Keysight Technologies
RF Testing for Civil Unmanned Aerial Vehicles

Application Note
RF Testing for Civil Unmanned Aerial Vehicles

An unmanned aerial vehicle (UAV), also known as a drone, is an aircraft without a human pilot aboard. The flight of UAVs is manually controlled by the remote control of a pilot on the ground, or autonomously controlled by onboard computers. In the past, UAVs have mostly been used for military and special operation applications. But it is gaining more civil applications now in the areas such as commercial aerial surveillance, journalism, commercial and motion picture filming, search and rescue, and nonmilitary security work, such as inspection of grid system.

Main components of a civil UAV usually include the frame, propellers (either fixed-pitch or variable-pitch), electric motors, flight controller, stabilization gimbal, camera, and wireless communication.
Wireless Communication in a Civil UAV

Civil UAV is usually remotely controlled by a pilot on the ground, and wireless communication is adopted between the UAV and its remote controller. The wireless communication system on a civil UAV usually works in the ISM bands (Industrial, Scientific and Medical bands), e.g. 433 MHz, 815 MHz, 2.4 GHz and 5.8 GHz. Figure 2 shows the typical communication links between a UAV and its remote controller.

- **Uplink** is from the remote controller to the UAV and is used to transmit control signals. Uplink communications need to be stable and robust to overcome interference signals, so spread spectrum techniques such as frequency hopping spread spectrum (FHSS) or direct sequence spread spectrum (DSSS) are utilized.

- **Downlink** is from the UAV to the remote controller and is used to transmit data from the onboard sensors and real-time image/video data from the onboard cameras. Downlink needs to provide higher data throughput, so Wi-Fi or proprietary standards based on orthogonal frequency-division multiplexing (OFDM) are typically considered. Some vendors may even consider multiple-input and multiple-output (MIMO) antennas for better data throughput and immunity to interference.

![Figure 2. Communication links between a UAV and its remote controller](image-url)
Testing Wireless Communication Modules in Civil UAVs

Most civil UAVs work in the ISM bands, as it is free and does not require a license to use. Like the other electronic products working in the same bands, the UAVs have to comply with the various radio emission standards defined by each government, such as the European EN 300 328 and the USA FCC part 15.249. Most civil UAV vendors adopt off-the-shelf FHSS/OFDM/Wi-Fi chipsets or modules to develop their own products and have to test the UAVs from design phase to production phase to make sure their UAVs are transmitting wireless signals compliant to the various radio emission standards.

More importantly, UAV vendors need to optimize their product design for better end user experience. For example, EN 300 328 specifies the maximum RF output power shall not exceed 20 dBm. In order to get a wider and more reliable remote control range, UAV vendors need to optimize the antenna design so that the antenna return loss is 14 dB (VSWR 1.5) or even 20 dB (VSWR 1.2).

Table 1 lists RF transmitter test items defined in EN 300 328. EN300 328 defines two categories of the 2.4 GHz transmitter: Category 1 refers to transmitters adopting frequency hopping spread transmitter (FHSS) technologies, and category 2 refers to transmitters adopting non-frequency-hopping technologies such as orthogonal frequency-division multiplexing (OFDM) and direct sequence spread spectrum (DSSS). The two transmitter categories have different test items and test methods. For example, 4.3.1.3 is dwell time, minimum frequency occupation and hopping sequence is a compulsory test for a category 1 transmitter, and 4.3.2.2 Power Spectral Density is a compulsory test for a category 2 transmitter.

Table 1 EN 300 328

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Requirement conditionality</th>
<th>Test specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 RF output power</td>
<td>U</td>
<td>E</td>
</tr>
<tr>
<td>2 Power spectral density</td>
<td>C</td>
<td>Only for modulations other than FHSS</td>
</tr>
<tr>
<td>3 Duty cycle, Tx-sequence, Tx-gap</td>
<td>C</td>
<td>Only for non-adaptive equipment</td>
</tr>
<tr>
<td>4 Dwell time, minimum frequency occupation &amp; hopping sequence</td>
<td>C</td>
<td>Only for FHSS</td>
</tr>
<tr>
<td>5 Hopping frequency separation</td>
<td>C</td>
<td>Only for FHSS</td>
</tr>
<tr>
<td>6 Medium utilisation</td>
<td>C</td>
<td>Only for non-adaptive equipment</td>
</tr>
<tr>
<td>7 Adaptivity</td>
<td>C</td>
<td>Only for adaptive equipment</td>
</tr>
<tr>
<td>8 Occupied channel bandwidth</td>
<td>U</td>
<td>E</td>
</tr>
<tr>
<td>9 Transmitter unwanted emissions in the OOB domain</td>
<td>U</td>
<td>E</td>
</tr>
<tr>
<td>10 Transmitter unwanted emissions in the spurious domain</td>
<td>U</td>
<td>E</td>
</tr>
<tr>
<td>11 Receiver spurious emissions</td>
<td>U</td>
<td>E</td>
</tr>
<tr>
<td>12 Receiver blocking</td>
<td>C</td>
<td>Only for adaptive equipment</td>
</tr>
</tbody>
</table>
A Cost-Effective Solution to Test UAV RF Performance

The civil UAV industry is rapidly growing and many vendors are small to medium size, including start-ups. Since FHSS/DSSS/OFDM are mature technologies, these small to medium size vendors often prefer to test several key RF specifications instead of a comprehensive RF test, especially in the production phase. A cost-effective RF test solution based on the Keysight’s N9320B and N9322C basic spectrum analyzers (BSAs) is ideal in this case.

Transmitter RF test

The device under test (DUT) is set to test mode so it will only transmit in a pre-defined frequency. Frequency hopping is disabled. The N9320B and N9322C BSAs can make quick measurements of the following items:

- Max RF output power and power spectral density (not for FHSS transmitters)
- Occupied bandwidth
- Spectrum emission mask (masks are different for frequency hopping transmitters and non-frequency-hopping transmitters)
Antenna test

The N9322C BSA offers a built-in VSWR bridge to enable one-port return loss, VSWR, insertion loss, and distance-to-fault measurement capabilities for frequencies up to 7 GHz. The valley point of return loss measurement represents the resonant frequency of the antenna. Figures 6 and 7 depict a 2.4 GHz antenna measurement using an N9322C.
Conclusion

The N9320B and N9322C BSAs present cost-effective test solutions for civil UAVs because:

- Both N9320B and N9322C BSAs offer basic performance and functions required to make essential RF tests for civil UAVs
- The N9322C BSA offers cable and antenna test capability to verify the antenna performance and cable installation quality

For more information about the N9320B and N9322C BSAs, please visit the following web addresses:

www.keysight.com/find/n9320b
www.keysight.com/find/n9322c
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