

Lecture 2

2021/2022

Microwave Devices and Circuits for Radiocommunications

2021/2022

- 2C/1L, **MDCR**
- Attendance at minimum 7 sessions (course + laboratory)
- Lectures- **associate professor Radu Damian**
 - Monday 11-13, Online, Microsoft Teams
 - E – 50% final grade
 - problems + (2p atten. lect.) + (3 tests) + (bonus activity)
 - first test L2: 28.02.2022 (t2 and t3 not announced)
 - 3p=+0.5p
 - all materials/equipments authorized

2021/2022

- Laboratory – **associate professor Radu Damian**
 - Thursday 16-18 (17:30), Il.13
 - Friday 10-12, Il.13
 - L – 25% final grade
 - ADS, 4 sessions
 - Attendance + personal results
 - P – 25% final grade
 - ADS, 3 sessions (-1? 25.02.2022)
 - personal homework

Materials

■ <http://rf-opto.etti.tuiasi.ro>

Laboratorul de Microunde si Opti

Not secure | rf-opto.etti.tuiasi.ro/microwave_cd.php?chg_lang=0

☆

Main

Courses

Master

Staff

Research

Students

Admin

Microwave CD

Optical Communications

Optoelectronics

Internet

Antennas

Practica

Networks

Educational software

Microwave Devices and Circuits for Radiocommunications (English)

Course: MDCR (2017-2018)

Course Coordinator: Assoc.P. Dr. Radu-Florin Damian
Code: EDOS412T
Discipline Type: DOS; Alternative, Specialty
Credits: 4
Enrollment Year: 4, Sem. 7

Activities

Course: Instructor: Assoc.P. Dr. Radu-Florin Damian, 2 Hours/Week, Specialization Section, Timetable:
Laboratory: Instructor: Assoc.P. Dr. Radu-Florin Damian, 1 Hours/Week, Group, Timetable:

Evaluation

Type: **Examen**

A: 50%, (Test/Colloquium)
B: 25%, (Seminary/Laboratory/Project Activity)
D: 25%, (Homework/Specialty papers)

Grades

[Aggregate Results](#)

Attendance

[Course](#)
[Laboratory](#)

Lists

[Bonus-uri acumulate \(final\)](#)
[Studenti care nu pot intra in examen](#)

Materials

Course Slides

[MDCR Lecture 1](#) (pdf, 5.43 MB, en, [99](#))
[MDCR Lecture 2](#) (pdf, 3.67 MB, en, [99](#))
[MDCR Lecture 3](#) (pdf, 4.76 MB, en, [99](#))
[MDCR Lecture 4](#) (pdf, 5.58 MB, en, [99](#))



 **English** |  Romana |

Main

Courses

Master

Staff

Rese

Grades

Student List

Exams

Photos

Online Exams

In order to participate at online exams you must get ready following

1. On the main menu, choose the language you are comfortable

Materials

- RF-OPTO
 - <http://rf-opto.etti.tuiasi.ro>
- **David Pozar, “Microwave Engineering”,**
Wiley; 4th edition , 2011
 - 1 exam problem ← Pozar
- Photos
 - sent by email/online exam
 - used at lectures/laboratory

Profile photo

- Profile photo – online “exam”

Examene online: 2020/2021

Disciplina: MDC (Microwave Devices and Circuits (Engleza))

Pas 3

Nr.	Titlu	Start	Stop	Text
1	Profile photos	03/03/2021; 10:00	08/04/2021; 08:00	Online "exam" created f ..
2	Mini Test 1 (lecture 2)	03/03/2021; 15:35	03/03/2021; 15:50	The current test consis ..

Online

- access to **online exams** requires the **password** received by email

English | Romana |

Main Courses Master Staff Research **Student**

Grades Student List Exams Photos

POPESCU GOPO ION

Fotografia nu exista

Date:

Grupa	5700 (2019/2020)
Specializarea	Inginerie electronica si telecomunicatii
Marca	7000000

[Access the site as this student](#) | [request access to software](#)

Grades

Inca nu a fost notat.

