
HD153031RF

36-Mbps Data Channel Processor



Rev. 1
Aug. 1993
Preliminary

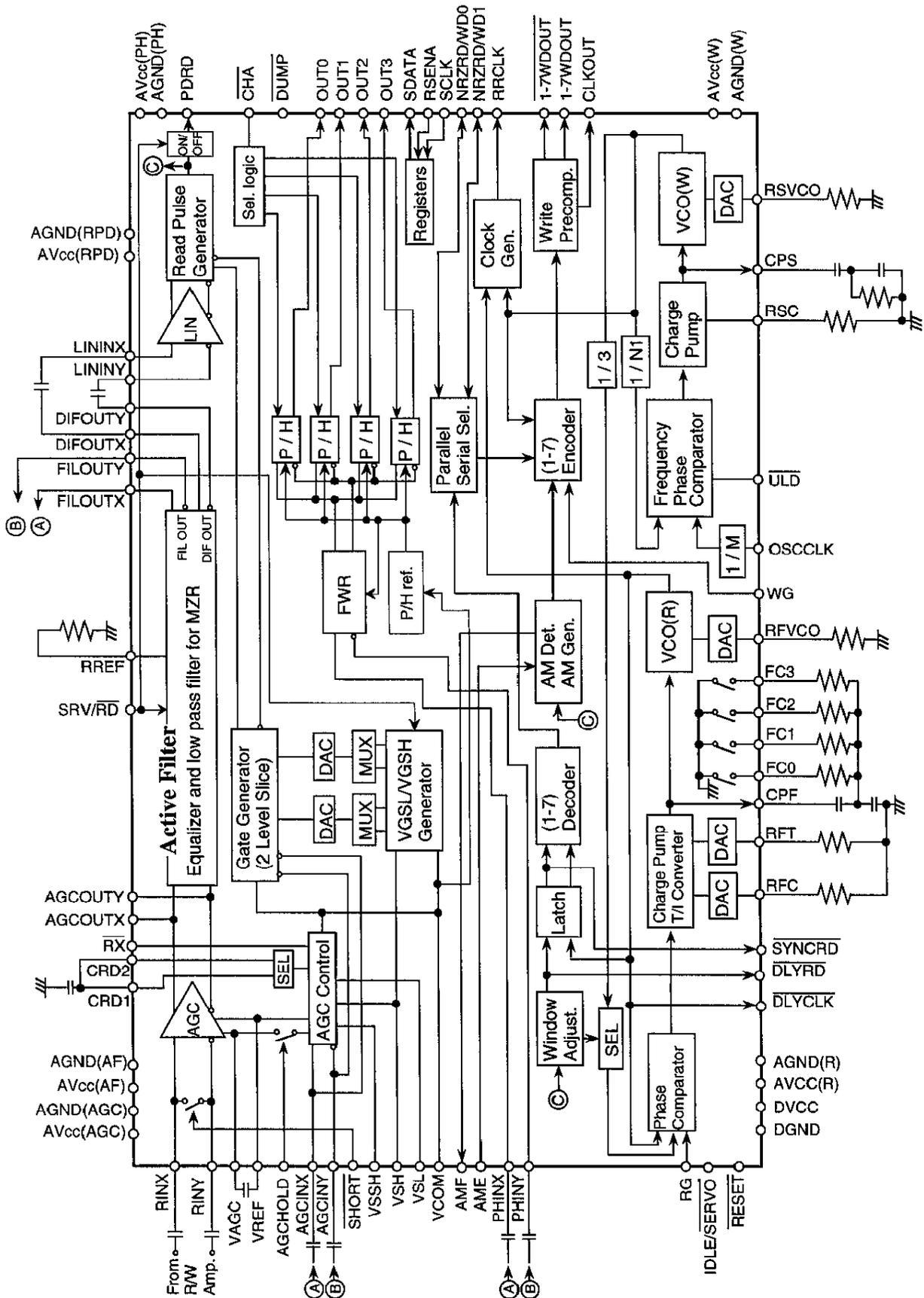
Description

The HD153031RF is a 36 Mbps 1-7 ENDEC data separator with built-in read pulse detector, active filter, frequency synthesizer and synchronizer developed for use in magnetic disk drives. In read mode the HD153031RF decodes the read wave form output from the read/write amplifier into an NRZ signal. In write mode it encodes the NRZ signal output from the controller into a 1-7 RLL code.

