HARDWARE & SOFTWARE REALISATION FOR THE FEED POSITIONING SYSTEM

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13/7/92

Introduction

Feed positioning system controls the rotation of the feed turret to enable operation at any of the selected frequency band. Earlier reports outlined various schemes and performance specifications. (Feed Positioning system NCRA Technical reports, Accn# 90198. & Feed Drive control System ITR/SERVO/1 20/8/91.)

This report, describes hardware and software for the working prototype.

Encoder

Encoder selected for the application is ROD 420 - 2048 manufactured by Heidenhain. This is an incremental encoder with 2048 line counts per revolution of the encoder shaft. It gives two incremental output signals with a 90^{o} phase shift. Direction of rotation determines whether channel A or channel B leads. In addition, a reference pulse is produced once per revolution. All signals are balanced and confirm to RS - 422 specifications. Further information and data sheet is included in the Appendix. 1.

Mechanical Configuration

Feed drive motor is coupled to the feed turret through two stages of reduction (Fig. 1) A worm gear with 300 :1 reduction and feed bull gear with a reduction of 5:1. Encoder is coupled to the output shaft of the worm gear. ie there is a reduction of 5:1 between the encoder shaft and the feed turret.

Controller Hardware

Please refer to Fig.2 and Fig.3 for the description that follows;

The controller is based on a microcontroller (Intel 80C51FA). Regulated 5 V DC is supplied to the encoder from the controller board. Outputs of the encoder are connected to balanced line receivers. Use of balanced drivers and receivers enable long cable lengths with excellent common mode noise immunity. TTL outputs of the line receivers are further passed through digital filters to reject noise spikes. Incremental signals are then decoded into COUNT and DIRECTION signals. COUNT gives a pulse train at twice the line count. DIRECTION indicates the direction of rotation. These two signals are connected to the microcontroller input pins. Position count is maintained by incrementing or decrementing a 16 bit counter on the 80C51FA. This is done in hardware by enabling the appropriate mode. Thus, there is no danger of missed counts.

Reference pulse output goes to an interrupt on the 80C51. This reference pulse occurs at fixed shaft position of the encoder and is very acurate. The 16 bit position count is initialised on the first occurance of the reference pulse. The position count maintained is thus with respect to the first index pulse. Since there is a 5:1 reduction between the encoder shaft and the feed turret, there will be multiple reference pulses in one complete rotation of the feed turret. It is thus necessary to 'mark' one of the reference pulses. This 'marked' reference can then be used to maintain absolute position count. This marking can be provided by a limit switch. Positioning accuracy of the limit switch is not important as the count is maintained from the reference pulse.

Feeds will be positioned at 90° intervals on the turret. This corresponds to 450° on the encoder shaft. 450° rotation of the encoder shaft corresponds to 2048 X 1.25 lines. This corresponds to 5120 (2048 X 1.25 X 2)pulses at the microcontroller. Feeds 1 to 4 are assigned position counts differing by 5120.

Pulse width modulation (PWM) is used to control the power to the motor. In this scheme, power to the motor is switched ON and OFF at a fast rate. The ratio of ON to OFF times determines the average power fed to the motor. Speed of the motor can thus be controlled by controlling the duty cycle of the switches. MOSFETS (IRF 540) are used as the switching elements. These are capable of handling 10 A safely and have a turn on resistance of only 85 mΩ when driven properly.

PWM controller is also implemented in hardware in the 80C51FA. It is only necessary to write the appropriate count to the proper register after suitable configuration. H Bridge is used to control the Servo motor. Four MOSFET switches and servo motor are connected in the form of an 'H'. Direction of rotation can be controlled by turning ON switch pairs 1 & 4 or 2 & 3. Thus, speed of the servo motor is controlled by PWM and direction by chosing the appropriate pair of MOSFETS.

Brake of the servo motor is controlled by an output pin of 80C51 through an opto isolator and a Darlington transistor. Interlocking is done to ensure that the motor does not turn ON if the brake is not released. Short circuit / stalled motor current limit can be implemented by chosing appropriate resistance at the ground end of the H bridge. When voltage drop across the resistance exceeds, 0.6 V transistor Q is turned ON. This turns OFF the MOSFETs as the charge pump cannot supply enough gate drive. Charge pump generates an isolated 12 - 16 DC voltage source capable of driving the MOSFET gates. Gates of the MOSFETs can thus be driven by a source which is about 12 V higher than the source and drain. This is required to ensure proper turn ON of the MOSFETs. The charge pump oscillator frequency is at about 50 - 100 KHz.

Controller Software

Present software on the controller is very basic and ensures standalone operation with a PC or any RS 232 / RS 422 terminal. Presently, the servo hand held terminal (Oriole PBT) is used.

Counts corresponding to the four feeds are put in the EPROM. These are 90^{o} apart on the feed turret. Position count is with respect to the first reference pulse encountered. Feed one is assumed to be located at the first reference pulse location.

After the first reference pulse, position counter is initialised and the motor is stopped. When any of the feeds is 'selected' the direction and magnitude of the displacement required is computed. This is used to chose the appropriate direction and PWM for the motor. PWM is increased gradually to limit the start up current. As along as the target position is outside the proportional region, motor runs at full speed. When target position is near, speed is gradually reduced. Brake is applied when position error is below a certain limit. Currently, proportional region starts when the target position is within 256 counts. Brake is applied when is error is less than 5 counts. These parameters have to be modified based on performance with feeds mounted.

There is also a 'manual' mode where the motor can be 'Run', 'Stopped' and the 'Direction' changed. Position count by obtained by pressing the 'Position' key. Appendix.2 lists the current commands supported.

Appendix.3 gives the assembly program listing. Program is straight forward and easy to follow with the comments. Initialisation and proper use of hardware resources is unambiguous.

Further improvements & modifications

HARDWARE

1. Currently, provision for connecting the 'marking' limit switch is not there. This limit switch can be connected to int1 pin of 80C51 through a pull up resistor. Noise rejection is not critical as, position accuracy of the switch is not important. Limit switch is sensed only at the start. Int1 should be disabled after initialisation.

2. If the FPS is to be used as an MCM, an RS 485 interface is required. ie. only one twisted pair is used. In such a case, transmitter (U8A) should be enabled only when FPS has to transmit. This can be achieved by connecting the enable pin of U8A to P1.6 or P1.7 of 80C51. One of the LED's will then indicate the transmit status.

3. Power ground (PGND) and signal ground (GND) should be separate for best noise immunity and isolation. Oriole hand held terminal may misbehave when large switching spikes occur on the common ground.

4. As indicated on the schematic, filter capacitors must be placed close to the servo motor.

5. It is suggested to restrict the maximum current to the motor to 10 A eventhough the rated maximum is 12 A. This can be achieved

by restricting the 50 V power supply to 10 A. Max.

6. Heat sinks for Q1 - Q4 should be improved for reliable continuous operation. Commercial heatsinks like AFCOSET should be used. Insulation is not required between any two transistors of the top or bottom.

SOFTWARE :

7. When starting from rest PWM should be increased GRADUALLY. Full power should never be applied when the motor is at rest.

