AirPrime HL Series Antenna Detection

2174045-3.2

Author:	Sierra Wireless	Date:	January 24, 2018

APN Content Level	BASIC		INTERMEDIATE	✓	ADVANCED		Confidentiality	Public	✓	Private	

Hardware Compatibility	Product Line	AirPrime	Series	HL6528x	HL6528RDx
				HL75xx	HL76xx
				HL85xxx	

Software Compatibility	ALL	Document Type	Application Note	✓	Technical Note	

1 Version

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2 Introduction

This Application Note (APN) is provided to Sierra Wireless distributors and clients to aid more rapid development of embedded applications using the Sierra Wireless portfolio of cellular solutions. To request a new application note, contact your regional Sierra Wireless Product Marketing Manager.

3 Application Note Description

This application note describes the antenna detection feature of the AirPrime HL Series embedded module.

The following table lists the product naming convention used for the HL Series embedded modules throughout this document and the corresponding variants applicable to each naming convention.

Table 1: Product Naming Convention

Naming Convention Used	Applicable HL Variant
HL6528x	HL6528 HL6528-G HL6528-2.8V HL6528-G2.8V
HL6528RDx	HL6528RD HL6528RD-G HL6528RD-2.8V HL6528RD-G2.8V
HL75xx	HL7528 HL7538 HL7539 HL7548 HL7549 HL7588
HL76xx	HL7618RD HL7648 HL7650 HL7688 HL7690 HL7692

Naming Convention Used	Applicable HL Variant
HL85xxx	HL8518 HL8528 HL8529 HL8548 HL8548-G HL8549

By adding a few additional passive components and running specific AT commands, the antenna detection feature can be integrated to any customer application circuit that uses the AirPrime HL Series embedded module. Note however that antenna detection can only be used with DC terminating resistor antennas. The usual value used for the DC terminating resistor is 10kΩ.

4 Principles of Antenna Detection

The antenna detection feature can be used to determine the following antenna status:

- Antenna is connected with the correct DC terminating resistance
- Antenna is shorted to ground
- Antenna is shorted to (any) supply voltage (VBATT for example)
- Antenna is not connected (open)

Diagnosis can be run by the application once the HL Series embedded module is powered ON. Communication between the module and application is done using AT commands.

5 Antenna Detection Circuit

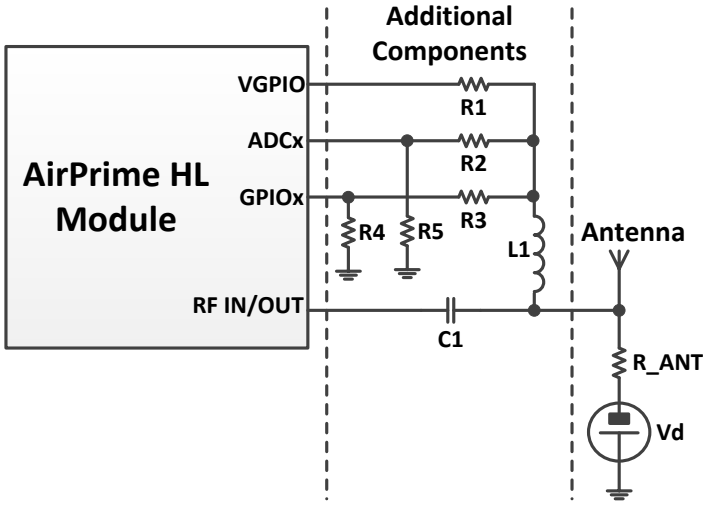


Figure 1. Antenna Detection Circuit

R1, R2, R3, R4, R5, C1 and L1 are additional components that should be added to the customer's application schematic.

C1 and L1 are added to the RF part between the module and antenna; thus, they have to be chosen and placed on the circuit carefully. Recommendations for these two components are given in the table below.

R_ANT is the equivalent DC termination resistor of the antenna. The nominal value of this resistance should be close to 10kΩ.

Vd is the voltage drop disturbance, or ground offset voltage, which can, for example, appear on the antenna cable. In normal conditions, Vd = 0V.

Recommended component values listed below are grouped into two sets. Set A is used for the HL6528x, while Set B is used for all other HL Series embedded module that support antenna detection.