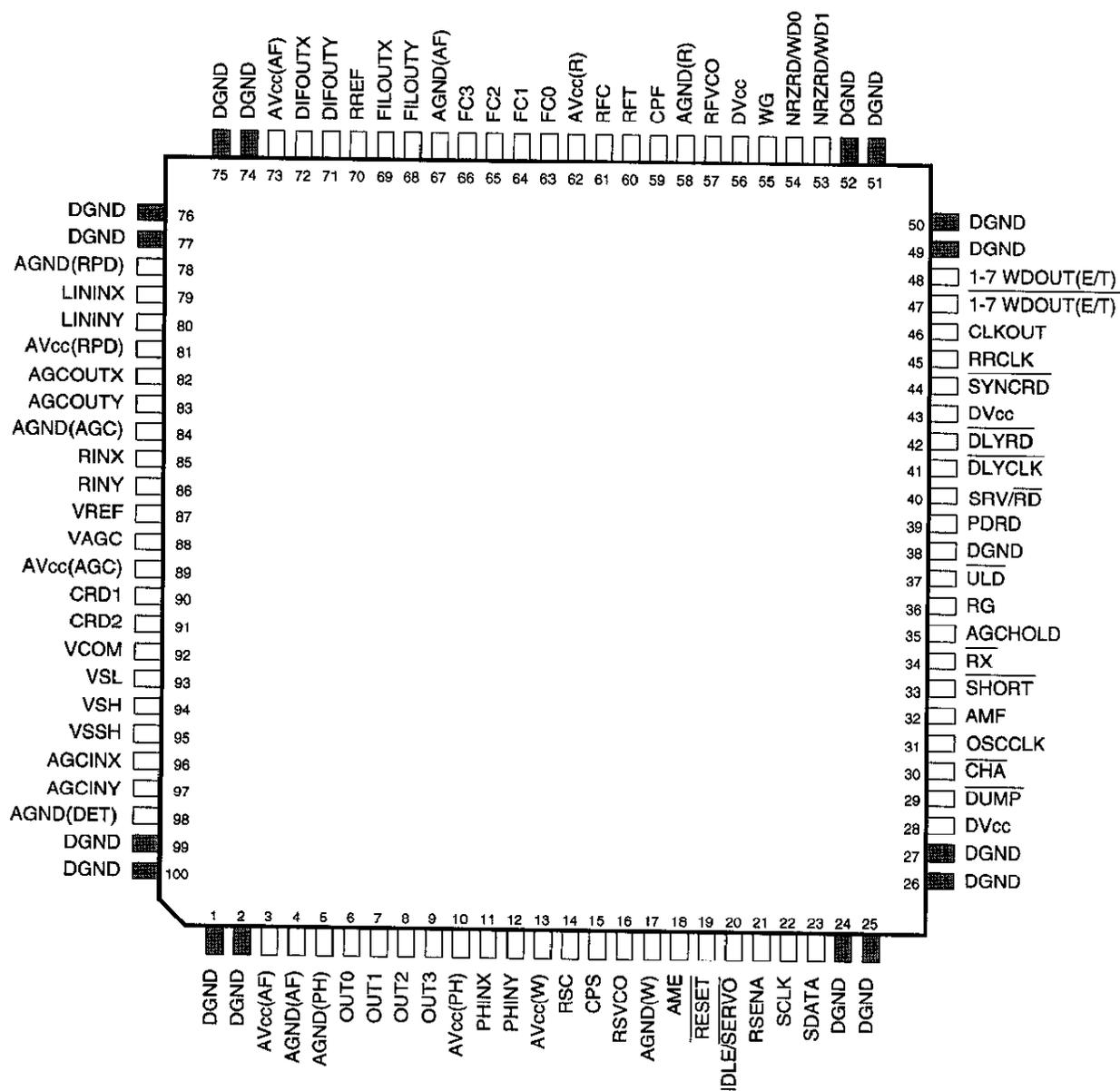
Features

- Maximum NRZ data transfer rate : 36Mbps.
- Data transfer clock frequency : 1.5 data transfer rate (54MHz maximum).
- Settings are micro-computer programmable.
- On-chip frequency synthesizer generates encode clock for writing (1% steps at $f_{MAX}/f_{MIN}=2.55$).
- Programmable window centering adjustment and window monitoring functions.
- User-selectable single zone recording or multiple zone recording options. The following are programmable for multiple zone recording : VCO center frequency (192 settings), loop Filter constant (2 settings), charge pump current levels (8 settings), T/I converter output current (8 settings), active filter cutoff frequency for servo and data modes (128 settings).
- Dual-mode phase detector compares both phase and frequency to ensure a wide capture range.
- Built-in active filter 7-bit programmable cut-off frequencies.
- Two sets of 4-bit High and Low slice levels for reliable pulse detection .
- 1-7WDOUT outputs are selectable differential pseudo-ECL or TTL pair for high speed transfer without timing error.
- High-speed acquisition can be accomplished with highly stable reproduction by switching between normal-gain and high-gain modes, and by switching loop filter constants.
- VCO oscillation timing capacitor is built in for better noise immunity.
- PLL characteristic frequency and damping rate are defined without 2T-8T (1-7RLL) signal cycle.
- Built-in AGC amplifier for stable reproduction despite varying media and head characteristics.
- Gate generator eliminates incorrect read pulse problems that occur with time-domain filtering with appropriate slice-level setting.
- Head resolution can be increased without incorrect read pulse worries.
- AGC amplifier gain can be set to zero during writing.
- Built-in write phase compensation function with programmable delay time.
- Early or Late write pre-compensation amounts can be programmed independently.
- High speed data transfer inputs and outputs are done via complementary TTL output pairs.
- Hi-BiCMOS process achieves high speed with low power dissipation.
- Idle mode and power down functions.
- QFP-100 pin package suitable for compact surface mounting (resin size : 14mm x 14mm)
- Required only a single 5V supply.

2. Block diagram



3. Pin arrangement



(Top view)

4. Pin Functions

| Pin Name | Pin No. | Type | Function |
|--|----------|-----------------------------|---|
| RG (Read gate) | 36 | In | High level at the input selects read mode. This signal switches the clock for counters and internal circuits, and begins phase synchronization of the decode clock generator's VFO with the 1-7 decode data. |
| PHINX PHINY | 11 12 | In | Differential inputs for the servo Peak/Hold circuit. |
| RESET | 19 | In | Low input initializes internal circuits. Drive this line low at power-up. Low input also locks the two built-in VCOs to their center frequencies. Keep this line high during normal operation. |
| OSCCLK (Oscillator clock) | 31 | In | Clock synthesizer's reference clock input. The frequency synthesizer generates encode clock frequencies from the input on this line. Data writing is synchronized with the encode clock. When not reading data, the decode clock generator's VFO is also synchronized with frequency 1.5 times the data transfer rate. |
| 1-7WDOUT 1-7WDOUT (Write Data outputs) | 48 47 | Out | 1-7 RLL Write Data Differential Output. Pseudo ECL/TTL are available by bit 6 of register "\$hD". When this bit is "H", these outputs are TTL. When this bit is "L", these outputs are ECL. These Pin provide the 1-7WDOUT write data that goes to the Read/Write amplifier after the write pre-compensation. When WG goes high, 1-7 WDOUT pin are output mode. |
| CLKOUT | 46 | Out | This clock is for the external write pre-compensation in the Write mode. This clock(TTL level) is synchronized with 1-7WDOUT. |
| ULD (Unlock detect) | 37 | Out | Error output from the encode clock generator's frequency synthesizer. ULD goes low to indicate that the PLL in the encode clock generator's frequency synthesizer has lost lock. The disk controller should immediately halt the write operation. Data must be written again from the beginning. |
| RSVCO | 16 | External component required | Connect a resistor to set the center frequency of the VCO in the encode clock generator's frequency synthesizer. |
| CPS | 15 | External component required | Current output to an external loop filter. |
| RSC | 14 | External component required | Connect a resistor to set the charge pump output current for the encode clock generator's frequency synthesizer. |

Pin Functions (cont)

