Agile L-band amplifiers with independent gain and slope control over a broad dynamic range.

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Abstract: This paper presents ETL's latest range of L-band amplifiers. These cover the frequency range from 850 to 2150MHz, and provide independent gain and slope control over a broad dynamic range. The gain characteristics are controllable in 0.5dB monotonic steps from 5 dB to 36dB at 0dB gain vs. frequency slope. At any gain setting, the gain vs. frequency slope can be continuously controlled to give 0 to 8dB of positive slope. This allows correction to the negative gain slope inherent in cable runs and other RF equipment. An extensive range of test data is presented which illustrates repeatable and accurate control of the transfer characteristics, good linearity and noise figure over the amplifiers' dynamic range. The amplifiers are designed to operate as standalone components and can be readily inserted into a 19" rack mountable chassis and controlled locally or remotely via a web browser interface as well as TCI/IP and serial ports.

Introduction: The amplifier is designed as a modular unit built into a 19" rack mountable 1U or 2U high chassis. The chassis has an LCD control panel for local control and an RJ45 port for remote control and web browser access, as shown in Figures 1a and 1b. Gain and gain vs. frequency slope can be controlled locally and remotely. The monitoring functions include PSU alarms (dual redundant PSUs are used), amplifier status monitoring (current sensing), input RF level detection (over a 60dB dynamic range), and temperature sensing. Up to 16 independently controlled amplifier channels can be accommodated in 2U high chassis or up to 6 in a 1U high chassis.

All RF and other ports are conveniently located on the rear panel of the chassis.

Figure 1a: Front panel of 1U Cougar Series Amplifier

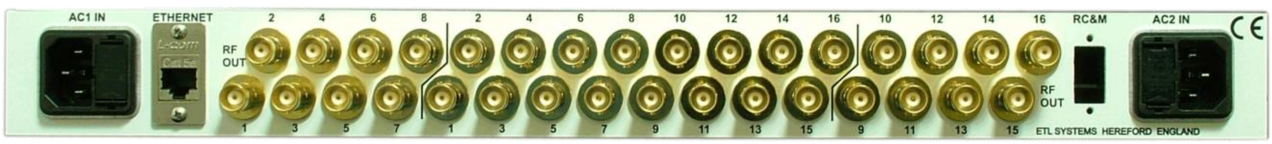

Figure 1b: Rear Panel of a similar equipment showing the RF ports in relation to IEC and RJ45 communication ports.

Figure 1c: Cougar series L-band amplifier in 1U chassis

Amplifiers Modules: The chassis system comprises a CPU/PSU module with multiple amplifier modules. The CPU controls and manages all communications, locally or remotely, whilst the amplifier modules provide the RF functionality over the entire L-band, extending well beyond the usual 850 to 2150MHz bandwidth. However in this publication only the performance across 850 to 2150 MHz is studied and presented.

The simplified schematic diagram of the amplifier line up is shown in Figure 2. The input and output ports are buffered to maintain good VSWR, irrespective of the gain and slope settings. Active as well as passive slope compensation is used to achieve a flat frequency response at all gain settings as well as agility on slope control at any gain setting.

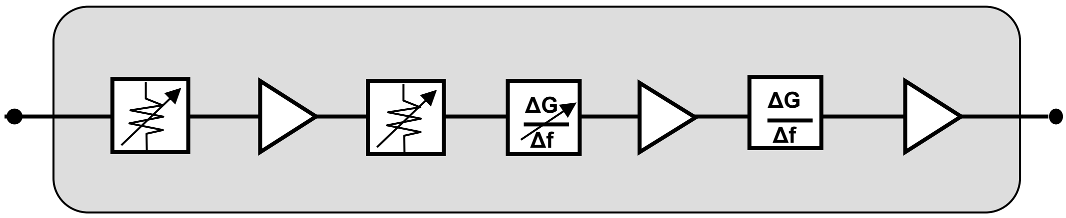

Figure 2: Simplified Schematic Diagram.

Each amplifier's gain is controlled independently at any selected slope setting in 0.5dB gain steps over a 31.5dB gain control range. The variation in gain is monotonic as illustrated in the test results presented in Figures 3a and 3b. The input and output VSWR remain good across the dynamic range with input and output match greater than 18 and 20 dB respectively. See figures 4a and 4b for the measurements.

