7 **(a)** The EZ-Link card is a “contactless” smartcard used for payments in Singapore, especially for transportation.

Fig. 7.1 shows part of the internal circuitry and wiring of an EZ-link card. The circuitry consists of a transmitter which is connected to 3 wire loops around the edges of the card. The transmitter requires electrical energy to communicate with an external device such as a card reader. However, there is no internal power source in the card. The area of the EZ-Link card is 4.00×10^{-3} m^2.

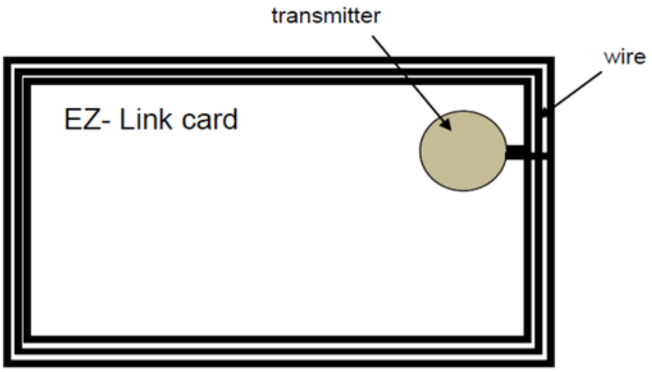

Fig. 7.1

Fig. 7.2 shows a card reader which produces a sinusoidal magnetic field of frequency 13.56×10^6 Hz.

Fig. 7.2

(i) State Faraday’s Law and Lenz’s Law.

Faraday’s Law: ……………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Lenz’s Law: ………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(ii) Using Faraday's Law, explain how electrical energy is generated to power the transmitter of the EZ-link card when it is tapped onto the card reader.

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…………………………………………………………………………………………………

………………………………………………………………………………………………. [3]

(iii) The card reader generates a magnetic field given by the equation $B = B_o \sin(2\pi ft)$.

1. Calculate the magnitude of the peak e.m.f. generated in the card in terms of B_o. Show your working clearly.

peak e.m.f. = …………………………….. B_o [3]

2. Calculate the peak magnetic flux density B_o if the card needs a r.m.s.voltage of 10.0 mV to operate.

peak magnetic flux density B_o = …………………………….. T [2]

(iv) The system is designed such that it can work if the card is tapped with either face. Explain briefly why this is possible.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(b) Explain what is meant by the *root-mean-square* (r.m.s) value of an alternating current.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(c) A hair blower used in Singapore is rated at 240 V r.m.s., 1000 W. A student plans to bring the blower to the United States of America (USA), where the voltage is 120 V r.m.s..

(i) State one advantage of having alternating current from the mains rather than direct current.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(ii) It was suggested that the student needs to bring a transformer along to USA to operate the blower.

Determine the transformer's turns ratio $\frac{N_s}{N_p}$.

$\frac{N_s}{N_p}$ = ………………………….. [1]

(iii) The primary coil of the transformer is connected to the 120 V r.m.s. supply of the USA outlet. The secondary coil is connected to the blower.

Determine the r.m.s. primary current when the blower is operating at 1000 W.

State also any assumption you have made in your working.

r.m.s. current = ………………………….. A [2]

(iv) The transformer is non-ideal and electrical energy is converted to thermal energy in the windings of the transformer at a rate of 600 W.

1. Determine the r.m.s. secondary current.

secondary current = …………………………….. A [3]

2. Calculate the efficiency of the transformer.

efficiency = …………………………….. % [1]

End of Paper