| Pin Name | Pin No. | Type | Function | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----------------------------|---------------|-----------------------------|--|-----------------------|---------------|-----|--|--|--|-----|-----|-----|-----|-------|------|----|----|-----|-----|--------|----|-----|-----|-----|-------|------|-----|-----|----|----|--------|-----|-----|----|-----|
| RFC | 61 | External component required | Connect a resistor to set the charge pump output current for the decode clock generator's VFO. The charge pump current level is set by GAC[5:3] and CPO[4:0] registers. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RFT | 60 | External component required | Connect a resistor to set the T/I converter's sampling feedback gain to 1(nominal). The T/I converter's output current is determined by this resistor, and registers VFC[4:0] & GAC[2:0] & TIO[4:0]. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CPF | 59 | External component required | Current output to the external loop filter. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RREF | 70 | External component required | Connect to a resistor to set the reference current for the Active Filter's DAC. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| FC0 | 63 | External component required | Connect to a loop filter resistor to set the attenuation ζ of the PLL. Each line is grounded through an MOS switch is selected by PLL gain mode and bit 6 of register GAC. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| FC1 | 64 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| FC2 | 65 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| FC3 | 66 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | <table border="1"> <thead> <tr> <th rowspan="2">Bit 6 of register GAC</th> <th rowspan="2">PLL gain mode</th> <th colspan="4">Pin</th> </tr> <tr> <th>FC0</th> <th>FC1</th> <th>FC2</th> <th>FC3</th> </tr> </thead> <tbody> <tr> <td rowspan="2">" 0 "</td> <td>High</td> <td>ON</td> <td>ON</td> <td>OFF</td> <td>OFF</td> </tr> <tr> <td>Normal</td> <td>ON</td> <td>OFF</td> <td>OFF</td> <td>OFF</td> </tr> <tr> <td rowspan="2">" 1 "</td> <td>High</td> <td>OFF</td> <td>OFF</td> <td>ON</td> <td>ON</td> </tr> <tr> <td>Normal</td> <td>OFF</td> <td>OFF</td> <td>ON</td> <td>OFF</td> </tr> </tbody> </table> | Bit 6 of register GAC | PLL gain mode | Pin | | | | FC0 | FC1 | FC2 | FC3 | " 0 " | High | ON | ON | OFF | OFF | Normal | ON | OFF | OFF | OFF | " 1 " | High | OFF | OFF | ON | ON | Normal | OFF | OFF | ON | OFF |
| Bit 6 of register GAC | PLL gain mode | Pin | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | FC0 | FC1 | FC2 | FC3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| " 0 " | High | ON | ON | OFF | OFF | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Normal | ON | OFF | OFF | OFF | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| " 1 " | High | OFF | OFF | ON | ON | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Normal | OFF | OFF | ON | OFF | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RFVCO | 57 | External component required | Connect to a resistor to set the center frequency of the VCO in the decode clock generator's VFO. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SRV/ $\overline{\text{RD}}$ | 40 | Input | "H":Servo Mode,"L":Read Mode. In the servo mode ,"CFCB" register set the A/F's cutoff frequency and VGSLB register set the gate slice low level. In the read mode ,"CFCA" register set the A/F's cutoff frequency and VGSLA register set the gate slice level. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RINX | 85 | Differential input | Differential input lines for the signal read from the recording medium. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RINY | 86 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| LINIX | 79 | Differential input | Differential input lines for the zero-crossing comparator. Normally connect to DIFOUTX/Y of the active filter with bypass capacitors. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| LININY | 80 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| AGCINX | 96 | Differential input | Differential input lines for the AGC output amplitude detector. Connect to FILOUTX/Y outputs of the AF with bypass capacitors. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| AGCINY | 97 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Pin Functions (cont)

| Pin Name | Pin No. | Type | Function | | | | | | |
|-------------------------|---------------|-----------------------------|--|-----------------------|----------|------|--------------|-----|---------------|
| \overline{RX} | 34 | In | TTL-level input that switches the AGC loop on or off. <table border="1" style="margin-left: 20px;"> <tr> <td>\overline{RX} input</td> <td>AGC loop</td> </tr> <tr> <td>High</td> <td>AGC loop on.</td> </tr> <tr> <td>Low</td> <td>AGC loop off.</td> </tr> </table> | \overline{RX} input | AGC loop | High | AGC loop on. | Low | AGC loop off. |
| \overline{RX} input | AGC loop | | | | | | | | |
| High | AGC loop on. | | | | | | | | |
| Low | AGC loop off. | | | | | | | | |
| AGCHOLD | 35 | In | TTL-Level input that locks the AGC amplifier gain. When AGCHOLD goes high, the gain is locked at its immediately preceding value. | | | | | | |
| AGCOUTX AGCOUTY | 82 83 | Differential output | Differential output lines for monitor from the AGC amplifier. The outputs are open-emitter type and would need ext. 1~10K pulldowns. | | | | | | |
| VREF | 87 | Monitor line | Monitor line for the AGC amplifier reference voltage. | | | | | | |
| VAGC | 88 | Monitor line | Monitor line for the AGC amplifier gain setting voltage. | | | | | | |
| PDRD | 39 | Out | Output line for the data read from disk as reshaped into digital data by the read pulse detector. When SRV/RD(40Pin) goes high, PDRD outputs read data pulse. When SRV/RD goes low, PDRD is disenable mode. | | | | | | |
| VCOM | 92 | External component required | Reference voltage output line for the AGC output amplitude detector and the Gate generator. | | | | | | |
| VSL | 93 | External component requird | Voltage input line for seting the low slice level of AGC output amplitude detector. Corresponds to the discharge current threshold. Normally this level is set 67% of the VSH level. | | | | | | |
| VSH | 94 | External component required | Voltage input line for setting the high slice level of the AGC output amplitude detector. Corresponds to the charge current threshold | | | | | | |
| VSSH | 95 | External component required | Voltage inputline for setting the fast attack(high gain) high slice voltage of the AGC output amplitude detector. Normally this level is set 160% of the VSH level. | | | | | | |
| $\overline{IDLE/SERVO}$ | 20 | In | The input is used in combination with the two Mode bits in the PCN register to reduce power consumption in the Idle mode. When PCN=00, device is in the R/W normal mode, all circuits are ON. When PCN = 11, device is in the Sleep mode, all circuits are OFF except the I/O and logic. When PCN = 10, then depending on the logic level of the $\overline{IDLE/SERVO}$ pin; if it is High, then chip is in the Idle mode and all circuits are OFF except for the I/O, logic, and the bias CKT's; if it is Low, then the device is in the Servo mode and the I/O, logic, bias CKT's, AGC, active filter, Read Pulse Detector, and Peak/Hold should be ON with only the RD PLL and the WR PLL being OFF. | | | | | | |

Pin Functions (cont)