Main Courses Master Staff Research

Grades **Student List** Exams Photos

Login

Use the last name and email stored in the database

Name

POPESCU GOPO

Email/Password

Write the code below

828f26b

Send

Password

■ received by email

Important message from RF-OPTO

Inbox x



Radu-Florin Damian

to me, POPESCU



Romanian

> English

[Translate message](#)



Laboratorul de Microunde si Optoelectronica
Facultatea de Electronica, Telecomunicatii si Tehnologia Informatiei
Universitatea Tehnica "Gh. Asachi" Iasi

In atentie: POPESCU GOPO ION

Parola pentru a accesa examenele pe server-ul **rf-opto** este

Parola: [REDACTED]

Identificati-va pe [server](#), cu parola, cat mai rapid, pentru confirmare.

Memorati acest mesaj intr-un loc sigur, pentru utilizare ulterioara

Attention: POPESCU GOPO ION

The password to access the exams on the **rf-opto** server is

Password: [REDACTED]

Login to the [server](#), with this password, as soon as possible, for confirmation.

Save this message in a safe place for later use

Reply

Reply all

Forward

Subject	Correspondents
Important message from RF-OPTO	POPESCU GOPO ION
Validation of MD/CR exam from 02/05/2020	[REDACTED]
[REDACTED]	[REDACTED]

From: Me <rdamian@etti.tuiasi.ro> ★

Subject: Important message from RF-OPTO

To: [REDACTED]

Cc: Me <rdamian@etti.tuiasi.ro> ★



Laboratorul de Microunde si Optoelectronica
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Attention: POPESCU GOPO ION

The password to access the exams on the **rf-opto** server is

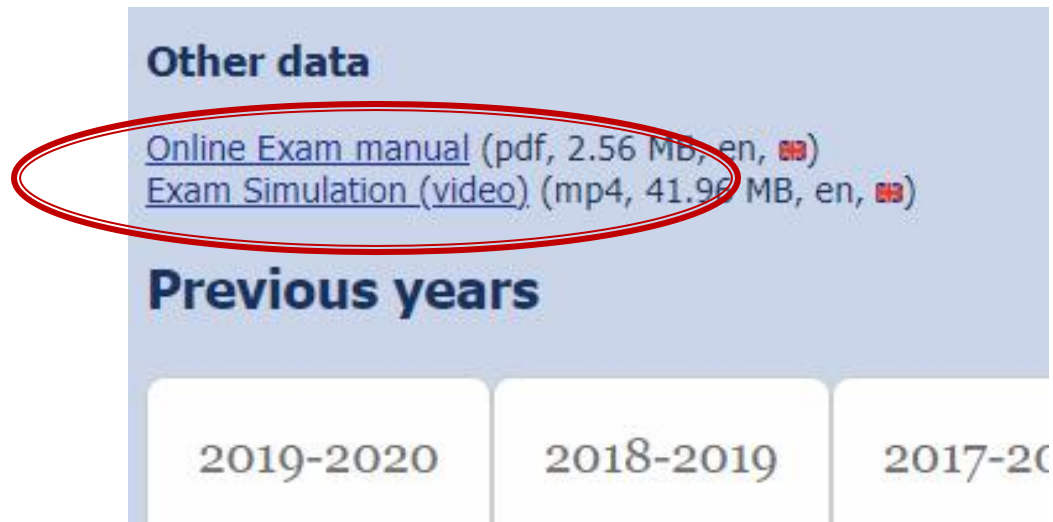
Password: [REDACTED]

Login to the [server](#), with this password, as soon as possible, for confirmation.



Save this message in a safe place for later use

Online Exam manual

- The online exam app used for:
 - lectures (attendance)
 - laboratory
 - project
 - examinations



The screenshot shows a light blue rectangular box containing the following elements:

- Other data**: A section header in bold dark blue text.
- [Online Exam manual](#) (pdf, 2.56 MB, en, ): A blue underlined link followed by file details.
- [Exam Simulation \(video\)](#) (mp4, 41.96 MB, en, ): A blue underlined link followed by file details.
- Previous years**: A section header in bold dark blue text.
- Below the header, there are three white rectangular buttons with rounded corners, each containing a year range: **2019-2020**, **2018-2019**, and **2017-20**.

A red hand-drawn oval highlights the two download links in the 'Other data' section.