8. For use as an MCM, commands have to be embedded in a proper frame to make them compatible with other MCM's.

9. Automatic address recognition feature of 80C51 can be used to simplify the software.

10. Appropriate TX enable (P1.6 or P1.7) should be added depending on the hardware change to interface with other MCM's.

11. Proportional range may have to be increased to enable smooth braking at the final position without over shoot. Count at which brake has to be applied can be determined only after study with the feeds loaded on the turret. PWM can be decremented rapidly to ensure faster braking.

12. Direction of rotation can be reversed after zero PWM has been reached to realise sudden braking.

13. Speed and displacement can be monitored to detect motor stall and other fault conditions.

14. Positions of the feeds can be downloaded from the ABC for flexibility. Similarly target position can also be downloaded.

15. Watchdog timer on 80C51 can be activated for reliability.

16. Feeds can be given multiple position counts to enable selection of shortest path between any two feeds subject to cable wrap.

Some of the suggestions are illustrated in Appendix 4.

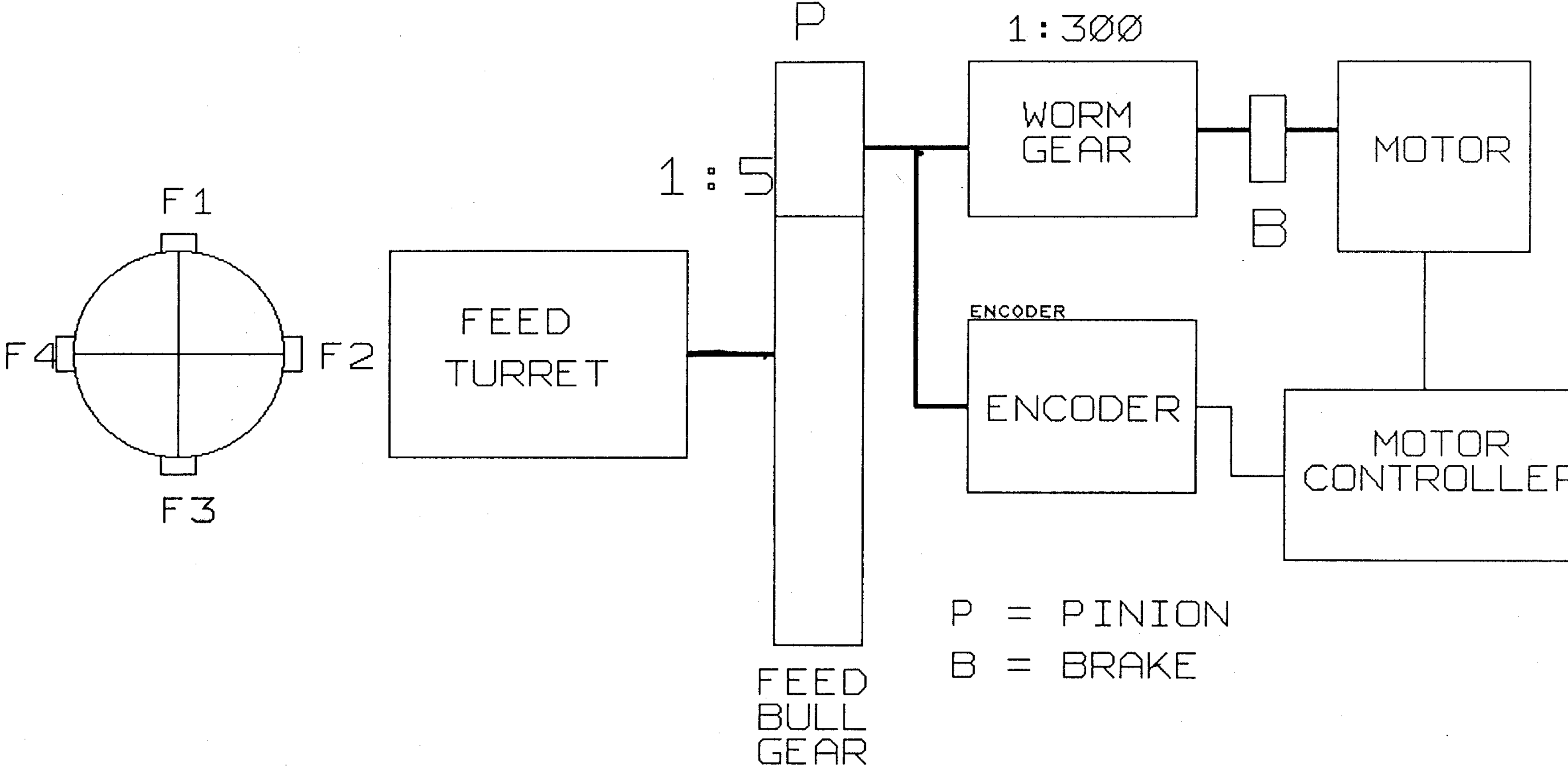
References

1. Vaidya.V, Kulkarni.G.R., "Feed Drive (
ITR/SERVO/1 20/8/91

2. A.Ramakrishna., "Feed Positioning Syst
NCRA Technical Reports Accn # 90198.

3. Intel, 8 Bit Microcontroller Handbook.

4. Motorola, Power MOSFET Handbook.



Adopted from Ref. 1		
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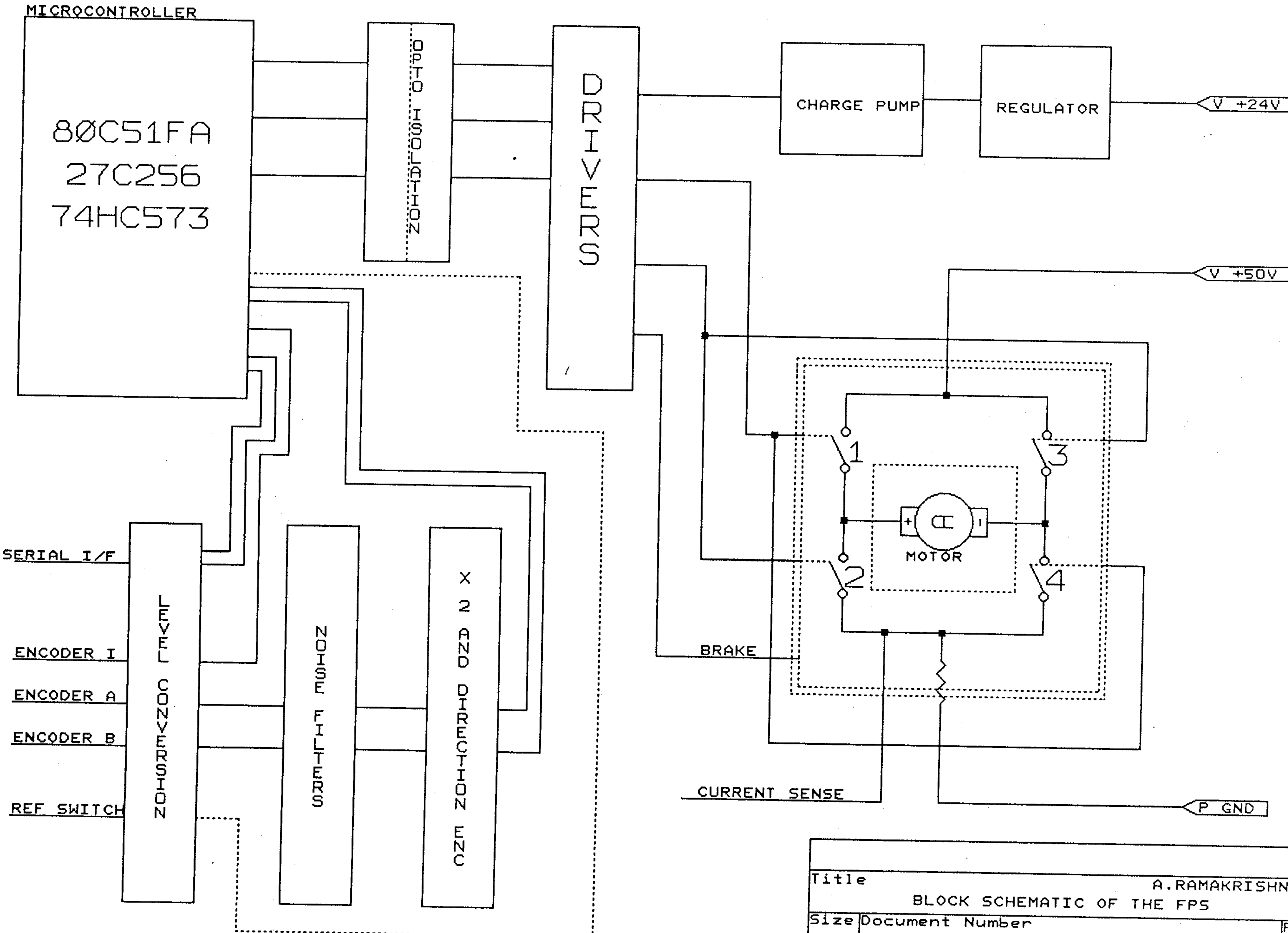
Date: July 11, 1992	Sheet of	