Table 2: Component Recommendations

Component	Set A Values	Set B Values
R1	15 kΩ	15 kΩ
R2	100 kΩ	100 kΩ
R3	15 kΩ	7.5 kΩ
R4	5.6 kΩ	2.2 kΩ
R5	33 kΩ	33 kΩ
C1	33 pF	33 pF
L1	47 nH	47 nH

6 Antenna Detection Algorithm

Caution: *Specific values and examples used in this section were based on the HL8548 and should be used as reference only.*

The antenna detection algorithm measures the input voltage of the module's ADC using 3 different configurations of a GPIO. Table 3: ADC used per HL Module tabulates the ADCs used per antenna per module, and the 3 GPIO configurations available are:

- GPIO in read mode (as an input)
- GPIO in logic "1" write mode (as an output); where logic "1" corresponds to V_{GPIO}
- GPIO in logic "0" write mode (as an output); where logic "0" corresponds to 0V

By default, GPIO5 is used for main antenna detection, and GPIO1 for GNSS antenna detection. This can be changed using AT commands **AT+KGSMAD** and **AT+KGNSSAD**. For more information about these commands, refer to the corresponding AirPrime HL Series AT command manual listed in section 8 Reference Documents.

Table 3: ADC used per HL Module

Module	Main Antenna	GNSS Antenna
HL6528x and HL6528RDx	ADC0	N/A
HL6528-Gx and HL6528RD-Gx	ADC0	ADC1
HL75xx, HL7688	ADC1	N/A
HL76xx (except HL7688)	ADC0	N/A
HL8518, HL8528 and HL8529	ADC0	N/A
HL8548 and HL8549	ADC0	N/A
HL8548-G	ADC0	ADC1

Note: The HL6528x, HL6528RDx, HL75xx, HL76xx, HL8518, HL8528, HL8529, HL8548 and HL8549 do not support GNSS.

By computing the three configuration measurements mentioned above, the algorithm can then calculate the value of the antenna DC terminating resistor and give a corresponding diagnosis.

Assuming that the GPIO to use for main antenna detection is GPIO5, the antenna detection algorithm steps are as follows.

1. Set GPIO5 to “input” by entering **AT+KGPIOCFG=5,1,0**
2. Read GPIO5 using **AT+KGPIO=5,2**
3. Set GPIO5 to “1” by entering **AT+KGPIOCFG=5,0,2** and **AT+KGPIO=5,1**
4. Read ADC0 using **AT+KADC=4,2**
5. Set GPIO5 to “0” by entering **AT+KGPIO=5,0**
6. Read ADC0 again using **AT+KADC=4,2**

In steps 4 and 6, the values read by the ADC with V_{GPIO}=High and V_{GPIO}=Low as a function of the R_ANT value is represented in the following graph, with the condition Vd=0V.

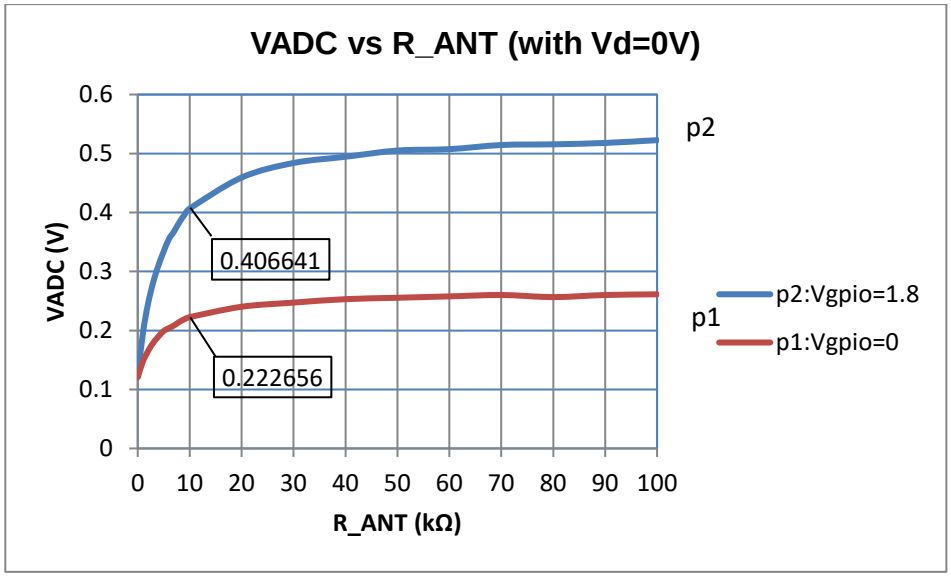


Figure 2. V_{ADC} vs. R_ANT (using an HL8548 module; for reference only)

When reading the ADC0 value using the **AT+KADC=4,2** command, the value returned is the value in Volts * 1000000. For example, if the input voltage of the ADV was 1.1V, the value returned by **AT+KADC=4,2** will be 1100000.