Examen online

- always against a **timetable**
 - long period (lecture attendance/laboratory results)
 - short period (tests: 15min, exam: 2h)

Announcement 23:59 (10/05/2020)	Support material 00:05 (11/05/2020)	Exam Topics 00:07 (11/05/2020)	Results 00:10 (11/05/2020)	End 00:20 (15/05/2020)	Confirmation 00:20 (16/05/2020)	Next timeframe in: 05 m 43 s Refresh now
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Announcement

This is a "fake" exam, introduced to familiarize you with the server interface and to perform the necessary actions during an exam: thesis scan, selfie, use email for co

Server Time

All exams are based on the server's time zone (it may be different from local time). For reference time on the server is now:

10/05/2020 23:59:16

Online results submission

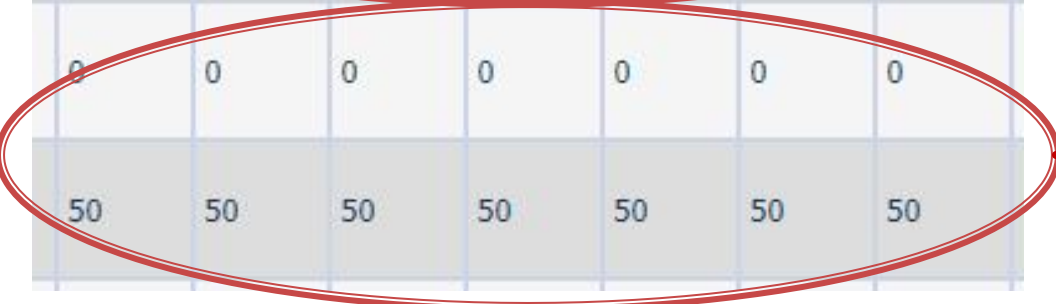
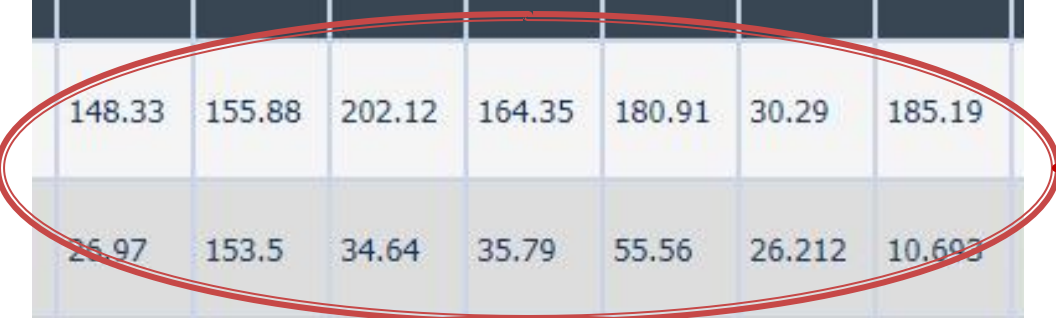
- many numerical values/files

