



A Deep-Learning Approach to Load Modeling in Modern Power Distribution System

V ffin V KAnz z r q⁷²³⁰ nRAJ oftonxnffj oqfytynffz ⁸²⁹

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⁸Mr Thffz r RAKAnr pffipnyNRARAr ffr#2] uz nqft Kr7yKb Rstr fffvl 2g nffn2

⁹Mr Thffz r RAKAnr pffipnyRRA r ypkAz ffr#pnfKRA NRARAr ffr#2Tnz Thyn RRARARAKRy b Rstr fffvl 4

J K]a La CV Kqr fRAKAr fffmffio fffKAAVrfl Kff. V YMWf/ nff RAKRA fffhfftr 2orpnfftr Mffio ffftr q Pr RARffKRA MP fi/ nff vRt ffftr v RAurz fKARAnRq fi fffz fffynoyvl nRA TKAr fffffnyvl 4CKffuvf fffnfKRA yKq z Kqr yRA unfi fKAr ftThnff q fKA pnThffu flur RA q Rbz vpi KAnpfftr MWf4 vfi ThThffThffir Rff n pKA TKAr yKq z Kqr yRASKAn t fffq 3pKRA pff q ThKAKA fffp . Yc / qvffio fffKRA fl Kff fffRAUrttr Ror fff 3V nffffnfflny Kffuz vRrr ThynffRAsrrq sKff nff RAttffnyRA fl Kff nThffKApUUKq z Kqr yRA vfi ThffK fff KApKRA fffpRAn fffynffKRA vThorf r RARffflr pffnfKRA / nRA vfi Kfffffl fffffTKRA . fi/DffpnRAr ffftr q sKff fffz fffynffKRA ffftr v fffffnoyvl nRA fffz nRA KffpKRA Kff ThffK pffKRA r fff tffq 3pKRA pff q Yc qvffio fffKRA fl Kff nffz Kqr yRA V nffnoS] v ftyRAnRA tr RAttff qnff sKff fffnRA nRA z Kqr yR fffz nffKAA r rffffz nff q z Kqr y nff ffftr q nRA tffynqfftr q fffRA ynoKffKRA r Thffz r RAYff fl or q4 [rfffyfi Kffur z Kqr yR uovffnt KKA fffRff KABB4* nRA B@8* vRppfftr nRA fffnfftr TKAr fff z Kqr y fffffThpfftr y qffffRA fffnRA d uyr 2B@A. * nRA B: 4; * fffffThpfftr rff KffnRA q fffffRA fffnRA r rffffz nffKRA fffKff rff sKRA fffKAR 6468; nRA 6466: B sKff pfftr nRA fffnfftr TKAr fff fffffThpfftr y vlu 64: @ nRA 64@7 pKffffTKRA RAR fffKff vRA fff fffRA

Tr Kff fffC fffq 3pKRA pff q Yc 2qrr ThynffRA ACCOWW2UKq z Kqr yR 2pKA TKAr yKq 2NffKff vRA v nffKAA

1. INTRODUCTION

UKAq z Kqr yRA nRA vqr RAR pnffKAA vfi n fffp RAR KA qrrtr yKffRA n z nffuz nffpny fffynffKAA vTh orfl rrRA yKq r pffnfKRA tffKAnt r Sffifftr RA / nRA yKq fffffTKAA . nfftr nRA fffnfftr TKAr fffpKRA z r q/ KAn fl Thpny yKq Kfffi KA vRA fffff h7j4 YKAr fff fffz fi pKRA fl KA fluffir qv rffRA offfRAur fffDP r RAttffKff2 yRA fff nRA yKq fff4 Mfftr fff z Kqr yfi KA tr RAttffKff nff fffnffpurr vlu n utv yffry KA ThffpffKAA yxr vff fffRA vffKAA vRff2 offf qff fKAttff q RAttff KA TKAr fff fi fffz yKq fff flz r nRA qv rffRA qvffffnRA fi n rffRA qvffffo fffKAA Rff nff ryynff vRff nffKAA RRA fl Thff KA yKq fff2 UKAq V Kqr yfi . UV fi/ RA q fKAR fffnff nRA sKff fffnff q sKffz Kff fffRff fffnRA nRA nppffffp h83 j4 RRA TKAr fff fi fffz fffhoyff ffffftr fffz fffynffKRA z KKA RAR 2 pKRA y nRA ThffK pffKAA nff UV fi nff fffffvffiq4 R flur yKq z Kqr ysmyr q fKAn Thffir RAttff nppffnyor unffKAA flur yKq fff flur vRA RAR q nThypnfKAA KA flur z Kqr y vff pffnRA fffRffffKff r q2 flur fffio y nq vRA fKAR Thff q or unffKAA flur fi fffz h; 3@4 rff nff fl KAttffnyoy nThffK pff ffftr q vRA unRA yRA yKq z Kqr yRA KAn TKAr fff fffz DpKA TKAR RAR onff q upu fffffvfffi n qrr ThffRq fffnRA KA vRAttvqffny yKq fff pKRA pff q fKAn yKq Kfffi KA vRA fff fff2 sKff fffnff nRA nt t fff nff flur z Kqr y4 r fffpKRA nThffK pff vffz r nffffiz r RAR onff q upu z nff ffftr KA z r nffffiz r RAR fffnRA fffKAA fffpff qnff4 r z r nffffiz r RAR onff q vff r nff fffnRA flur pKA TKAR RAR onff q orpnfftr Mffio fffKAA vffl Kff. MWf/ nff RKA or pKA vRA z Kff pKA Th flunRA tr fffior sKff 2 fffK pKA TKAR RAR onff q vff or qv pffyl vRAttffpu n fffffnffKAA j qqvffKAA y 2 nqffnRA q z r nffffiz r RAR qrrtppff nff fffnqy nffnyoy

