متحكم مؤسس على المعالج الدقيق
لتنظيم فولتية الخرج لمجهز القدرة غير المنقطع

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Microprocessor-Based Controller for the Uninterruptible Power Supply Voltage Regulation

By
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Abstract

Good regulation and stability are important factors to be considered in designing of the uninterruptible power supplies systems, which depend on the load requirements. On the other side, the cost factor roles the proper design selection of the uninterruptible power supply, especially for the commercial applications. A pulse width modulation uninterruptible power supplies are considered to have good features over the rival one.

This paper presents a suggested method for the controlling of the uninterruptible power supplies to regulate the output voltage, by using an easy practicable, low cost, and one-sensor, microprocessor-based regulator. This regulator circuit depends on minimizing the hardware complicity with efficient software. The practical results show that a good and reliable regulation performance in the applications when the fluctuation in both input DC voltage and load occurred, such as the applications using the solar cells or batteries as the input voltage source supplying variable load conditions.

قبل في 2004/12/2 **أستلم في 2004/8/10**

[illegible]

[illegible] (regulation) [illegible] (disturbance) [illegible] (UPS) [illegible] (switching conversion) [illegible] .[1] [illegible] [2] [illegible] (on-) [illegible] PWM [illegible] [3] [illegible] 25 MHz (clock frequency) [illegible] (DSP56001) DSP [illegible] (line [illegible] [4] [illegible] (Lookup tables) [illegible] 5 [illegible] (degree of freedom) [illegible] (On-line) [illegible] PWM [illegible].

[illegible].

[illegible]

[illegible] (inverters) [illegible] [5] [illegible]:

1. [illegible] (load regulation):

[illegible] (1) [illegible].

$$\text{Load reg} = \frac{\text{Vout(no-load)} - \text{Vout(full load)}}{\text{Vout(no load)}} * 100\ \% \qquad \ldots(1)$$

2. [illegible] (line regulation):

[illegible] (2) [illegible]

$$\text{Line reg} = \frac{\text{Vout (highest input)} - \text{Vout(lowest input)}}{\text{Vout(nominal)}} * 100\ \% \qquad \ldots(2)$$

[illegible] UPS [illegible]

[illegible]

[illegible] UPS [illegible] (1) [illegible]

[illegible]

[illegible]

[illegible] Intel 486 DX [illegible] (Parallel [illegible] .SIS 486 PCI/ISA(VER. C2) (mother board) [illegible] ADC [illegible] (Voltage Sensor) [illegible] . PWM [illegible] LPT1 Port) [illegible] AD573 [illegible] 10bit [illegible] ADC [illegible] (buffer) [illegible]

[illegible]

[illegible] 16 [illegible] .ISA slot [illegible] ADC [illegible] (2) [illegible] (3) [illegible] ADC [illegible] ADC [illegible] ADC [illegible] (I/O memory) [illegible] 277H [illegible] ADC [illegible] 16.8 usec [illegible] 12 [illegible] ADC $\overline{st-conv}$ [illegible] 18 [illegible] end - conv [illegible] ADC [illegible] (4) [illegible] .ADC [illegible]

[illegible] $\overline{RD}$ [illegible] 74LS244 [illegible] .(Bus) [illegible] "0" [illegible] st - conv [illegible] .7474 D-Type Flip-Flop [illegible] $\overline{st-conv}$ [illegible] D_{11} [illegible] "1" [illegible] ADC [illegible] D_{11} [illegible] (5) [illegible]

[illegible] "0" [illegible] $\overline{st-conv}$ [illegible] "0" [illegible] $\overline{st-conv}$ [illegible] (latched) [illegible] "1" [illegible] $\overline{end-conv}$ [illegible] "1" [illegible] ADC [illegible] (MSB's) [illegible] ((3) [illegible]) 16-bit select [illegible] LSByte [illegible] " 0 " [illegible] 16-bit select [illegible] " 1 " [illegible]

.10bit [illegible] ADC [illegible] 19 [illegible] 20 [illegible] . ISA-Slot [illegible] –12V [illegible] +5 [illegible] (voltage sensor) [illegible] 14 [illegible] UPS [illegible]

[illegible] .(10 Vp.p) ADC [illegible]
.50 k ohm [illegible]

ADC [illegible]

[illegible] . 10 bit [illegible] ADC [illegible] +5 [illegible] -5 [illegible] ADC [illegible]
:[illegible] ADC [illegible] (1) [illegible]

[illegible]	[illegible]	ADC [illegible]
V_{in}	0	512
$V_{in(max)}$	5	1023
$V_{in(min)}$	-5	0

[illegible] ADC [illegible] (1) [illegible]

[illegible] ADC [illegible]
:[illegible]

$$\Delta V = \frac{V_{in(\max)} - V_{in(\min)}}{2^{10} - 1} = 9.775 \text{ m}V \qquad \ldots (3)$$

[illegible] 1% [illegible] UPS [illegible]
:[illegible] ADC [illegible] V_{out}

$$\Delta reading(t) \approx \text{int}(.01 V_{out} K_v \sin(\omega t)/\Delta V) \qquad \ldots (4)$$

.(sensor gain) [illegible] K_v [illegible]

[illegible]

[illegible] SIS 486 (VER. C2) (mother board) [illegible] Intel 486 DX [illegible] (off-line) [illegible] .(PWM) [illegible] (fundamental) [illegible] .(lookup tables) [illegible] .N=12 (degree of freedom) [illegible] [6]SLN1[illegible] .PWM [illegible] 50 [illegible] .(Normal binary (NB)) [illegible] 16-bit [illegible] %100 [illegible] %50 [illegible] %1[illegible]

(51 ...)

[51*50*2-byte=5100 byte]

LPT1 (parallel Port)

.(driver circuit)

(pin) "1"

"0" (counter)

(dead time)

UPS

(sample)

(9) (6) π/2

π/2 ADC

.PWM

.PWM

PWM

ADC

(actuated (proportional control)

value)

ADC .01 (4) .01

$$\Delta reading = \mathrm{int}\left(\frac{.01*(1/3.5)*17.5\sin(2\pi 50*.0042)}{9.775m}\right) \cong 5 readings \qquad \ldots(5)$$

5 5 int(difference between readings/5) 8086 [4]

MOSFET (on-line) UPS ((10)) .IRFP150 (smooth) 6.8uF

.IRFP150 MOSFET (11) (buffer) 3507j (operational amplifier) 74LS244 PWM (source) 3601 (optocoupler) (buffer) 3507j (operational amplifier) MOSFET 10V 0.45 usec (fall time) 0.65 usec (rise time) (dead time) 4usec

