**SRM Institute of Science and Technology**
**College of Engineering and Technology**
**DEPARTMENT OF ECE**
SRM Nagar, Kattankulathur – 603203, Chengalpattu District, TamilNadu
**Academic Year: 2023-24 (EVEN)**

| BATCH-2 |
|---|
| SET-C |

**Test:** CLA-T1 **Date:** xx-Feb-2024
**Course Code & Title:** 21ECC202T – Analog and Integrated Electronic Circuits **Time:** 12:30 to 01:20 P.M
**Year & Sem:** 2nd Year / 4th Sem / B.Tech / ECE **Max. Marks:** 25

| Course Articulation Matrix | | Program Outcomes (POs) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Graduate Attributes | | | | | | | | | | | | PSOs | | |
| **COs** | *At the end of this course, learners will be able to:* | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **1** | **2** | **3** |
| **CO-1:** | Apply the small-signal equivalent circuit in the analysis of single and multistage transistor amplifier circuits | 2 | 2 | 3 | | - | - | - | - | - | - | - | - | - | - | 3 |
| **CO-2:** | Infer the DC and AC characteristics of the operational amplifier | 2 | 2 | 3 | | - | - | - | - | - | - | - | - | - | - | 3 |
| **CO-3:** | Classify and identify the suitable feedback topologies and oscillators | 2 | 2 | 3 | | - | - | - | - | - | - | - | - | - | - | 3 |
| **CO-4:** | Elucidate and design linear and non-linear applications of op-amp | 2 | 2 | 3 | | - | - | - | - | - | - | - | - | - | - | 3 |
| **CO-5:** | Illustrate the function of application-specific ICs | 2 | 2 | 3 | | - | - | - | - | - | - | - | - | - | - | 3 |

## Part – A (5 x 1 = 5 Marks)
## Answer ALL the following questions

| | Marks | BL | CO | PO |
|---|---|---|---|---|
| 1. A small-signal amplifier<br>(a) always has an output signal in the mV range.<br>(b) uses only a small portion of its load line.<br>(c) goes into saturation once in each input cycle.<br>(d) refers to a multi-stage amplifier. | 1 | 2 | 1 | 1 |
| 2. Each stage of a four-stage amplifier has a voltage gain of 15. The overall voltage gain is<br>(a) 94.1 dB<br>(b) 19.4 dB<br>(c) 35.6 dB<br>(d) 69.1 dB | 1 | 3 | 1 | 2 |
| 3. A certain common-source amplifier has a voltage gain of 50. If the source bypass capacitor is removed,<br>(a) the transconductance will increase<br>(b) the transconductance will decrease<br>(c) the voltage gain will increase<br>(d) the voltage gain will decrease | 1 | 3 | 1 | 2 |
| 4. The common-gate (CG) amplifier differs from both the CS and CD configurations in that it has a<br>(a) much higher voltage gain<br>(b) much lower voltage gain<br>(c) much higher input resistance<br>(d) much lower input resistance | 1 | 4 | 1 | 2 |
| 5. A certain FET has a $g_m$=4 mS, internal $r`_{ds}$=10 KΩ and external $R_D$=1.5 KΩ. What is the voltage gain of the FET including the effect of $r`_{ds}$?<br>(a) 6<br>(b) 40<br>(c) 5.2<br>(d) 46 | 1 | 3 | 1 | 2 |

## Part – B (2 x 4 = 8 Marks)
## Answer ANY 2 of the following questions

| | Marks | BL | CO | PO |
|---|---|---|---|---|
| 6. Sketch the circuit of a two-stage direct-coupled BJT amplifier using a common-emitter input stage and an emitter-follower output stage. Discuss the circuit operation. | 4 | 3 | 1 | 2 |

| | | Marks | BL | CO | PO |
|---|---|---|---|---|---|
| 7. | Discuss the effect of coupling capacitors, bypass capacitors and internal transistor capacitances on the frequency response of an amplifier. | 4 | 2 | 1 | 1 |
| 8. | Sketch the low- and mid-frequency equivalent circuit for a MOSFET. Identify all the components and briefly explain how the equivalent circuit represents the device. | 4 | 3 | 1 | 2 |