The slope characteristics of each amplifier channel can be controlled independently and the slope can be set to any value within the range of 0 to +8dB. The measured gain vs. frequency characteristics at different slope settings and at min, mid and max gain levels are shown in figures 5a, b and c. In this design the pivot point for slope control is selected at 2150MHz. Hence the gain remains fixed at this point whilst it varies at the lower frequencies as different slopes are selected. The gain variation is linear, with positive slope across the full bandwidth of 850 to 2150MHz.

The corresponding return loss characteristics, given in figures 6a, b and c, show excellent input and output return loss across the entire bandwidth. The output return loss is better than 20dB and the input return loss exceeds 18dB at all gain and slope settings.

The amplifier is designed with distributive slope and gain control functions which enables it to maintain good linearity, and NF characteristics. The measured 1dB GCP (Gain Compression Point) data shown in figures 7a and b gives 14.6 dB to 18.8 dBm 1dB GCP (output power). The NF (Noise Figure) is typically 9 to 10 dB at gain levels above 20dB and increases to 20dB as gain is reduced down to minimum gain of 5 to 6dB.

Conclusion: The amplifier presented in this paper provides finely settable positive slope control as well as gain control. The gain is controlled digitally over 31.5dB dynamic range in steps of 0.5dB and the slope is controlled by an analogue function within the range of 0 to +8dB range. Very good input and output VSWR characteristics are maintained across the entire control range, making it ideal for many applications where gain and slope compensation are required with minimal effect on in-band ripple. One such application is where long and varied cable lengths are used between various RF equipment requiring slope compensation and amplification to retain the desired signal levels across the L-band spectrum. This is an increasingly important issue with the growing number of satellite teleports where new antennas are regularly being added.

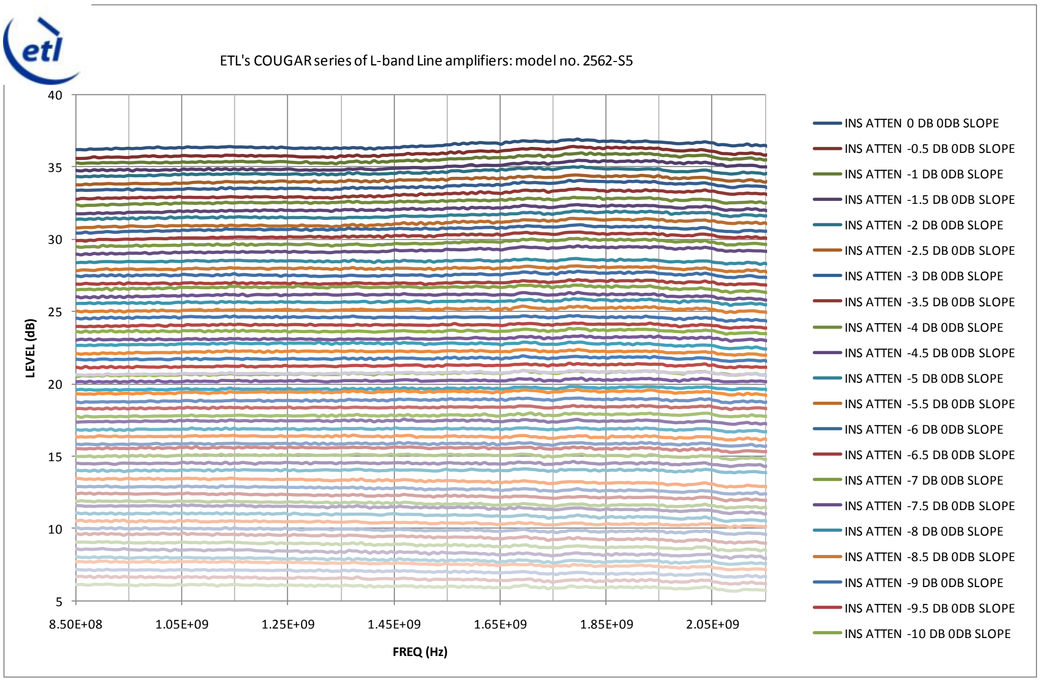

Figure 3a: Monotonic Gain Control steps over 31.5dB range.