(13 12) V_d (15) (14) 90% UPS PWM .R=6.9 Ω V_d=10

hʋʅʒFďĎŽlĺƐ

LJŏþŏlĺk!f NlkǖŏĂdž LJƵ ƨŏdžkŏ (PWM inverter) ƗƜhlǰ!f ƯƧƵ LJŏdžƜk ƧŏƺdžDžþƤkʅŏ ĭƦ!f UPS ù!f ƨǤnjƞ LJǫ ƘǤơƬƧdž Džƞơ Ŏ5 ƗƮǤƤĂ Ɨ5ĺƗ!f ýfƨkƤf ydž ɯƧƤ!f ƗƞĂdž Ŏ5 NlŏĂƬk!f ýŏlĺkĂ DžƗơk!f lƇǤ5Ɨ Ɨŏơ LJdž Ŏ!Ǥz!f ǤfþǕǤƕ ýǤƤþǕf Ɨŏk!Ă5 Ŏ5 ĂD ýdžơ!f Ŏ5 ƗŏƑǤƞ5!f ƘfƧŏƺkĺ! ǯʅǤʅơ LJĂƗŏ Ǖ LJD UPSù!f ƨǤnjƞ Ŏ5 Džnjdž!f LJdžĂ .ƗdžþƤkʅdž!f lƧþl!f ǤǤƺ!ǫ ƘǤŏƞŏkfƧkʅf ƘfƨŏdždžLJdž lþǤ5kʅǕf ƗŏlǰǤƗdžǫ Ơŏkŏ ƽŏpþ!f Ɲ!Ǥzdž!f DžfþƤkʅf LJǫ . LJŏƶdž ăþdž LJdžƜ lƧdžkʅdž!f Džldžƪdž!f ŎdžpƧ!f DžƗơk!f DžǤƱlǰ ƧnjƱD þl! Ă .ɯƧƤ!f Ɨŏk!Ă5 DžŏƱlǰk ýƞD LJdž ƧŏƺdžǤƕ ƽĂĂdž!f DžƗơk!f Ĭ!ǫ Ɨ5ǤƜǗǤƕ ƘǤŏl5fĂk!f LJƗdžŏ Ă .Ʀŏ5lǰk!f ƗƱǤʅƕ LJdž DžƸƧ!Ǥƕ lƧdžkʅdž!f ýǤƤþǕf Ɨŏk!Ă5 Ƨŏƺk! ǺƮǤƤ Ă Ɨ!ĂƕǏdž ƝFǤklǰ UPS ùĺ! ɯƧƤ!f Ɨŏk!Ă5 DžŏƱlǰk! ýĂƪơĺ! ɯƧƤ!f ƗƞĂdž LJƵ ƧλƗD ƘǤdžĂǏzdž ýǤƤþǫ ĬĺƵ þdžkzŏ ǂþŏlzk ƧλƗD DžǤƱlǰ! ƩǤʅǕf ƟƧkldž!f DžǤƱlǰ!f fƦNj LJĂƗŏ LJD .Ɨŏ!Ǥz!f lƧþl!f ƘfƦ ƗŏƵǤlǰƪ!f ƘǤlŏhƱk!f Ŏ5 ƗƮǤƤĂ ýƜ5D DžŏƱlǰk ĬĺƵ

