Rev. 2016-10-26

IMS2017 Student Design Competition Rules

As part of the technical program, the Student Design Competition (SDC) is one of the most energetic parts of IMS. The SDCs have proven to be very successful events in the past 12 years, as evidenced by the ever increasing student participation and the support it has enjoyed from the organizers, both logistically and financially. The IMS2017 in Honolulu will continue the legendary tradition of enthusiasm with a very strong SDC program.

TC number and name:

MTT-10 BIOLOGICAL EFFECTS AND MEDICAL APPLICATIONS
MTT-20 WIRELESS COMMUNICATION

The title of Student Design Competition:

High-Sensitivity Fast-Response Motion Sensing Radar

Submission Deadline: Friday, 31 March 2017

Sponsors:

MTT-10 Biological Effects and Medical Applications
MTT-20 Wireless Communications

Primary contact name(s), email address, and phone number (of host or competition leader(s)):

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A short abstract or summary describing the competition:

A high sensitivity fast-response low-power radar sensor design competition is open to all students registered at an educational institution. Competitors are required to design, fabricate, and demonstrate a high sensitivity (as measured by the motion amplitude that can be detected), fast-response, low-power portable mono-static ra-

dar. This project will introduce students to modern radar motion sensors. The winner will be judged considering a figure of merit (FOM) determined from the sensitivity, the response time, the dc power consumption, and the weight of the radar sensor.

Evaluation Criteria:

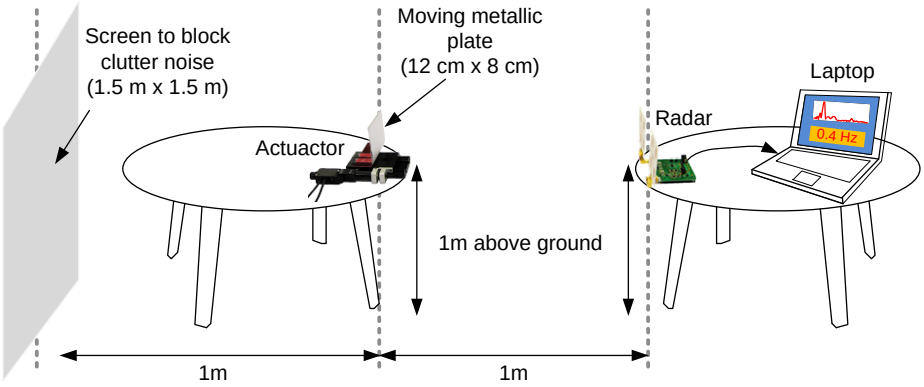

Figure 1. Setup of the testing and judging environment.

As shown in Fig. 1, the radar sensor needs to detect periodic mechanical motion 1 m away from the target. The periodic motion pattern is between sinusoidal wave and triangular wave, as some harmonics of the fundamental tone will present (but not dominate). The target is a 12 cm by 8 cm metal plate. There will be a reflector screen that is 1.5 m × 1.5 m behind the target to block undesired clutter noise. Nobody will be allowed between the radar and screen during the competition. **Each team will be given 10 minutes to set up and calibrate their radar before the official measurement**. During the 10 minutes, the judges will help the team to control the actuator per the team's requirement. It should be noted that each team is only given a one-time 10-min setup before the measurement. Once the measurement starts, the team cannot redo setup or calibration.

A power supply with a single dc voltage output up to 15 V will be provided to power up the radar, no battery is allowed on the radar. The dc power consumption **Pdc** (in mW) will be measured as the product of the actual supply voltage and current. The target's motion will be controlled by an actuator to produce several periodic displacements with amplitudes of 10 μm, 0.1 mm, 0.5 mm, 1mm, and 2.0 mm. For each amplitude, the motion frequency will be randomly chosen from 0.4, 0.5, 0.6, 0.7, and 0.9 Hz, and the team will be given 40 seconds to detect the frequency and write it down on the answer sheet. Measurement will be continued for all the five displacement amplitudes, no matter if a team's reading is correct or not. The average radar response time $\mathbf{T_{average}}$ and the total score $\mathbf{S_{total}}$ earned for all the

measurements will be evaluated using Table 1 (filled by teams) and Table 2 (filled by judges).