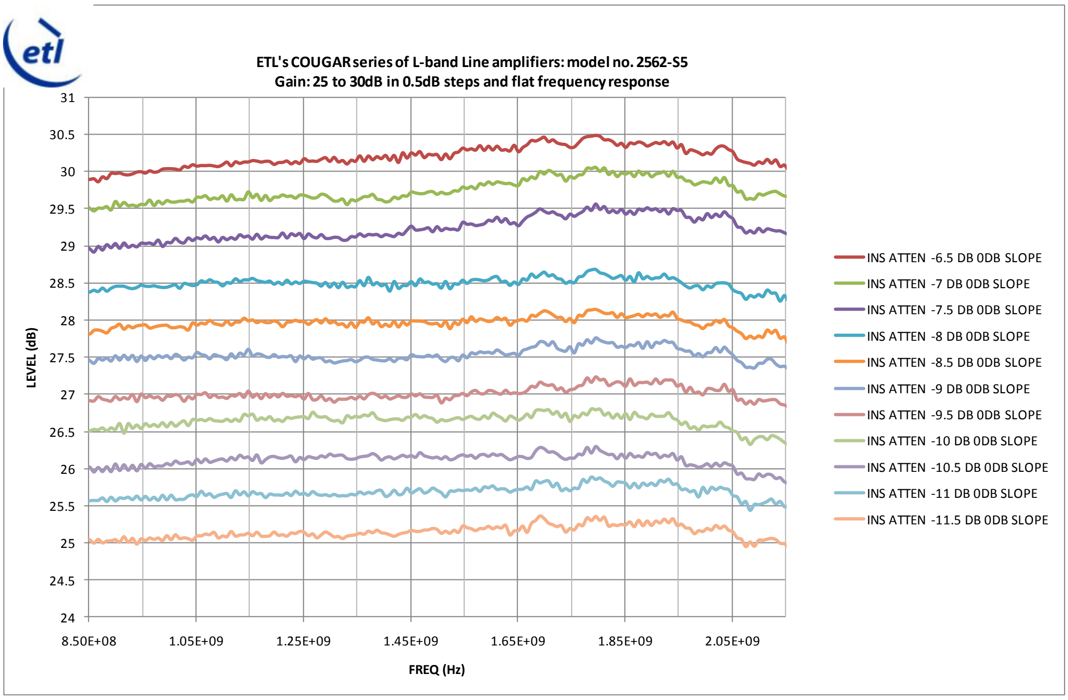

Figure 3b: Gain vs. frequency characteristics over 25 to 30dB range.

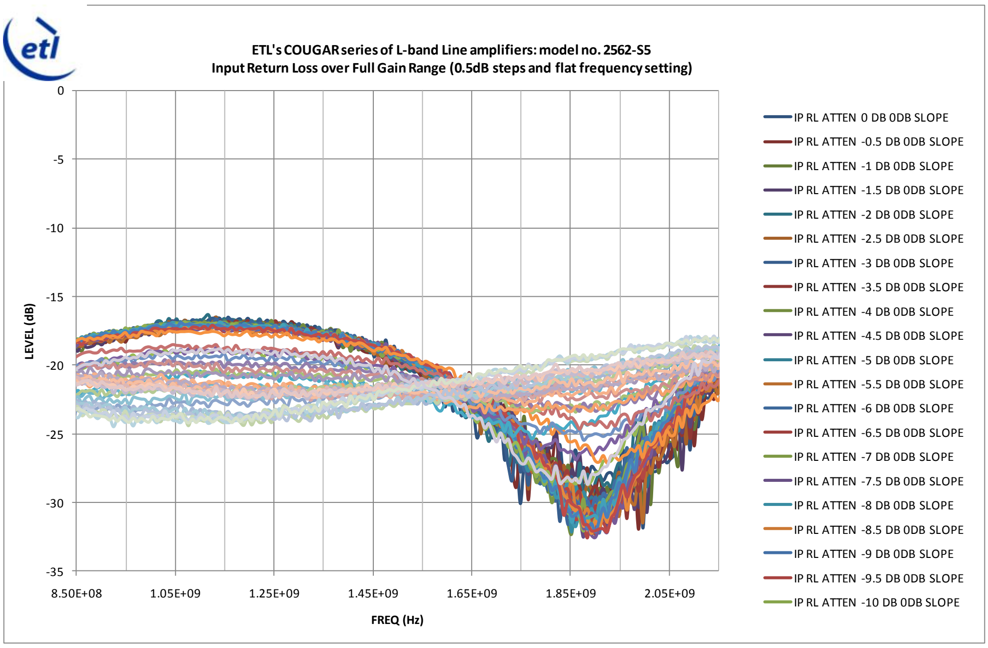

Figure 4a: Input return loss characteristics over full gain control range at flat frequency vs. gain setting.

