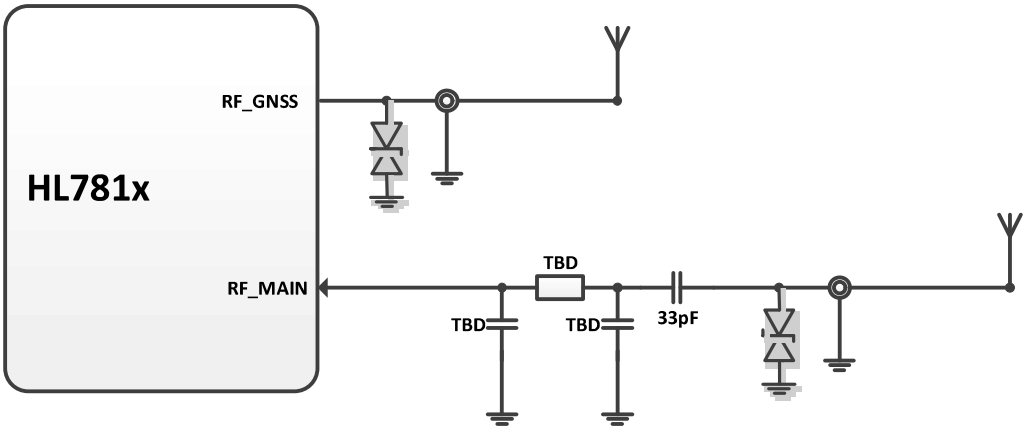


Figure 6-5: Antenna Connection

Semtech recommends using the following ESD diodes:

- Panasonic EZAEG1N50AC for RF_MAIN
- Diodes Inc. D5V0X1B2LP3-7 for RF_GNSS

6.6.2 RF Circuit

The RF signal must be routed on the application board using tracks with a 50Ω characteristic impedance.

The characteristic impedance depends on the dielectric, the track width and the ground plane spacing.

It is recommended to use stripline design if the RF path is fairly long (more than3 cm), since microstrip design is not shielded. Consequently, the RF (transmit) signal may interfere with neighboring electronic circuits. In the same way, the neighboring electronics (micro-controllers, etc.) may interfere with the RF (receive) signal and degrade the reception performance.

The RF trace on the development board is routed from the module antenna port to the RF connector (SMA). The RF trace is designed as a 50Ω coplanar stripline and its length is 24.8 mm.

The following drawings show the location of the HL781x module on the development board, the routing cross section and the top view of the RF trace on the development board.