GNSS antenna detection is identical to the steps described above except for the AT command, GPIO and ADC used.

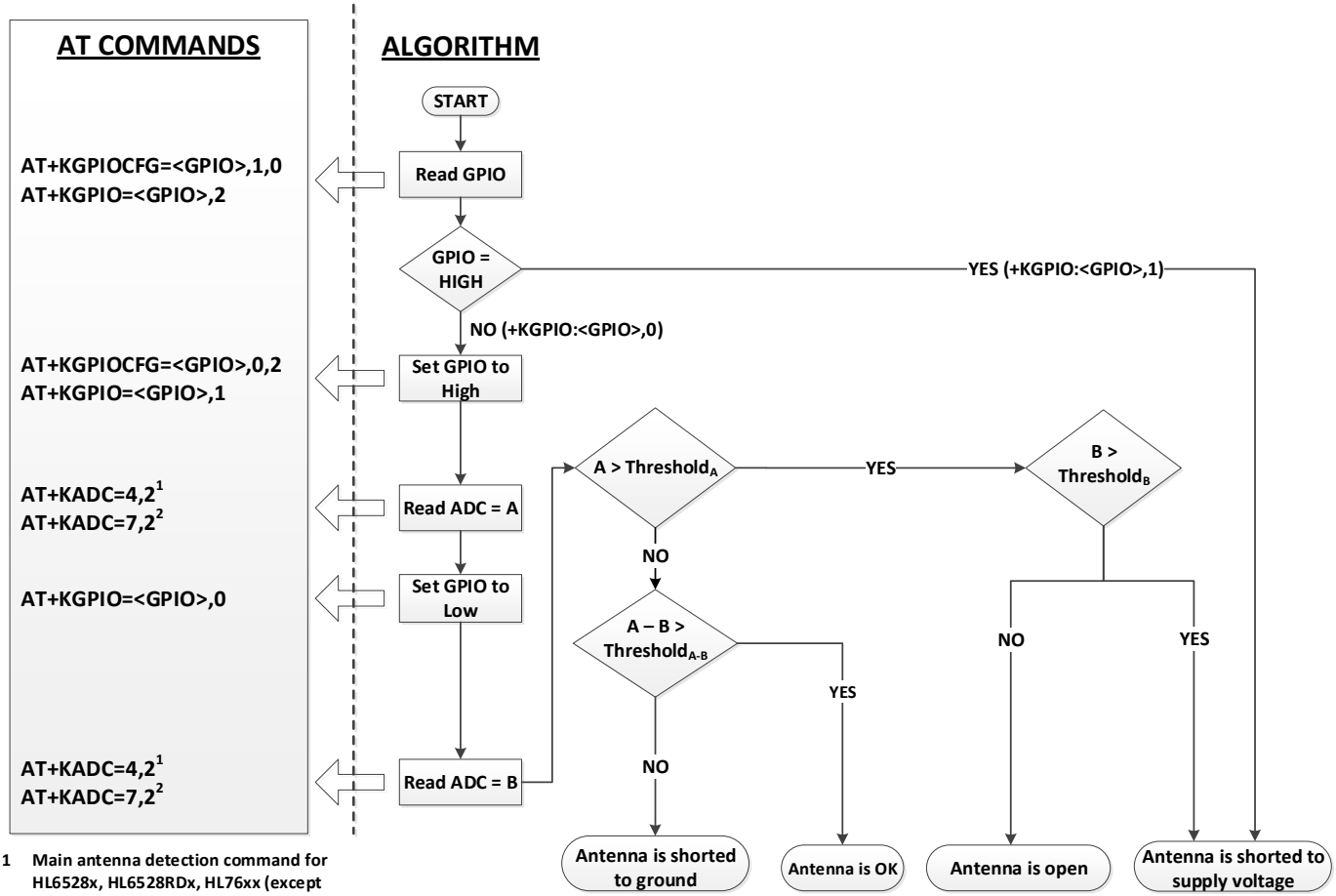
6.1 Launching the Antenna Detection Algorithm

AT command **AT+KGSMAD** can be used to launch the antenna detection algorithm for the main antenna. This command enables either periodic antenna detection (**AT+KGSMAD=1**), or instanteanous antenna detection (**AT+KGSMAD=2**). Other specifications such as the interval between detections, GPIO to use, as well as the option of displaying URCs can also be defined using this command.