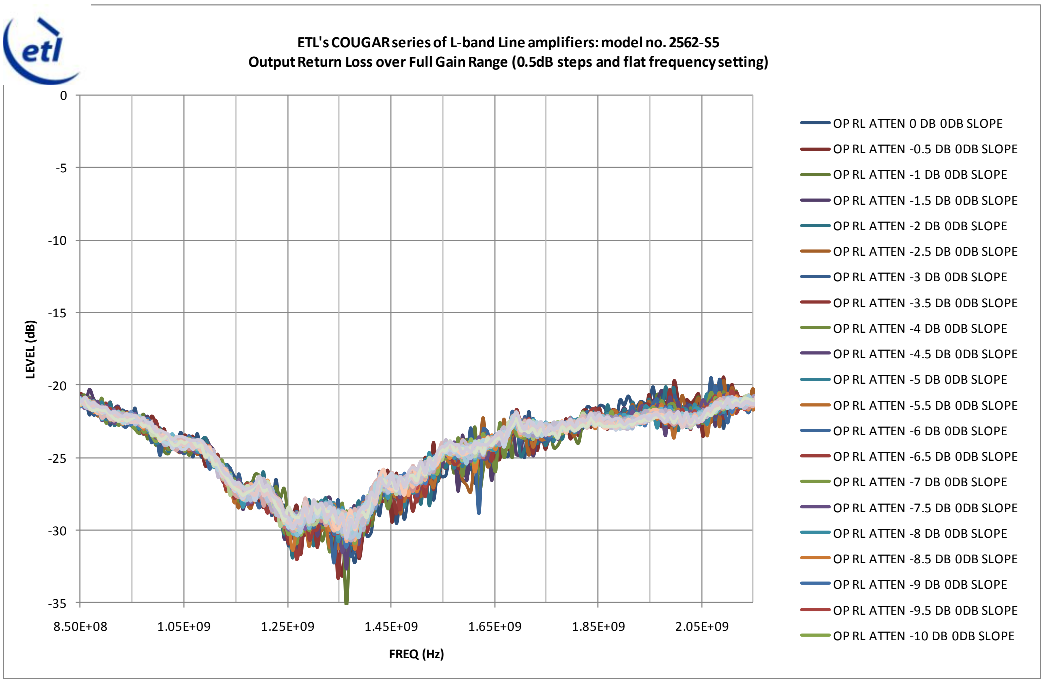

Figure 4b: Output return loss characteristics over full gain control range at flat frequency vs. gain setting.

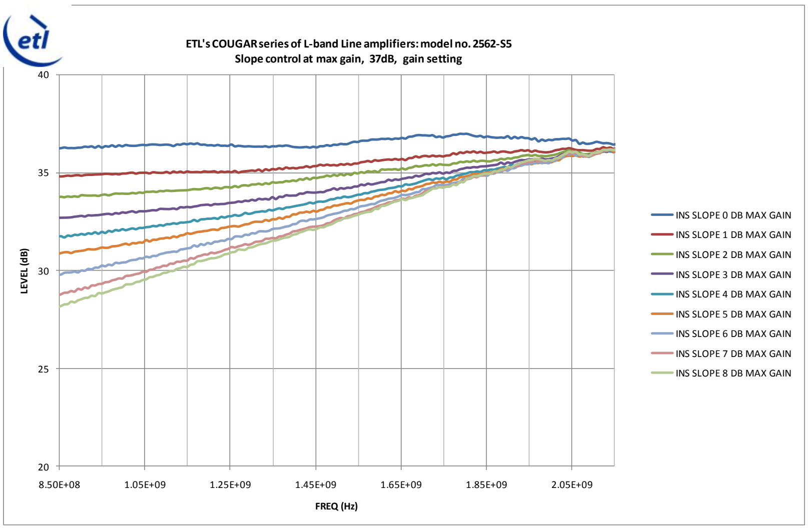

Figure 5a: Gain vs. frequency slope characteristics at max gain and different slope settings.