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	BLOCK SCHEMATIC OF THE FPS
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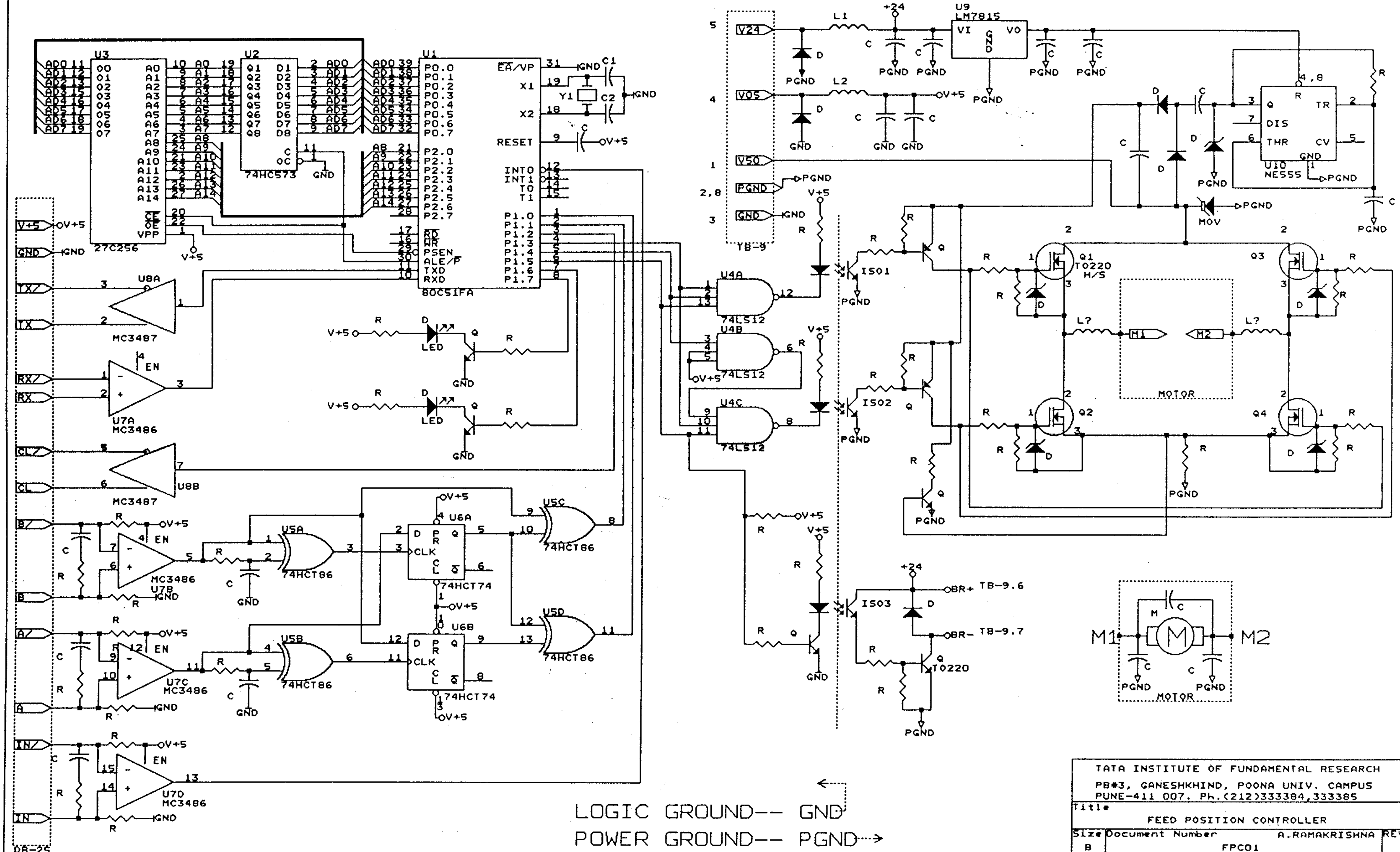