Schema finala	Rezultate - castig	Rezultate - zgomot	Fisier justificare calcul (factor andrei)	Fisier zap (optional)	T1, fisier parametri	T2, fisier parametri	Z1	Z2	Z3	Z4	Z5	Z6	Z7	Ze1	Zo1	Ze2	Zo2	Ze3	Zo3	Ze4	Zo4	Ze5	Zo5	Ze6
86 - 5428 - 259 ...	86 - 5428 - 260 ...	86 - 5428 - 261 ...	86 - 5428 - 316 ...	-	86 - 5428 - 314 ...	86 - 5428 - 315 ...	148.33	155.88	202.12	164.35	180.91	30.29	185.19	79.9	37	68.89	45.14	61.83	45.05	57.97	46.02	61.85	45.05	68.8
86 - 5622 - 259 ...	86 - 5622 - 260 ...	86 - 5622 - 261 ...	86 - 5622 - 316 ...	86 - 5622 - 262 ...	86 - 5622 - 314 ...	86 - 5622 - 315 ...	26.97	153.5	34.64	35.79	55.56	26.212	10.693	0	0	0	0	0	0	0	0	0	0	0
86 - 5488 - 259 ...	86 - 5488 - 260 ...	86 - 5488 - 261 ...	86 - 5488 - 316 ...	86 - 5488 - 262 ...	86 - 5488 - 314 ...	86 - 5488 - 315 ...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86 - 5391 - 259 ...	86 - 5391 - 260 ...	86 - 5391 - 261 ...	86 - 5391 - 316 ...	-	-	-	50	50	50	50	50	50	50	70.14	40.39	61.85	44.59	55.7	45.2	54.89	45.38	58.65	45.8	70.0
86 - 5664 - 259 ...	86 - 5664 - 260 ...	86 - 5664 - 261 ...	86 - 5664 - 316 ...	-	86 - 5664 - 314 ...	86 - 5664 - 315 ...	168.02	150.5	178.28	133.75	92.12	121.67	144.48	94.36	36.19	70.77	42.56	65.69	42.05	55.17	42.29	65.59	42.05	70.7
86 - 5665 - 259 ...	86 - 5665 - 260 ...	86 - 5665 - 261 ...	86 - 5665 - 316 ...	-	86 - 5665 - 314 ...	86 - 5665 - 315 ...	162.2	80.8	209.2	140.85	135.1	183.7	167.6	94.58	36.15	78.16	39.77	65.57	45.05	65.57	45.05	78.16	39.77	94.5
86 - 5433 - 259 ...	86 - 5433 - 260 ...	86 - 5433 - 261 ...	86 - 5433 - 316 ...	-	86 - 5433 - 314 ...	86 - 5433 - 315 ...	165.138	106.228	226.157	130.134	72.71	180.177	164.616	101.36	36.11	77.22	42.49	68.02	45.62	60	45.42	68.02	45.62	77.2
86 - 5608 - 259 ...	86 - 5608 - 260 ...	86 - 5608 - 261 ...	86 - 5608 - 316 ...	-	86 - 5608 - 314 ...	86 - 5608 - 315 ...	150.84	152.5	30.94	32.37	54.36	19.837	29.85	64.14	40.145	54.32	46.32	53.8	46.7	53.8	46.7	54.32	46.32	54.9
86 - 5555 - 259 ...	86 - 5555 - 260 ...	86 - 5555 - 261 ...	86 - 5555 - 316 ...	-	86 - 5555 - 314 ...	86 - 5555 - 315 ...	168.001	150.288	178.399	133.115	92.491	121.257	144.126	97.05	36.16	71.13	43.09	65.45	42.12	55.66	42.18	65.45	42.12	71.1

Online results submission

- many numerical values

	Z1	Z2	Z3	Z4	Z5	Z6	Z7
	148.33	155.88	202.12	164.35	180.91	30.29	185.19
	25.97	153.5	34.64	35.79	55.56	26.212	10.693
	0	0	0	0	0	0	0
	50	50	50	50	50	50	50



Online results submission

Grade = Quality of the work +
+ Quality of the submission

Course Objectives 4



“Engineering”
Sinapses



Course Topics

- Transmission lines
- Impedance matching and tuning
- Directional couplers
- Power dividers
- Microwave amplifier design
- Microwave filters
- ~~■ Oscillators and mixers?~~

Textbooks

- <http://rf-opto.etti.tuiasi.ro>
- Irinel Casian-Botez: "Microunde vol. 1: Proiectarea de circuit", Ed. TEHNOPRES, 2008
- **David Pozar**, Microwave Engineering, Wiley; 4th edition , 2011, ISBN : 978-1-118-29813-8 (E), ISBN : 978-0-470-63155-3 (P)