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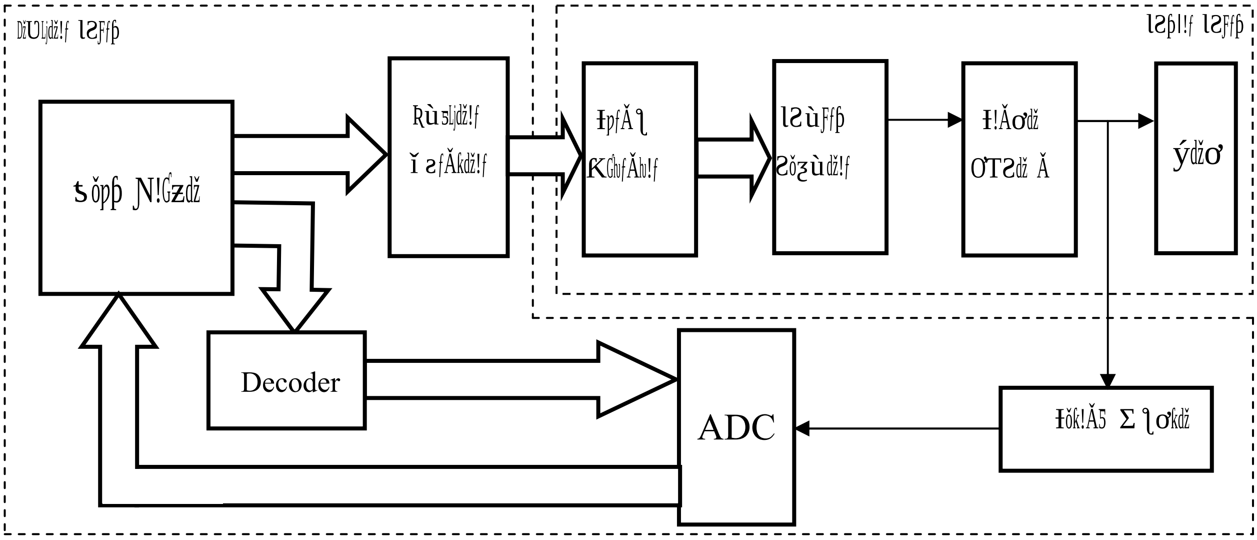
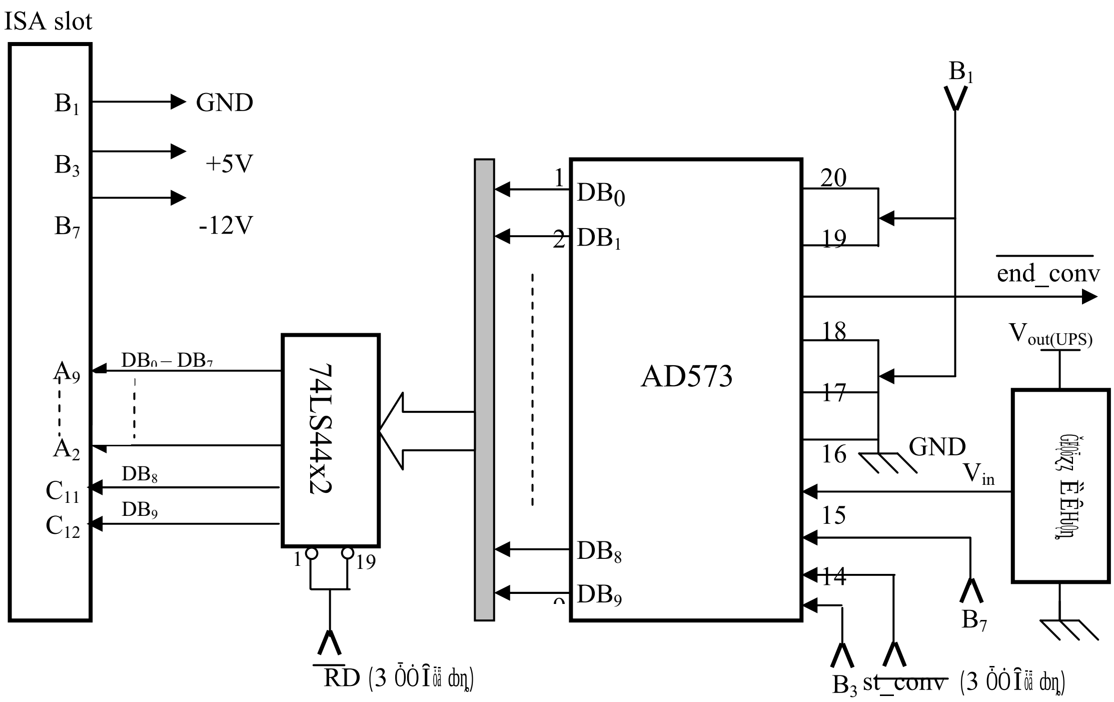
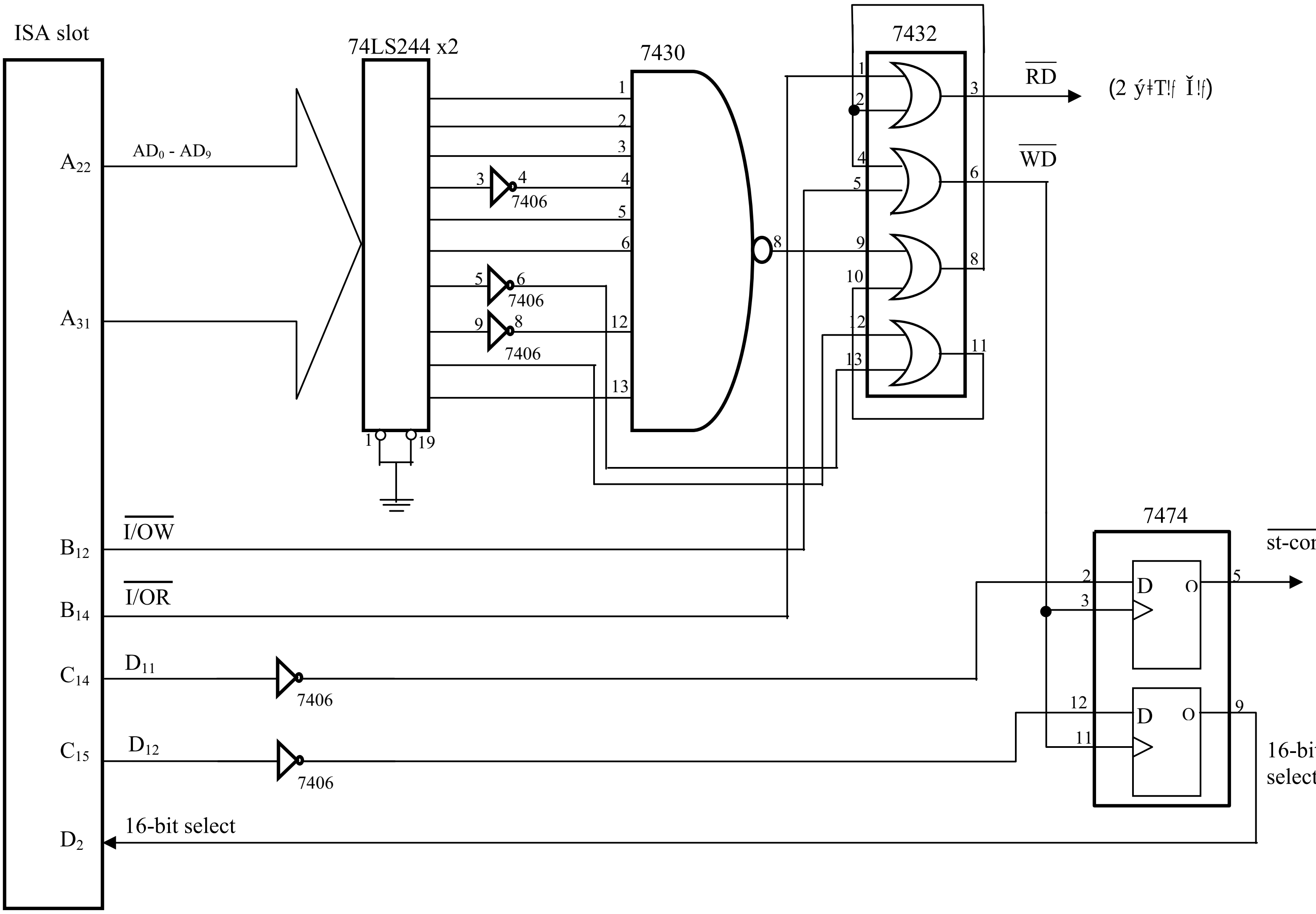


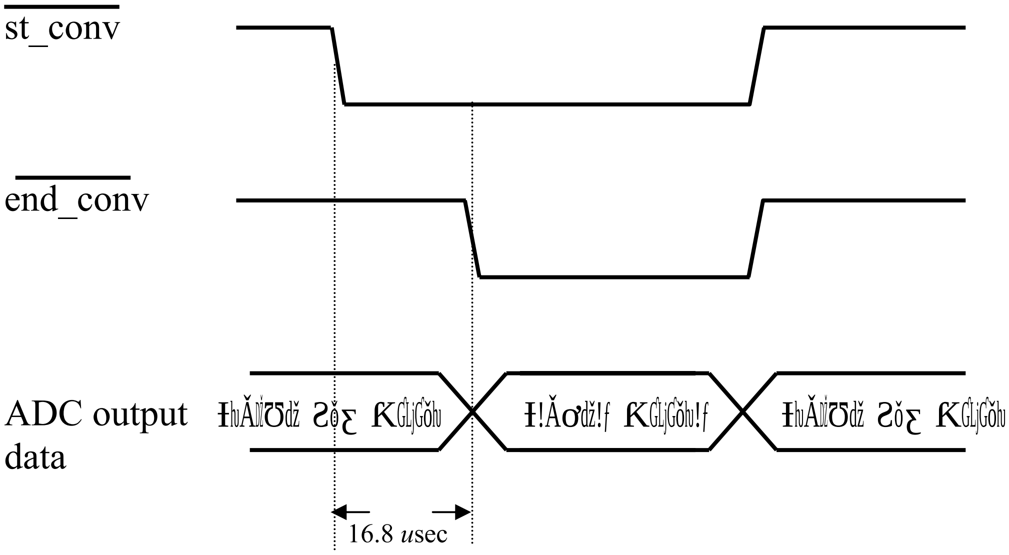
ĐŽƯŀǰďž!ƒ UPS ù!ƒ ĐžƓƯŀ! ŎĎŀŧ!ƒ ƠƠƤďž!ƒ (1) ýŧT