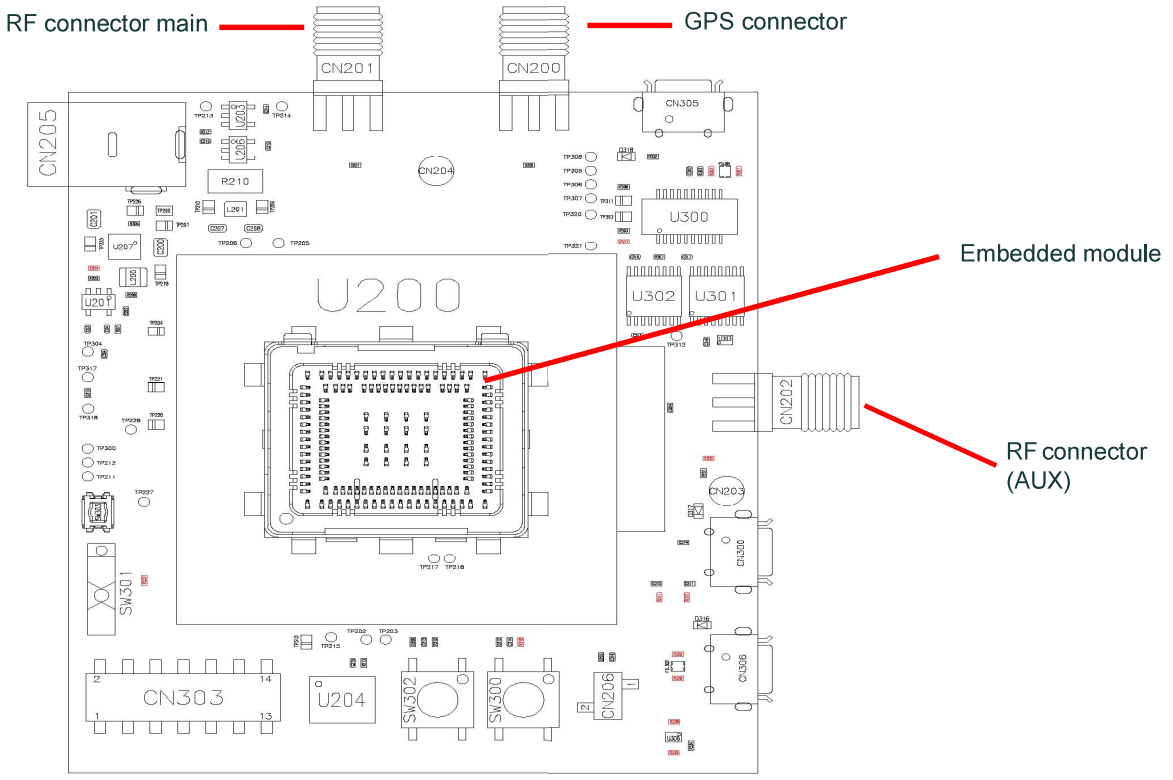


Figure 6-6: Module Location on Development Board

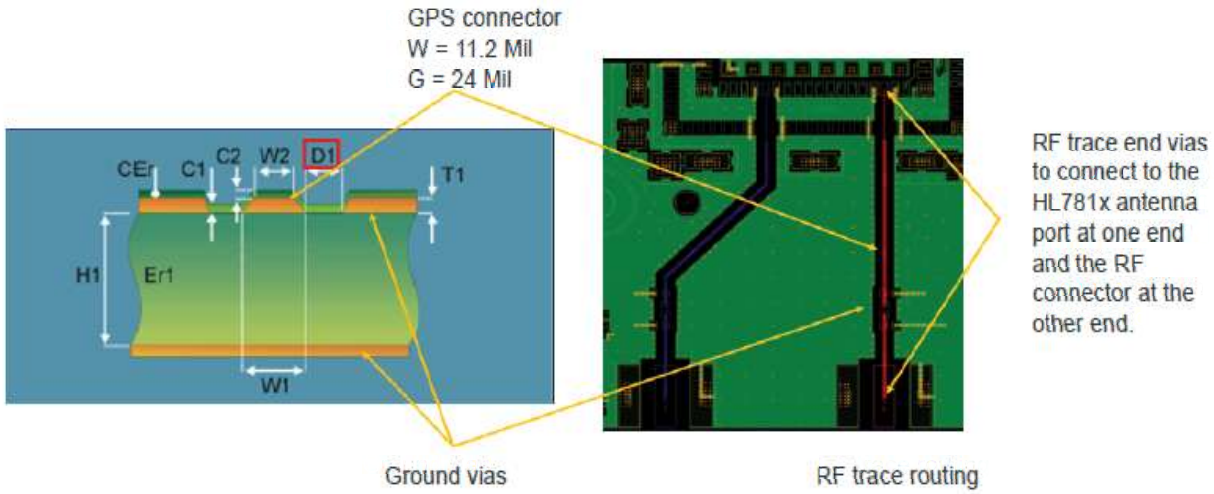


Figure 6-7: Development Board RF Trace Design

7: Reliability Specification

The HL781x module will be tested against the Semtech Industrial Reliability Specification defined below.

7.1 Preconditioning Test

Per JESD22A113, this tests the preconditioning of non-hermetic surface mount devices prior to reliability testing.