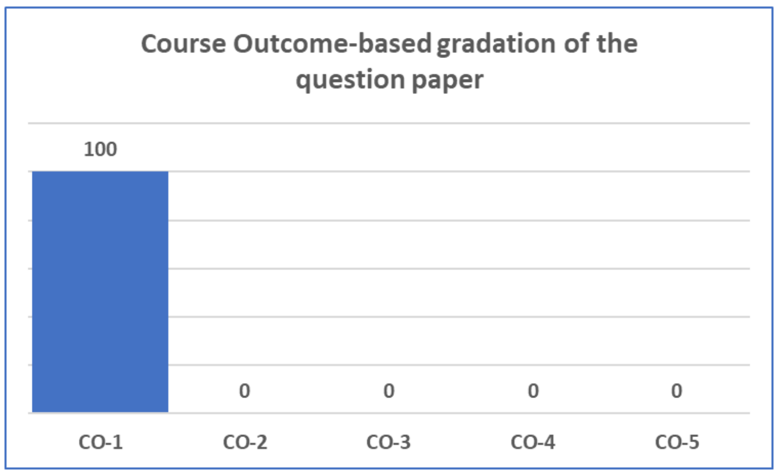
**Part – C (1 x 12 = 12 Marks)**
**Answer ANY 1 of the following question**

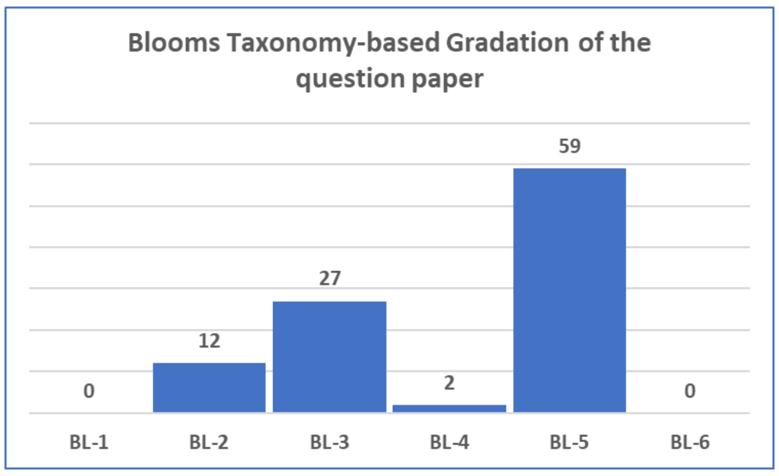
9.a. The emitter-follower circuit has $R_B$=74 KΩ, $R_E$=750Ω, $R_L$=5 KΩ, $r_s$=200Ω, $V_{CC}$=18V and $V_{BE}$=0.7V. Assume $\beta_F$=100 and $V_A=\infty$ — Marks: 12, BL: 5, CO: 1, PO: 3
- (i) Derive expressions for the input resistance $R_{in}$, output resistance $R_{out}$, voltage gain $A_v$ and current gain $A_i$.
- (ii) Find the Q-point defined by $I_B$, $I_C$ and $V_{CE}$, and the small-signal parameters $g_m$ and $r_\pi$.
- (iii) Calculate Rin, Rout, Av and Ai values.

[or]

9.b. The source-follower circuit has $R_1$=700 KΩ, $R_2$=300 KΩ, $R_S$=10KΩ, $R_L$=20 KΩ, $r_s$=50Ω, $V_{DD}$=15V, $C_1=C_2=\infty$, $V_A=\infty$, $k_n=1mA/V^2$. and $V_t$=1.7V. Assume $\beta_F$=100 and $V_A=\infty$. — Marks: 12, BL: 5, CO: 1, PO: 3
- (i) Derive expressions for the input resistance $R_{in}$, output resistance $R_{out}$ and voltage gain $A_v$.
- (ii) Determine $I_D$, $V_{GS}$, $V_{DS}$ and $g_m$.
- (iii) Calculate the values for $R_{in}$, $R_{out}$ and $A_v$.

