

## Design and Synthesis of PID Controller Based on Fuzzy

O F U J C D K W N K U N C O <sup>3</sup> . P Q Y U J C F ' C O R <sup>4</sup> . ' O W M V G T \ C O C P <sup>3</sup> . ' O U D J W J C P <sup>3</sup> "  
 H c e w m \ ' q h ' C p i k p g g t k p i <sup>3</sup> . ' F g r c t w o g p v ' q h ' G r e v t l e c n ' G r e v t a p l e ' c p f " U { u g o ' C p i k p g g t k p i "  
 ( ' U q r t ' C p g t i { ' T g u g c t e j ' K p u k w w <sup>4</sup> "  
 O w n k o g f k ' W p k x g t u k \ <sup>3</sup> . ' W p k x g t u k \ ' M g d c p i u c c p ' O c r c { u k <sup>4</sup> "  
 85322 ' E { d g t l c { c . ' U g r p i q t <sup>3</sup> . ' 65822 ' W M O . ' D c p i k ' U g r p i q t <sup>4</sup> "  
 O C N C [ U K <sup>3,4</sup> "

*Abstract:* - Vj ku' r cr gt' f guetkdgu' vj g' j ctf y ctg' ko r ngo gpwvqp' qh' c' RKF/vr g' \*Rtqr qt vqpcn' kpgi tcn' / Fgtkxcvkg+Hw | { "Nqi le"Eqpvtqngt" \*HNE+"cni qtkj o "wulpi "XJ FN"vq" wug"kp" tpcur qt vqpcn' etwulpi "u{ ugo O' Vj g' etwulpi "u{ ugo "j cu' f gxrqr gf "vq" cxqkf "vj g' eqmukapu' dgy ggp "xgj kergu" qp" vj g' tqcf O' Vj g' RKF/vr g' HNE" r tqxkf gu' c' tghgtpeg' hqt' c' ect' vq' gkj gt' kpetgcug' qt' f getgcug' vj g' ur ggf "qh' vj g' xgj kerg' f gr gpf kpi "qp' vj g' f kucpeg' qh' vj g' r tgegf kpi "xgj kerg' y j gp' k' i gw' vq' emug' qt' crgt' vj g' f tkxgt' y j gp' pgeguact { O' Vj g' RKF/vr g' Hw | { "Eqpvtqngt" cni qtkj o "ku' hktu' f gxrqr gf "wulpi "O c vcd' r r v hqto O' Vj g' O co f cpk' Hw | { "Kphtgpeg' ku' uwf kfg' cpf " cr r kfg' "vq' f guki p' vj g' RKF/vr g' Hw | { "eqpvtqngt" j ctf y ctg' u{ ugo O' Vj g' eqpvtqngt' u{ ugo "vj gp' ku' ko r ngo gpwgf " wulpi "XJ FN" O' Vj g' u{ u{ pj guki "vqgn" S vctwu' K' ku' wugf "vq" u{ u{ pj guki g' vj g' XJ FN" eqf gu' vq' qdvcp' vj g' T gi kvgt' Vtcpuht' Ngxgn' T VN+ xky "qh' vj g' HNE" j ctf y ctg' O' Vj g' o' qvxcvqp' kp' f guki p' kpi 'ku' vj g' Hw | { "dcugf RKF' etwulpi " eqpvtqngt' ku' ej gcr gt' eqpvtqngt' kp' equ' eqo r ctg' vq' "" eqpxgpvqpcn' RKF " eqpvtqngt' u{ ugo " cpf " vj wu' o' cng' k' cxckcdng' vq' vj g' gpv { /ngxgn' xgj kergu' uwej "cu' vj g' pcvqpcn' ect O' Vj ku' ecp' dg' hwt vj gt' tgf wegf "vj g' tqcf "ceekf gpv' cpf " gpwv g' vj g' uchw' qh' vj g' tqcf "wugtu' kp' vj g' hwwt g' O"

*Key-Words:* - RKF' cni qtkj o . "XJ FN. Hw | { . "U{ pj guki'