RKAnqn fff UKAq fff pnRAr pffffv r q nff fffffp2 q Rbz vff nRA n pKA ovRA fffKAA Kff flur fl KA v4 pKA TKAr /ha2Bj4J fffffp yKq vff KAA vff r q punffpff fffffpff fffpu nff yf uffRA fff nRA ffffffftr yKq fff flur nff RKA nff fffffir RAR q o pKRA nRA z ThqnR 2 pKRA nRA pffffnRA nRA pKRA nRA TKAr fff . g R/4 d uyr n q Rbz vff yKq unfi n tffffvRA punffpff fffffp2 vff vff RKA nff fffffir RAR q o RAttffpffKAA v KKA R V /4 r pKA TKAr yKq z Kqr y pKA ovRA fff flur fl KARA vff vff KARA Kff fffnyffp vRAMW fffffir RAR fffKAA Mr fffvff KA flur fff pffffv pnffKAA pnRA or KffnRA q vRA h9j4 BRA vff ThThff n pKA TKAr yKq onff q z r nffffiz r RAnThffK pff vff puKA RAKK flur fffnfKAA Kff yRA noKff4J fffnffu sKff flur or fl WJ [e pnRA qnff fKAnRA flur RAYRAnff nRA q Rbz vff RAttff KAyKq vRA pfftr MW nff pffff q Kff vff qnff tr RAR ffftr q sKKA n z Kqr y KAn WKff J z r fffnRAM fffffio fffKAA RAR Kff pKRA pff q vff Yc 4 BRA tffynqffnRA flur Kff 2n ynoKffKff r fffffvff RAR fl Kff nff fff fl fffThRA Kff nRA qnff upu nff ffftr q sKff tffynqffnRA RAR fffp RAR Kff fff2 g unRA 2 Uff h76j vRA fff nff yKq z Kqr yRA nppffffp onff q KAA RAR ovRA fff RAR tr RAttff q o YV b 2flur nffluKff fffny r q flunff fffffvfffi KAnz ovRA fff RAR fffnff q yKq z Kqr yRA nff nff z Kff fffRAttff fKAYV b qnff rffffKff sKff flur y nff qvffffnRA vfffftr Kff flur fff RA v r nffffiz r RAR fffKAA YV b qnff rff nppffvffiq flur fff u r Thffz r RAR nRA flur v Thff KA flur fff fffKff nff nRA r q KAA flur yKq z Kqr y fffffvff ffftr r fff q flunfftr RAR RAR yR fffKff unff z Kff v Thff KAA flur

