IMS-2019 Student Design Competition Instructions

Sponsoring TCs:
MTT-10 BIOLOGICAL EFFECTS AND MEDICAL APPLICATIONS
MTT-20 WIRELESS COMMUNICATION

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Title of Student Design Competition:

High-Sensitivity Motion Sensing Radar

A short abstract or summary describing the competition:

A 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 radar. This project will introduce students to modern radar motion sensors.

Evaluation criteria:

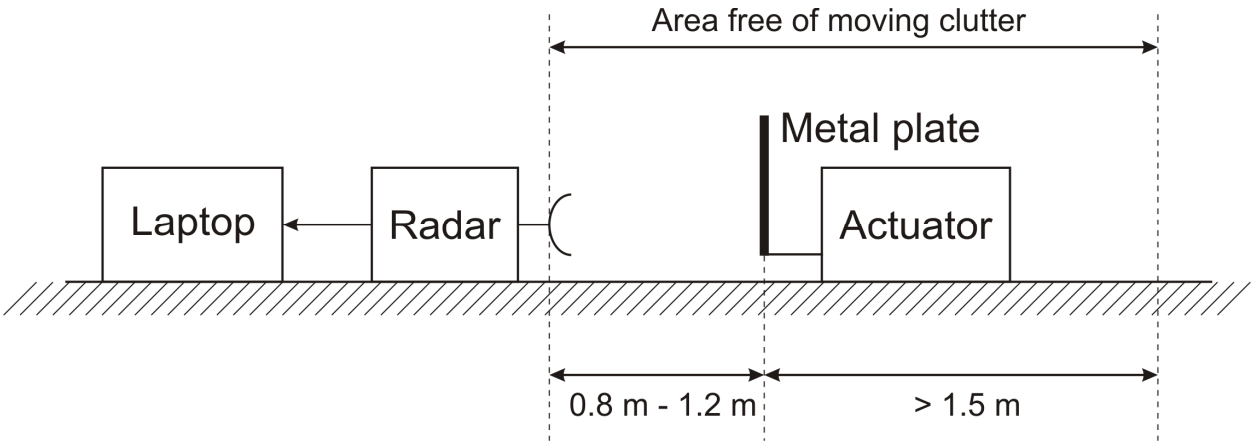

Figure 1. Setup of the testing and judging environment

Fig. 1 shows the testing and judging environment. The radar sensor needs to detect and measure the mechanical motion of a metal plate (size 12 cm x 8 cm) that it is periodically moving. Only the fundamental component of the periodic motion is to be detected and measured. During the calibration stage, the team can locate the radar in a range between 0.8 m to 1.2 m to the metal plate. No moving clutter will be allowed 1.5 m behind the vibrating moving plate in the line-of-sight direction. Depending on the alternatives provided by the convention center, the space between the radar and the metal plate can be a flat surface (one-table solution), or open air (two-table solution). If the one-table solution is possible, that will be the deployment used for all the experiments.

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 will be measured as the product of the actual supply voltage and current. The power consumption must be the same during all the measurements. The actuator can produce several periodic displacements of the metal plate with peak amplitudes of only 10 μm, 0.1 mm, 0.5 mm, 1mm, and 2.0 mm and frequencies of only 0.4, 0.5, 0.6, 0.7, and 0.9 Hz.

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 score, 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 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.

Competition procedure:

- **Calibration phase**
  The judges will tell the team how to use the actuator to set up different motions of the metal plate. After this, each team will be given 15 minutes to set up and calibrate their radar before the official measurements. This calibration phase is very important, since the actuator has small errors in the amplitude and the frequency of the established motion. The calibration time can also be used to correctly point the radar and to situate it in the range of 0.8 m-1.2 m to the metal plate.

- **Phase 1**. Determination of unknown frequencies with known amplitudes
  The amplitude will be set up to 2.0 mm, 0.5 mm, and 10 µm, with unknown frequencies that can be repeated. The team will take note of the measured frequencies. The judges will take note of the needed time to do each measurement. The maximum detection time is 50 s.

- **Phase 2**. Determination of unknown amplitudes with known frequencies
  The frequency will be set up to 0.9 Hz, 0.6 Hz, and 0.4 Hz, with unknown amplitudes that can be repeated. The team will take note of the measured amplitudes. The judges will take note of the needed time to do each measurement. The maximum detection time is 50 s.

- **Phase 3**. Determination of unknown amplitudes and frequencies
  The actuator will be set up to three randomly-chosen unknown configurations (unknown amplitudes and frequencies). The team will take note of the measured amplitudes and frequencies. The judges will take note of the needed time to do each measurement. The maximum detection time is 50 s.

- **Determination of DC power consumption**
  The DC power consumption will be measured as the product of the actual supply voltage and current. The power supply provided by the organization is unknown. If the power supply is not sensitive enough and the team does not provide another power supply to actually measure the DC power consumption, the score for this section will be 0 points. This measurement will be done with the actuator set up with a configuration chosen by the team. The team must demonstrate to the judges that, at least, the frequency of the motion is being correctly measured by the radar. Otherwise, the team will be eliminated from the competition.