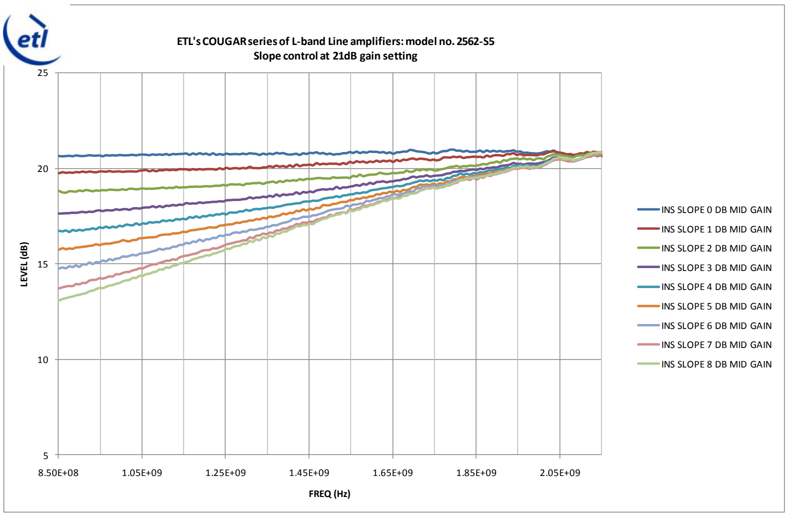

Figure 5b: Gain vs. frequency slope characteristics at mid gain and different slope settings.

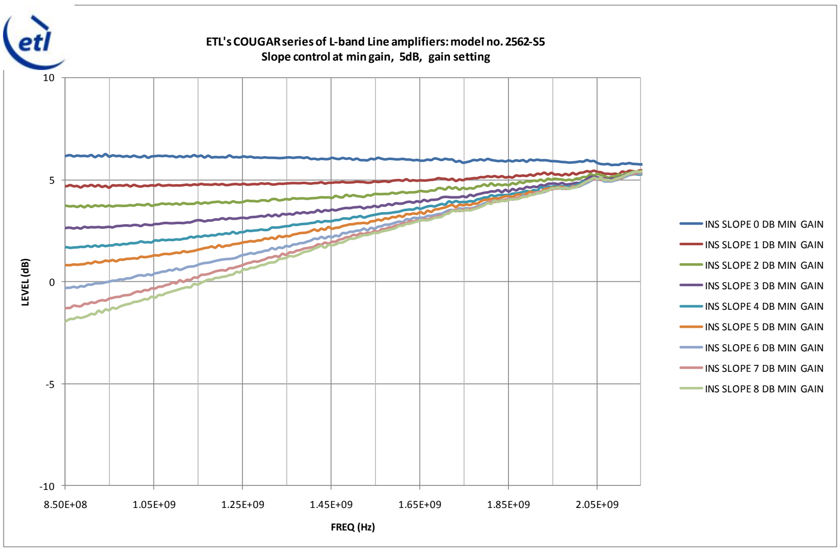

Figure 5c: Gain vs. frequency slope characteristics at min gain and different slope settings.

