APPLICATION NOTE

Reduction on GaN's Pulse Recovery Time

Introduction

A Low Noise Amplifier (LNA) in electronic warfare (EW) applications often encounter challenges from unwanted high input power such as incoherent and coherent jamming signals. These interference jamming signals can make it difficult for the EW target receiver to decode the signal. Thanks to the superior material properties and robustness of Gallium Nitride (GaN) compared to Gallium Arsenide (GaAs), GaN-based LNAs can protect the receiver from this high-power interference. Additionally, GaN LNAs eliminate the need for limiters, which are commonly used with GaAs LNAs to protect against this interference. However, despite GaN's excellent resistance to high input power interference signals, it still presents certain limitations.

When an interference signal applied to GaAs or GaN LNAs is turned off, there is a brief period in which the amplifier's performance remains below its original state. The time required for the amplifier to restore its gain to the original state is known as the pulse recovery time. GaAs amplifiers typically recover within a few nanoseconds, whereas GaN amplifiers can take anywhere from nanoseconds to several hours to recover. In some cases, GaN devices may never recover from the interference.

This application note summarizes findings from various studies and offers insights into methods for reducing GaN's pulse recovery time. The test setups used in compiling this data closely resemble that depicted in Figure 1.

Recovery Time and Interference

First let's review a brief study previously published by Custom MMIC (now part of Qorvo). This study noted that the pulse recovery time depends on the energy and action of the interference (Equation. 1). To put it in simpler terms, interference energy is the input power of the interference received by the device under test (DUT); interference action is the duration of the interference energy presented to the DUT.

$$T_{Recovery} = C \times \sqrt[m]{P_{IN,WATTS} \times t_{INTERFERENCE,SECONDS} \times 10^6}$$

Equation. 1 [1]

In Equation. 1, *C* and m vary depending on the duration of interference. In the paper from Custom MMIC, the equation was derived for short interference pulses and long interference pulses (Equation. 2). Short pulses have a duration of less than or equal to 10 µs. Long pulses have a duration of greater than or equal to 100 µs.

$$T_{Recovery} = \begin{cases} 27 \times \sqrt[0.145]{P_{IN} \times t \times 10^6}, & t \leq 10\ \mu s \\ 0.224 \times \sqrt[0.53]{P_{IN} \times t \times 10^6}, & t \geq 100\ \mu s \end{cases}$$

Equation. 2 [2]

The Custom MMICs paper did not specify the device used as the DUT, which raises a couple of questions that are yet to be answered. The equations derived above are likely to apply to only specific devices. Nevertheless, the equation derived above could still provide insight and be used as a reference. More data in the future may be useful to verify and derive Equation. 1 and Equation. 2 with further details.

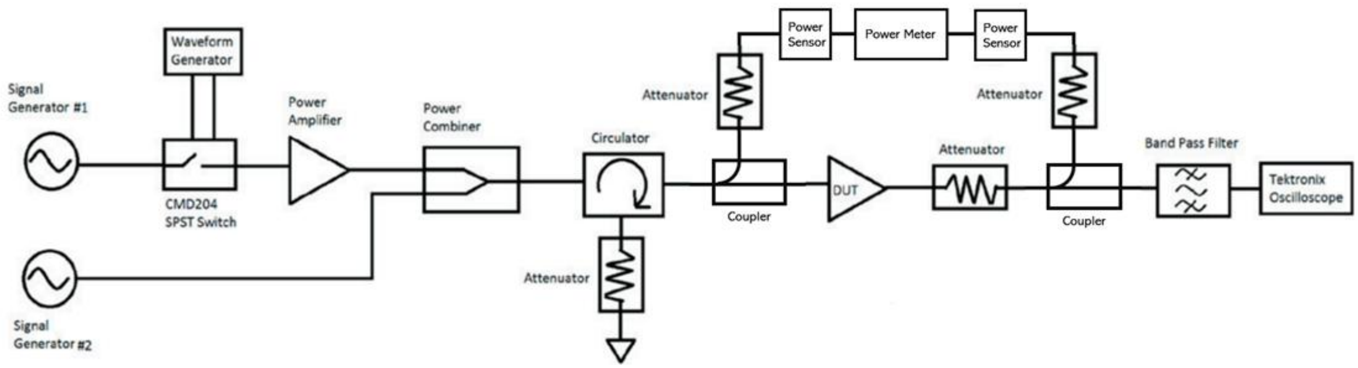

Figure. 1 – Test Setup for QPM1002; Signal Generator #1 presents the interference signal to the DUT. Signal Generator #2 presents the desired signal [1]