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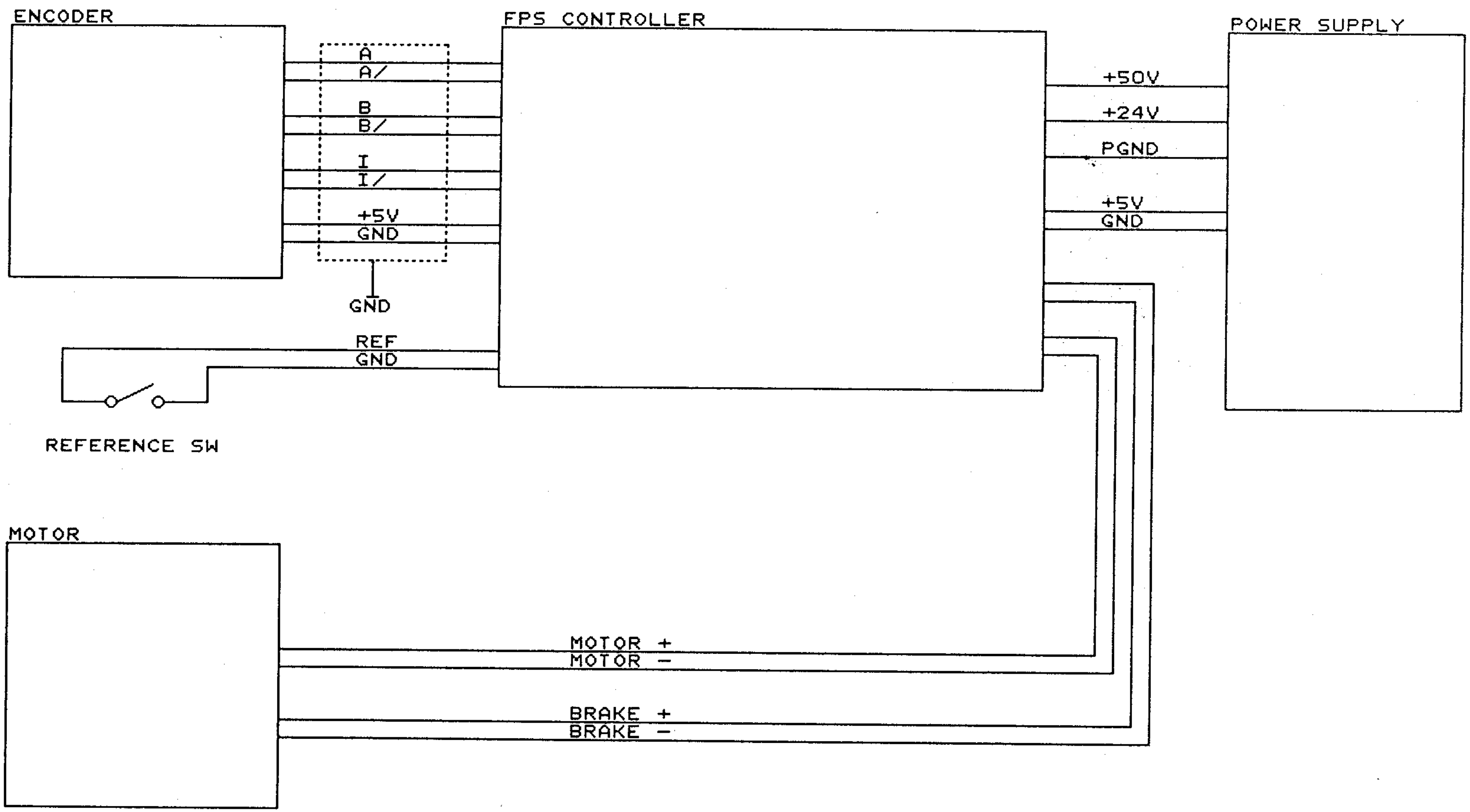
PUNE-411 007. Ph.(212)333384,333385

Title	FEED POSITION CONTROLLER		
Size B	Document Number FPC01	A.RAMAKRISHNA	REV
Date: June 4, 1992	Sheet 1 of 2		



Title	INTERCONNECTION FPS		
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Date:	July 11, 1992	Sheet	of

Technical Specifications

Mechanical Data		ROD 420
Line counts		50/60/100/120/125/128/150/180/200/250/254/256/360/400/420/500/512/600/625/635/720/800/900/1000/1024/1080/1125/1250/1270/1500/1750/1800/2000/2048/2080/2500/2540/2920/3000/3600/3750/4000/4096/4500/5000 (special line counts upon request)
Accuracy		± 18°/ z (≙ 1/20 grating period) z = line count
Resolution		0.018° with 5000 lines and 4-fold evaluation in the subsequent electronics
Slewing speed		max. 6 000 rpm
Moment of inertia of rotor		$1.8 \cdot 10^{-6}$ kgm^2
Torque at 20° C (68° F)		≤ 0.01 Nm
Shaft load	axial	max. 40 N
	radial	max. 60 N (at shaft end)
Weight		approx. 0.3 kg (0.55 lb)
Type of protection		IP 64 according to IEC 529
Operating temperature		0° to 70° C (32° to 158° F)
Storage temperature		–30° to 80° C (–22° to 176° F)
Vibration (10 to 2000 Hz)		≤ 100 m/s^2
Shock (11 ms)		≤ 1000 m/s^2

Appendix

Technical Specifications

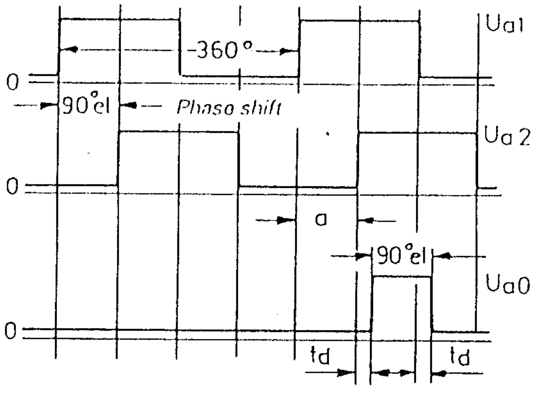
Electrical Data

ROD 420

Power supply

5 V ± 5 % / max. 205 mA (without load)
Light source: filament lamp 5 V/0.6 W

Output signals



Incremental signals
TTL square-wave pulse trains U_{a1}, U_{a2} and their in
$\overline{U_{a1}}$ and $\overline{U_{a2}}$. U_{a2} lag U_{a1} with clockwise rotation (s
side)

Edge separation
a ≥ 0.8 µs at scanning frequency 160 kHz

Reference signal
1 square-wave pulse U_{a0} per revolution and its inv
pulse $\overline{U_{a0}}$

Lag time
lag of pulse U_{a0} to signals U_{a1} and U_{a2}
$|t_d| \leq 50$ ns

Signal level
$U_{aHigh} \geq$ 2.5 V at $-I_{aHigh} = 20$ mA
$U_{aLow} \leq$ 0.5 V at $I_{aLow} = 20$ mA

Loading
$-I_{aHigh} \leq$ 20 mA
$I_{aLow} \leq$ 20 mA
$C_{Load} \leq$ 1000 pF

Switching times
rise time $t+ \leq$ 100 ns
fall time $t- \leq$ 100 ns

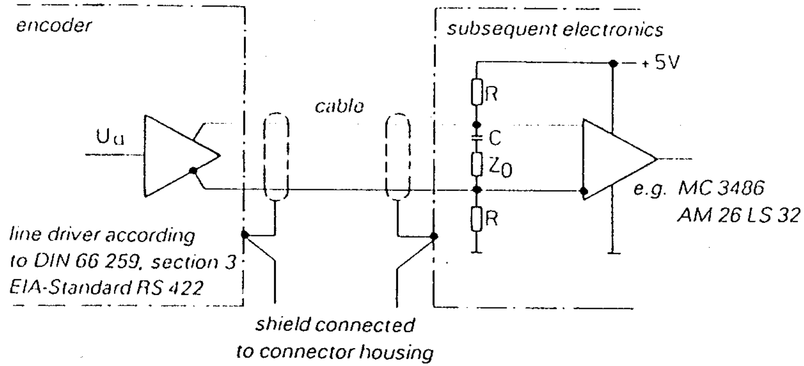
Scanning frequency

0 to 160 kHz

Slewing speed

0 to $(160/z \times 10^3 \times 60)$ rpm   z = line count

Recommended input circuitry of subsequent electronics



$R = 4.7\ k\Omega$; prevents switching of the receiver during line break

C = 1 to 10 nF; reduces the DC loading of the rotary encoder

Z_0 = 120 up to 140 Ω (with HEIDENHAIN cable) or corresponding to the characteristic impedance of the cable