| Pin Name | Pin No. | Type | Function |
|---------------------------|----------|-----------------------------|---|
| CRD1 | 90 | External component required | In reading the normal data, the charge /discharge current output line for the AGC output amplitude detector. connected to 91PIN (CRD2) |
| CRD2 | 91 | External component required | External capacitor is needed for AGC output amplitude detector. |
| FILOUTX FILOUTY | 69 68 | Differential output | Differential output line from Active Filter. Connect to AGCINX,Y and PHINX,Y through capacitors. |
| DIFOUTX DIFOUTY | 72 71 | Differential output | Differential output line from Active Filter. Connect to LININX,Y through capacitors. |
| $\overline{\text{SHORT}}$ | 33 | In | When this terminal is 'L', RINX and RINY are shorted. |
| OUT0~ OUT3 | 6,7,8,9 | External component required | Connect to external capacitors for servo peak/hold. |
| WG | 55 | In | Write gate signal input. Set this PIN high during writing |
| NRZRD/WD1 | 53 | In/Out | I/O pin of NRZ signal. This pin is effective only in the case of parallel transferring. NRZ Data select bit 7 of register(\$h8) controls parallel/serial. (When this bit is " H" , NRZ mode is parallel) |
| NRZRD/WD0 | 54 | In/Out | I/O pin of NRZ signal. In the serial transfer mode, only this pin is effective. NRZ Data select bit 7 of register(\$h8) controls parallel/serial. (When this bit is " L" , NRZ mode is serial) |
| SDATA | 23 | In/Out | Data is transmitted in 16-bit packet MSB first. The first 2 bits determine the read or write mode, the next bit is "Don't Care", the next 4 bits are for the register address, followed by 1 "Don't Care" bit, then the last 8 bits are for the Write or Read Data. |
| RSENA | 21 | In | This active low input selects the device and enables the serial port. |
| AMF | 32 | Out | Output pin of the address mark found signal in the soft sector mode. |
| AME | 18 | In | Input pin for the address mark enable in the soft sector mode. In the hard sector mode, this pin must set low. |
| $\overline{\text{CHA}}$ | 30 | In | Input pin of the control signal of Peak/hold circuit(TTL level) Position signal is sampled by $\overline{\text{CHA}}="L"$ |
| $\overline{\text{DUMP}}$ | 29 | In | Input pin of the discharge control signal of Peak/hold circuit. TTL level, $\overline{\text{DUMP}}="L"$ is for discharge. |

Pin Functions (cont)

| Pin Name | Pin No. | Type | Function |
|-----------|--|--------|---|
| SCLK | 22 | In | This is the serial clock sent in by the hard disk controller or other ASIC device. When the serial port is not enabled, this clock line should be driven low. For either read or write transfer, a 16 clock burst is required for proper operation. Data is latch in during write or sent out during read with the rising edge of the SCLK. |
| DLYCLK | 41 | Out | Monitor pin(TTL level) for Window adjustment. This pin allows the VCO clock signal output by the PLL circuit to be monitored. Contact Hitachi,Ltd. for special instrustions if use of this function is required. |
| DLYRD | 42 | Out | Monitor pin(TTL level) for Window adjustment. This pin allows the read data signal output from the window adjustment circuit to be monitored. Contact Hitachi,Ltd. for special instructions if use of this function is required. |
| SYNCRD | 44 | Out | Monitor pin(TTL level) for Window adjustment. This pin outputs the read data outputs the read data input to the PLL block latched by the VCO clock. Contact Hitachi,Ltd. for the special instructions if use of this function is required. |
| RRCLK | 45 | Out | Read refernce clock output(TTL level). At read time,this pin provides a clock which is synchronized with the converted NRZRD signal. This controller should read NRZRD by this clock. Other than read, reefernce clock is provided to disk controller. |
| DGND | 1, 2, 24,25,26, 27, 38, 49, 50, 51, 52, 74, 75, 76, 77, 99,100 | Ground | Digital ground. |
| DVcc | 28, 43, 56 | Power | Digital Vcc power supply. |
| AVcc(PH) | 10 | Power | Analog Vcc power supply for peak hold. |
| AGND(PH) | 5 | Ground | Analog ground for peak hold. |
| AVcc(W) | 13 | Power | Analog Vcc power supply for synthesizer. |
| AGND(W) | 17 | Ground | Analog ground for synthesizer. |
| AVcc(R) | 62 | Power | Analog Vcc power supply for synchronizer. |
| AGND(R) | 58 | Ground | Analog ground for synchronizer. |
| AVcc(AF) | 3, 73 | Power | Analog Vcc power supply for active filter. |
| AGND(AF) | 4, 67 | Ground | Analog ground for active filter. |
| AVcc(AGC) | 89 | Power | Analog Vcc power supply for AGC. |
| AGND(AGC) | 84 | Ground | Analog ground for AGC. |
| AVcc(RPD) | 81 | Power | Analog Vcc power supply for read pulse detector. |
| AGND(RPD) | 78 | Ground | Analog ground for read pulse detector. |
| AGND(DET) | 98 | Ground | Analog ground for AGC control circuit |

5. Registers

The HD153031RF has 16 address's 8 bits-register that control the center frequency of the decode clock generator's VFO and the frequency of the encode clock generator's frequency synthesizer, control the synthesizer's gain, control the read data pulse width and its polarity, control the

synchronizer's gain and offset, adjust the decode window, apply the early/late write precompensation, control the prescaling value, adjust the active filter's cut-off frequency, and controls various functions.

| Address register value MSB LSB | Name | Abbreviation |
|--|---|--|
| 0 0 0 0 | VCO center frequency control register | VFC register |
| 0 0 0 1 | RD-PLL Gain control register | GAC register |
| 0 0 1 0 | RD-PLL Charge Pump offset control register Write precompensation delay control register (L) | CPO register WPL register |
| 0 0 1 1 | RD-PLL T/I offset control register Write precompensation delay control register (S) | TIO register WPS register |
| 0 1 0 0 | Window adjustment register (0.67ns typ. /step) Window fine adjustment register(0.25ns typ. /step) | WAJ register WFA register |
| 0 1 0 1 | AGC Mode control bit (FAST / SLOW) Read data (PDRD) polarity control register Read data (PDRD) pulse width control register WR-PLL Gain control register | AGS bit RDSEL register PW register SGC register |
| 0 1 1 0 | Prescaler of WR-PLLcontrol register | PSC register |
| 0 1 1 1 | AF cut-off frequency control register(for Read) | CFCA register |
| 1 0 0 0 | NRZ Data 1bit - serial / 2bits parallel select bit AF cut-off frequency control register(for Servo) | NRZM bit CFCB |
| 1 0 0 1 | Unlock detect gain control register (for WR-PLL) Boost level control register | ULD register BLC register |
| 1 0 1 0 | High pass filter cut-off frequency control register(for Read) | HPCA register |
| 1 0 1 1 | High pass filter cut-off frequency control register(for Servo) | HPCB register |
| 1 1 0 0 | Gate generator's High-slice level control register(for Read) Gate generator's Low-slice level control register(for Read) | VGSHA register VGSLA register |
| 1 1 0 1 | 1-7 WDOUT output type control bit (ECL / TTL) Write precompensation delay control register (E) Write precompensation delay control register (N) | WDM bit WPE register WPN register |
| 1 1 1 0 | AGCOUT enable control bit Power management control register Gate generator's Low-slice level control register(forServo) | AOE bit PCN register VGSLB register |
| 1 1 1 1 | Test Mode control register | MDC register |