Minimizing Pulse Recovery Time

The previous section outlined the discoveries noted in the Custom MMICs paper, which focused on contributing factors to increased recovery times in GaN LNAs. This section provides more recent data demonstrating that a higher quiescent bias current (IDQ) effectively reduces pulse recovery times.

Figure 2 illustrates data collected from the QPM1002 device with an interference signal fixed at 33 dBm for a duration of 100 µs. The results clearly demonstrate that increasing the bias current significantly reduces the device's recovery time to nominal gain. However, there is one exception. The trace for VD = 10V, IDQ = 100 mA, indicates that its recovery time is not faster than when IDQ = 50 mA.

As shown in Figure 2, having a higher biasing current does increase the overall power dissipation and channel temperature of the device. However, it is likely the increase in channel temperature at 100 mA, causes the degradation in maximum Gain and has a negative impact on the pulse recovery time. Based on our observations, we hypothesize that the recovery time depends not only on interference energy and interference action, but also on the maximum available Gain. However, this hypothesis has not yet been proven.

Regardless of the theory above, increasing the bias current as an effective way to reduce pulse recovery time may not always be consistent. The optimal device bias current may vary depending on LNA characteristics. In cases where a device never recovers or takes a long time to recover, re-biasing is another option.

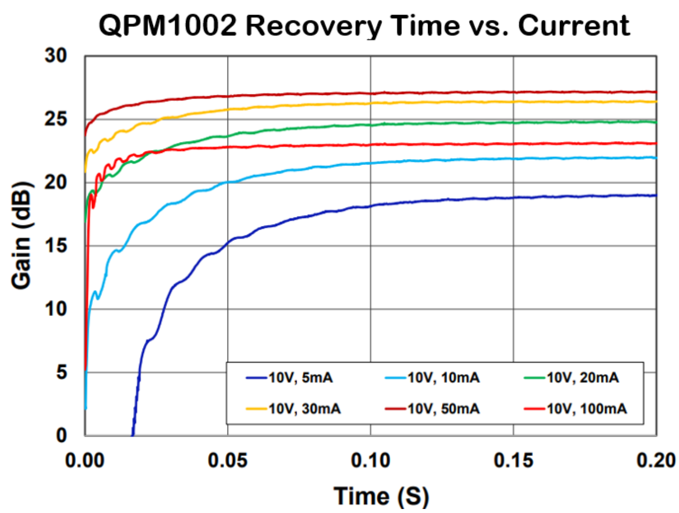

Figure. 2 [4]

Reference

[1] *Nicholas Novaris, Paul Blount, and Charles Trantanella. On the Measurement of Pulse Recovery Times in Gallium Nitride Low Noise Amplifiers*

[2] *Chris Gregoire (2019). Improving Pulse Recovery Times in Gallium Nitride LNAs [PowerPoint Slides]*

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[3] *Qinghui Wang (2017). QORVO LNA Stress Recovery Time Test Data [PowerPoint Slides].*

Defense & Aerospace Application Engineering, Qorvo

[4] *Pulse Recovery Test Data Summary [PowerPoint Slides]*

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[5] *Pulse Recovery Test Report QPM6000 and QPM1002 [PowerPoint Slides]*

Support Data

The Qorvo Factory Applications Engineering team has extensive GaN technology knowledge and can be reached via Qorvo's technical support. Additionally, you can find more information by visiting our Qorvo Design Hub for a rich assortment of videos, technical articles, white papers, tools and more. For technical support please visit Qorvo.com or reach out to Technical Support.

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