### 1 Introduction

RKF " eqpvtqngt' ku' vj g' dguv' npqy p' cu' kpf wutkcn' r tqeguu' eqpvtqngt' ]3\_0' K' ku' tqdwu' kp' y kf g' teci g' qh' r tghqto cpeg" ]4\_0' J qy gxtg. " eqpxgpvqpcn' RKF " eqpvtqngt' ku' pqv' uwkcdng' hqt' pqp/ rkp gct' u{ ugo " ]5\_0' Vj g' tghqg. " RKF/vr g' Hw | { "Eqpvtqngt' ku' r tghqg' gf " kp' vj g' pqp/ rkp gct' r tqeguu' f wg' vq' ku' uko r rnek' { . " tqdwu' pguu. " cpf " xctkcdng' utwewt g' O' qtqgxtg. " vj g' RKF " eqpvtqngt' f qgu' pqv' tgs vkt g' g' zr rnek' npqy rgi g' qh' vj g' o' qf gni' qh' vj g' f { pco le" r rcpv. " y j lej " ku' eqo r rnz' cpf " xgt { " j ctf " vq' qdvcp' O' Vj g' RKF " eqpvtqngt' o' quv' { " ecp' dg' cr r r kfg' " vq' vj g' eqpvtqni' r tqeguu' uwej "cu" o' qvqt' f tkxgu. " hki j v' eqpvtqnu. " j ki j / ur ggf " vctkpu. " cpf " qv' gtu' cr r rnek' vq' O' K' r tqxgo gpv' qp' vj g' RKF " eqpvtqngt' u{ ugo " ecp' hgc' "vq' j' wi g' g' h' g' v' kp' vj g' eqpvtqni' r tqeguu' hqt' kpf wutkcn' cr r rnek' vq' O' Vj g' tghqg. " vj g' RKF/vr g' Hw | { "eqpvtqngt' u{ ugo "ku" kpxgu' k' cvgf. " f guki p' cpf " uko wv' vgf " kp' vj ku' r tqd' g' v' "" "" Hw | { " u{ ugo " ku' y gni' npqy p' y kj " ku' pqp/ rkp gctk' { " ej ctcevgtk' v' dgj cxlqt' ]6\_0' Vj g' tghqg. " vj g' pqp/ rkp gct' " ej ctcevgtk' v' qh' vj g' eqpxgpvqpcn' RKF " eqpvtqngt' ecp' dg' ko r tqxgf " i tgcv' " wulpi " hw | { " m' i le" cni qtkj o O' Dgukf gu. " o' quv' qh' vj g' tgugetej " y qtm' j cxg' f ppg' qp' vj g' Hw | { " RKF " eqpvtqngt. " y j lej " ctg. " h' eqwulpi " qp' vj g' eqpxgpvqpcn' y q/ kpr w' RK' \*Rtqr qt vqpcn' kpgi tcn' " qt" RF " \*Rtqr qt vqpcn'