Examen: Logarithmic scales

$$\text{dB} = 10 \cdot \log_{10} (P_2 / P_1)$$

$$0 \text{ dB} = 1$$

$$+ 0.1 \text{ dB} = 1.023 (+2.3\%)$$

$$+ 3 \text{ dB} = 2$$

$$+ 5 \text{ dB} = 3$$

$$+ 10 \text{ dB} = 10$$

$$-3 \text{ dB} = 0.5$$

$$-10 \text{ dB} = 0.1$$

$$-20 \text{ dB} = 0.01$$

$$-30 \text{ dB} = 0.001$$

$$\text{dBm} = 10 \cdot \log_{10} (P / 1 \text{ mW})$$

$$0 \text{ dBm} = 1 \text{ mW}$$

$$3 \text{ dBm} = 2 \text{ mW}$$

$$5 \text{ dBm} = 3 \text{ mW}$$

$$10 \text{ dBm} = 10 \text{ mW}$$

$$20 \text{ dBm} = 100 \text{ mW}$$

$$-3 \text{ dBm} = 0.5 \text{ mW}$$

$$-10 \text{ dBm} = 100 \mu\text{W}$$

$$-30 \text{ dBm} = 1 \mu\text{W}$$

$$-60 \text{ dBm} = 1 \text{ nW}$$

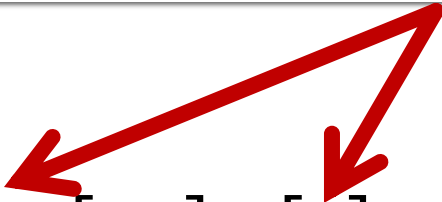
$$[\text{dBm}] + [\text{dB}] = [\text{dBm}]$$

$$[\text{dBm/Hz}] + [\text{dB}] = [\text{dBm/Hz}]$$

$$[x] + [\text{dB}] = [x]$$

Computing powers

$$\text{Loss} = \frac{P_{out}}{P_{in}} < 1$$


$$\text{Loss[dB]} = [-] 10 \cdot \log_{10} \left(\frac{P_{out}}{P_{in}} \right)$$

$$\text{Gain} = \frac{P_{out}}{P_{in}} > 1$$

$$\text{Gain[dB]} = 10 \cdot \log_{10} \left(\frac{P_{out}}{P_{in}} \right)$$

Computing powers

$$\text{Loss} = \frac{P_{out}}{P_{in}} \quad \text{Loss[dB]} = [-] 10 \cdot \log_{10} \left(\frac{P_{out}}{P_{in}} \right)$$

$$\text{Loss[dB]} = [-] 10 \cdot \log_{10} \left(\frac{P_{out}}{P_0} \cdot \frac{P_0}{P_{in}} \right) = [-] 10 \cdot \left[\log_{10} \left(\frac{P_{out}}{P_0} \right) - \log_{10} \left(\frac{P_{in}}{P_0} \right) \right]$$

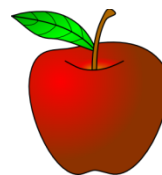
$$\text{Loss[dB]} = [-] (P_{out} [\text{dBm}] - P_{in} [\text{dBm}])$$



=



-

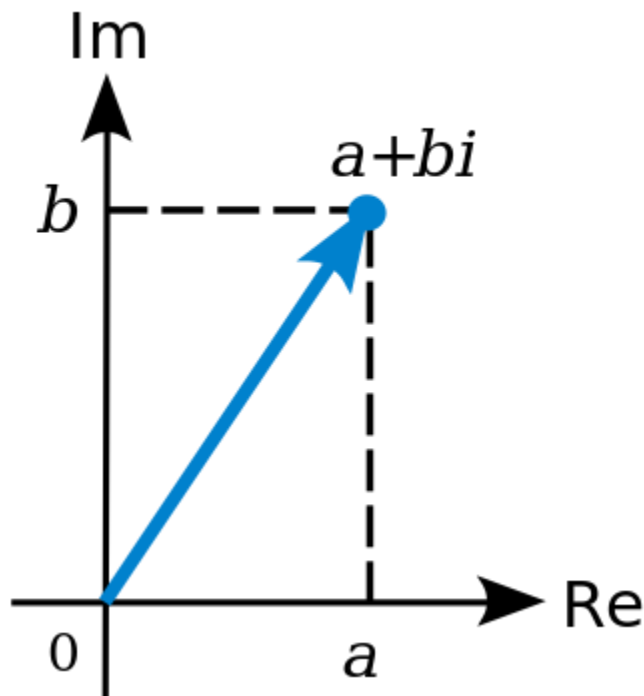


Examen

- Complex numbers arithmetic!!!!
- $z = a + j \cdot b ; j^2 = -1$

Complex plane

- abscissa – real part
- ordinate – imaginary part
- any of them can be negative, whole plane, 4 quadrants



Elementary operations

- Addition

$$z + w = (a + j \cdot b) + (c + j \cdot d) = (a + c) + j \cdot (b + d)$$

- Subtraction

$$z - w = (a + j \cdot b) - (c + j \cdot d) = (a - c) + j \cdot (b - d)$$

- Multiplication

$$z \cdot w = (a + j \cdot b) \cdot (c + j \cdot d) = (a \cdot c - b \cdot d) + j \cdot (b \cdot c + a \cdot d)$$