## Course Outcome (CO) and Bloom's Level (BL) Coverage in Questions




## Evaluation Sheet

**Name of the Student:**

**Register No.:**

| Q. No. | CO | PO | Max. Marks | Marks Scored | Total Marks |
|---|---|---|---|---|---|
| **Part-A (5 x 1 = 5 marks)** | | | | | |
| 1. | CO-1 | PO-1 | 1 | | |
| 2. | CO-1 | PO-2 | 1 | | |
| 3. | CO-1 | PO-2 | 1 | | |
| 4. | CO-1 | PO-2 | 1 | | |
| 5. | CO-1 | PO-2 | 1 | | |
| **Part-B (2 x 4 = 8 marks)** | | | | | |
| 6. | CO-1 | PO-2 | 4 | | |
| 7. | CO-1 | PO-1 | 4 | | |
| 8. | CO-1 | PO-2 | 4 | | |
| **Part-C (1 x 12 = 12 marks)** | | | | | |
| 9.a. | CO-1 | PO-3 | 12 | | |
| 9.b. | CO-1 | PO-3 | 12 | | |
| | | | | **Grand Total** | |

| CO | Max. Marks | Marks Scored |
|---|---|---|
| **CO-1** | **25** | |
| **CO-2** | **-** | **-** |
| **CO-3** | **-** | **-** |
| **CO-4** | **-** | **-** |
| **CO-5** | **-** | **-** |
| **CO-6** | **-** | **-** |
| **Total** | **25** | |

| PO | Max. Marks | Marks Scored |
|---|---|---|
| **PO-1** | **1** | |
| **PO-2** | **12** | |
| **PO-3** | **12** | |
| **PSO-3** | **-** | **-** |
| **Total** | **25** | |

# Answer Key

**Test** : CLA-T1 **Date** : 17/2/2024

**Year & Sem** : II year / IV Sem / B.Tech / ECE **Max. Marks** : 25

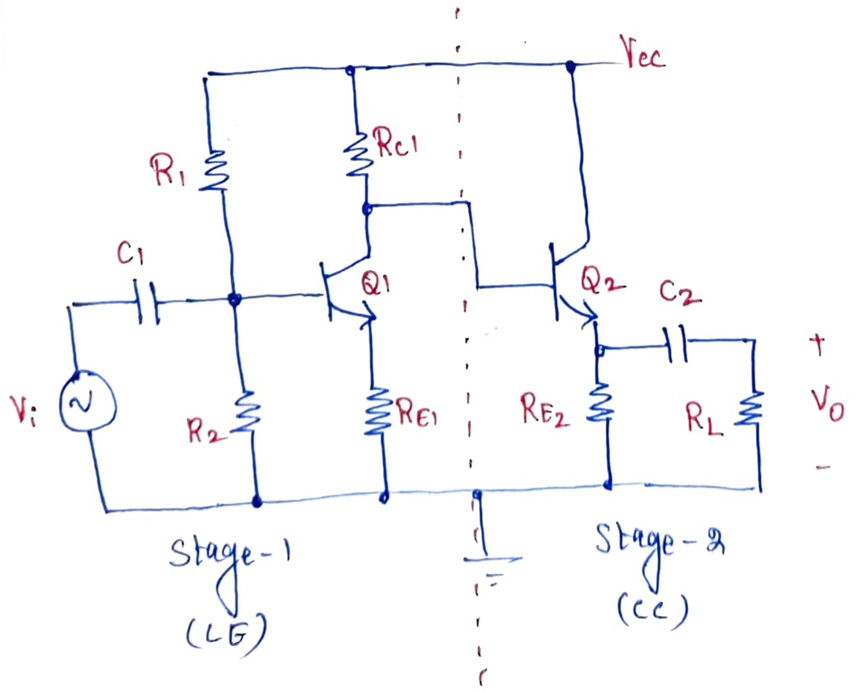
**Course** : 21ECC202T - Analog and Integrated Electronic circuits

## Part-A

1. (b) uses only a small portion of its load line
2. (a) 94.1 dB
3. (d) the voltage gain will decrease
4. (d) much lower input resistance
5. (c) 5.2