6. Register Descriptions

| Address | BIT7 | BIT6 | BIT5 | BIT4 | BIT3 | BIT2 | BIT1 | BIT0 | Register Functions |
|---------|--------|--------|--------|--------|--------|--------|--------|--------|---|
| 0 0 0 0 | VFC7 | VFC6 | VFC5 | VFC4 | VFC3 | VFC2 | VFC1 | VFC0 | VFC: controls the center frequency of the WR-PLL & RD-PLL. |
| 0 0 0 1 | 0 | RFC4 | GAC5 | GAC4 | GAC3 | GAC2 | GAC1 | GAC0 | GAC: controls the RD-PLL's T/I and Charge Pump gain. |
| 0 0 1 0 | WPL2 | WPL1 | WPL0 | CPO4 | CPO3 | CPO2 | CPO1 | CPO0 | CPO: controls the Off-Set of the RD-PLL's Charge Pump circuit. WPL: sets the write precompensation delays. (L) |
| 0 0 1 1 | WPS2 | WPS1 | WPS0 | TIO4 | TIO3 | TIO2 | TIO1 | TIO0 | TIO: controls the Off-Set of the RD-PLL's T/I converter. WPS: sets the write precompensation delays. (S) |
| 0 1 0 0 | WFA2 | WFA1 | WFA0 | WFA4 | WFA3 | WFA2 | WFA1 | WFA0 | WFA: fine adjusts data window. WAJ: adjusts data window. |
| 0 1 0 1 | AGCSEL | RDSEL1 | RDSELO | PW1 | PW0 | SGC2 | SGC1 | SGC0 | AGCSEL: sets AGC mode Fast or Slow. RDSEL: controls PDRD pulse polarity PW: controls PDRD pulse width. SGC: sets the WR-PLL gain. |
| 0 1 1 0 | 0 | PSC6 | PSC5 | PSC4 | PSC3 | PSC2 | PSC1 | PSC0 | PSC: sets the WR-PLL prescaler's counter value. |
| 0 1 1 1 | 0 | CFCA6 | CFCA5 | CFCA4 | CFCA3 | CFCA2 | CFCA1 | CFCA0 | CFCA: controls Read Mode Active Filter's Cut-Off frequency. |
| 1 0 0 0 | NRZM | CFCB6 | CFCB5 | CFCB4 | CFCB3 | CFCB2 | CFCB1 | CFCB0 | NRZM: selects 1bit or 2bits NRZ data CFCB: controls Servo Mode Active Filter's Cut-Off frequency. |
| 1 0 0 1 | TSTBF | ULD1 | ULD0 | BLC4 | BLC3 | BLC2 | BLC1 | BLC0 | ULD: sets unlock detect period. BLC: controls AF's Boost level. |
| 1 0 1 0 | 0 | 0 | 0 | HPCA4 | HPCA3 | HPCA2 | HPCA1 | HPCA0 | HPCA: controls high-pass filter cut-off frequency(for Read) |
| 1 0 1 1 | TSTPD | 0 | 0 | HPCB4 | HPCB3 | HPCB2 | HPCB1 | HPCB0 | HPCB: controls high-pass filter cut-off frequency(for Servo) |
| 1 1 0 0 | VGSHA3 | VGSHA2 | VGSHA1 | VGSHA0 | VGSLA3 | VGSLA2 | VGSLA1 | VGSLA0 | VGSHA: sets high-slice level of the gate generator(for Read) VGSLA: sets low-slice level of the gate generator(for read) |
| 1 1 0 1 | 0 | WDM | WPN2 | WPN1 | WPN0 | WPE2 | WPE1 | WPE0 | WDM: selects output type of 1-7 WDOUT (TTL / pseudo ECL) WPE / WPN: sets the write precompensation delays. (E/N) |
| 1 1 1 0 | AOE | 0 | PCN1 | PCN0 | VGSLB3 | VGSLB2 | VGSLB1 | VGSLB0 | AOE: AGCOUTX/Y outputs enable control PCN: power saving control register for the analog modules. VGSLB: sets low-slice level of the gate generator(for Servo) |
| 1 1 1 1 | TEST | 0 | MDC5 | MDC4 | MDC3 | MDC2 | MDC1 | MDC0 | MDC: TEST mode control register. |

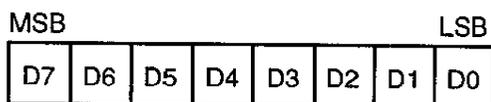
 : these bits are set to "1" during reset time.

Register Descriptions (cont)

VCO Center Frequency Control register (VFC)

Address \$h0 (at write = "C0" hex, at read = "80" hex),

VFC Register



VFC register is 8 bits long.

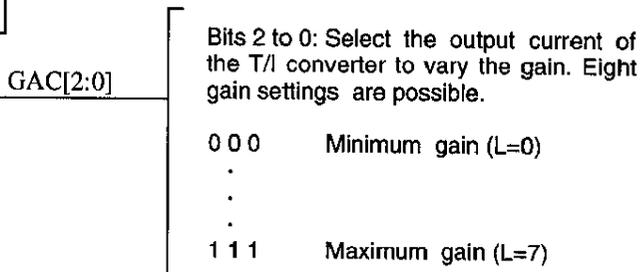
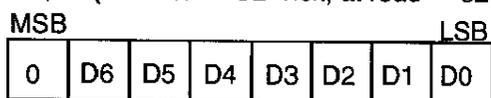
This register is used in multiple-zone recording to set the center frequency of the decode clock generator's VCO, the T/I converter's reference current, and the oscillation frequency of the encode clock generator's frequency synthesizer. Bit D7 is cleared when reset pin is asserted.

Resistors connected to the RFVCO and RSVCO lines set these values for the minimum data transfer rate. The VFC register raises these values in step of 1.56%, permitting 192 settings up to a maximum transfer rate 3.98 times of the minimum rate.

- 0 1 0 0 0 0 0 0 Minimum transfer rate (reference rate)
- ⋮
- ⋮
- 1 1 1 1 1 1 1 1 Maximum transfer rate (3.98 times speed)

Gain Control Register (GAC) : RFCA, GAC[5:0] for Read PLL synchronizer

Address \$h1 (at write = "C2" hex, at read = "82" hex)



Bits 2 to 0: Select the output current of the T/I converter to vary the gain. Eight gain settings are possible.

- 0 0 0 Minimum gain (L=0)
- ⋮
- ⋮
- 1 1 1 Maximum gain (L=7)

Bits 5 to 3: Select the output current of the Charge pump to vary the gain. Eight gain settings are possible.