Cable length	at encoder	1 m (3.3 ft) other lengths upon request
	to subsequent electronics	50 m (164 ft) max., with HEIDENHAIN cable $(4 \times 2 \times 0.14 + 4 \times 0.5)\ mm^2$ with sufficient power supply at the encoder

Pin Layout	B/	V+5	A IN	$\overline{\text{A IN}}$	A	$\overline{A}$		B		Gnd	Gnd	V+5
Pin	1	2	3	4	5	6	7	8	9	10	11	12
Signal	$\overline{U_{a2}}$	sensor + 5 V	U_{a0}	$\overline{U_{a0}}$	U_{a1}	$\overline{U_{a1}}$	free	U_{a2}	shield *	0 V	sensor 0 V	+ 5 V
Color	pink	$0.25 mm^2$ blue	red	black	brown	green	/	gray	/	$0.25 mm^2$ white/ green	$0.25 mm^2$ white	$0.25 mm^2$ brown/ green

* shield is on the connector housing and is connected to pin 9 in the connector

Permissible bending radii of cable

Cable diameter	Permissible bending radius for Repeated bending	Stationary config.
Ø 4,5 mm (.18 in.)	R ≥ 50 mm (2 in.)	R ≥ 10 mm (.4 in.)
Ø 6 mm (.24 in.)	R ≥ 75 mm (3 in.)	R ≥ 20 mm (.8 in.)
Ø 8 mm (.31 in.)	R ≥ 100 mm (4 in.)	R ≥ 40 mm (1.6 in.)

MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

IRF540
IRF541
IRF542

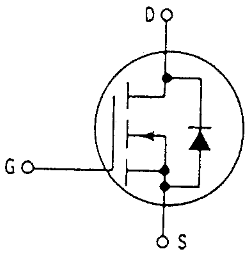
Power Field Effect Transistor

N-Channel Enhancement-Mode Silicon Gate TMOS

These TMOS Power FETs are designed for low voltage, high speed power switching applications such as switching regulators, converters, solenoid and relay drivers.

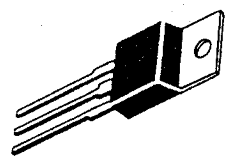
- Silicon Gate for Fast Switching Speeds
- Low $r_{DS(on)}$ to Minimize On-Losses. Specified at Elevated Temperature
- Rugged — SOA is Power Dissipation Limited
- Source-to-Drain Diode Characterized for Use With Inductive Loads

TMOS



TMOS POWER FETs
24 and 27 AMPERES
$r_{DS(on)}$ = 0.085 OHM
60 and 100 VOLTS
$r_{DS(on)}$ = 0.11 OHMS
100 VOLTS

3



CASE 221A-04
(TO-220AB)

MAXIMUM RATINGS

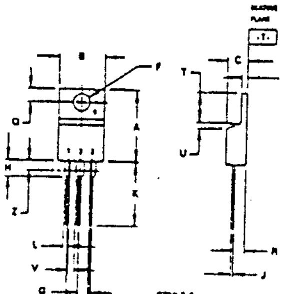
Rating	Symbol	IRF 540	IRF 541	IRF 542	Unit
Drain-Source Voltage	V_{DSS}	100	60	100	Vdc
Drain-Gate Voltage (R_{GS} = 20 kΩ)	V_{DGR}	100	60	100	Vdc
Gate-Source Voltage	V_{GS}	±20			Vdc
Drain Current Continuous, T_C = 25°C T_C = 100°C Peak, T_C = 25°C	I_D	 27 17 108		 24 15 96	Adc
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	125 1			Watts W/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−55 to 150			°C

THERMAL CHARACTERISTICS

Rating	Symbol	Value	Unit
Thermal Resistance — Junction to Case — Junction to Ambient	$R_{\theta JC}$ $R_{\theta JA}$	1 62.5	°C/W
Maximum Lead Temp. for Soldering Purposes, 1/8″ from Case for 5 Seconds	T_L	300	°C

See the MTP25N10 Designer's Data Sheet for a complete set of design curves for the product on this data sheet.

OUTLINE DIMENSIONS



STYLE 5:
PIN 1. GATE
2. DRAIN
3. SOURCE
4. DRAIN

NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIM Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	14.48	15.75	0.570	0.620
B	9.66	10.28	0.380	0.405
C	4.07	4.82	0.160	0.190
D	0.64	0.88	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.42	2.66	0.095	0.105
H	2.80	3.93	0.110	0.155
J	0.36	0.55	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.15	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.15	1.39	0.045	0.055
T	5.97	6.47	0.235	0.255
U	0.00	1.27	0.000	0.050
V	1.15	—	0.045	—
Z	—	2.04	—	0.080

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 0.25 mA)		IRF540, IRF542 IRF541	$V_{(BR)DSS}$	100 60	— —	Vdc
Zero Gate Voltage Drain Current (V_{DS} = Rated V_{DSS}, V_{GS} = 0) (V_{DS} = 0.8 Rated V_{DSS}, V_{GS} = 0, T_J = 125°C)			I_{DSS}	— —	0.2 1	mAdc
Gate-Body Leakage Current, Forward (V_{GSF} = 20 Vdc, V_{DS} = 0)			I_{GSSF}	—	100	nAdc
Gate-Body Leakage Current, Reverse (V_{GSR} = 20 Vdc, V_{DS} = 0)			I_{GSSR}	—	100	nAdc
ON CHARACTERISTICS*						
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 0.25 mA)			$V_{GS(th)}$	2	4	Vdc
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 15 Adc)		IRF540, IRF541 IRF542	$r_{DS(on)}$	— —	0.085 0.11	Ohm
On-State Drain Current (V_{GS} = 10 V) (V_{DS} ≥ 2.3 Vdc) (V_{DS} ≥ 2.6 Vdc)		IRF540, IRF541 IRF542	$I_{D(on)}$	27 24	— —	Adc
Forward Transconductance (V_{DS} ≥ 2.3 V, I_D = 15 A) (V_{DS} ≥ 2.6 V, I_D = 15 A)		IRF540, IRF541 IRF542	g_{FS}	6.0 6.0	— —	mhos
DYNAMIC CHARACTERISTICS						
Input Capacitance	(V_{DS} = 25 V, V_{GS} = 0, f = 1 MHz)		C_{iss}	—	1600	pF
Output Capacitance			C_{oss}	—	800	
Reverse Transfer Capacitance			C_{rss}	—	300	
SWITCHING CHARACTERISTICS*						
Turn-On Delay Time	(V_{DD} ≈ 30 V, I_D = 15 Apk, R_{gen} = 4.7 Ohms)		$t_{d(on)}$	—	30	ns
Rise Time			t_r	—	60	
Turn-Off Delay Time			$t_{d(off)}$	—	80	
Fall Time			t_f	—	30	
Total Gate Charge	(V_{DS} = 0.8 Rated V_{DSS}, V_{GS} = 10 Vdc, I_D = Rated I_D)		Q_g	40 (Typ)	60	nC
Gate-Source Charge			Q_{gs}	17 (Typ)	—	
Gate-Drain Charge			Q_{gd}	23 (Typ)	—	
SOURCE DRAIN DIODE CHARACTERISTICS*						
Forward On-Voltage	(I_S = Rated I_D, V_{GS} = 0)		V_{SD}	1.5 (Typ)	2.3(1)	Vdc
Forward Turn-On Time			t_{on}	Limited by stray inductance		
Reverse Recovery Time			t_{rr}	450 (Typ)	—	ns
INTERNAL PACKAGE INDUCTANCE						
Internal Drain Inductance (Measured from the contact screw on tab to center of die) (Measured from the drain lead 0.25″ from package to center of die)			L_d	3.5 (Typ) 4.5 (Typ)	— —	nH
Internal Source Inductance (Measured from the source lead 0.25″ from package to source bond pad)			L_s	7.5 (Typ)	—	

*Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
(1) Add 0.1 V for IRF540 and IRF541.