- Division

$$z / w = \frac{a + j \cdot b}{c + j \cdot d} = \frac{(a + j \cdot b) \cdot (c - j \cdot d)}{(c + j \cdot d) \cdot (c - j \cdot d)} = \left(\frac{a \cdot c + b \cdot d}{c^2 + d^2} \right) + j \cdot \left(\frac{b \cdot c - a \cdot d}{c^2 + d^2} \right)$$

Conjugate

- z $z = a + j \cdot b$
- z^* $z^* = a - j \cdot b$
- Symmetry over the real axis

$$\operatorname{Re}(z) = a = \frac{1}{2} \cdot (z + z^*)$$

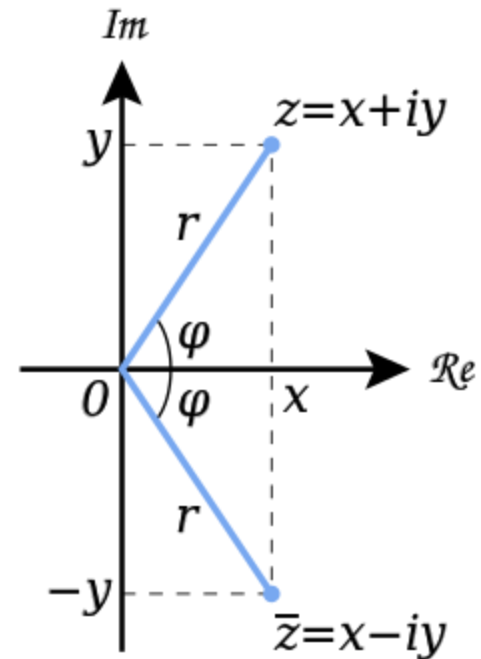
$$\operatorname{Im}(z) = b = \frac{1}{2 \cdot j} \cdot (z - z^*) = \frac{j}{2} \cdot (z^* - z)$$

$$(z + w)^* = z^* + w^*$$

$$(z - w)^* = z^* - w^*$$

$$(z \cdot w)^* = z^* \cdot w^*$$

$$(z / w)^* = z^* / w^*$$

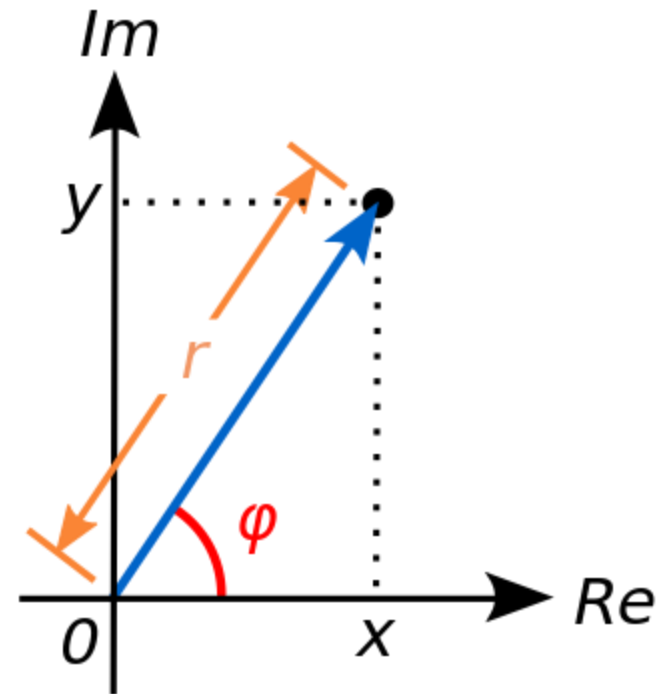


Polar representation

- Polar representation
 - modulus
 - phase relative to the real axis

$$z = a + j \cdot b = |z| \cdot (\cos \varphi + j \cdot \sin \varphi)$$

$$|z| = \sqrt{a^2 + b^2}$$
$$\varphi = \arg(z) = \begin{cases} \arctan\left(\frac{b}{a}\right), & a > 0 \\ \arctan\left(\frac{b}{a}\right) + \pi, & a < 0, b \geq 0 \\ \arctan\left(\frac{b}{a}\right) - \pi, & a < 0, b < 0 \\ \frac{\pi}{2}, -\frac{\pi}{2}, \text{nedefinit} & a = 0 \end{cases}$$