Table 7-1: Preconditioning Test

Designation	Condition
Preconditioning Test PCRM	2 reflow cycles with Tmax 245-250°C

7.2 Performance Test

Table 7-2: Performance Test

Designation	Condition
Performance Test PT3T & PTRT 	Standard: N/A

	Special conditions:
	▪ Temperature:
	  ▪ Class A: -30°C to +70°C
	  ▪ Class B: -40°C to +85°C
	  ▪ Rate of temperature change: ± 3°C/min
	▪ Recovery time: 3 hours

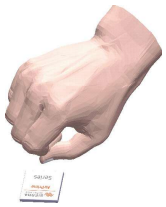
	Operating conditions: Powered
	Duration: 14 days

7.3 Aging Tests

Table 7-3: Aging Tests

Designation	Condition
High Temperature Operating Life test HTOL 	Standard: IEC 60068-2-2, Test Bb
	Special conditions: ▪ Temperature: +85 °C ▪ Temperature variation: 1 °C/min
	Operating conditions: Powered ON with a power cycle of 45 minutes ON and 15 minutes Idle
	Duration: 20 days
Thermal Shock Test TSKT 	Standard: IEC 60068-2-14, Test Na
	Special conditions: ▪ Temperature: -40 °C to +85 °C ▪ Temperature Variation: less than 30s ▪ Number of cycles: 300 ▪ Dwell Time: 10 minutes
	Operating conditions: Unpowered
	Duration: 7 days
Humidity Test HUT 	Standard: IEC 60068-2-3, Test Ca
	Special conditions: ▪ Temperature: +85 °C ▪ RH: 85%
	Operating conditions: Powered on, DUT is powered up for 15 minutes and OFF for 15 minutes.
	Duration: 10 days

7.4 Characterization Tests

Designation	Condition
Low Temperature and Cold Start Cycles LTCS	Special conditions: ▪ Temperature: -40°C ▪ AT commands read or write memory
	Operating conditions: 5 mins powered ON, 30 mins powered OFF (1 power cycle)
	Duration: 5 days
Component Solder Wettability CSW 	Standard: JESD22 - B102, Method 1/Condition C, Solderability Test Method
	Special conditions: ▪ Test method: Surface mount process simulation test (preconditioning 16h ±30 minutes dry bake)
	Operating conditions: Unpowered
	Duration: 1 day
Unprotected Free Fall Test FFT1 	Standard: IEC 680068-2-32, Test Ed
	Special conditions: ▪ Number of drops: 6 drops per unit (1 drop per direction: ±X, ±Y, ±Z) ▪ Height: 1m
	Operating conditions: Unpowered
	Duration: 1 day

8: Regulatory Compliance and Industry Certifications

8.1 Disposing of the Product

This electronic product is subject to the EU Directive 2012/19/EU for Waste Electrical and Electronic Equipment (WEEE). As such, this product must not be disposed of at a municipal waste collection point. Please refer to local regulations for directions on how to dispose of this product in an environmental friendly manner.

8.2 Compliance Acceptance and Certification

The HL7810 and HL7812 is designed to be compliant with the 3GPP Release 14 E-UTRA Specification for Mobile Terminated Equipment. The HL7812 is designed to be compliant with the 3GPP Release 9 UTRA and Release 13 E-UTRA Specifications for Mobile Terminated Equipment.

Final regulatory and operator certification requires regulatory agency testing and approval with the fully integrated UE host device incorporating the HL7810/HL7812 module.

The OEM host device and, in particular, the OEM antenna design and implementation will affect the final product functionality, RF performance, and certification test results.

Note: Tests that require features not supported by the HL7810 / HL7812 (as defined by this document) are not supported.