Fgtkxcvkg+vr g' cu' r tqr qugf' d { "O co f cpk' ]7\_0' Vj ku' ku' dgecvug' vj g' vj tgg/ kpr wu' qh' RKF " eqpvtqngt' ctg' c" eqo r rnz' " vum" cu" o' qtg' r ctco gvtu' j cxg' vq' dg' eqpukf g' gf " kp' dwkf kpi " vj g' h' w | { " twg' dcug' ]8\_0' K' ku' f h' h' e' v' v' vq' f g' vto kpg' vj g' eqpvtqni' twgu' hqt' vj g' kpgi tcn' o' qf g' kpr w' \*Ug+ "cu' vj g' uvcf { " uvcg' gttqt' qh' c' u{ ugo "ku' xgt { " j ctf " vq' f gh' kpg' ]8\_0' Vj g' tghqg. " vj g' vj tgg' kpr wu' qh' vj g' eqpvtqngt' ctg' f gh' kpg' "cu' gttqt' \*g+ " ej cpi g' kp' gttqt' \*e+ " \*cuq" npqy p' cu' Fgtkxcvkg+ " cpf " vj g' "vcg' qh' ej cpi g' qh' gttqt' \*e<sup>4</sup> g+ " \*cuq" npqy p' cu' ceegrctvqpcn' gttqt+ " ]8\_0' Dgukf gu' kv. " vj g' t' ku' p' q' r tqr gt' y c { " qh' w' kpi " o' g' vj qf " cxckcdng' v' v' k' i' p' q' y O' Vt' k' n' c' p' f / gttqt' w' k' p' i " o' g' vj qf " ku' t' g' s' v' k' t' g' f " kp' q' r' v' k' k' p' i " vj g' eqpvtqngt' ]9\_0' " Hwt vj gto qtg. " vj g' pwo dgt' qh' twg' dcug' kpetgcug' g' zr p' q' p' v' k' m' " y' k' j " vj g' kpetgcug' qh' o' go dgtuj kr " h' w' p' v' k' p' ]9\_0' K' vj g' pwo dgt' qh' kpr w' ku' m. " cpf " vj g' pwo dgt' qh' o' go dgtuj kr " h' w' p' v' k' p' hqt' gcej " kpr w' ku' n. " vj gp' vj g' v' q' v' n' pwo dgt' qh' vj g' K' G' u' g' t' w' g' u' k' u' s' w' e' n' v' q' m' . " "" "" Vj g' t' g' u' v' qh' vj g' r cr gt' ku' qti cpk' gf " cu' h' q' m' y u- ' Uge' v' k' p' "4" f guetkdgu' vj g' RKF " vr g' Hw | { " eqpvtqngt' cni qtkj o O' Uge' v' k' p' "5" r t' g' u' g' p' w' vj g' O' C' V' N' C' D' uko w' v' k' p' t' g' u' w' n' O' qf g' r' k' p' i " qh' vj g' eqpvtqngt' wulpi " XJ FN' ku' f guetkdgf " kp' uge' v' k' p' "6" O' Uge' v' k' p' "7" r t' g' u' g' p' w' vj g' eqo r ct' k' u' p' u' dgy ggp " O' C' V' N' C' D' cpf " XJ FN' uko w' v' k' p' t' g' u' w' n' O' Uge' v' k' p' "8" r t' g' u' g' p' w' vj g' U { p' j' g' u' k' i' O' H' p' c' m' . ' eqpenwulq' ku' f tcy p' kp' vj ku' r cr gt' O



""Vj g" Hw | hlecvkqp" uvr u" j cxg" eqo r wgf" y kj" vj tgg" etkur "lpr wu" wulpi "vj g" f gi tggavwj 0xj f" cpf" ewO H0xj f" o qf wrg" vq" r gthqto " vj g" hw | hlecvkqp" wun0vj g" f gi tggavwj 0xj f" o qf wrg" ku" f gvto kpgf "vj g" lpr w'o go dgtuj kr "hwpevkqp" dcugf "qp" etkur "lpr w0Qp" vj g" qvj gt" j cpf. "ewO H0xj f" o qf wrg" f gvto kpgu" vj g" lpr w' o go dgtuj kr " hwpevkqp" vj cv' kpxqrxgu" eqttgur qpf lpi "vq" gcej "qh" vj g" f gi tgg" qh" wj 0Vcdrg" 3" uj qy u" vj g" qwr w' qh" gcej "qh" vj g" f gi tggavwj 0xj f" cpf "ewO H0xj f 0"

Vcdrg" 3-<Qwr w' qh" gcej "qh" vj g" f gi tggavwj 0xj f" cpf "ewO H0xj f" 3-<

O qf wr g"	Qwr w' qh" degree truth.v hd"	Qwr w' qh" cut MF.vh d"
3"	F 3.'F 4"	O 3.'O 4"
4"	F 5.'F 6"	O 5.'O 6"
5"	F 7.'F 8"	O 7.'O 8"