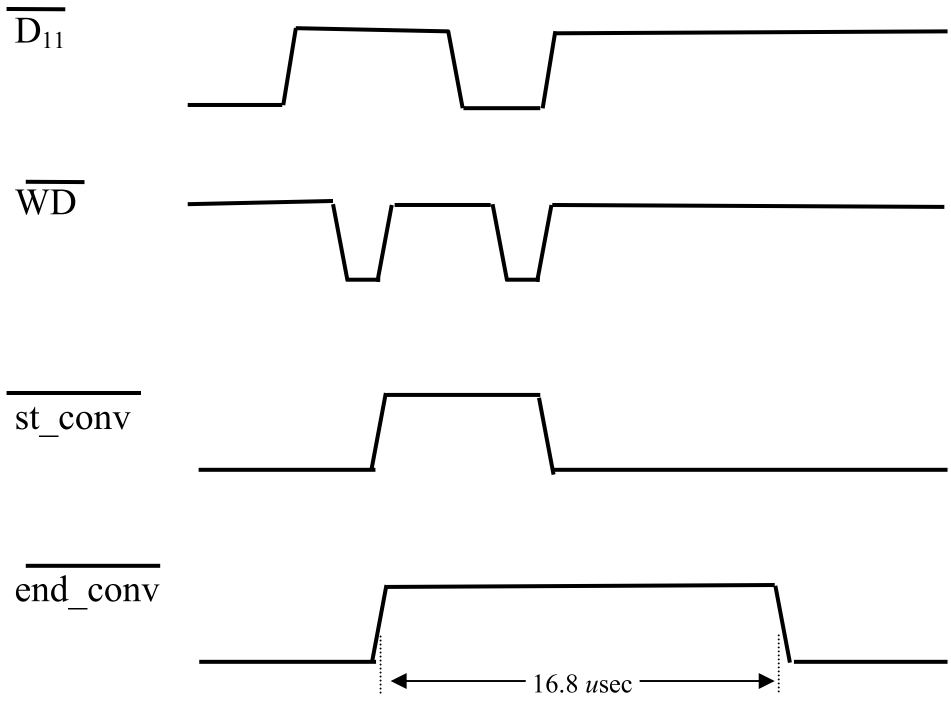
ISA slot ƽőƧƠ ǈƵ ƝǃƓžďž!ƒ ỳďž ADCù!ƒ ƠƅƧ (2) ýŧT



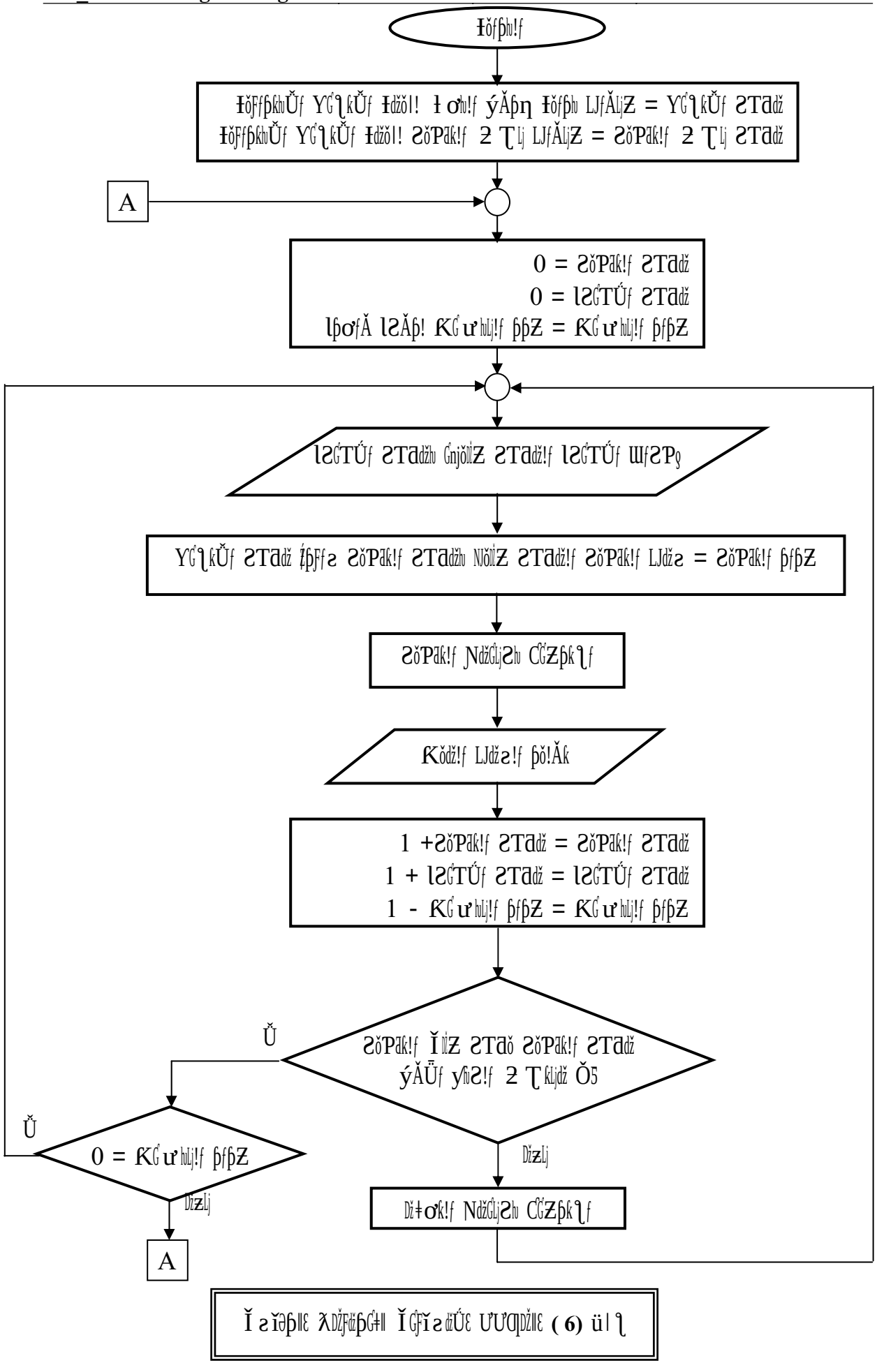
ADC ùǃ! Ďǂơƙ!ƒ ƘƒƧƠTƺ ƥŏ!Ăƙ Ă ŁǀĂǀƶ!ƒ ƖƧƑƥ (3) ýǂT