COMMANDS ON APS

Appendix 2

- RUN ie Release Brake & accelerate gradually
- Stop : ie: Gradually reduce speed & apply brake
- Direction : ie change direction of rotation
  at rest - changes direction for next R
  while running reverses direction by
  Slowing the motor & restores old speed

- Displays Current Position Count in HEX
- ~~Select~~ Position Feed 1 Location 1000H
- Position Feed 2 Location 2400H
- Position Feed 3 " 3800H
- " " 4 " 4C00H

...ial Terminal : Async 9600, n, 1,

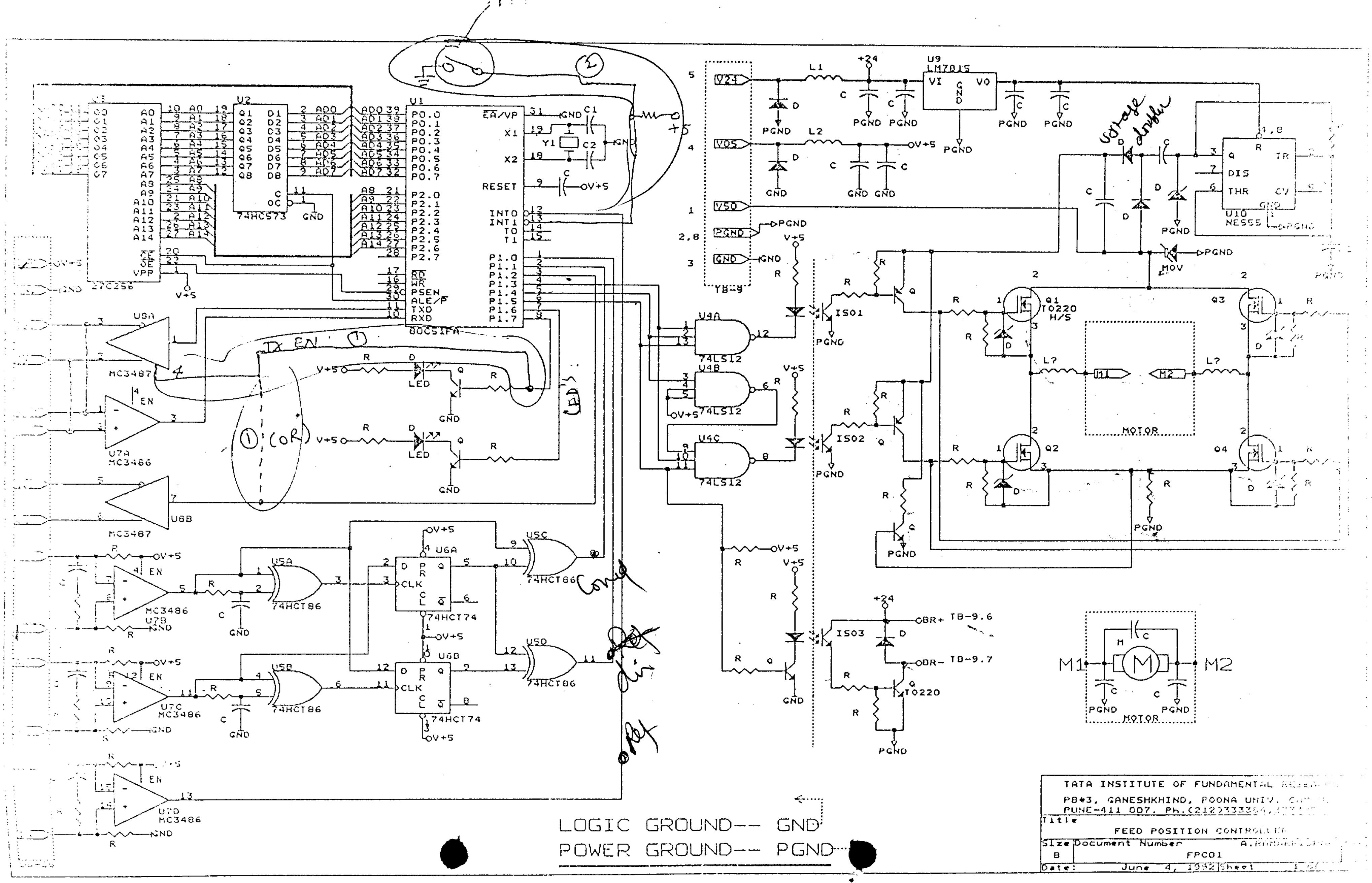
```
;########################################################################
;#                                                                      #
;#   ASSEMBLY LANGUAGE LISTING OF PROGRAM.          - A.RAMAKRISHNA -   #
;#                                                                      #
;########################################################################


$ NOMOD51
NAME FPS

        restart         CODE    00H
        start0          CODE    30h
        TIMER2          CODE    2BH

$ INCLUDE (RG51FA.PDF)

CSEG AT EXTI0

                LJMP    INXISR

CSEG AT         TIMER2

                LJMP    T2ISR

CSEG    AT      restart

                ljmp    start

CSEG    AT      start0

        start:
                clr     p1.5                            ;brake on
                clr     ren
                mov     IP,#00H                 ;NO PRIORITY
                mov     IE,#01H                 ;EN EXT0,EA=0

                MOV     T2MOD,#01H              ;DN COUNT EN
                MOV     T2CON,#0AH              ;T2 UP/DN MODE+DIS T2

                MOV     RCAP2H,#0H              ;LOW LIMIT FOR UP/DN COUNT
                MOV     RCAP2L,#0H

                clr     psw.1                   ;speed flag
                mov     pcon,#0h                        ;3.68MHz
        ;       mov     pcon,#80h                       ;Double BR for 1.8M
                mov     tmod,#21h                       ;t1 auto reload,t0
                mov     th1,#0ffh                       ;9600 baud
                setb    TR1                             ;Start timer1
                setb    cr                              ;PCA on
        ;       setb    cf                              ;
                mov     cmod,#00h                       ;*** :-12, 1.2KHz.
                mov     ccapm0,#42h             ;P1.3(cex0) PWM
                mov     ccap0h,#0ffh            ;pwm=0

                mov     scon,#40h               ;mode 1,clr ti,ri.
                setb    ren                     ;EN RX
                clr     ri
                SETB    EA                      ;ENABLE INTERRUPTS(EXT0)
                SETB    P1.4                    ;DIR +
 rdchs:
                jnb     ri,$                    ;chs aval ?
                mov     a,sbuf
                clr     ri
                cjne    a,#'r',st               ;if ne r may be s OR ...

 run:                                           ;chs=r. RUN
                clr     p1.6                    ;led2 off
```

```
        cjne    a,#0ffh,rdchs   ;if already running ignore

        dec --  a
        mov     ccap0h,a
        call    delay
        cjne    a,#0d,dloop     ;increase speed slowly till 100pc
        jmp     rdchs           ;running,look for next chs

        cjne    a,#'s',dir      ;if not s may be d OR ....

                                ;chs=s. STOP
        clr     p1.7                    ;led1 off
        setb    p1.6                    ;led2 on
        mov     a,ccap0h
        cjne    a,#0d,rdchs     ;not running? skip
        inc     a
        mov     ccap0h,a
        call    delay
        cjne    a,#0ffh,iloop   ;till pwm=0.
        clr     p1.5                    ;Brake
        jmp     rdchs           ;look at next chs

        cjne a,#'d',FE1 ;if not d CHECK FOR.. .

                                ;chs=d.CHANGE DIRECTION.
        clr     p1.7                    ;led1 off STOP
        setb    p1.6                    ;led2 on
        mov     a,ccap0h                ;GET CURR PWM
        cjne    a,#0ffh,ilop    ;pwm ne 0 ? dec pwm

        cpl     p1.4                    ;change dir
        jbc     psw.1,run               ;old speed NE 0
        jmp     rdchs           ;look at next chs

o:setb          psw.1           ;flag for restoring speed
        inc     a
        mov     ccap0h,a
        call    delay
        cjne    a,#0ffh,ilop    ;till pwm=0
        jmp     flip                    ;ok to flip now



        CJNE    A,#31H,FE2      ;IF NOT 1 CHECK 2,3,4,p
        MOV     R0,#10H                 ;MSB REF          1000H
        MOV     R1,#00H         ;LSB REF
        CALL    TARGET


        CJNE    A,#32H,FE3      ;IF NOT 2 CHECK 3,4,p
        MOV     R0,#24H         ;MSB REF        2400H
        MOV     R1,#00H         ;LSB REF
        CALL    TARGET


        CJNE    A,#33H,FE4      ;IF NOT 3 CHECK 4,p
        MOV     R0,#38H         ;MSB REF        3800H
        MOV     R1,#00H         ;LSB REF
        CALL    TARGET


        CJNE    A,#34H,POSRET   ;IF NOT 4 CHECK FOR 'p'
        MOV     R0,#4CH         ;MSB REF        4C00H
        MOV     R1,#00H         ;LSB REF
        CALL    TARGET

---------------------------------------------------------
        ROUTINES FOR OUTPUTING POSITION IN HEX
```

```
TXC1:MOV        DPTR,#TABL          ; TABL START OF LOOKUP TBL
        MOVC    A,@A+DPTR                   ; BIN2HEX
TXC:    clr     ti                          ; CHS OUTPUT
        mov     sbuf,a
        jnb     ti,$
        RET


        CJNE    A,#70H,RSH          ;IF NOT 'p' LOOK FOR NEXT CHS

        MOV     A,#'P'              ; P =
        CALL    TXC
        MOV     A,#' '
        CALL    TXC
        MOV     A,#'='
        CALL    TXC
        MOV     A,#' '
        CALL    TXC
        MOV     A,TH2
        ANL     A,#0F0H             ;MASK LOWER NIBBLE OF MSB
        SWAP    A
        CALL    TXC1
        MOV     A,TH2
        ANL     A,#0FH              ;MASK UPPER NIBBLE OF MSB
        CALL    TXC1

        MOV     A,TL2
        ANL     A,#0F0H             ;MASK LOWER NIBBLE OF LSB
        SWAP    A
        CALL    TXC1
        MOV     A,TL2
        ANL     A,#0FH              ;MASK UPPER NIBBLE OF LSB
        CALL    TXC1

        MOV     A,#'H'              ; H
        CALL    TXC
        MOV     A,#0AH              ; LF
        CALL    TXC
        MOV     A,#' '
        CALL    TXC
        MOV     A,#0DH              ; CR
        CALL    TXC

RSH:    LJMP    RDCHS               ;JMP TO RDCHS / BRIDGE REL JM


        clr     tr0                         ;disable t0
        clr     tf0                         ;clr flag
        mov     th0,#0F8h                   ;>5mS delay
        mov     tl0,#0h
        setb    tr0                         ;start t0
        jnb     tf0,$               ;
        ret


        SETB    P1.6                        ;BOTH LED'S ON
        SETB    P1.7

        CLR     C
        MOV     A,R1                        ;LSB POS COUNT
        SUBB    A,TL2
        MOV     R3,A                        ;LSB ERROR
        MOV     A,R0
        SUBB    A,TH2
        MOV     R2,A                        ;MSB ERROR
        JC      FMOD                        ;ERROR -ve
        SETB    P1.4                        ;+ DIR
        JMP     PROP
```