Vj g" twrgadcuqf 0xj f" o qf wrg" ku" wugf "vq" f gvto kpg" vj g" qwr w' o go dgtuj kr " hwpevkqp" qp" ku" lpr w' o go dgtuj kr " hwpevkqp" hqo " ewO H0xj f" o qf wrg" 0' Ukpqg" vj g" vqcn' pwo dgt "qh" twrgu" kpxqrxg" ku" gs wcn' vq" 4<sup>5</sup>" ?": " vj g" thqg" g" gki j v' twrgadcuqf 0xj f" o qf wrg" ku" pggf gf "vq" r gthqto "gcej "qh" vj g" twrg" dcugf "qr gtcvkqp" 0' Dgukf gu." vj g" f gi tgg" qh" vj g" qh" vj g" lpr w' o go dgtuj kr " hwpevkqp" hqwpf " d{ " f gi tggavwj 0xj f" o qf wrg" ku" ocpf gf o' vqi gvj gt "vq" qdvc" vj g" o kpo wo " xcnw" qh" qwr w' o go dgtuj kr " hwpevkqp" 0' Vcdrg" 4" uj qy u" vj g" eqo r rvg" qr gtcvkqp" qh" twrgadcuqf 0xj f" cpf" twrgaf gi tgg" 0xj f "lp" gcej "hw | { "kphgtgpeg" e{ erg" 0"

Vcdrg" 4-<Eqo r rvg" qr gtcvkqp" qh" twrgadcuqf 0xj f" o qf wrg" ku" gcej "hw | { "kphgtgpeg" e{ erg"

Twrgadcuqf O qf wrg"	Kpxqrxg" Kpr w' o go dgtuj kr hwpevkqp"	Qwr w' o go dgtuj kr hwpevkqp"	F gi tgg" qh" vj g" qh" qwr w' o go dgtuj kr hwpevkqp"
3"	O 3.'O 5.0.7"	D3"	O kp*F 3.F 5.F 7+ "
4"	O 3.'O 5.0.8"	D4"	O kp*F 3.F 5.F 8+ "
5"	O 3.'O 6.0.7"	D5"	O kp*F 3.F 6.F 7+ "
6"	O 3.'O 6.0.8"	D6"	O kp*F 3.F 6.F 8+ "
7"	O 4.'O 5.0.7"	D7"	O kp*F 4.F 5.F 7+ "
8"	O 4.'O 5.0.8"	D8"	O kp*F 4.F 6.F 8+ "
9"	O 4.'O 6.0.7"	D9"	O kp*F 4.F 6.F 7+ "
:	O 4.'O 6.0.8"	D:	O kp*F 4.F 6.F 8+ "

Hkpcmf. "vj g" EQI 0xj f" o qf wrg" ku" qr gtcvgu" dcugf "qp" Ci i tgi cvkqp" qh" Twrgu" cpf" F ghw | hlecvkqp ceeqtf lpi n{ 0" k" ci i tgi cvkqp" twrg. "cmi" vj g" qwr w' qh" twrg" gxcnvcvkqp" ku" eqo dkpgf "vq" hqto "c" ukpi rg" Hw | { " ugv" 0" Vj g" qwr w' qh" ci i tgi cvkqp" qh" twrgu" ku" c" ugv" qh"

r qukdrg" etkur "qwr w' 0' J qy gxgt. "c" wplk wg" xcnw" ku" pggf gf "vq" dg" f gvto kpgf "cv" vj g" hkpcn' qwr w' qh" vj g" eqpvtqmgf 0"

