Student Design Competition

APMC 2025 Jeju Island, Korea

Low Phase Noise Oscillator Design at 10 GHz

Supported by MTT-S TC-3 Microwave Measurements Committee

Introduction

RF oscillators are essential components for all RF systems, including wireless communication, radar, and RF energy applications. They serve as the foundation for these systems, acting as local oscillators in communication setups and as the primary signal source in RF energy applications. The key specifications for RF oscillators are frequency stability and phase noise.

In this design competition, students will design a 10 GHz, low-phase-noise oscillator.

Design specifications and rules

In this competition, students will design a low-phase-noise oscillator operating at 10 GHz. Here are the design specs and rules:

- Output Power: min 0 dBm (at 50 ohm)
- Supply voltage: < 10V & 200 mA
- 2^{nd} 3^{rd} Harmonics Power: < -10 dBc
- Any substrate materials and passive components (such as ceramic and multi-layer) are allowed for circuit design.
- The connectors should be Female type and suitable for 2.92 mm Male cable connections (2.92 mm, 3.5 mm, and SMA connectors are compatible (mateable) with each other.)
- The total area of the designs should not exceed 15 cm^2 (3 cm x 5 cm, 1cm x 15 cm, etc.). Extension of connectors will not be considered (only PCB dimension).
- There will be a power supply for biasing (10 V, 200 mA max) and a tuning supply (if necessary). Additional power supply, battery, or super-capacitor is not allowed.

An off-the-shelf commercial oscillator is not permitted. The students should use a transistor and design an oscillator themself. An amplifier integrated into the design is allowed to increase output power. It should be on the same circuit board as the oscillator (a single PCB for both). Additional biasing will not be provided for it. Note that this may affect the efficiency score due to the additional power supply requirement.

Students can contact the organizing committee for their questions and technical guidance at anytime. We are more than happy to answer their questions and share our design and fabrication experience.

The Design Competition is open to teams of full-time undergraduate and/or graduate students who are currently enrolled at a university or other accredited educational institution. Students must show a valid student ID during the competition.

Students may enter individually or form a team of up to 3 students. A student is allowed to join only one team. Multiple entry is not allowed. Each team may submit up to two entries but can only receive an award for one entry. There is no age restriction.

Students are advised to use email addresses issued by their respective institutions for all communication regarding the competitions, rather than personal email addresses (e.g., Gmail, Hotmail).

Evaluation process

A phase noise analyzer will be used to measure the oscillation frequency, output power, and phase noise. A short and low-loss 2.92mm coaxial cable (< 25 cm) will connect the designed oscillator to the phase noise analyzer.

Before measurements, the organization committee will visually inspect the submitted circuits to ensure no commercial oscillator, battery, or super-capacitor is installed. Sealed casings are not allowed. If the circuit is placed in a package or enclosure, it should be suitable for visual inspection (removable cover, transparent box, etc.).

The students will connect their circuit(s) to the coaxial RF cables, which have 2.92 mm male connectors for the measurements. The implemented circuits should be structurally reliable enough to withstand mechanical forces, such as torque and cable tension. The competition committee accepts no responsibility for any physical damage that may occur during the competition. The designs meeting the technical design rules will be evaluated during the competition.

Each circuit will be given a maximum of 7 minutes to complete cable connections and prepare the circuit for the measurement (including tuning if necessary). The measurements will be done in a conference room open to all participants. A constant temperature condition cannot be guaranteed.

No tuning is allowed during the measurements while the circuit is connected to the phase noise analyzer.

If there is enough time after measuring all of the participants' circuits, it may be possible to re-measure some circuits if time permits.

Remote participation is allowed in cases of last-minute travel issues, such as visa problems or COVID-19 etc. In that case, the circuits should arrive at the Maury Microwave US location at least 5 days before the competition. The organizers will do their best to protect the circuits and ensure safe measurements. Organizers do not accept any responsibility for damage or loss during shipment.

