Tampere University of Technology **DEE-34106 Converter dynamics and EMC** 19.5. 2015
Electrical Engineering
Teuvo Suntio Programmable calculator allowed 5 questions/ á 6 pts

Question 1. Explain shortly the following concepts related to the dynamics of a switched-mode converter (Note: Repeating the English words does not suffice): **a)** SSA method, **b)** two-port model, **c)** state space, **d)** PI, **e)** PCM-control, and **f)** DDR-control. (á 1pt)

Question 2. Fig. 1 shows an electrical equivalent circuit representing the dynamics of a certain class of switched-mode converters. Define symbolically based on Fig. 1 **a)** $Z_{\text{o-o}}$, **b)** $Z_{\text{in-o}}$, and **c)** $T_{\text{oi-o}}$ (Each subquestion gives 2 pts).

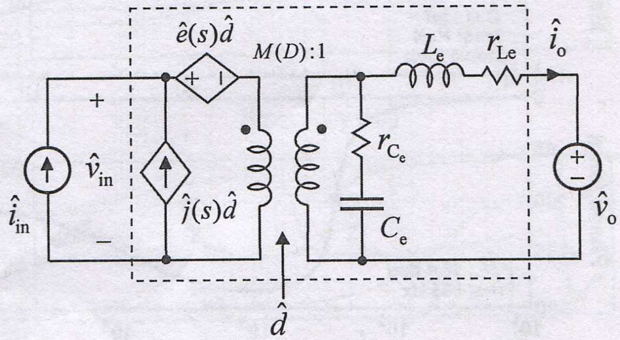

Fig. 1.

Question 3. A control-block diagram representing a generalized closed-loop input dynamics of an input-side-controlled converter is given in Fig. 2. **a)** Define the equation for the feedback-loop gain (L_{in}) using the symbols of Fig. 2, **b)** Define symbolically the closed-loop $\hat{y}_{\text{in}} / \hat{u}_{\text{in}}$, and **c)** Define symbolically $\hat{y}_{\text{in}} / \hat{u}_{\text{r-in}}$. (Each subquestion gives 2 pts)

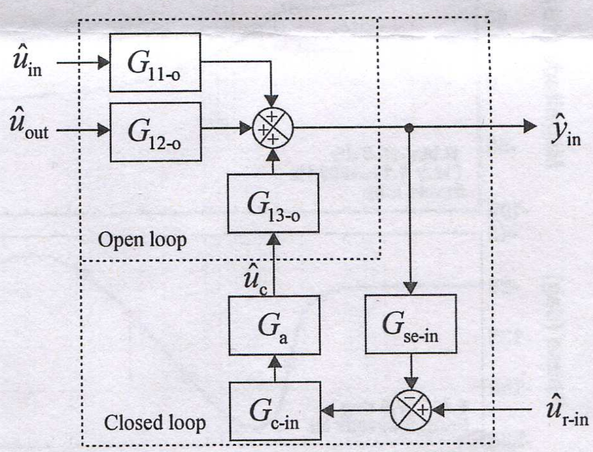

Fig. 2.

Question 4. The frequency responses of the control-to-output-voltage transfer function ($G_{\text{co-o}}$) and the output-voltage-feedback loop gain (L_{out}) of a buck converter are shown in Fig. 3a, and Fig. 3b, respectively.

a) Compute the approximate value of the output capacitor of the converter when its output inductor is 400 μH ? (2pts)
b) Evaluate the feasibility of the control design based on Fig. 3b: Why it is /Why it is not? (2pts)
c) What is the type of the used controller? I, P, PI, PID? Justify your answer! (2pts).

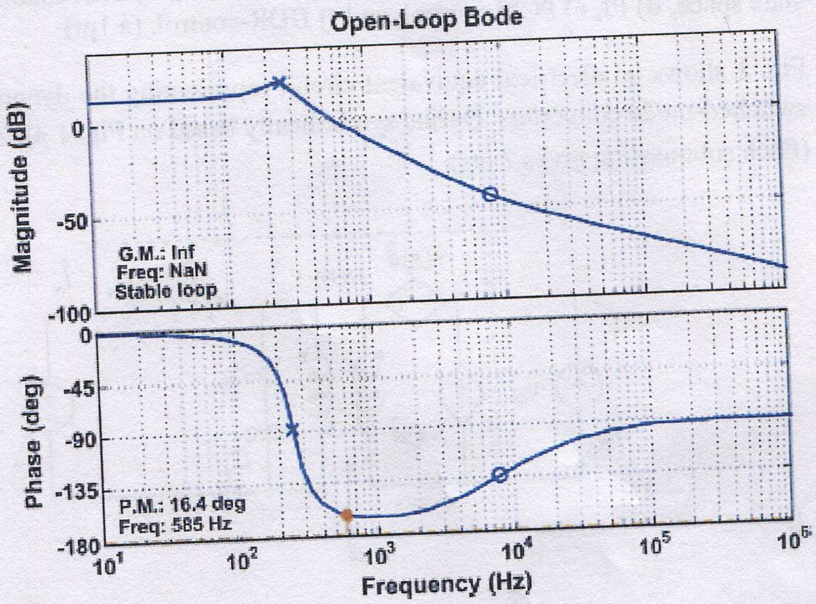

Fig. 3a.