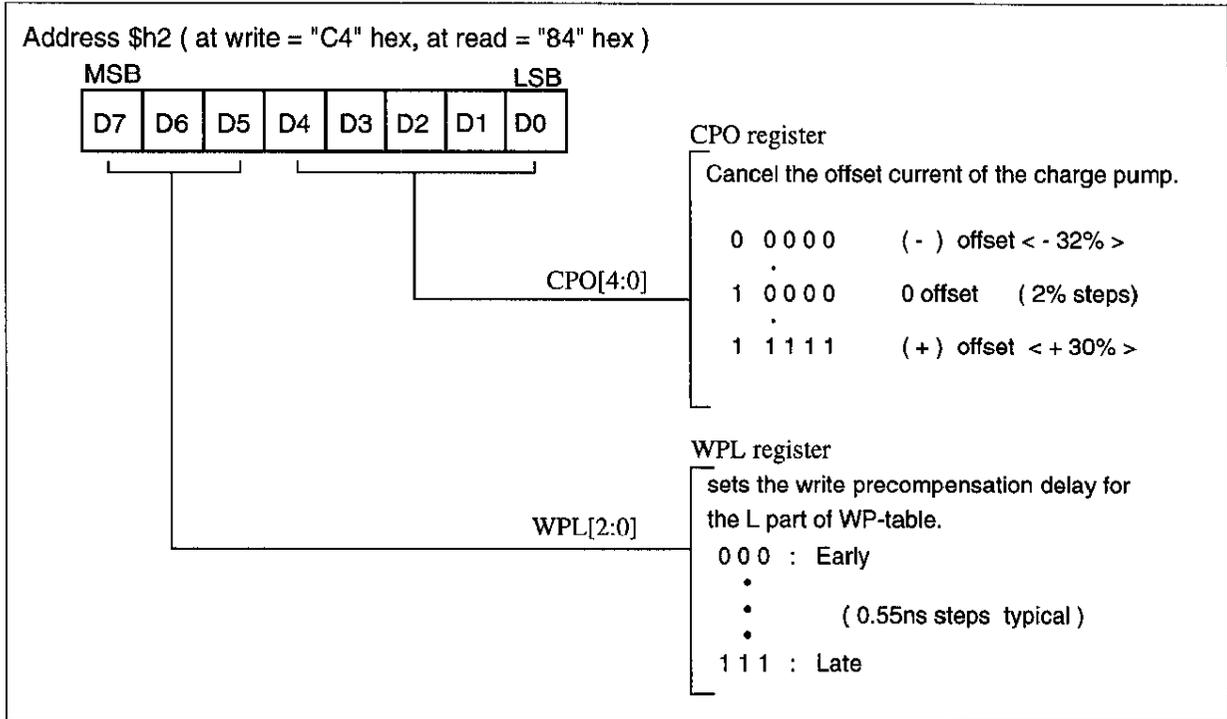
- 0 0 0 Minimum gain (P=1)
- ⋮
- ⋮
- 1 1 1 Maximum gain (P=8)

RFCA
 Bit 6 selects the resistors that determine the attenuation ξ of the loop filter for the decode clock generator's VFO.
 Bit 6 = 0: resistors connected to the FC0 and FC1 are selected
 Bit 6 = 1: resistors connected to the FC2 and FC3 are selected

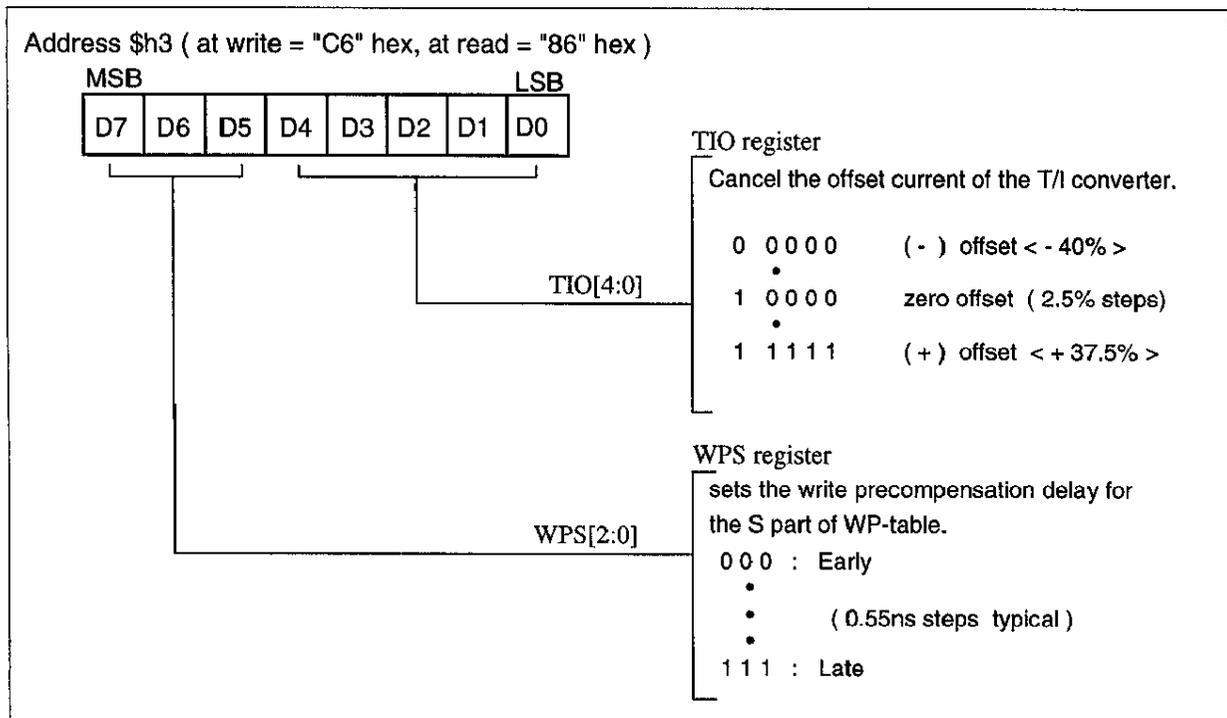
Unused bit. must be 0 when written.