8.3 Regulatory and Industry Approvals/ Certifications

The HL7810/HL7812 module is designed to meet, and upon commercial release, will meet the requirements of the following regulatory bodies and regulations, where applicable:

- Federal Communications Commission (FCC) of the United States
- The Certification and Engineering Bureau of Industry Canada (IC)
- (HL7810) The National Communications Commission (NCC) of Taiwan, Republic of China
- Regulatory Compliance Mark (RCM), Electrical Regulatory Authorities Council (Australia and New Zealand)
- Radio Equipment Directive (RED) of the European Union
- Ministry of Internal Affairs and Communications (MIC) of Japan

Upon commercial release, the following industry certifications will have been obtained, where applicable:

- GCF
- PTCRB

Additional certifications and details on specific country approvals may be obtained upon customer request — contact your Semtech account representative for details.

Additional testing and certification may be required for the end product with an embedded HL7810/HL7812 module and are the responsibility of the OEM. Semtech offers professional services-based assistance to OEMs with the testing and certification process, if required.

8.4 Japan Radio and Telecom Approval

The HL7810 and HL7812 modules have been granted Japan radio and telecom approvals with the approval numbers shown below.

- HL7810:

- HL7812:

8.5 Important Compliance Information for North American Users

The HL7810 and HL7812 modules have been granted modular approval for mobile applications under:

- HL7810— FCC ID: N7NHL78A
- HL7812— FCC ID: N7NHL78C
- HL7810— IC ID: 2417C-HL78A
- HL7812— IC ID: 2417C-HL78C

Integrators may use these modules in their end products without additional FCC/IC (Industry Canada) certification if they meet the following conditions. Otherwise, additional FCC/IC approvals must be obtained.

1. The end product must use the RF trace design approved with the HL7810 or HL7812. The Gerber file of the trace design can be obtained from Semtech upon request.
2. At least 20 cm separation distance between the antenna and the user's body must be maintained at all times.
3. To comply with FCC/IC regulations limiting both maximum RF output power and human exposure to RF radiation, the maximum antenna gain including cable loss in a mobile-only exposure condition must not exceed the limits stipulated in Table 8-1.

Table 8-1: Product Name Antenna Gain Specifications

Device	Technology	Band	Frequency (MHz)	Maximum antenna gain (dBi)	
				Standalone	Collocated
HL7810 and HL7812	LTE	B2	1850–1910	6	6
		B4	1710–1755	5.5	5.5
		B5	824-829	6	4
		B8	897.5-900.5	6	4
		B12	699-716	6	4
		B13	777-787	6	4
		B23	2000-2019.9	8.5	8.5
		B25	1850-1915	6	6
		B26	814-849	6	4
		B66	1710-1780	5.5	5.5
		B85	698-716	6	4
		B255	1626.5-1660.4	8.5	8.5
HL7812	GPRS	GPRS G850	824-849	3	1
		GPRS G1900	1850-1910	2	2

4. The HL7810 or HL7812 may transmit simultaneously with other collocated radio transmitters within a host device, provided the following conditions are met:
   - Each collocated radio transmitter has been certified by FCC/IC for mobile application.
   - At least 20 cm separation distance between the antennas of the collocated transmitters and the user's body must be maintained at all times.
   - The radiated power of a collocated transmitter must not exceed the EIRP limit stipulated in Table 8-2.

Table 8-2: HL7810, HL7812 Collocated Radio Transmitter Specifications

Device	Technology	Frequency (MHz)	EIRP Limit (dBm)
Collocated transmitters[a]	WLAN 2.4 GHz	2400–2500	30
	WLAN 5 GHz	5150–5850	30
	BT	2400–2500	16

a. Valid collocated transmitter combinations: WLAN+BT; WiGig+BT. (WLAN+WiGig+BT is not permitted.)

5. A label must be affixed to the outside of the end product into which the HL7810 or HL7812 is incorporated, with a statement similar to the following:
   - **(HL7810)— This device contains FCC ID: N7NHL78A / IC: 2417C-HL78A**
   - **(HL7812)— This device contains FCC ID: N7NHL78C / IC: 2417C-HL78C**

6. A user manual with the end product must clearly indicate the operating requirements and conditions that must be observed to ensure compliance with current FCC/IC RF exposure guidelines.