Polar representation

■ Euler's formula

$$e^{j \cdot x} = \cos x + j \cdot \sin x; \forall x \in R$$

■ Polar representation

$$z = a + j \cdot b = |z| \cdot e^{j \cdot \varphi}$$

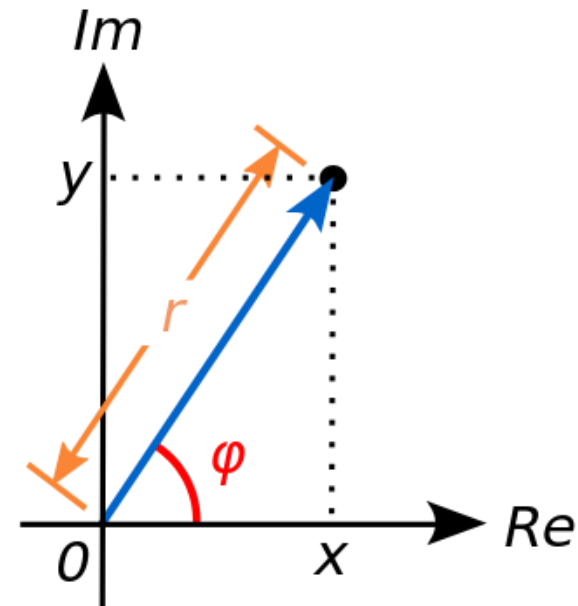
$$z = a + j \cdot b = |z| \cdot (\cos \varphi + j \cdot \sin \varphi)$$

$$z^n = (|z| \cdot e^{j \cdot \varphi})^n = |z|^n \cdot e^{j \cdot n \cdot \varphi} = |z|^n \cdot [\cos(n \cdot \varphi) + j \cdot \sin(n \cdot \varphi)]$$

$$\sqrt{z} = (|z| \cdot e^{j \cdot \varphi})^{1/2} = \sqrt{|z|} \cdot e^{j \cdot \frac{\varphi}{2}} = \sqrt{|z|} \cdot \left(\cos \frac{\varphi}{2} + j \cdot \sin \frac{\varphi}{2} \right)$$

$$z \cdot w = |z| \cdot e^{j \cdot \varphi} \cdot |w| \cdot e^{j \cdot \theta} = |z| \cdot |w| \cdot e^{j \cdot (\varphi + \theta)} = |z| \cdot |w| \cdot [\cos(\varphi + \theta) + j \cdot \sin(\varphi + \theta)]$$

$$z/w = \frac{|z| \cdot e^{j \cdot \varphi}}{|w| \cdot e^{j \cdot \theta}} = \frac{|z|}{|w|} \cdot e^{j \cdot \varphi} \cdot e^{-j \cdot \theta} = \frac{|z|}{|w|} \cdot [\cos(\varphi - \theta) + j \cdot \sin(\varphi - \theta)]$$