Register Descriptions (cont)

Charge Pump Offset Control Register (CPO), Write Precompensation delay control Register (WPL)

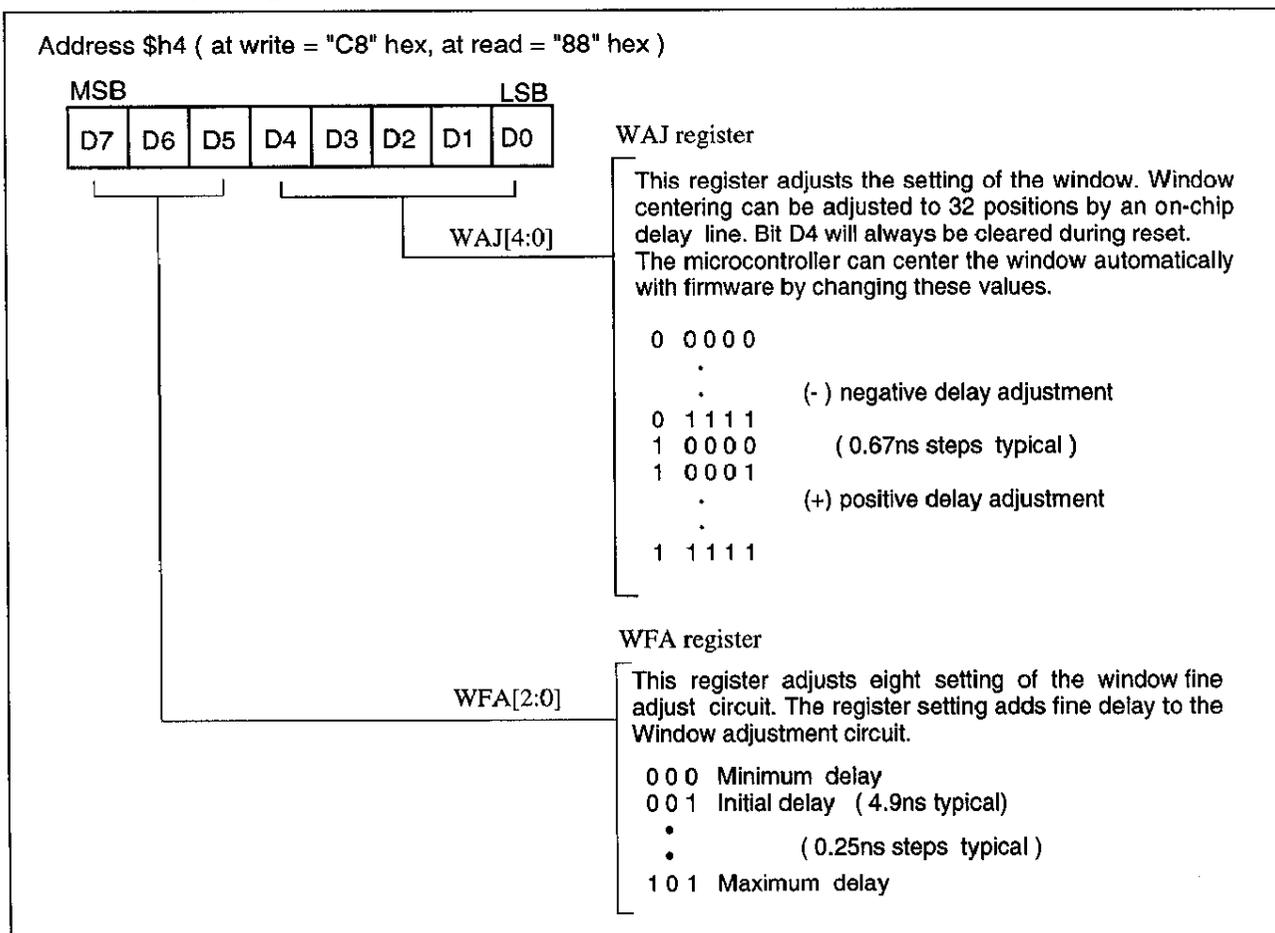


T/I Offset Control Register (TIO) , Write Precompensation delay control Register (WPS)



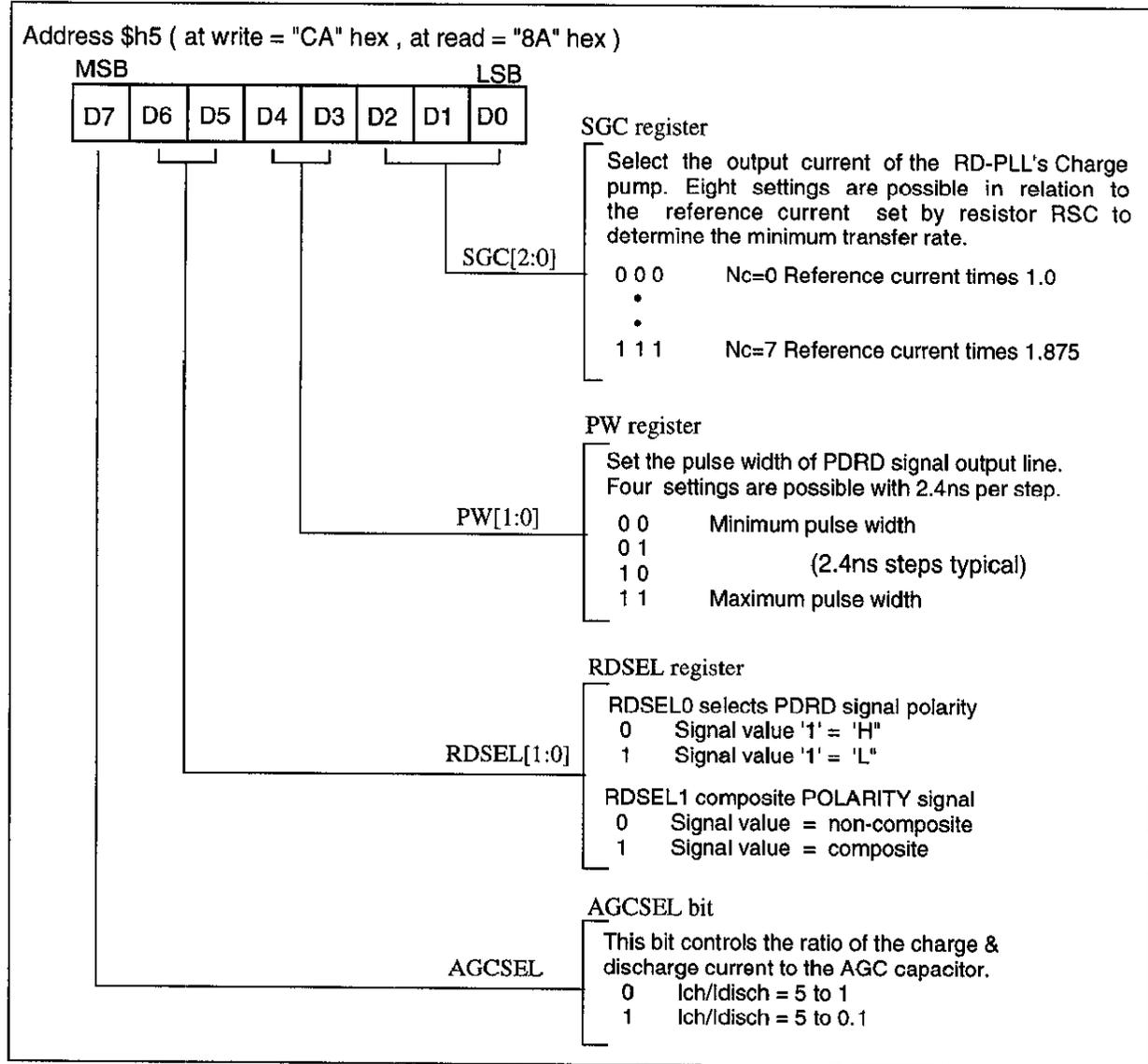
Register Descriptions (cont)

