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Chapter 18 solutions

1.

(a) Since the tag transmits data once every minute, the total number of transmissions per day is given by:

[DISP]

N = 1 x 60 x 24 = 1440.

[DISPX]

[FT]The tag is operational for 20 milli-seconds per transmission when programmed in the beacon mode. Therefore, total time per day when active is given by:

[DISP]

$t_2 = N \times 20 = 28.8$ sec.

[DISPX]

[FT]The tag operates at 3V and requires 20 milli-amperes when active. Therefore, total energy consumed per day when active is given by:

[DISP]

E_{active} = 3V x 20 x t_2 = 1.728 Watt-sec.

[DISPX]

[FT]Total time in sleep state per day is given by:

[DISP]

t_1 = (24 hr x 60 min x 60 sec) – t_2 = 86400 – 28.8 = 86371.2 sec.

[DISPX]

[FT]The tag consumes 20 micro-amperes in sleep state. Therefore, total energy consumed in sleep state per day is given by:

[DISP]

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E_{sleep} = 3V x 20 x t_1 = 5.182 Watt-sec.

[DISPX]

[FT]Total energy consumed per day is given by:

[DISP]

$E_{total} = E_{active} + E_{sleep}$ = **6.91 Watt-sec**.

[DISPX]

(b) The harvester produces 300 micro-watts per cm^3 per 0.1g of source excitation. Therefore, at one g excitation the available power is:

[DISP]

P_{vib} = 10 x 300 = 3 milli-watts.

[DISPX]

[FT]Total energy consumed by the tag per day is calculated to be:

[DISP]

E_{total} = 6.91 Watt-sec.

[DISPX]

[FT]Therefore, the number of hours of sustained vibrations is:

[DISP]

$t_3 = E_{total} / (P_{vib}$ x 3600) = **0.64 hours**.

[DISPX]

[FT]Table 18.1 summarizes solution for problems 1 and 2.

Table 18.1 Power analysis summary for problems 1 and 2.

Axcess tag powered by battery	3V
Power available from vibrations/cm^3	3000 uW
Current available from vibrations (i_{source})	1000.00µA
Transmission of ID to receiver takes	20ms
Current draw during transmission (i_{active})	20mA
Energy necessary/transmission	0.0012 Watt-sec.
Number of transmissions/day	1440
Transmission time/day (t_2)	28.8 sec.
Energy necessary for transmissions (E_{active})	1.728 Watt-sec.
Idle state current draw (i_{sleep})	20 µA
Idle state time/day (t_2)	86371.2 sec.
Energy necessary for idle conditions/day (E_{deep})	5.18 Watt-sec.
Total energy reqd (idle + transmission)/day (E_{total})	6.91 Watt-sec.
Time required to gather this energy from vibrations/day (t_3)	0.64 hrs

(c) With two hours of sustained vibrations, the energy available from harvester must be:

[DISP]

$E_{harvester} \geq E_{total}$.

$\therefore P_{vib} \times 2 \times 3600 \geq 6.91$ Watt-sec

$\therefore P_{vib} \geq 0.96$ mill-Watts.

[DISPX]

[FT]For a harvester producing 3 milli-Watts per cm^3 at 1 g of source excitation, the size must be:

[DISP]

$Size \geq 0.96 / 3 \geq \mathbf{0.32\ cm^3}$.

[DISPX]

[FT]Similarly, for a harvester producing 300 micro-Watts per cm^3 at 1 g of source excitation, the size must be:

[DISP]

Size ≥ 0.96 / 0.3 ≥ **3.2 cm^3**.

[DISPX]