Additionally for the HL6528-Gx, HL6528RD-Gx and HL8548-G, the antenna detection algorithm can also be used on its GNSS antenna using AT command **AT+KGNSSAD**. Similarly, either periodic antenna detection (**AT+KGNSSAD=1**), or instanteanous antenna detection (**AT+KGNSSAD=2**) can be enabled using this command; other specifications such as the interval in between detections, GPIO to use, as well as the option of displaying URCs can also be defined.

For more information about these commands, refer to the corresponding AirPrime HL series AT command manual listed in section 8 Reference Documents.

6.2 Algorithm Flowchart



1 Main antenna detection command for HL6528x, HL6528RDx, HL76xx (except for HL7688) and HL85xxx modules.

2 Main antenna detection command for the HL75xx and HL7688; GNSS antenna detection command for the HL6528-Gx, HL6528RD-Gx and HL8548-G modules.

Figure 3. Main Antenna Detection Algorithm Flowchart (using an HL8548 module; for reference only)

Threshold values vary depending on the firmware of the AirPrime HL Series module.

Using an HL8548 module as an example, given $Threshold_A$ = 0.51V, $Threshold_B$ = 0.3V, and $Threshold_{A-B}$ = 0.15V, the results should be interpreted as follows when there is no voltage disturbance on the antenna (Vd=0V).

- Antenna is shorted to ground means that R_ANT < 6 kΩ
- Antenna is OK means that 6 kΩ < R_ANT < 60 kΩ
- Antenna is open means that R_ANT > 60 kΩ
- Antenna is shorted to supply voltage (for example, VBATT) means that voltage is applied on the antenna (where VBATT is assumed to be greater than 2.8 V)

6.3 Vd Influence

Voltage disturbance, Vd, can appear in some systems due to faulty conditions. The usual tolerance for good operating conditions is about ±1 V.

Vd also has an influence on the values of A and B as read by the antenna detection algorithm. If the influence is too strong, there is a possibility that the algorithm might provide an erroneous diagnosis.