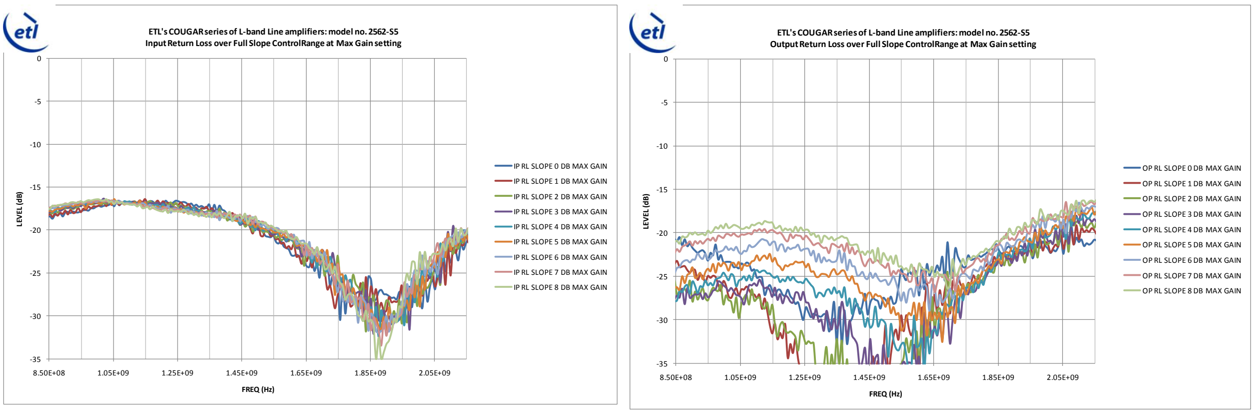

Figure 6a: Input & Output return loss characteristics at max gain and different slope settings.

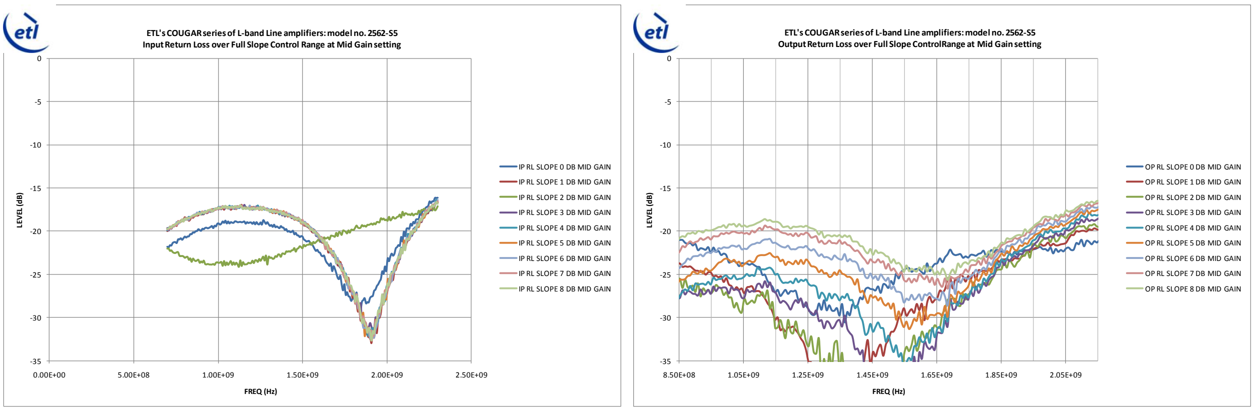

Figure 6b: Input & Output return loss characteristics at mid gain and different slope settings.

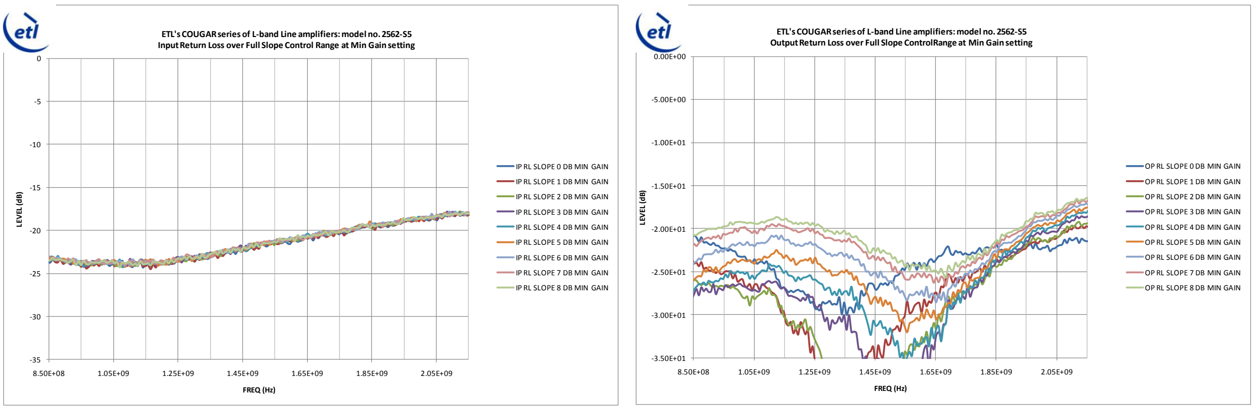

Figure 6c: Input & Output return loss characteristics at min gain and different slope settings.