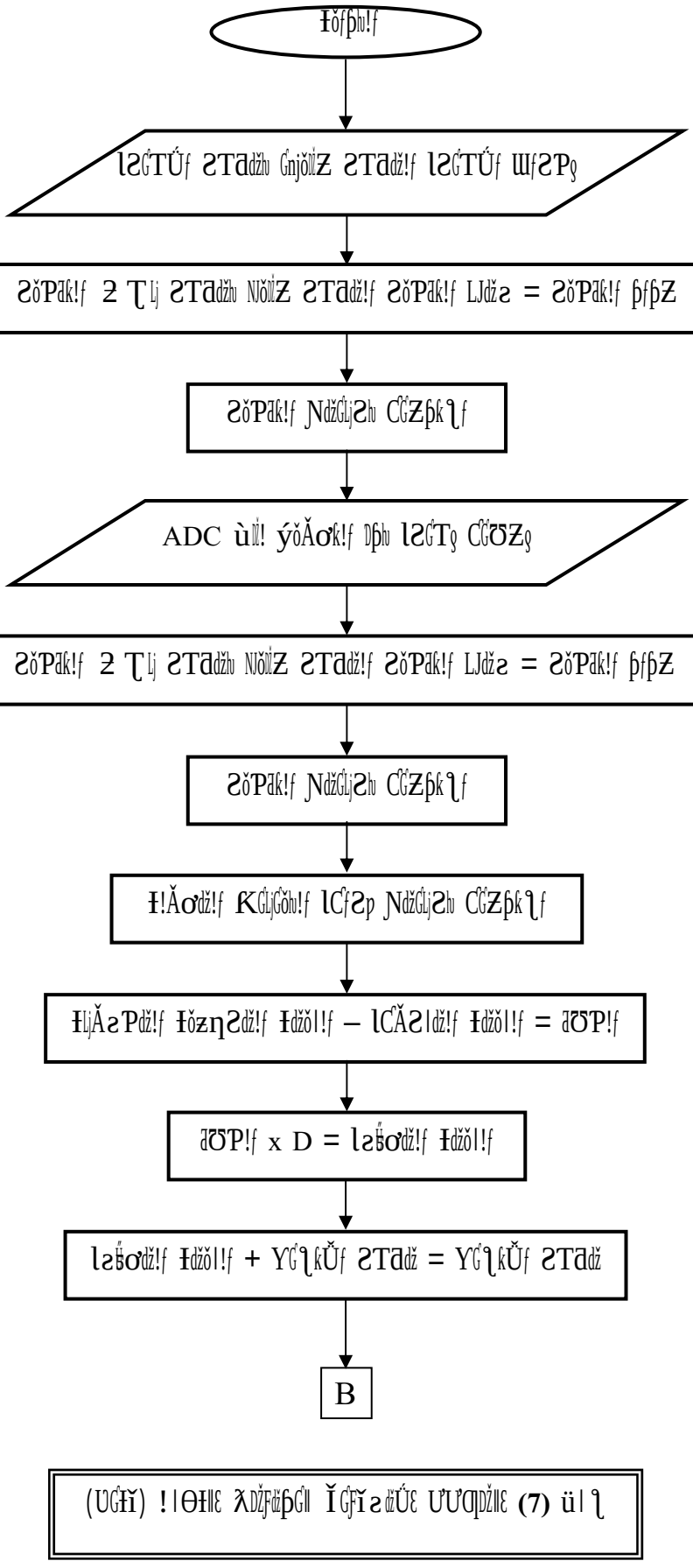
Ł!Ăơďž!ƒ ƘĜǈĜŏlj!ƒ Ă ýŏĂơƙ!ƒ Ćƥlj ƖƧĜTŰ ǑǈǉžƧ!ƒ ƱƱƤďž!ƒ (4) ý‡T