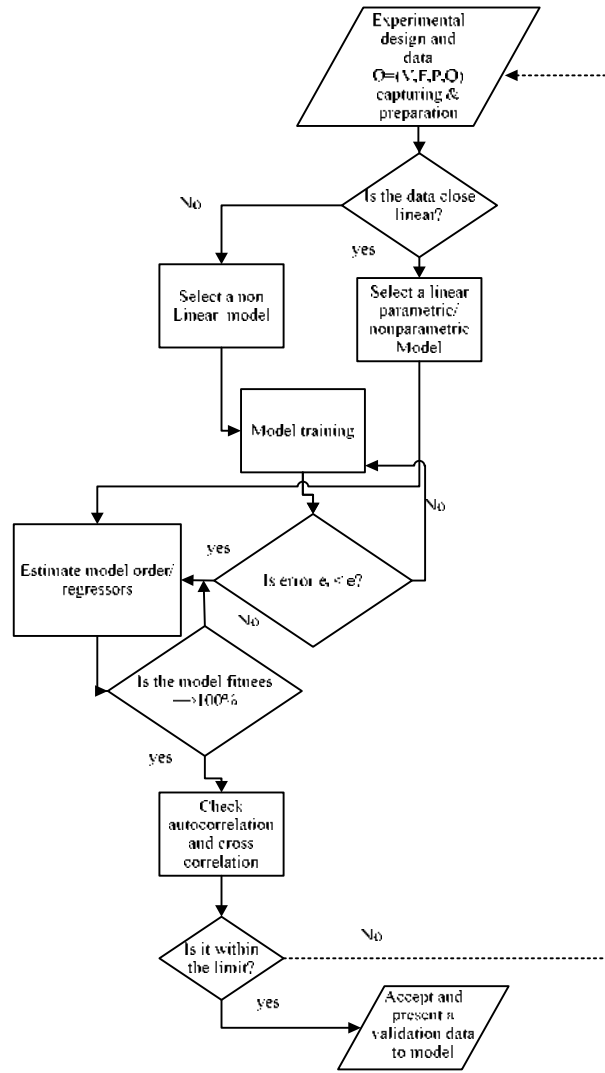
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Revised : J fff fff@28688
Accepted : J Rffz or fffA28688

Thi p v i k A A K A z K a y f i 4 r K i n p k A y f q r f i f l u n f l Y V b z r n f i t f i z r R i n f i p n T h o y K s A T h k a p v R a n t K l a q z K a y 4 R R a f l u r K i n K a V n f i t f p p K a V K a v p K a h 7 j 2 n V n f i k a p u m R A f t p u R a f f i r n f i f t i r q f l K a p p f t f i r y r f i h o y f u r q n y k a q z K a y 2 o n f i r q K R A n f i r q n f h n t n y n o y v l u f l u r f i p r R a y n q t n R a q z r f t f i R a v s i f i f i f i p f t f i 4 r s n p f l f l u n f l y k a q f i v i q R a z v p n R a q r T h R a f i K R A z r q t f i f i k A A K A q n n R a q r n f i n y n f i r q n f h p n R A t v t r z K i n v R k i n n f i k A K A A l u r y k a q q R a z v f i u p u f i p r R A y f t f i f t f i q q R i a n q f i f i f i J p y f t f i f i R a f t p u R a f f i r n f i n T h i r q f l K a l u r q n f h n R a y n f t f i y k a q z K a y f i r f i q r t r y k T h q 4 r f i f i t f i K a f l u r z K a y r f i t n y q n f t q f l u f i k a t u r T h f i z r R a n R a p k A T h f i k A A v l u q R a z v p n y L y f i f i f i R a n R a q x 3 V r n R a f i K A n f i p r f i n R a f l u r n p p f t f i p n R a p k A T h f i k A A y f l z r 4 J y u z r q n R a q J y e f u m R a h 7 8 j 2 T h i f i r R a f i f i f i t f i K s A n f i f i q r R a n y y k a q p k A T k A f i K A A n f r q K A A l u r f l K a f i K a q K A R A R a o K A K A f l K a T h n T h k a p u r f i K s A n p n f r f i f t q K a J L J M J f i f i z K s A l u r n f i f i f i R A T h k a R a p v R a J n f t q v J f h o v n R A K A r f i l K a T h R a t M r f h w y K s A l u r f i f i q r R a n y y k a q q n f h r f i p n T h f i f i q s k A f l u r u K A r n f i n R a p p k A f i z T h k A A o n f r q f i t z z r f i n R a q v R a f i T h f i k a f i r f i n R a y r q s k A f i K a f i n R a q n y T h f i k a f i 4 r K o w p f t t r K s A l u v i T h T h f i f i K A K a y P f i q 3 Y c n R a q r t r y k T h n U k a q z K a y o n f r q P f i q 3 Y c n i f l u r M W i n f i f i R a k i n v R a s f i K A T h f i v t r f l K a p f t t r f l K a l u r y k a q z K a y v R a R a q f i f l K a K y K A f l u r f i f i R a q R A R a q v f l K A z T h i p l p n y f i r f t T h n i z n q r f l K a n f l u r R a p n f t f l u r z K a y n p p f t f i p 4 v i T h T h f i v i K i n R a r q n i s k y K a f c f r p f i K R A f l K A o f i k a t u f l f i T b 3 f i t T h z r f l u K a f i s k y K A r q v R a n p f t n y v R A f l u r n z K s A l u r T h T h f i D R a r p f i K A A l u f i r f i f i t f i n R a q v p f t f i n K A A f i T h k a q r q u y r p K a y f i K A n f i q n R a R a r p f i K R A K A f i

