IMPERIAL COLLEGE LONDON

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
EXAMINATIONS 2014

EEE PART II: MEng, BEng and ACGI

Corrected Copy

**ANALOGUE ELECTRONICS 2**

Wednesday, 18 June 2014 2:00pm

Time allowed: 2 hours

There are THREE questions on this paper.

ALL questions are compulsory.
Question 1 carries 40% of the marks and Questions 2 and 3 carry 30% each.

Any special instructions for invigilators and information for candidates are on page 1.

Basic expressions for voltage gain, input and output resistance for single stage amplifiers are given on the last page.

Examiners responsible    First Marker(s):    T.G. Constandinou
                             Second Marker(s):   C. Toumazou

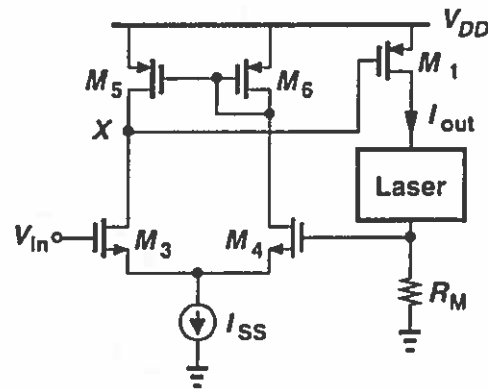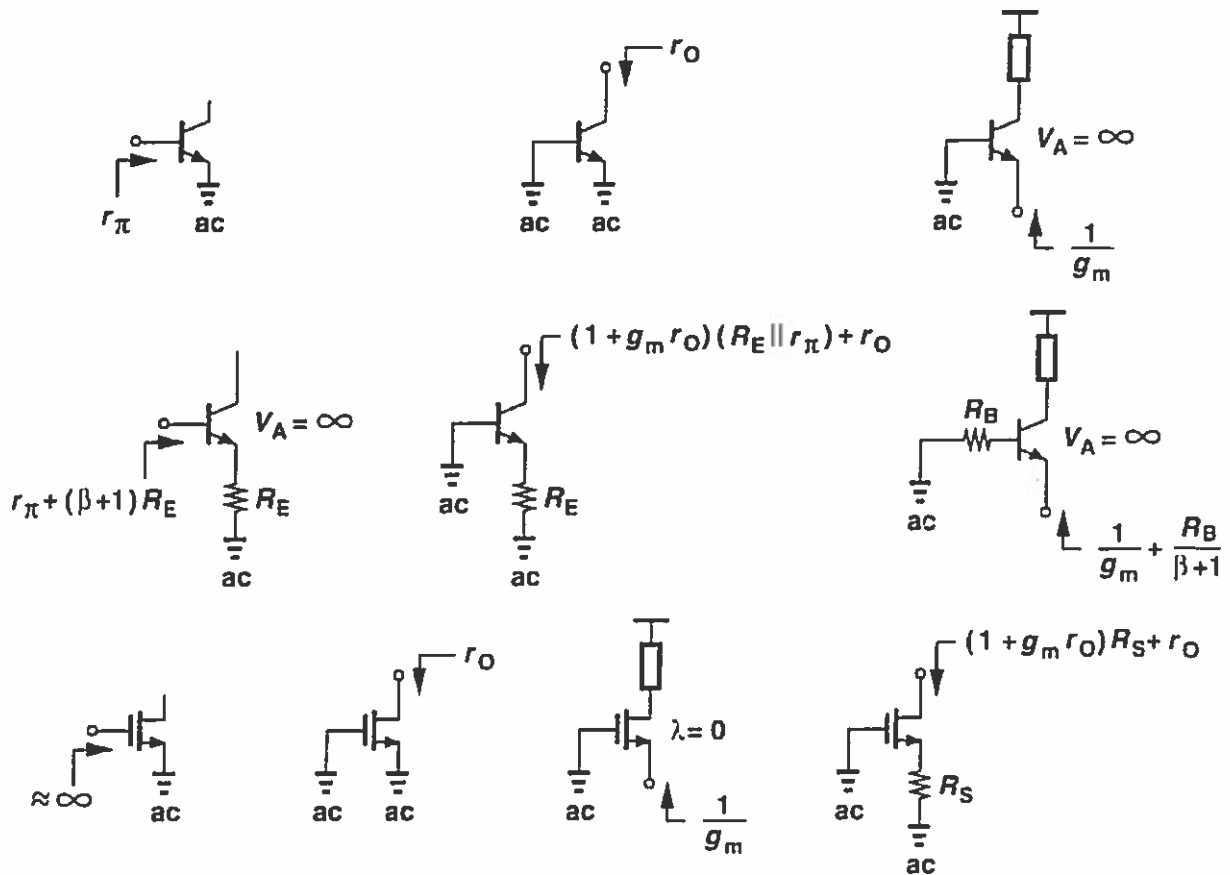2. The circuit shown below is a laser diode driver based on a transconductance amplifier with feedback.



Fig. 2.1

a) Determine the following open loop parameters of the transconductance amplifier (hint: you will need to break the loop):

(i) Open loop gain, [5]

(ii) Open loop output resistance. [5]

b) Determine expressions for the *feedback factor* and "error" signal. [5]

c) Using your answers to (a) and (b), provide an expression for the *closed loop output resistance*. [5]

d) Describe how the circuit designer can maximise the *loop gain* in this circuit. [5]

e) Explain how the resistance of $R_M$ should be selected. Given $V_{DD}$=10V and $I_{out}$=5mA, estimate a value for $R_M$, justifying your estimate. [5]

# Input and Output Impedances



$r_\pi$  ac

$\downarrow r_O$  ac  ac

$V_A = \infty$  ac  $\dfrac{1}{g_m}$

$r_\pi + (\beta+1)R_E$  $R_E$  $V_A = \infty$  ac

$\downarrow (1+g_m r_O)(R_E \| r_\pi)+r_O$  ac  $R_E$

$R_B$  $V_A = \infty$  ac  $\dfrac{1}{g_m} + \dfrac{R_B}{\beta+1}$

$\approx \infty$  ac

$\downarrow r_O$  ac  ac

$\lambda = 0$  ac  $\dfrac{1}{g_m}$

$\downarrow (1+g_m r_O)R_S + r_O$  ac  $R_S$  ac

## Voltage Gain Equations



$A_v = -g_m(R_C \| r_O)$

$A_v = -\dfrac{R_C}{\dfrac{1}{g_m} + R_E}$

$A_v = \dfrac{R_C}{\dfrac{1}{g_m} + R_E}$

$A_v = \dfrac{R_E \| r_O}{\dfrac{1}{g_m} + R_E \| r_O}$

$A_v = -g_m(R_D \| r_O)$

$A_v = -\dfrac{R_D}{\dfrac{1}{g_m} + R_S}$

$A_v = \dfrac{R_D}{\dfrac{1}{g_m} + R_S}$

$A_v = \dfrac{R_S \| r_O}{\dfrac{1}{g_m} + R_S \| r_O}$