- **Determination of weight**
  A scale will be used to determine the weight of the radar.

- **Determination of final score**
  The score of this competition will be calculated for each team according to Table II that only applies when the corresponding measurement is correct.

Table 1. Answer sheet for the teams.

	University:	
	Phase 1	
	Motion Amplitude	**Detected Frequency**
	2 mm	
	0.5 mm	
	10 µm	
	Phase 2	
	Motion Frequency	**Detected Amplitude**
	0.9 Hz	
	0.6 Hz	
	0.4 Hz	
	Phase 3	
	Detected Frequency	**Detected Amplitude**
Meas. 1		
Meas. 2		
Meas. 3		

Table 2. Scoring table.

Phase 1 (P1)			**Phase 2** (P2)			**Phase 3** (P3)		
Amp.	Det. time	Score	Freq.	Det. time	Score	Meas.	Det. time	Score
2 mm	$t_d < 10$ s	10	0.9 Hz	$t_d < 10$ s	40	Meas. 1	$t_d < 10$ s	100
2 mm	$10 < t_d < 25$ s	6	0.9 Hz	$10 < t_d < 25$ s	30	Meas. 1	$10 < t_d < 25$ s	80
2 mm	$t_d > 25$ s	4	0.9 Hz	$t_d > 25$ s	20	Meas. 1	$t_d > 25$ s	60
0.5 mm	$t_d < 10$ s	20	0.6 Hz	$t_d < 10$ s	50	Meas. 2	$t_d < 10$ s	100
0.5 mm	$10 < t_d < 25$ s	15	0.6 Hz	$10 < t_d < 25$ s	40	Meas. 2	$10 < t_d < 25$ s	80
0.5 mm	$t_d > 25$ s	10	0.6 Hz	$t_d > 25$ s	30	Meas. 2	$t_d > 25$ s	60
10 µm	$t_d < 10$ s	40	0.4 Hz	$t_d < 10$ s	60	Meas. 3	$t_d < 10$ s	100
10 µm	$10 < t_d < 25$ s	30	0.4 Hz	$10 < t_d < 25$ s	50	Meas. 3	$10 < t_d < 25$ s	80
10 µm	$t_d > 25$ s	20	0.4 Hz	$t_d > 25$ s	40	Meas. 3	$t_d > 25$ s	60
DC power consumption (P_{DC})			**Weight** (W_g)					
Range		Score	Range		Score	**Total Score:**		
$P_{DC} > 1$ W		20	$W_g > 100$ g		20	$Score_{P1,2mm} + Score_{P1,0.5mm} +$ $Score_{P1,10\mu m} + Score_{P2,0.9Hz} +$ $Score_{P2,0.6Hz} + Score_{P2,0.4Hz} +$ $Score_{P3,Meas1} + Score_{P3,Meas2} +$ $Score_{P3,Meas3} + Score_{PDC} +$ $Score_{Wg}$		
100 mW $< P_{DC} < 1$ W		40	10 g $< W_g <$ 100 g		40			
10 mW $< P_{DC} < 100$ mW		60	5 g $< W_g <$ 10 g		60			
1 mW $< P_{DC} < 10$ mW		80	$W_g <$ 5 g		80			
100 µW $< P_{DC} < 1$ mW		100						
$P_{DC} < 100$ µW		120						

Table 3. Scoring sheet for the judges.

University:					
Phase 1					
Motion Amplitude	**Actual Frequency**	**Detected Frequency**	**Answer Correct?**	**Detection Time**	**Score**
2 mm					
0.5 mm					
10 µm					
					S_{P1} =
Phase 2					
Motion Frequency	**Actual Amplitude**	**Detected Amplitude**	**Answer Correct?**	**Detection Time**	**Score**
0.9 Hz					
0.6 Hz					
0.4 Hz					
					S_{P2} =
Phase 3					
Measurement	**Actual Freq./Amp.**	**Detected Freq./Amp.**	**Answer Correct?**	**Detection Time**	**Score**
Meas. 1	/	/			
Meas. 2	/	/			
Meas. 3	/	/			
					S_{P3} =
DC power consumption, weight, and total score					
DC Power Consumption		**Weight**		**Total Score** ($S_{P1} + S_{P2} + S_{P3} + S_{PDC} + S_{Wg}$)	
P_{DC}	Score	W_g	Score		
	S_{PDC} =		S_{Wg} =		

Testing and judging of the radar will be performed at the 2019 International Microwave Symposium (IMS). On the date of the competition, at least one member of the design group must show up to complete all the measurements. The team with the highest total score will be selected as the winner. The judges of this competition will be radar experts who are not solely affiliated with one institute.

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 2019 International Microwave Symposium.