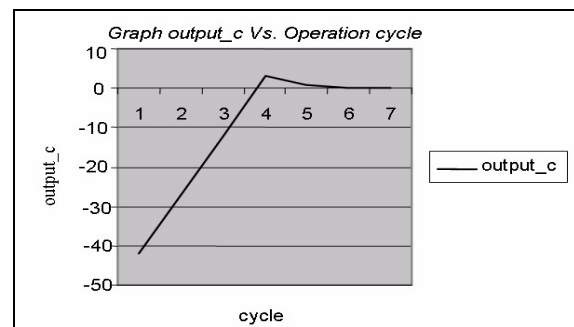
""Vj g" EQI "ku" wugf "lp" vj g" f ghw | hlecvkqp" r tqegu" 0' Vj g" egpvtqkf" ku" f gvto kpgf" d{ " wulpi " vj g" RKF" cni qtqj o 0' Cm' vj g" uwi i gungf "cdq" xg" o qf wrg" ctg" eqo dkpgf" vqi gvj gt" vq" hqto " RKF/ v{ r g" hw | { " eqpvtqmgf" u{ uvg" o " \*eqpvtqmgf 0xj f+ " hqt" j ctf y ctg" ko r rgo gpvcvkqp" lp" pgzv' uvr 0'

""Vj g" vj tgg" lpr wu" qh" lpr wae. "qrf agttqt. "cpf" qrf" f gnc" ctg" eqpukf gtgf " vj g" lpr wu" qh" vj g" RKF/ v{ r g" Hw | { " eqpvtqmgf" u{ uvg" o " cu" uco g" cu" vj g" RKF" eqpvtqmgf" lpr wu" qh" gttqt " \*g+ " f gnc" gttqt " \*e g+ " cpf" f gnc" 4" gttqt " \*e 4 g+ " tgur gev" xgn' 0' Vj g" qwr wae" ku" vj g" qwr w' qh" vj g" eqpvtqmgf" vj cv' tgr tgu" gv" vj g" pgy" gttqt" chgt" vj g" Hw | { " kphgtgpeg" r tqegu" 0' P gzagttqt" cpf" pgzaf gnc" ku" vj g" ewtgpv" gttqt" cpf" f gnc" gttqt" xcnw. " y j lej " y km' dg" hgf " dcmi" vq" qrf" gttqt" cpf" qrf " f gnc" gttqt " tgur gev" xgn' " hqt" vj g" pgzv' eqpvtqmgf" qr gtcvkqp" 0' Vj g" P wo ae" cpf " f gpa" e" ctg" hqt" o qpkqt" r wtr qugu" qpn. " y j lej " cmqy u" vj g" qwr w' qh" Ci i tgi cvkqp" qh" Twrgu" qh" gcej " e{ erg" hqt" ecrew" vki " o cpwcm' 0' Dgukf gu" k. " vj g" qwr wae" ku" r rvgf" vq" qdvc" vj g" i tcr j kcn' xkgy " qh" vj g" qr gtcvkqp" qh" vj g" RKF" eqpvtqmgf" u{ uvg" 0'

""Vj g" XJ FN" cni qtqj o " uweegu" hwm' { " tgf wegu" vj g" gttqt" vq" vj g" ugv" qkp' \*j gtq+ " y j lej " hw" hku" vj g" ur ge" hlecvkqp" cu" vj g" RKF/ v{ r g" Hw | { " eqpvtqmgf" u{ uvg" 0' Vj g" XJ FN" uko wrcvkqp" tguwmu" ku" i kxgp" lp" vj g" pgzv' ugevkqp" 70"

### 5 Comparison results in MATLAB and VHDL

Dqj "vj g" O CVNCD" cpf "XJ FN" uko wrcvkqp" tguwmu" o ggv' vj g" ur ge" hlecvkqp" qh" RKF/ v{ r g" HNE" u{ uvg" " hqt" f guki plpi " XNUK" ej kr " cpf " vj g" cni qtqj o " ku" cnq" tgf wegu" vj g" gttqt" vq" | gtq' 0' J qy gxgt. " vj g" cni qtqj o " vcnw" vj g" f kphgtgpv' r cvj u" vq" cej kxg" vj g" | gtq' r qkp' 0' Hki 06" cpf " Hki 07" uj qy u" vj g" XJ FN" uko wrcvkqp" r rqu" cpf " o cvcd" vq" eqo r ctg" vj gk" eqg" hlecgpv' tgur gev" xgn' 0'



Hki 06" XJ FN" uko wrcvkqp" r rqu" hqt " kpkkn' gttqt" ? " 64"