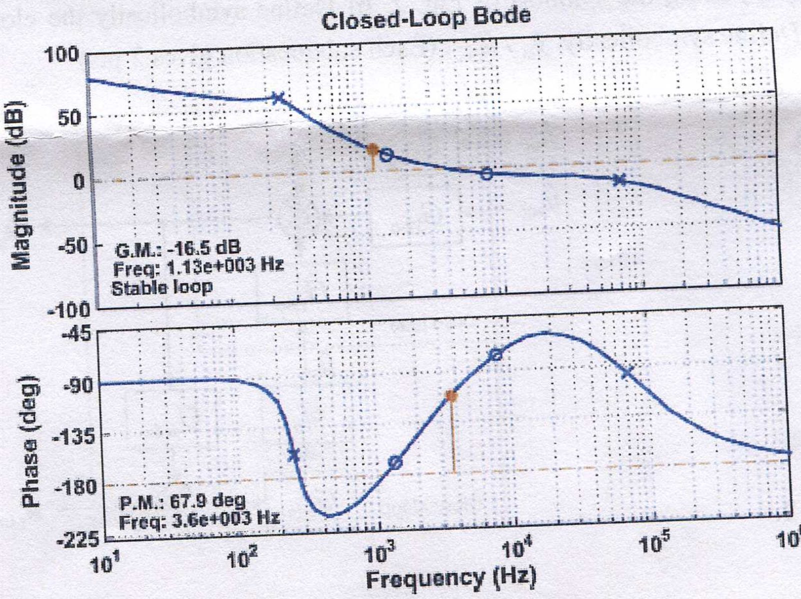

Fig. 3b.

Question 5. The measured open-loop ($Z_{\text{in-o}}$), closed-loop ($Z_{\text{in-c}}$), and short-circuit ($Z_{\text{in-sco}}$) input impedances of the output-voltage-feedback-controlled converter as well as the output impedances of the input EMI filter are given in Fig. 4. Analyze the effect of the input impedance (Z_s) of the input EMI filter on a) the stability of the converter, b) load-transient responses, and c) voltage-loop gain. Without the input filter, the converter is stable and the transient performance is excellent. Justify your thoughts based on Fig. 4 and the underlying formulas. The value of each sub-question is 2 points.

$$G_{\text{co-o}}^{S} = \frac{1+Z_s/Z_{\text{in-}\infty}}{1+Z_s/Z_{\text{in-o}}} G_{\text{co-o}} \quad Z_{\text{o-c}}^{S} = \frac{1+Z_s/Z_{\text{in-sco}}}{1+Z_s/Z_{\text{in-c}}} Z_{\text{o-c}} \quad Y_{\text{in-c}} = \frac{Y_{\text{in-o}}}{1+L_{\text{out}}} + \frac{L_{\text{out}}}{1+L_{\text{out}}} Y_{\text{in-}\infty}$$

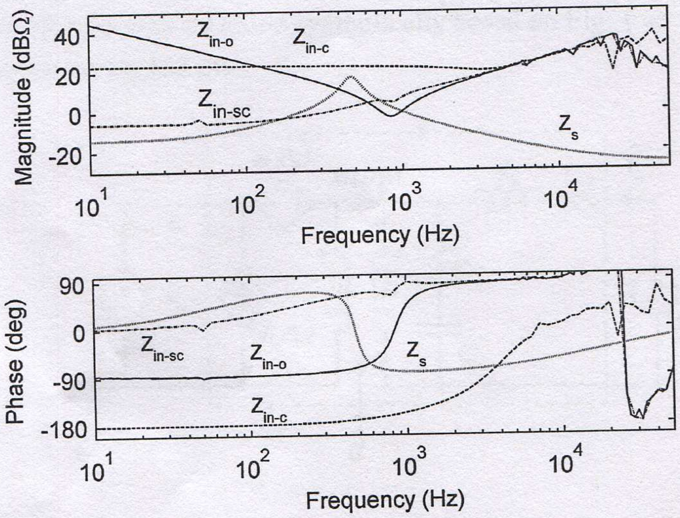

Fig. 4