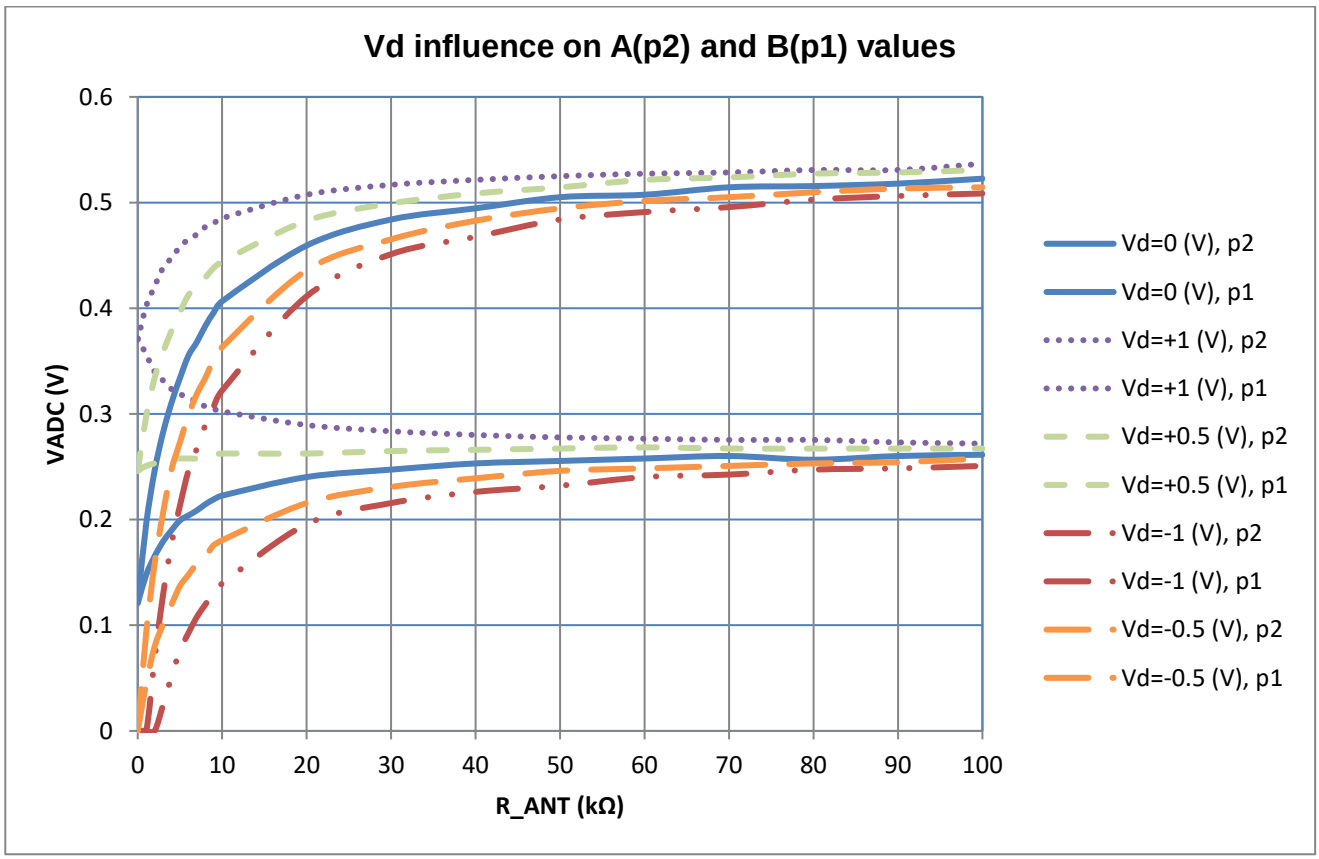


Figure 4. Vd Influence on A and B Values (using an HL8548 module; for reference only)

6.4 Algorithm Results

By taking into account R_ANT and Vd parameters, and assuming that -1V < Vd < +1V, the algorithm with the presented threshold values give the following results.

Table 4: Algorithm Results (using an HL8548 module; for reference only)

		R_ANT (kΩ)																		
		0	1	2	3	4	5	6	7	8	9	10	20	30	40	50	60	70	80	90	100
Vd (V)	-1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	-0.5	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	3	3
	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	3	3	3	3
	+0.5	1	1	1	1	1	1	0	0	0	0	0	0	0	0	3	3	3	3	3	3
	+1	1	1	1	1	1	1	1	0	0	0	0	0	3	3	3	3	3	3	3	3

Where:

0	Antenna is OK
1	Antenna is shorted to GND
2	Antenna is shorted to VBATT
3	Antenna is open

7 AT Commands

The AT commands used in the antenna detection algorithm are enumerated in the table below. For more information about these commands, refer to the corresponding AirPrime HL series AT command manual listed in section 8 Reference Documents.

Table 5: AT Commands Used in the Antenna Detection Algorithm

AT Command	Description
AT+KGSMAD	Antenna detection command
AT+KGNSSAD	GNSS antenna dection command
AT+KGPIO	Hardware IO control
AT+KGPIOCFG	GPIO configuration
AT+KADC	Analog to digital converter

8 Reference Documents

[1] AirPrime HL6 and HL8 Series AT Commands Interface Guide
Reference number: 4114680

[2] AirPrime HL6528RDx AT Commands Interface Guide
Reference number: 4117743

[3] AirPrime HL7518 and HL7548 AT Commands Interface Guide
Reference number: 4116303

[4] AirPrime HL7528 AT Commands Interface Guide
Reference number: 4116843

[5] AirPrime HL7538 AT Commands Interface Guide
Reference number: 4118675

[6] AirPrime HL7539 AT Commands Interface Guide
Reference number: 4118453

[7] AirPrime HL7549 AT Commands Interface Guide
Reference number: 4117461

[8] AirPrime HL7588 AT Commands Interface Guide
Reference number: 4117137

[9] AirPrime HL76xx AT Commands Interface Guide
Reference number: 4118395

9 Support

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10 Document History

Level	Date	History
1.0	July 04, 2014	Creation
1.1	July 11, 2014	Updated: • Figure 1 Antenna Detection Circuit • 6.1 Launching the Antenna Detection Algorithm • Figure 3 Main Antenna Detection Algorithm Flowchart • Table 5: AT Commands Used in the Antenna Detection Algorithm
1.2	July 15, 2014	Updated: • 6 Antenna Detection Algorithm • Figure 3 Main Antenna Detection Algorithm Flowchart
2.0	April 20, 2016	Added support for HL6528xx and HL8549x
	June 03, 2016	Added support for HL7538
	July 11, 2016	Added support for HL7528, HL7539 and HL7549
2.1	August 12, 2016	Added support for HL7648, HL7690, HL7692, HL8518, HL8528 and HL8529
2.2	September 06, 2016	Removed HL8549-G and HL7690
3.0	November 16, 2016	Added support for HL7618RD and HL7650

Level	Date	History
3.1	November 27, 2017	Updated Table 3: ADC used per HL Module
3.2	January 24, 2018	Added HL7548, HL7588, HL7688 and HL7690
		Updated: • Table 3: ADC used per HL Module • 6.2 Algorithm Flowchart • Table 4: Algorithm Results (using an HL8548 module; for reference only)

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