Table 1. Answer sheet for the teams.

University:	
Team Members:	
Motion Amplitude	**Detected Frequency**
10 μm	
0.1 mm	
0.5 mm	
1 mm	
2 mm	

The radar sensor can be connected to a laptop, smart phone, or tablet using a single cable for real-time signal processing. The cable can be used to transmit analog/digital signal through USB/audio port. But **no dc power can be transferred from the laptop/smartphone/tablet to power the radar**. If USB data acquisition cable (e.g., NI 6008/6009 or FTDI USB to serial converter cable) is used, the power drawn by the unit for data acquisition function will not be counted because of the difficulty in measuring the power. However, it should be noted that the weight of the data acquisition unit will be counted; and if two teams have the same FOM, the team not using USB data acquisition will be ranked higher. Energy harvesting from ambient sources is not allowed. The weight of the radar sensor **W** (in gram) will be measured as the total weight of everything in the radar system except for the laptop. This means the antenna, SMA connectors, SMA cables, radar front-end, ADC (if any) and signal cables will all be counted into the weight of the radar sensor.

Table 2. Scoring sheet for the judges. Note that the “Actual Frequency” will be randomly selected before the competition without letting the teams know, and the “Detected Frequency” will be obtained from each team’s scoring sheet. If “Actual Frequency” = “Detected Frequency”, then Score for that row will be 40, otherwise it will be 0 for that row. $T_{average}$ refers to the average of Detection Time [S] for correct detections only.

University:					
Team Members:					
Motion Amplitude	**Actual Frequency**	**Detected Frequency**	**Answer Correct?**	**Detection Time [S]**	**Score**
10 µm					
0.1 mm					
0.5 mm					
1 mm					
2 mm					
				$T_{average}$ =*	S_{total} =

* $T_{average}$ refers to the average of Detection Time [S] for correct detections only. If a team does not have any correct detection, $T_{average}$ would be infinite.

Finally, the radar sensor FOM will be calculated as:

$FOM_{radar} = \frac{1000 \times S_{total}}{P_{dc} \times W \times T_{average}}$, where

Pdc = DC power consumption in milliwatts

S_{total} = total score received (calculated from Table 2)

W = weight of the radar sensor in gram, excluding the laptop

$T_{average}$ = average response time in seconds for correct detections (from Table 2)

Testing and judging of the radar will be performed at the 2017 International Microwave Symposium (IMS). The participating teams are required to submit a preliminary status report by Friday, 31 March 2017. On the date of the competition, a member of the design group must show up to complete all the measurements. The team with the highest FOM will be selected as the winner. The judges of this competition will be radar experts who are not solely affiliated with one institute.

Design Specification/Rules:

1. Students enrolled by any educational institutions are eligible to participate to this contest. A statement from the institution confirming 1) good standing of the participating student(s) at the institution; 2) that the radar is the result of the student(s)'s effort, must be submitted by

either a professor or the student's department. Emails are accepted as long as a .edu (or foreign equivalent for educational institutions) email address is used. Contact details of the professor/institution must be provided.

2. The radar may use any technology. Use of commercial microwave/RF subsystems and passive components is allowed.
3. The radar shall allow for internal inspection of the circuitry.
4. The radar shall be able to detect periodic mechanical motion 1 m away from the target. The target is a 12 cm by 8 cm metal plate.
5. The only dc power source is a power supply with a single dc voltage output up to 15 V. A metered power supply will be provided at IMS2017 by the organizers.
6. No internal batteries or energy harvesting devices may be used.
7. A laptop, smart phone, or tablet is allowed to connect to the radar for real time signal processing. But the radar shall not draw any dc power from the laptop, smart phone, or tablet. Students need to bring their own laptop/smartphone/tablet.
8. The radar with the highest FOM will be the winner of the competition.

Prizes:

We will offer prizes such as cash award sponsored by the SDC and the National Instruments/AWR Design Kit sponsored by the NI/AWR. This will be a one-level competition with all students judged together.

The first-place winning team will receive a prize of $1000 and will be invited to submit a paper describing his/her project to the IEEE Microwave Magazine. The second- and third- place winning teams will receive a prize of $600 and $400 respectively. Participants will be recognized at the Student Awards Luncheon at the 2017 International Microwave Symposium.