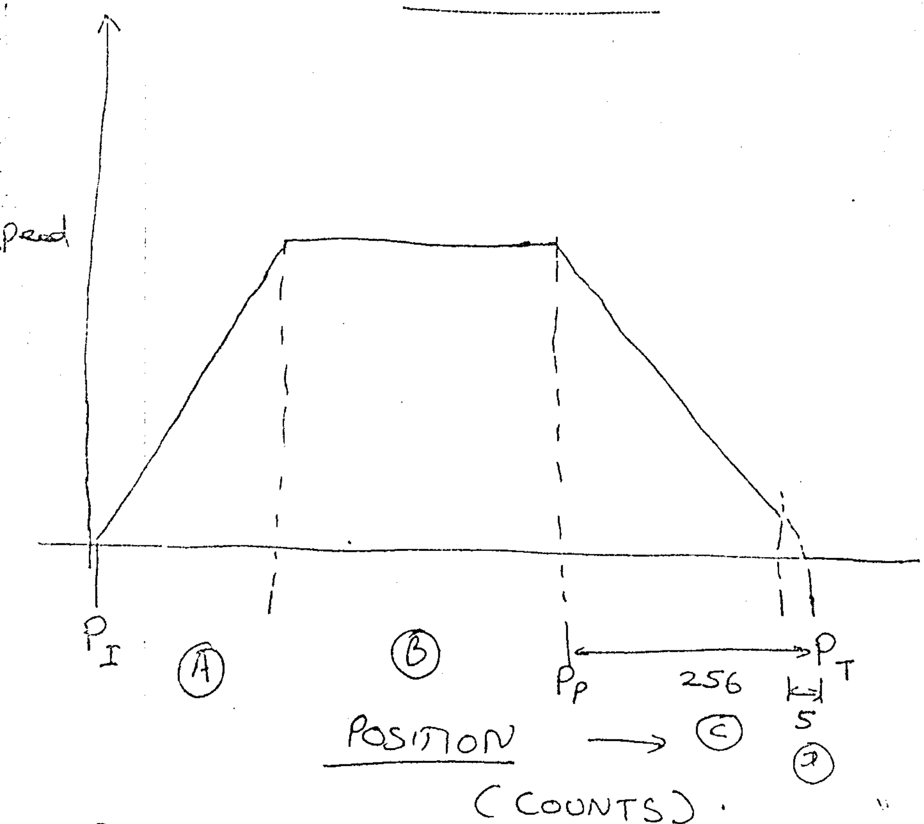
```
        CLR       C                              ;IF -ve MOD OF ERROR
        MOV       A,R3                           ;LSB ERROR
        SUBB      A,#1H              ;DEC R3
        JNC       COMPL              ;LSB DEC SUFFICIENT
        DEC       R2                             ;IF CARRY DEC MSB ALSO
 CPL    A
        MOV       R3,A                           ;MSB MOD ERROR

        MOV       A,R2
 CPL    A                            ;LSB MOD ERROR
        MOV       R2,A


        MOV       A,R2                           ;MSB ERROR
        JZ        INV                            ;ERROR<255

        SETB      P1.5                           ;RELEASE BRAKE
        MOV       A,CCAP0H
        CJNE      A,#0FFH,TARGET     ;IF ALREADY RUNNING IGNORE

:       DEC       A
        MOV       CCAP0H,A
        CALL      DELAY
        CJNE      A,#0H,DLOP         ;INCREASE SPEED SLOWLY TILL 100PC
        JMP       TARGET             ;AFTER START, TARGET

INV:
        SETB      P1.5                           ;REL BRAKE EVEN IF ERR<255
        MOV       A,#0FFH            ;ERR<255, INV FOR PWM REG
        CLR       C
        SUBB      A,R3                           ;INV OF PWM
        MOV       CCAP0H,A                       ;PWM'='ERROR
        CJNE      A,#0FAH,LEC

BRK: MOV          CCAP0H,0FFH        ;PWM=0
        CLR       P1.5                           ;BRAKE ON
        clr       p1.7                           ;led1 off
        setb      p1.6                           ;led2 on

        MOV       A,#07H             ;SOUND BELL
        clr       ti
        mov       sbuf,a
        jnb       ti,$

        CALL      DELAY

        MOV       A,#07H             ;SOUND BELL
        CLR                 TI
        MOV                 SBUF,A
        JNB                 TI,$

        JMP       RDCHS

LEC:    JNC       BRK                            ;IF ERROR < 5 BRAKE
        JMP       TARGET             ;WAIT TILL ERROR<= 5
- INDEX ISR ----------------------------------


        SETB      TR2                            ;ENABLE T2
        MOV       TH2,#10H                       ;REF POS 1st INDEX =1000H
        MOV       TL2,#00H

        MOV       CCAP0H,0FFH .      ;PWM=0

        SETB      P1.6                           ;BOTH LED'S ON
        SETB      P1.7
```

```
        CALL      DELAY
        SETB      P1.6                        ;BOTH ON
        SETB      P1.7

        CALL      DELAY
        CLR       P1.6                        ;BOTH OFF
        CLR       P1.7

        CALL      DELAY
        SETB      P1.6                        ;BOTH ON
        SETB      P1.7

        CALL      DELAY
        CLR       P1.6                        ;BOTH OFF
        CLR       P1.7

        CALL      DELAY
        SETB      P1.6                        ;BOTH ON
        SETB      P1.7

        CLR       P1.5                        ;BRAKE ON
        clr       p1.7                        ;led1 off
        setb      p1.6                        ;led2 on
        MOV       IE,#10H            ;DISABLE FURTHER EXT INT, EN T2 INT
        CLR       IE0                         ;EXT 0 SOURCE
        RETI

2 ISR ---------------------------------------

        CLR       P1.5                        ;BRAKE ON
        clr       p1.7                        ;led1 off
        setb      p1.6                        ;led2 on
        mov       r4,#10d
        mov       a,#45h             ;E
        clr       ti
        mov       sbuf,a
        jnb       ti,$
        clr       ti
        dec       r4
        cjne      r4,#0h,M1
        clr       ri
        CLR       TF2                         ;CLR SOURCE FOR T2 INT
        RETI
```