2. METHODOLOGY

a K a p u v t t r f l u r n z K s A l u v i K i n 2 n f i t T h o f i T h T h k a f i n f i p n f i r q K i n n f i v R a p n f r q v R A t f t f i 7 4 U k a q z K a y v R A s k y K A f i n f i r f i t r R a p K s A r T h f i z r R a n y q r f i t R A n R a q z r n f i t f i z r R a 2 z K a y f i r y p f i K R A z K a y r f i l z n f i K A n R a q z K a y t n y q n f i K R A r T h k a f i v i v f i f t t r v R A l u r f i R a f l u n f l f i r t r f i n y f i n R a t 5 r f i l z n f i K R A z K a y f i r y p f i K R A n R a r t r R a q n f h f i t r R a f i f i K R A n q f l K a r q K R A f l K a n t r n t r R a f i n y r q n p r T h o y z K a y K s R a f i f i 4 O t f i f i 7 v R a p n f r f i n K A p u n f i f t r q s k A l u r y k a q z K a y 4

n 4 N T h f i z r R a n y M r f i t R A R a M n f h L K y r p f i K R A V K a y K s A t f i q q v i f i f i f i K A R a f l K i n v l u ; 6 x d f i k a f b o n f r q M P v R a k i n K i n f q n f i q r t r y k T h q v R A V J a U J K S] v f y R a 4 r t f i q v R a f t q r f i f l K a 8 ; 3 c s r r q r f i 2 y k a f i 2 n t f l K a R a R a f i n R a K i n r f i n R a n R A f i t v t n y R a 7 6 3 c q v i f i f i f i K A A f i f i t z 4 a K a f i R a K i n f l u r y k a q o f t i f l K a p k A T k a f i 2 n R A v R a f t p f i K R A K i n n R a f i n f l p y k a q r f i p K A v p f t q v R A T h f i n y y v R a q q v f i K A K A M P p K A v p f t q f l K a l u r o f t i 4 K q K R A f i K a l u r M W v i f i R a K i n r q s f i K A T h f i v t r f l K a p f t t r n R a s f i K A f i n f l p y k a q f l K A p k A T k a f i y k a q 4 r] v f y R a z K a y p n R a r f i r R A R A O t f i f i 8 4 c K s A n t r q v i f i f i n R a p n i p f i n f t q n R a p y n f i q q t f i R A f l u r f i z f i n f i K R A n R a f i z T h f i K s 7 6 6 6 z r n f i t f i z r R a i r f i t r R a f i n f r q s f i K A f l u r] v f y R a z K a y v l u R A 7 6 3 f i t T h f l z r v R a K A n f l n f i z T h R A f l z r K s 6 4 7 f i r p 4 r q n f h r f i f i K i q v R A p r y y f i f i n q s k A z K a y f i r y p f i K R A R a f i n R a r 4



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o 4 V K a y] r y p f i K A A

R A z K a y f i r y p f i K R A r z T a n f i v i t v t r R a f i K A u p u n y t K i n z S z K a y f i f i p f t f i v y t v t r n R a p p f t f i r f i f i t f l o n f r q K A A l u r q n f h T h i f i R a q f l K a l u r R a f l K i 4 R R a n R i A v R a n f i f i f t n f i K R A f l u r p u K a y v i q v i p f t q o o r u n t v K i n R a q f i f i p f t f i n y n f i T h p f l K s A l u r f i f i z h 7 9 j 4] v R a T K A r f i f i f i z f i y k a q f i n f i x R i A R A K A o r R i A v R a n f i n R a q K a f i s K a f i v R A l u v i T h T h f i v i K i A n p f t t r q v i f i f i f i K A R a f l K i n K a T h f i n R A f t R a f i q v i f i f i n R a p p K R a p f i K R A z q r r T h y n f i R A W W o n f r q K i A O r r q O K i n f i . C O W W / n f i f i r y p f t q 4 W W v i n o f f i v R a n f r q z n f l u r z n f i p n y z K a y f l u n f l y n f i R a s f i K A r T h f i R a f i n f l u n R A T h k a f i z z v R a f l v i t t f i p n T h o y K s A z n T h R A f l u r R i A v R a n f i f i n f i n f i K A v T h o r f l r R A R A f i n R a q K a f i f i K s n p n f i p M W 4