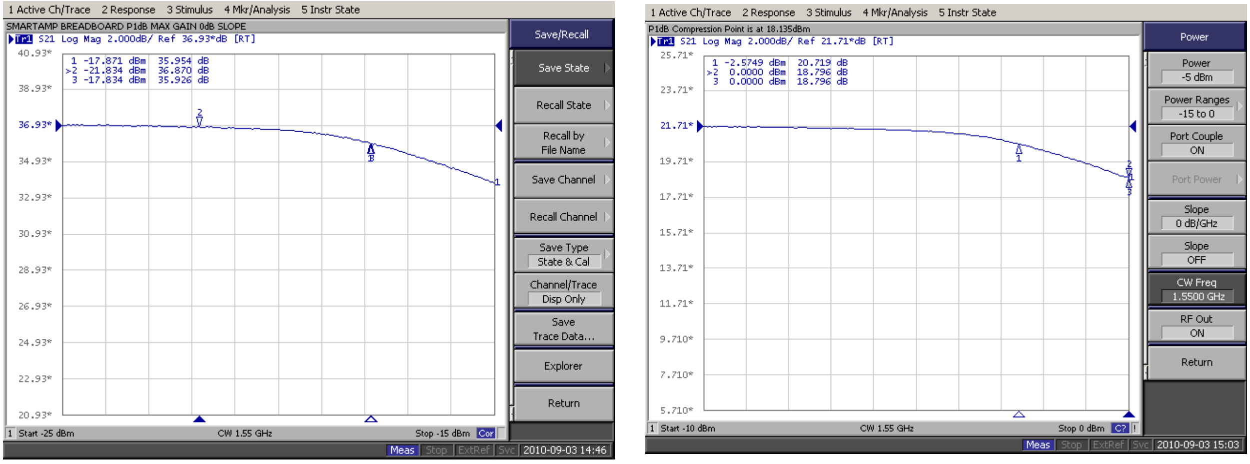

Figure 7a: Typical 1dB GCP plots at 1.55GHz (15dBm at max gain setting and 18.8dBm at mid gain settings).

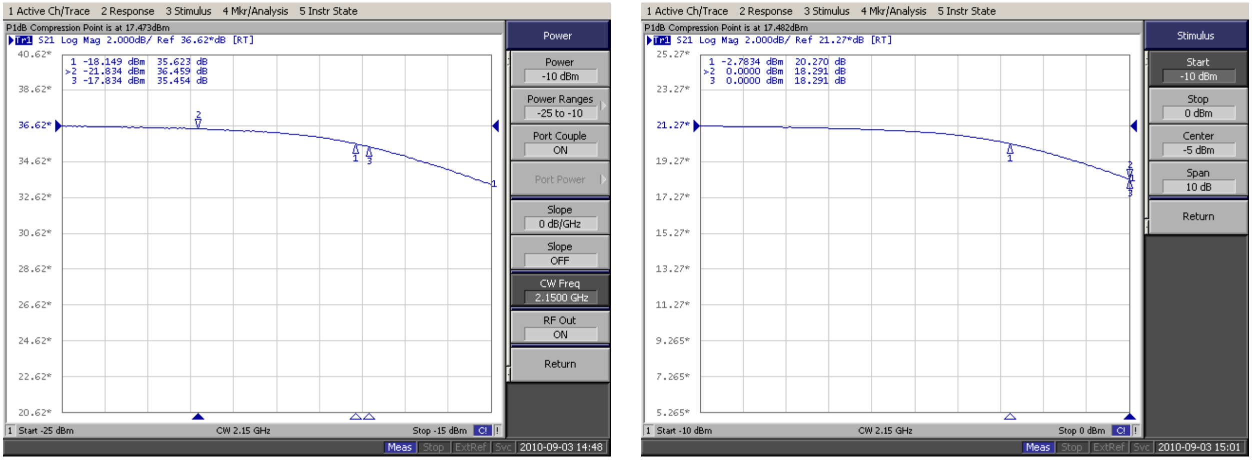

Figure 7b: Typical 1dB GCP plot at 2.155 at max and min gain settings (14.6dBm at max gain setting and 18.3dBm at mid gain settings).