TATA INSTITUTE OF FUNDAMENTAL RESEARCH
PB#3, GANESHKHIND, POONA UNIV. CAMPUS
PUNE-411 007. Ph.(212)
Title
FEED POSITION CONTROLLER
Size B
Document Number FPC01
Date: June 4, 1992 Sheet
LOGIC GROUND-- GND
POWER GROUND-- PGND
80C51FA
74HC573
27C256
74LS12
74HCT86
74HCT74
MC3486
MC3487
LM7815
NE555
IS01
IS02
IS03
MOTOR
M1
M2
TB-9.6
TB-9.7
TB-9
T0220 H/S
MOV
LED

MODIFICATIONS SUGGESTED

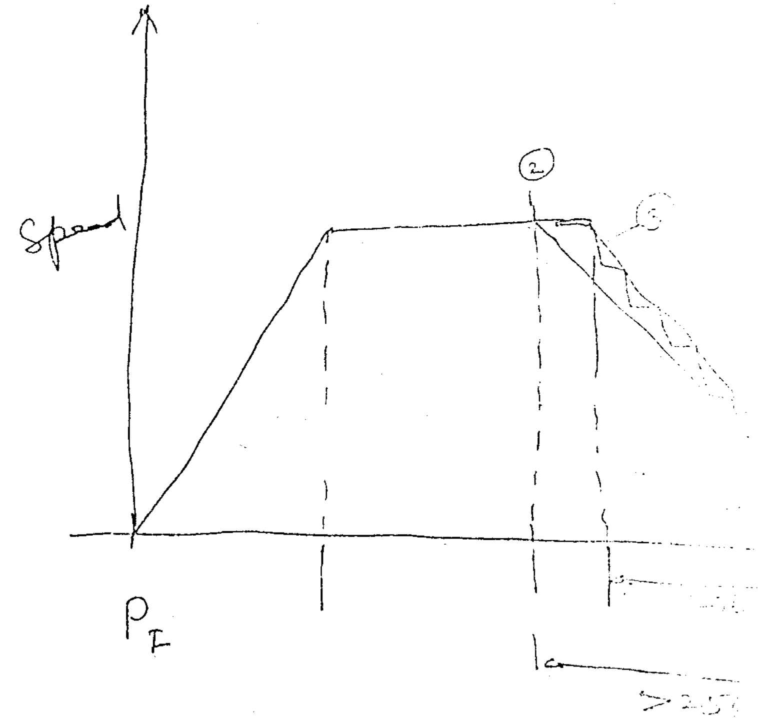
PRESENT



P_I - Initial Position
P_P - Start of Proportional Region
P_T - Target Position

Region A - Start up
B - Position error > 256
C - Prop. Region Pos err < 256.
D - [illegible]

SOFTWARE



(1) Braking region can be ch[illegible] obtain proper final position. (Brake when Pos error [illegible] 5

(2) Proportional region can be [illegible] beyond 256 counts.

(3) Proportional gain can [illegible]