## Part-B

6. Two-Stage Direct-Coupled BJT amplifier with i/p stage as a CE ampr. and an CC ampr. as an o/p stage.



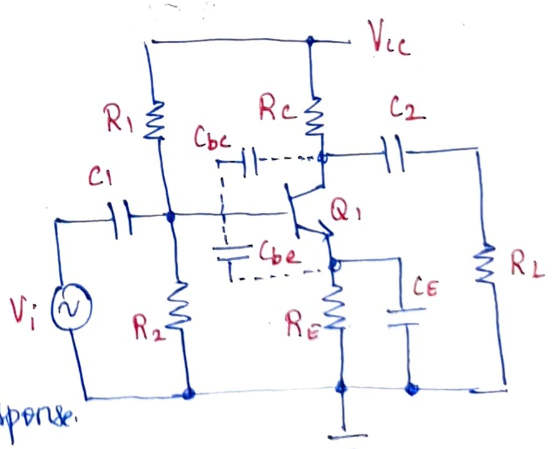
- in direct-coupled amplifiers, the o/p of one stage is directly connected to the o/p of the next stage.
- the dc biasing point of the 1st stage affects the dc conditions of the 2nd stage.
- the 1st stage is a CE amplifier that is designed to offer the maximum voltage gain.
- the 2nd stage is a cc amplifier that is designed to offer a low o/p resistance.
- if $A_{V1}$ and $A_{V2}$ are the voltage gains of the 1st & 2nd stage, respectively, then the overall voltage gain is

$$A_V = A_{V1} \times A_{V2}$$

- there will be a loading effect due to the interaction between between stages, and the effective voltage gain will be reduced.

7. Effects of the capacitive elements on an amplifier's operation.

consider a CE BJT ampr.




- $C_1$ & $C_2$ are the coupling capa.
- $C_E$ is the bypass capa.
- $C_{be}$ & $C_{bc}$ are the transistor's internal capacitances.
- The coupling & bypass capa. affect the ampr. low-freq. response.
- The internal capa. affect the ampr. high-freq. response.

When an amplifier is operating at mid-range frequencies

- the coupling and bypass capa. are considered to be ideal shorts and the internal transistor capa. are considered to be ideal opens.
- So, the effect of these capa. on the amplifier's operation are negligible.

Recall that $X_c = \frac{1}{2\pi f C}$. This formula shows that the capacitive reactance varies inversely with frequency.

At lower frequencies,

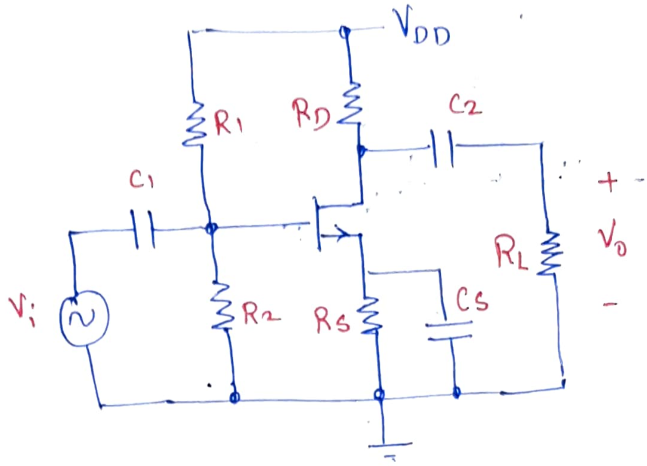
- the reactances of the coupling and bypass capacitors ~~do~~ increases with decreasing frequency, and hence, these capacitors can no longer be considered as shorts because their rectances are large enough to cause a significant signal drop across these capacitors, thus reducing the voltage gain.

At higher frequencies,

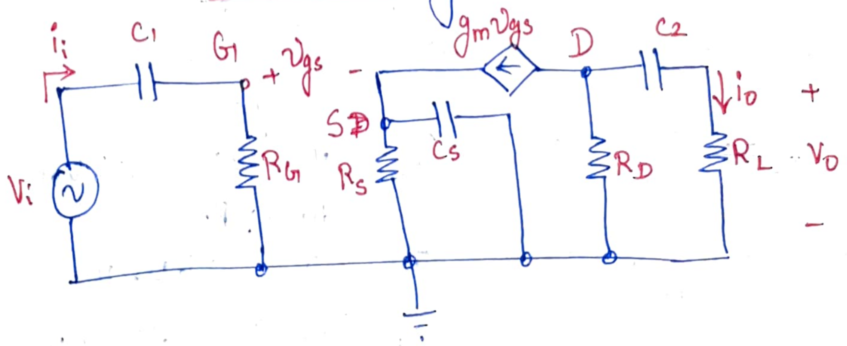
- the coupling and bypass capa. become effective ac shorts and do not affect the ampr. response.
- however, the transistor internal capa. can no longer ~~to~~ be considered as opens because their rectances become small enough reducing the amplifier's gain.

