# RSSI Gain Step Calibration in AD9361

## 1. Receiver Signal Chain Overview

Antenna → LNA → Mixer (LO Driven) → TIA → LPF → ADC → Digital Power Estimator

RSSI is measured after the ADC. Therefore, it includes total analog + digital gain.
RSSI_raw = P_in + G_total

## 2. Gain Step Index (GSI)

Gain in AD9361 is discrete. Each Gain Step Index represents a combination of:
- LNA Gain
- Mixer Gain
- TIA Gain
- Digital Gain

Mathematically:
P_in = RSSI_raw - G_total

However, G_total varies with frequency and hardware non-idealities.

## 3. LO (Local Oscillator) Dependency

The LO determines RF center frequency and impacts:
- Mixer conversion gain
- Frequency response
- Matching network behavior
- Gain flatness

Thus:
G_total = f(GSI, LO_frequency)

The same gain index produces different gain at 900 MHz vs 2.4 GHz.

## 4. RSSI Computation

RSSI is computed digitally:

$$RSSI = 10 \log_{10}\left( \frac{1}{N} * \Sigma (I^2 + Q^2) \right)$$

Initially measured in dBFS.
Converted to dBm using gain calibration tables.

## 5. Calibration Procedure

```
Step 1: Inject known RF power (e.g., -60 dBm)
Step 2: Fix LO frequency
Step 3: Sweep Gain Step Index
Step 4: Measure RSSI error
Step 5: Store correction for each (LO band, GSI)

Correction Table:
P_corrected = RSSI_measured - G_calibrated
```

## 6. AGC Interaction

```
In AGC mode, GSI changes dynamically.
Without calibration:
RSSI fluctuates even with constant RF input.

Corrected power:
P_in = RSSI - GainTable[GSI]
```

## 7. Temperature and Non■Idealities

```
Real-world effects:
• Gain ripple across frequency
• Step discontinuities
• Temperature drift
• LO leakage and DC offset

Practical model:
G = f(GSI, LO, Temperature)
```

## 8. Engineering Debug Strategy

```
• Use manual gain mode
• Fix LO frequency
• Inject calibrated RF tone
• Compare expected vs measured RSSI
• Sweep LO bands
• Validate gain table consistency
```

## 9. Final Mathematical Model

```
Complete expression:

P_in = 10 log10( (1/N) * Σ (I² + Q²) )
       - G_analog(GSI, LO)
       - G_digital

Calibration ensures G_analog(GSI, LO) is accurately known.

This guarantees stable AGC operation,
accurate channel power estimation,
and reliable SDR performance.
```