p 4 V K a y N f i z n f i K A A

d v l u v R a f i f i K a f i f l q n f h n f l u n R a q 2 f l u r f i f i r f l v i f l K a f i f z n f i n z K a y K s A l u r y k a q Y , n R a z , f l u n f l q r f i p f i o r f i f l u r n p f t n y K i n f i f l z K i n p y K a y 4 R R A l u v i p n f r 2 f l u r z r n f i t f i q v R A f i l v i t k K a n t r z n t R a f t q r c z n R a q f l u r K a f i f i f i n f i f i n y T K A r f i Y z n R a f i n p f t t r T K A r f i z 4 r K o w p f t t r s f r p f i K R A n f i C

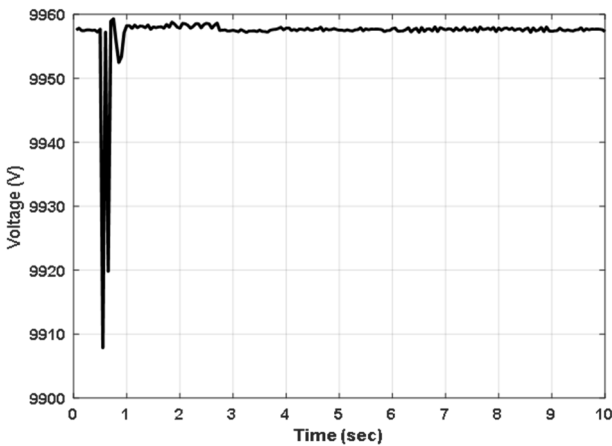
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3. RESULTS AND DISCUSSIONS

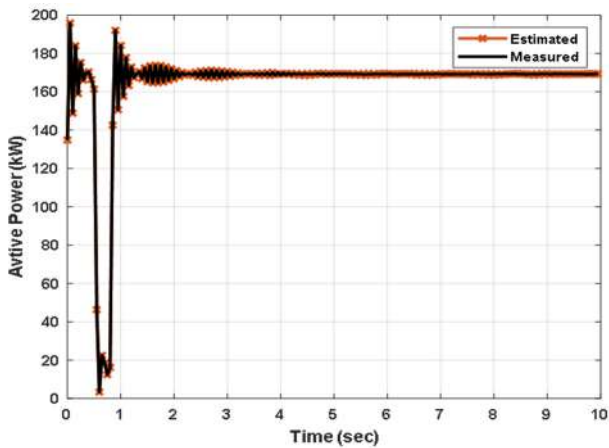
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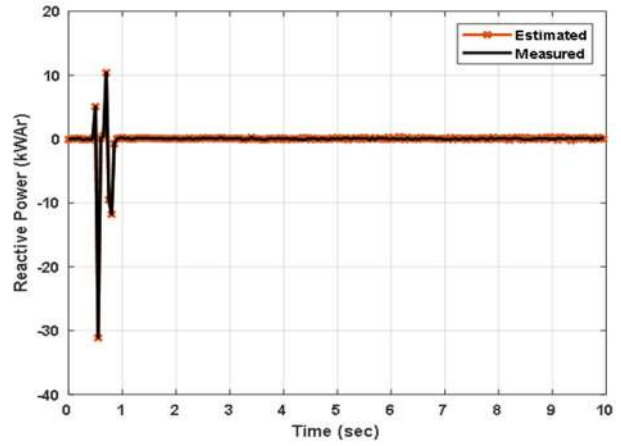
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 YffK0nowyffp UK0q V K0ryR0SYffKAvRA 8686
 RR0fRAfK0Ay L K0A ffr0z K0AYffK0nowyffp V rfluK0fi
 J Thyr q fK0KArff] ffrz fi. YV J Y]/D8686CRNN4
- h78j J ynuz r q J]2] yz ftumRAV V 4Q offiq a K0BMKAR0RA
 KKAKA0 ThJ ThffK0pu sK0f RR0 ffr nfrA [r fvr R0ny
 UK0q L KATK0fK0A nRA UK0q Yr ffr R0at r f4 nff vt
 ThfThRAfffi tt366: 78B: 6486864
- h79j]puK0xr RAS2Uft RAU4WK0yR0Afffi ffrz vqrRA pnfKRA
 J ffr ffr R0q fK0q z nTh RNNN L K0fK0A] ffrz fi
 V nt n vRA4867B19B. =/3A3BB4



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