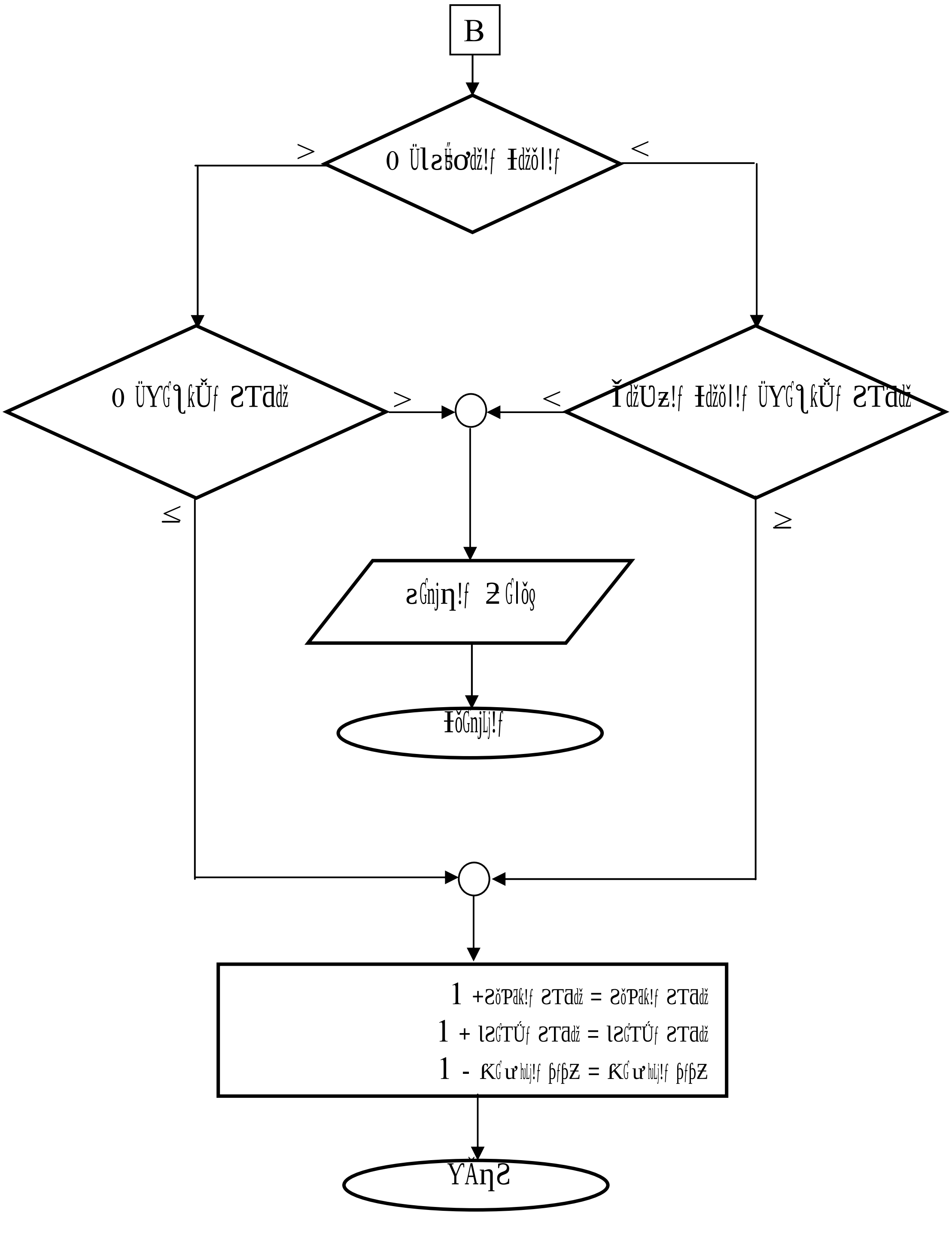


ýŏĂơƙ!ƒ Ďƥlj ƖƧĜTş ƥŏ!Ăƙ! ǑǈǉžƧ!ƒ ƱƱƤďž!ƒ (5) ý‡T



11


Ł ğfþw!f
lƧĠTÚf ƧTɑdžw ĠnjöẅZ ƧTɑdž!f lƧĠTÚf Wƒ Ƨ Pϱ
Ƨğ Pɑk!f 2 Ţ Lj ƧTɑdžw NÖẅZ ƧTɑdž!f Ƨğ Pɑk!f LJdžƨ = Ƨğ Pɑk!f þfþZ
Ƨğ Pɑk!f JNdžĠLjƧw CĠZþk l f
ADC ùẅ! ýğĂơk!f Dþw lƧĠTϱ CĠƵZϱ
Ƨğ Pɑk!f 2 Ţ Lj ƧTɑdžw NÖẅZ ƧTɑdž!f Ƨğ Pɑk!f LJdžƨ = Ƨğ Pɑk!f þfþZ
Ƨğ Pɑk!f JNdžĠLjƧw CĠZþk l f
Ł!Ăơdž!f KĠLjĠÖw!f lCƒƧp JNdžĠLjƧw CĠZþk l f
ŁLjĂƨPdž!f Łğzη Ƨdž!f Łdžğl!f – lCĂĆƨldž!f Łdžğl!f = ɗƵP!f
ɗƵP!f x D = lƨẅơdž!f Łdžğl!f
lƨẅơdž!f Łdžğl!f + YĠl kŬf ƧTɑdž = YĠl kŬf ƧTɑdž
B
(UĠĦĭ) !lΘĦlε ĂDŽFűžþĠl Ĭ ĠFĭƨűÚε UƯQpŽlε (7) ül l



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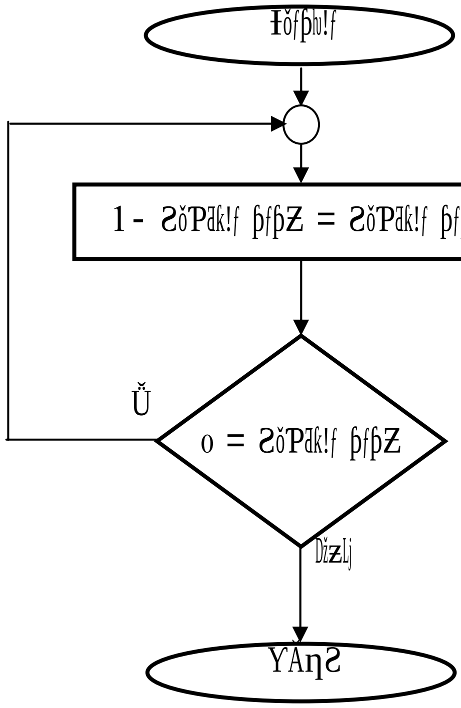

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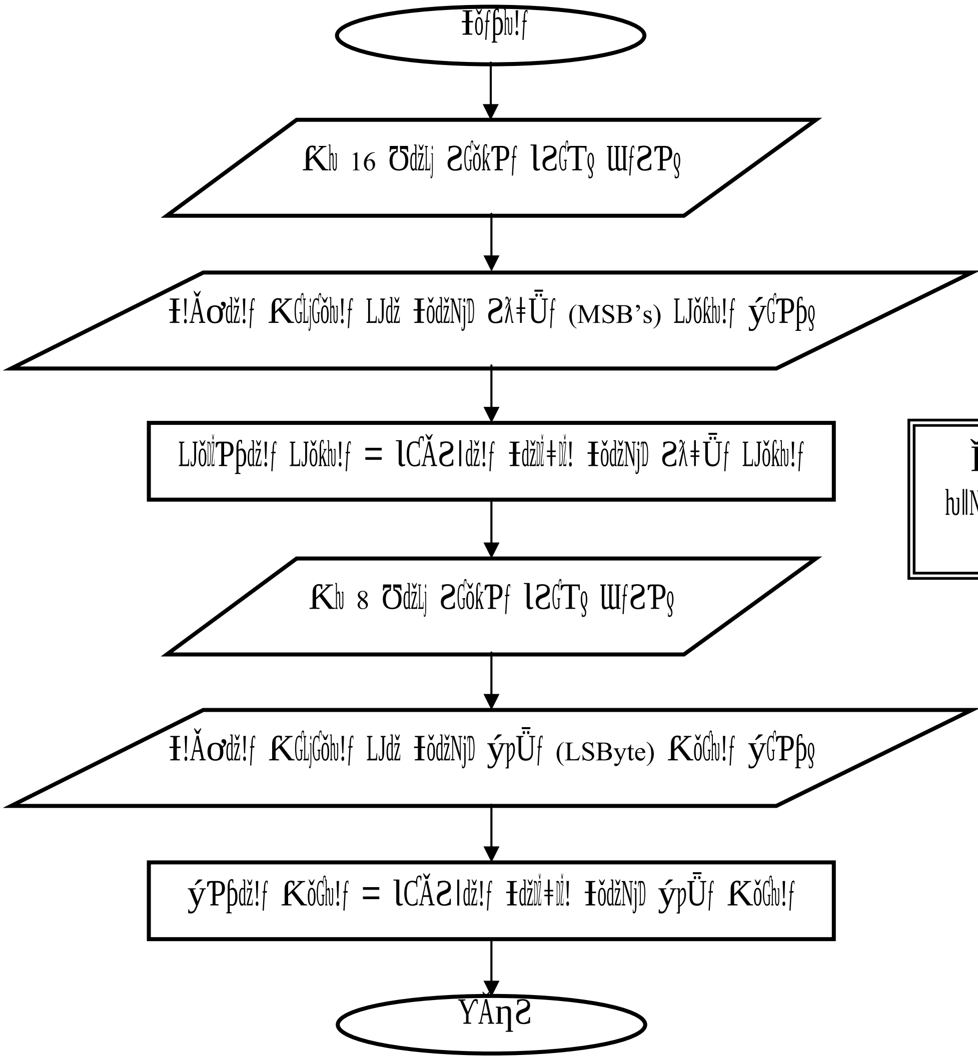