8. Small-Signal models of MOSFET.

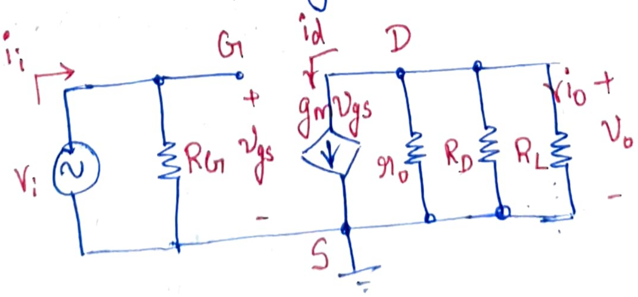
CS MOSFET amplifier




Low-Frequency Equivalent circuit

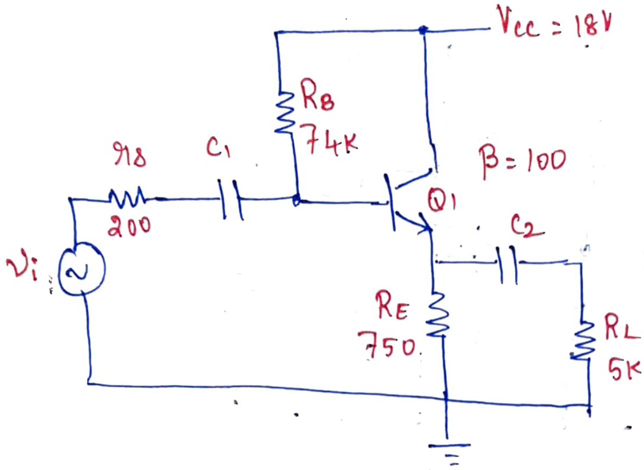



Mid-Frequency equivalent circuit

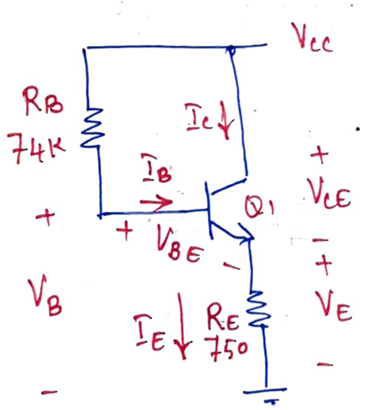


# Part-C

9.a. **Emitter follower**




## Dc operation




~~$V_B = V_{BE} + I_E R_E$~~

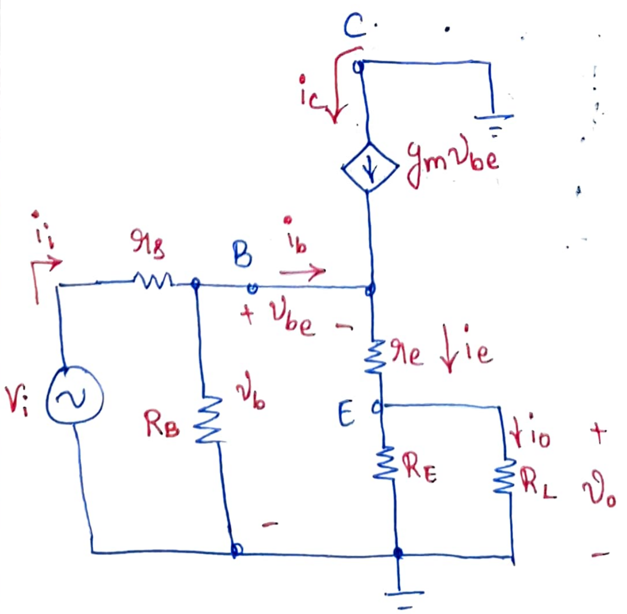
~~$\Rightarrow I_E = \frac{V_B - V_{BE}}{R_E}$~~