Scoring

The students will bring the circuits to the competition. They should have a short report, including transistor information (model, maker, etc.), simulation results (if available), and measurement results (if available). The designed oscillators must meet these requirements before scoring:

1. Visual inspection (no battery, super-capacitor, commercial oscillator)
2. Dimensions of the circuit
3. Oscillation frequency stability within ±1% (±100 MHz)
4. > 0 dBm output power
5. Power values of the signals at the 2^{nd} and 3^{rd} harmonic frequencies should be at least 10 dB lower than the fundamental oscillation frequency. (<-10 dBc)

The winner will be determined by the circuit that achieves the maximum score based on the evaluation criteria below:

- Oscillation frequency (average of three measurements)
- Highest Efficiency
- Highest output power
- Lowest phase noise at 100 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz (average 100)

Figure 1 displays the schematic of the measurement setup. The power analysis will consider the insertion losses due to cable, coupler, and adapters. Each criterion will be scored independently. Oscillation frequency will be scored up to 7: First is 7, second is 5, third is 3, and fourth is 1. Power consumption, output power, and phase noise at 100 Hz will be scored up to 5: First is 5, second is 3, third is 1. 1 kHz, 10 KHz, 100 KHz, and 1 MHz phase noise performances will be scored up to 3: First is 3, second is 2, third is 1.

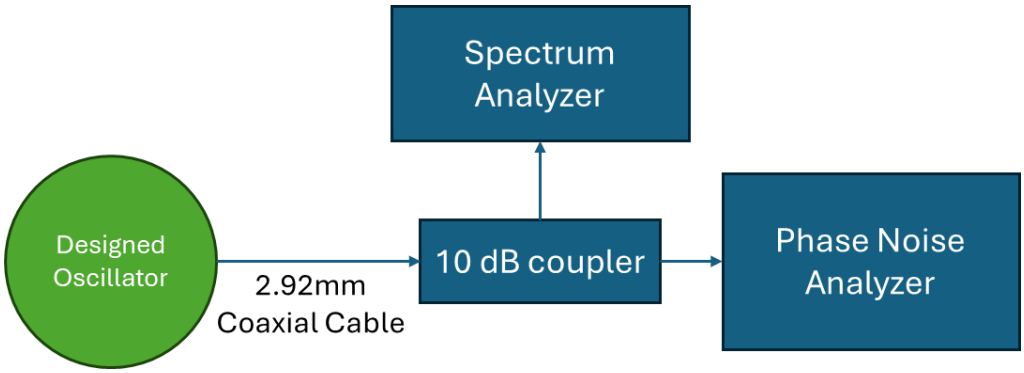

Figure 1. Measurement Setup

Example scoring:

Student	Oscillation Frequency [GHz]	Efficiency [%]	Output Power [dBm]	100 Hz [dBc]	1 KHz [dBc]	10 KHz [dBc]	100 kHz [dBc]	1 MHz [dBc]	Total
A	10.01 Score: 7	5.4 Score: 1	3.6 Score: 1	-50.6 Score: 3	-72 Score: 2	-85 Score: 2	-90	-105 Score: 3	19
B	10.06 Score: 3	7.1 Score: 3	5.0 Score: 3	-53.2 Score: 5	-76 Score: 3	-82 Score: 1	-91 Score: 1	-104 Score: 2	21
C	9.91 Score: 1	10.0 Score: 5	8.6 Score: 5	-46.0	-76 Score: 3	-86 Score: 3	-92 Score: 2	-103 Score: 1	20
D	9.95 Score: 5	2.2	1.2	-49.0 Score: 1	-70 Score: 1	-65	-93 Score: 3	-103 Score: 1	11

(All numbers are random. Do not use them as a reference!)

How to Participate:

Competing teams will be required to register for the APMC-2025 Student Design Competition following the rules posted on the conference homepage.

Students may enter as individuals or as a team. There may be no more than four students on a team, with a maximum of one entry per competing team.

Contact information

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