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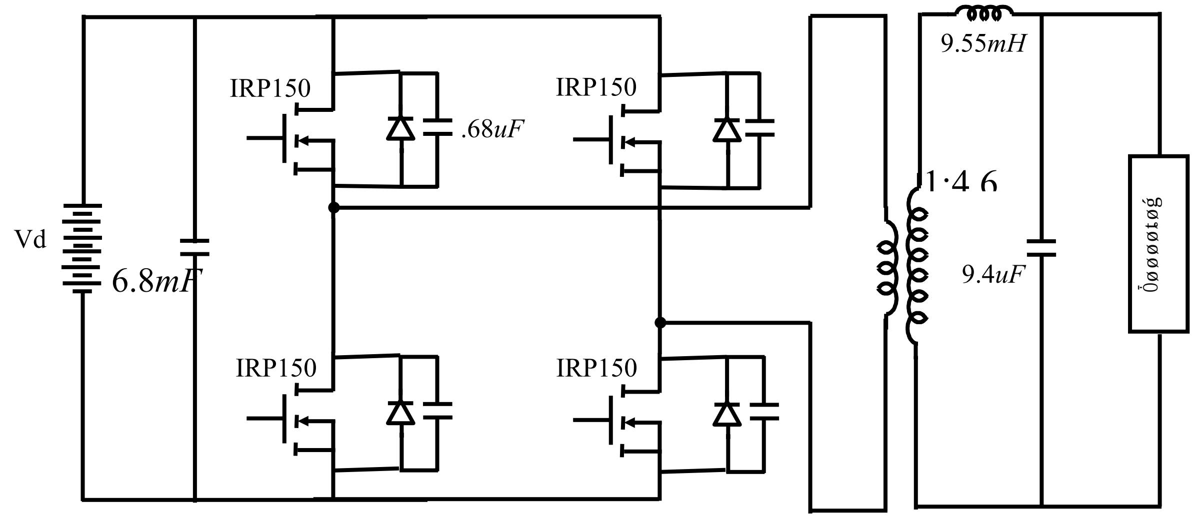
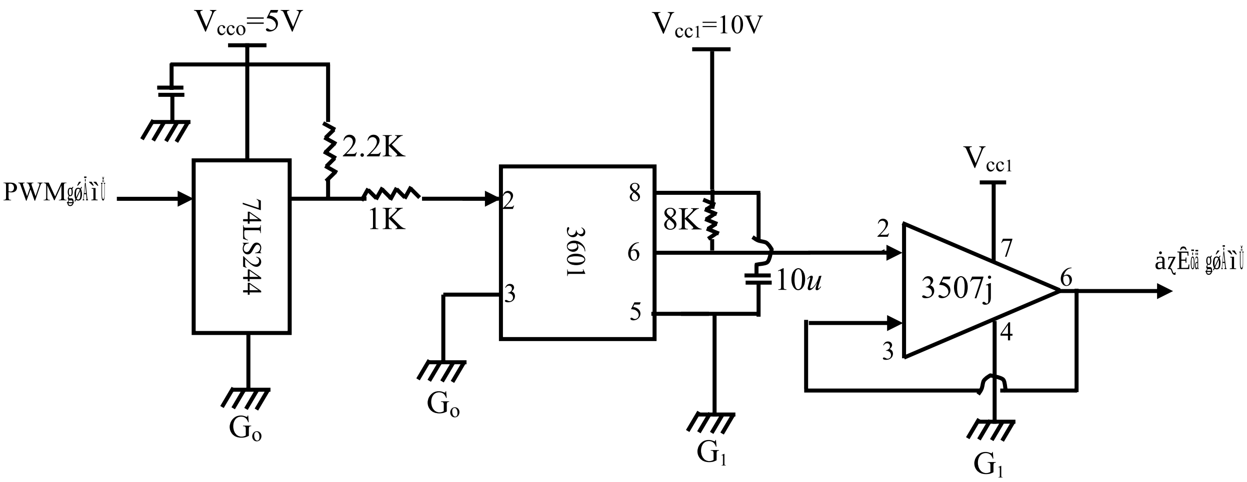
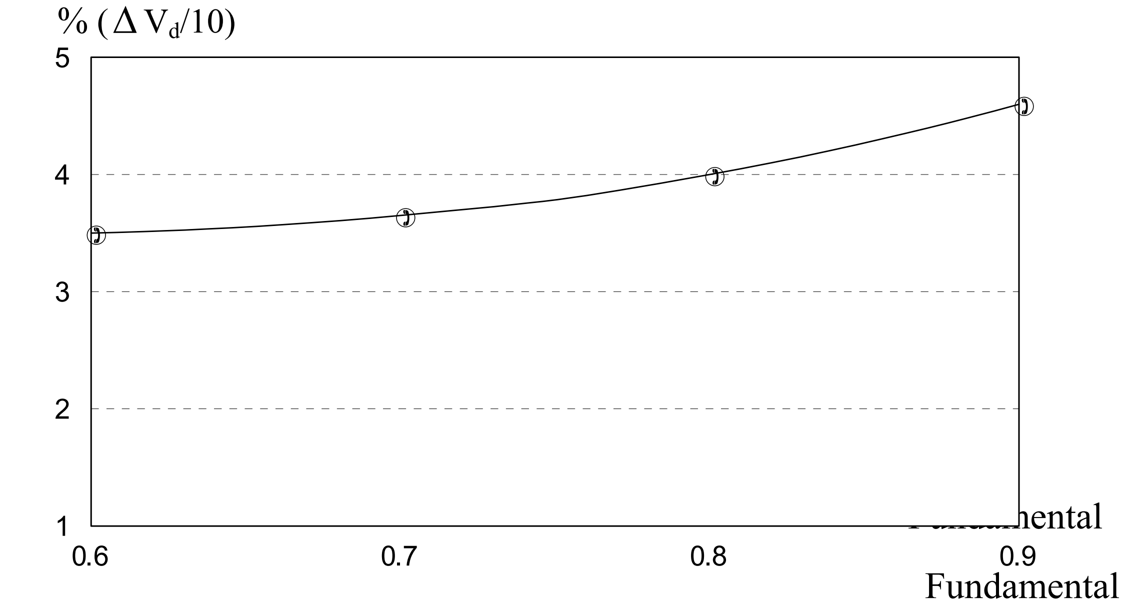