The end product with an embedded HL7810 or HL7812 may also need to pass the FCC Part 15 unintentional emission testing requirements and be properly authorized per FCC 15. If this module is intended for use in a portable device, you are responsible for separate approval to satisfy the SAR requirements of FCC Part 2.1093 and IC RSS-102.

8.6 Legal Information – Taiwan NCC Statement

減少電磁波影響，請妥適使用.

A: Appendix

For more details, several references can be consulted, as detailed below.

A.1 List of References

- HL78xx Series Customer Process Guidelines
  Reference: 41112095
- HL78xx AT Commands Interface Guide
  Reference: 41111821
- AirPrime HL Series Development Kit User Guide
  Reference: 4114877
- HL78xx Low Power Modes Application Note
  Reference: 2174229
- HL78xx Customization Guide Application Note
  Reference: 174213
- Sierra Wireless Ready-to-Connect Module Integration Guide
  Reference: 41113385
- Sierra Wireless HL78xx Firmware Update Methods Application Note
  Reference: 2174259

A.2 Terms and Abbreviations

Term / Abbreviation	Definition
Active state	All sub-systems, including the MAP process, are up and running. User can access module via UART (e.g. to configure/query module settings/states, and send/receive data.
ADC	Analog to Digital Converter
AT	Attention (prefix for modem commands)
AT-READY	Module is initialized and ready to accept AT commands
Cat-M1	LTE enhanced Machine Type Communication (eMTC) Category M1 (3GPP Release 14)
Cat-NB1	LTE Narrowband Internet of Things (NB-IoT) Category NB1 (3GPP Release 14)
CF3	Common Flexible Form Factor
CLK	Clock
DTR	Data Terminal Ready
DRX	Discontinuous Reception
eDRX	Extended DRX
EIRP	Equivalent Isotropically Radiated Power
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
EN	Enable
ESD	Electro-Static Discharges
ETSI	European Telecommunications Standards Institute
GLONASS	Global Navigation Satellite System
GND	Ground
GNSS	Global Navigation Satellite System
GPIO	General Purpose Input Output
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile communications
Hi Z	High impedance (Z)
IC	Industry Canada
I/O	Input/Output
LED	Light Emitting Diode
MAX	Maximum
MIN	Minimum

Term / Abbreviation	Definition
N/A	Not Applicable
PA	Power Amplifier
PC	Personal Computer
PCB	Printed Circuit Board
PCL	Power Control Level
periodic TAU	See TAU
PSM	Power Save Mode
PTW	Paging Transmission Window
PWM	Pulse Width Modulation
RF	Radio Frequency
RST	Reset
RTC	Real Time Clock
RX	Receive
SIM	Subscriber Identification Module
SINR	Signal to Interference plus Noise Ratio
SW	Software
TAU	Tracking Area Update ▪ TAU—An update sent when the PSM parameters are changed or when the module changes location. ▪ periodic TAU—Sent by the module to notify its availability to the network.
TBC	To Be Confirmed
TBD	To Be Determined To Be Defined
TP	Test Point
TX	Transmit
TYP	Typical
UART	Universal Asynchronous Receiver-Transmitter
UICC	Universal Integrated Circuit Card
USB	Universal Serial Bus
UIM	User Identity Module
UMTS	Universal Mobile Telecommunications System
USIM	UMTS Subscriber Identity Module
VBAT_BB	Main Supply Voltage from Battery or DC Adapter
VSWR	Voltage Standing Wave Ratio

A.3 Ordering Information

Model Name	Description	Part Number
HL7810	HL7810 embedded module	Contact Semtech for the latest SKU.
HL7812	HL7812 embedded module	Contact Semtech for the latest SKU.
DEV-KIT	HL781x Development Kit	6001210