$$I_B = \frac{V_{cc} - V_{BE}}{R_B + \beta R_E} = 116\ \mu A$$

$$I_C = \beta I_B = 11.6\ \cancel{\mu A}\ mA$$

$$I_E = (\beta + 1) I_B = 11.72\ mA$$

## Small-signal operation




$$g_m = \frac{I_C}{V_T} = 0.446\ \frac{A}{V}$$

$$r_\pi = \frac{\beta}{g_m} = 224\ \Omega$$

$$r_e = \frac{\alpha}{g_m} \simeq \frac{1}{g_m} = 2.24\ \Omega$$

Input impedance looking into the base is

$$Z_b = \beta(r_e + R_E) = 75.22K$$

Input impedance of the amplifier is

$$R_{in} = R_B \| Z_b = 37.3\,K\Omega$$

output impedance of the amplifier is

$$R_o = r_e \| R_E = 2.23\,\Omega$$

open-circuit voltage gain (ie, excluding $R_L$) of the ampr. is

$$A_{vo} = \frac{R_E}{r_e + R_E} = 0.997$$

Voltage Gain of the ampr. including the effect of $R_L$ is

$$A_v = \frac{A_{vo} \times R_L}{R_o + R_L} = 0.9966$$

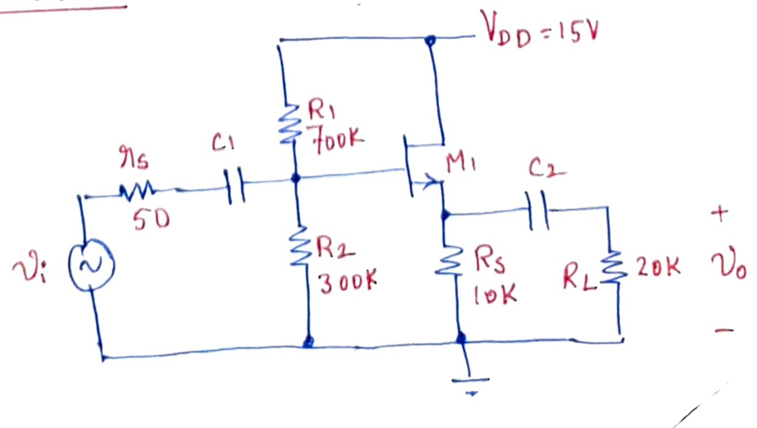
Total voltage gain of the amplifier including the effect of the internal resistance of the signal source is

$$A_{vs} = A_{vs} \times \frac{R_i}{r_s + R_i} = 0.991$$

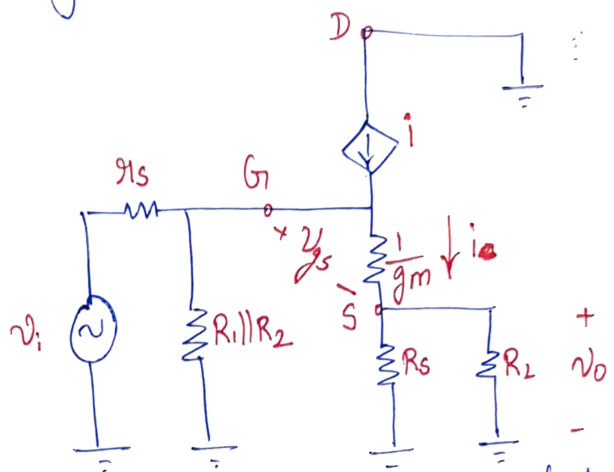
Current gain of the amplifier is

$$A_i = -(\beta + 1) = -101$$

9.b. Source Follower



## Small-Signal operation




Since $g_m$ value is not provided, the student has the freedom to choose its value. Assume a nominal value of $g_m$ as $\frac{1mA}{V}$.

Input impedance, $R_{in} = R_1 \| R_2 = 210\,K\Omega$

output impedance, $R_o = \frac{1}{g_m} \| R_S \| R_L = 869\Omega$

open-circuit voltage gain (excluding $R_L$) $A_{vo} = \dfrac{R_S}{\frac{1}{g_m} + R_S} = 0.91$

Voltage gain (including $R_L$), $A_v = \dfrac{R_S \| R_L}{\frac{1}{g_m} + (R_S \| R_L)} = 0.87$

Voltage gain (inculding $r_s$), $A_{vs} = A_v \times \dfrac{R_{in}}{r_s + R_{in}} = 0.8698$