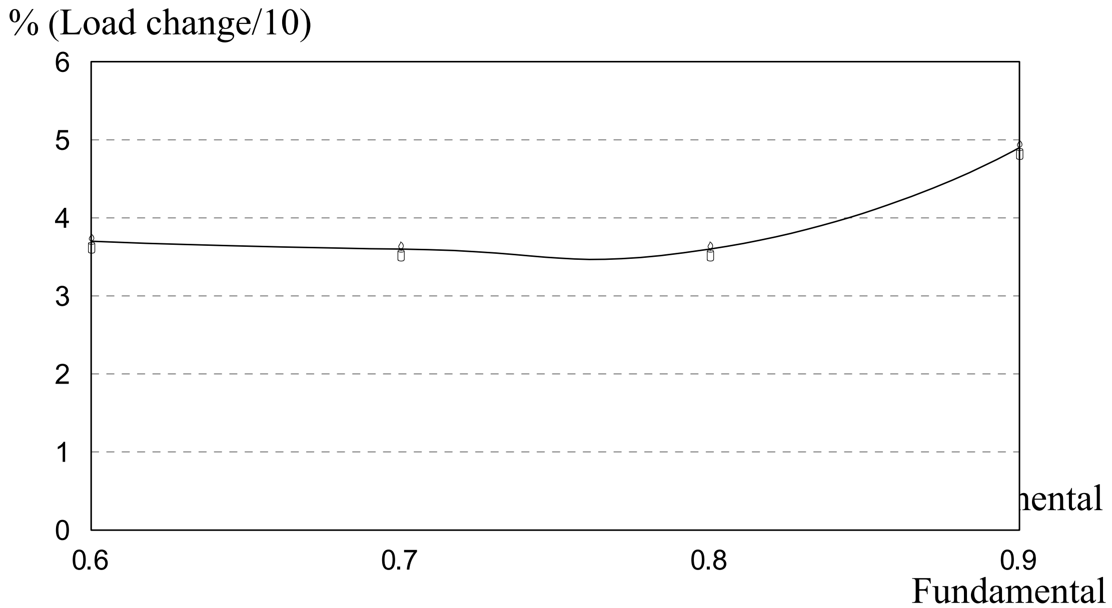
.hυĭǂĎžyⅡ٤ **UPS** ø‖٤ ỵƥƋƐɋ **(10)** ü׀ ʅ



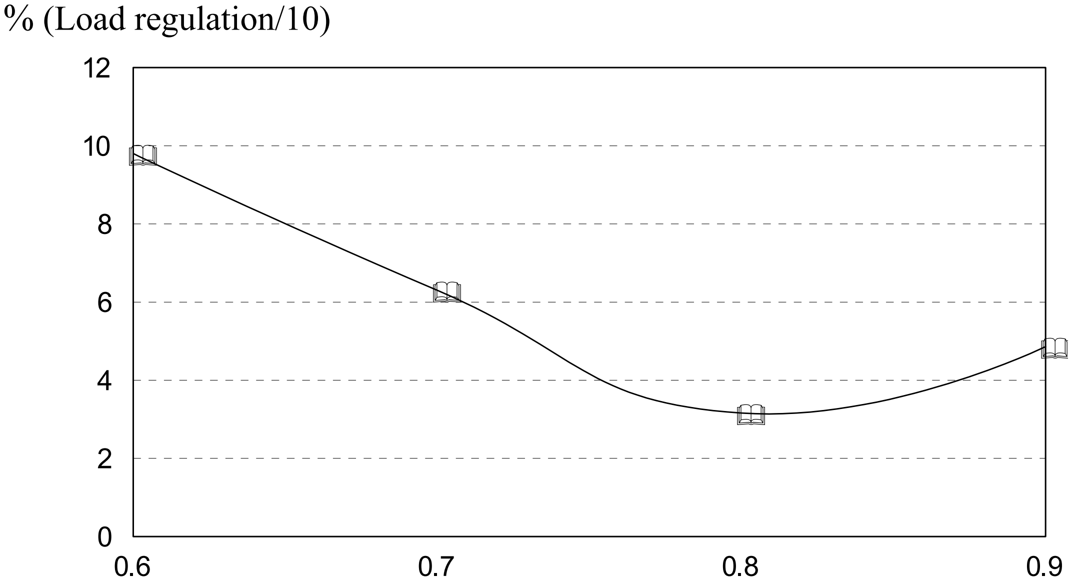
MOSFET ƼŊjƨ ỵƥƋƐɋ **(11)** ü׀ ʅ



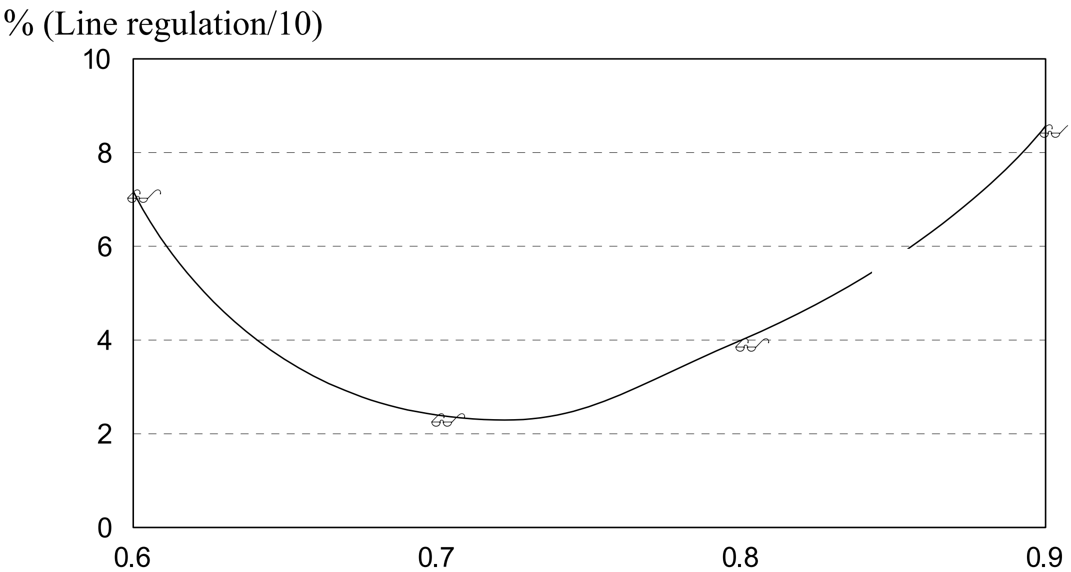
ϸĭŹŧ ǛĎž V_d ɣϸĎžŧƨĎžǁɛ üƑƢɊǗɛ ƕĭŧǁǋʒ Ĭʓ ϸĭŹŧǁɛ ǌɊĎž (14) ül ʅ
ƕĭƨƑƨǗɛ ƕǴlϸĎžǁɛ



ƕĭƨƑƨǗɛ ƕǴlϸĎžǁɛ ϸĭŹŧ ǛĎž üĎžƟǁɛ Ĭʓ ϸĭŹŧǁɛ ǌɊĎž (15) ül ʅ



ƕĭƨƒƨǗƐ ƕƓǀþǅǁƐ þĭƸƗ ǓǅǍ üǅǍΘǁƐ !ĭưǳƗ **(12)** ü|ǀ



ƕĭƨƒƨǗƐ ƕƓǀþǅǁƐ þĭƸƗ ǓǅǍ ƯƢǁƐ !ĭưǳƗ **(13)** ü|ǀ