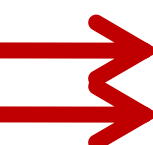


Polar representation

■ Polar representation

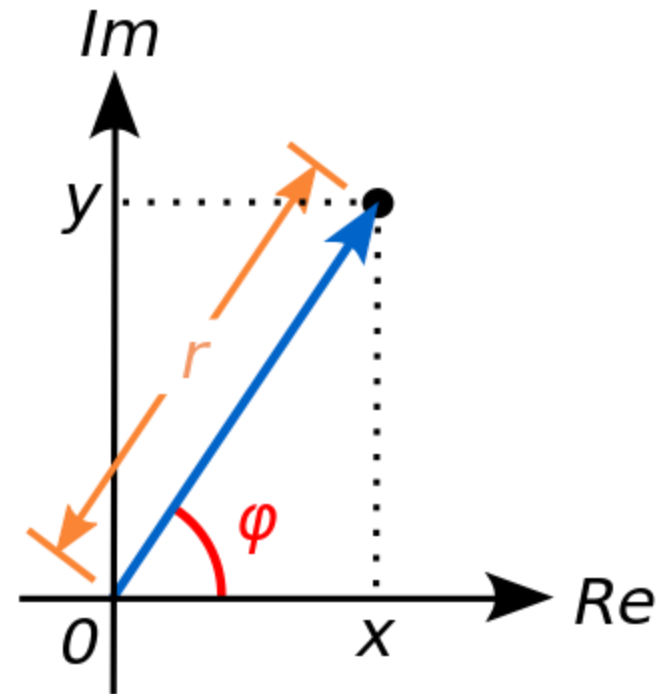
$$|z| = \sqrt{a^2 + b^2}$$

$$|z|^2 = z \cdot z^*$$


$$|e^{j \cdot x}| = |\cos x + j \cdot \sin x| = \sqrt{\cos^2 x + \sin^2 x} = 1$$

$$|e^{j \cdot x}| = 1; \quad \forall x \in R$$

$$\begin{aligned} z^* &= (|z| \cdot e^{j \cdot \varphi})^* = |z| \cdot (\cos \varphi + j \cdot \sin \varphi)^* = |z| \cdot (\cos \varphi - j \cdot \sin \varphi) = \\ &= |z| \cdot [\cos(-\varphi) + j \cdot \sin(-\varphi)] = |z| \cdot e^{-j \cdot \varphi} \end{aligned}$$



Polar representation

- standard unit for angles – radians
- microwaves traditional unit for angles – **degrees in decimal notation** (55.89°)

$$\varphi = \arg(z) = \begin{cases} \arctan\left(\frac{b}{a}\right), & a > 0 \\ \arctan\left(\frac{b}{a}\right) + \pi, & a < 0, b \geq 0 \\ \arctan\left(\frac{b}{a}\right) - \pi, & a < 0, b < 0 \\ \frac{\pi}{2}, -\frac{\pi}{2}, \text{undefined} & a = 0 \end{cases}$$

$$\varphi[^\circ] = 180^\circ \cdot \frac{\varphi[\text{rad}]}{\pi} \qquad \varphi[\text{rad}] = \pi \cdot \frac{\varphi[^\circ]}{180^\circ}$$

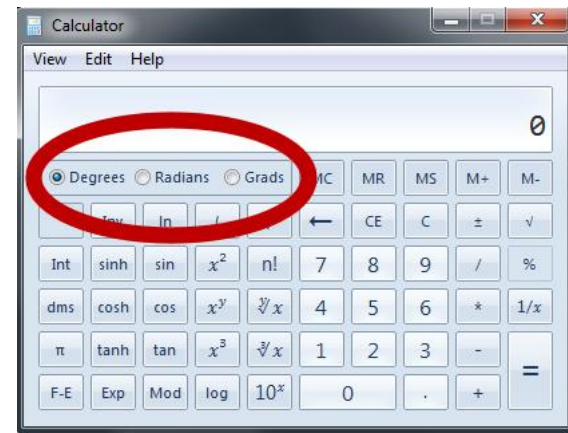
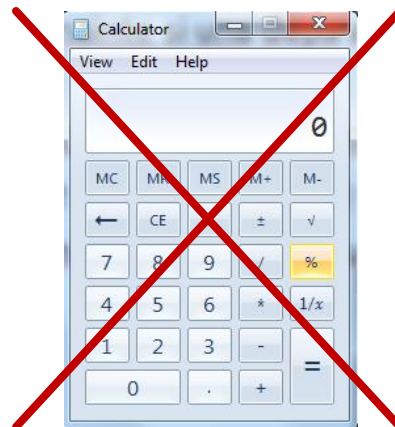


Polar representation

- **Attention to angle numerical values!!**
 - math software – work in standard unit: radians
 - a **conversion** is necessary before and after using a trigonometric function (sin, cos, tan, atan, tanh)
 - scientific calculators have the built-in option of choosing the angle unit
 - always **double check** current working unit

$$\varphi[^\circ] = 180^\circ \cdot \frac{\varphi[rad]}{\pi}$$

$$\varphi[rad] = \pi \cdot \frac{\varphi[^\circ]}{180^\circ}$$



Contact

- Microwave and Optoelectronics Laboratory
- <http://rf-opto.etti.tuiasi.ro>
- rdamian@etti.tuiasi.ro