Window Fine Adjust Register WFA[2:0] and Window Adjust Register WAJ[4:0]

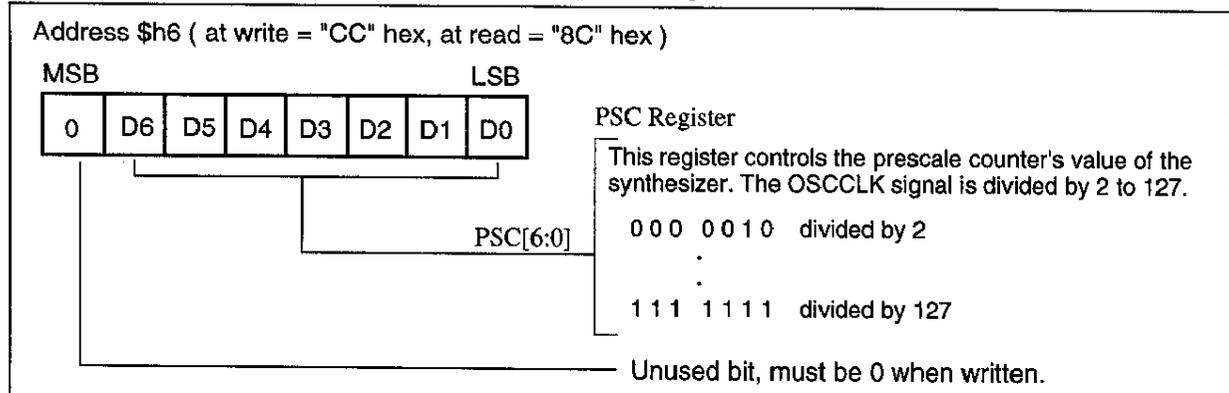


Register Descriptions (cont)

RD-PLL Gain Control Register (SGC), Read data Pulse Width Control Register (PW),
Read data Polarity Control Register (RPC) and AGC Mode Selects bit (AGS)

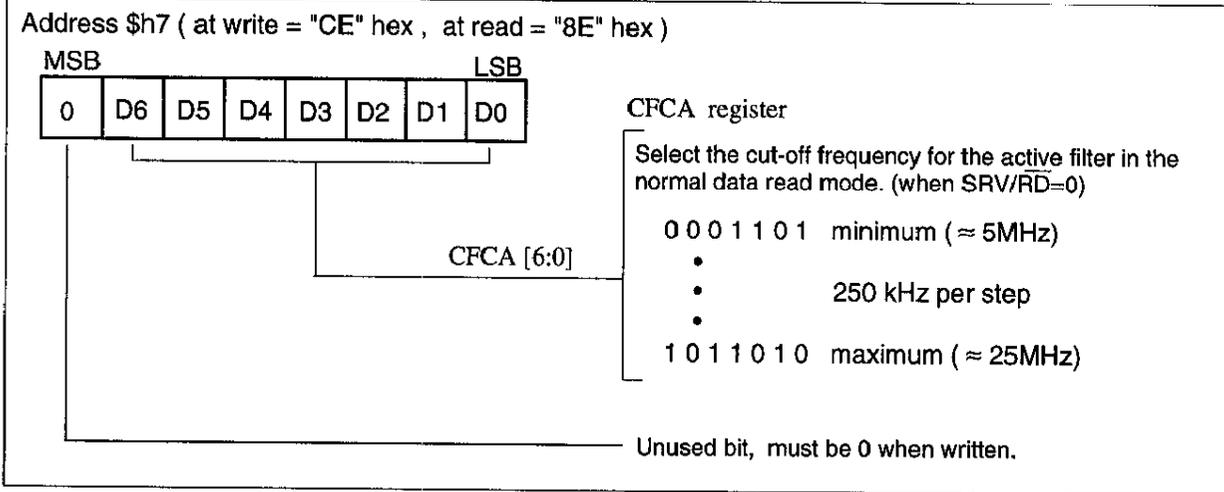


Prescaler of the Synthesizer Control Register (PSC) [M value]

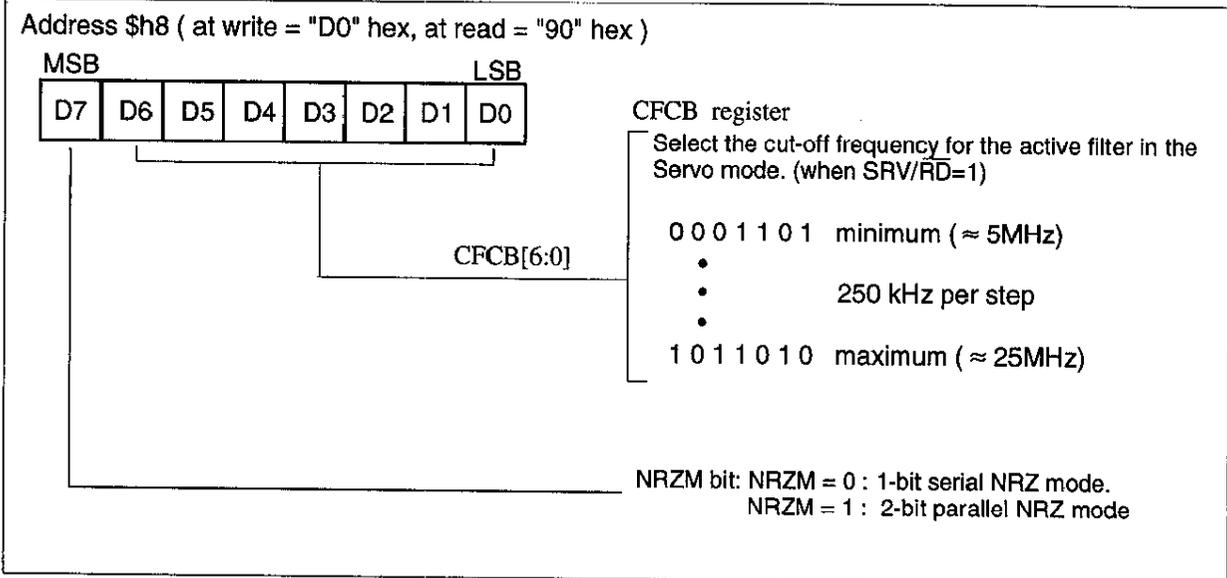


Register Descriptions (cont)

Read Mode AF Cut-Off Frequency Register (CFCA)

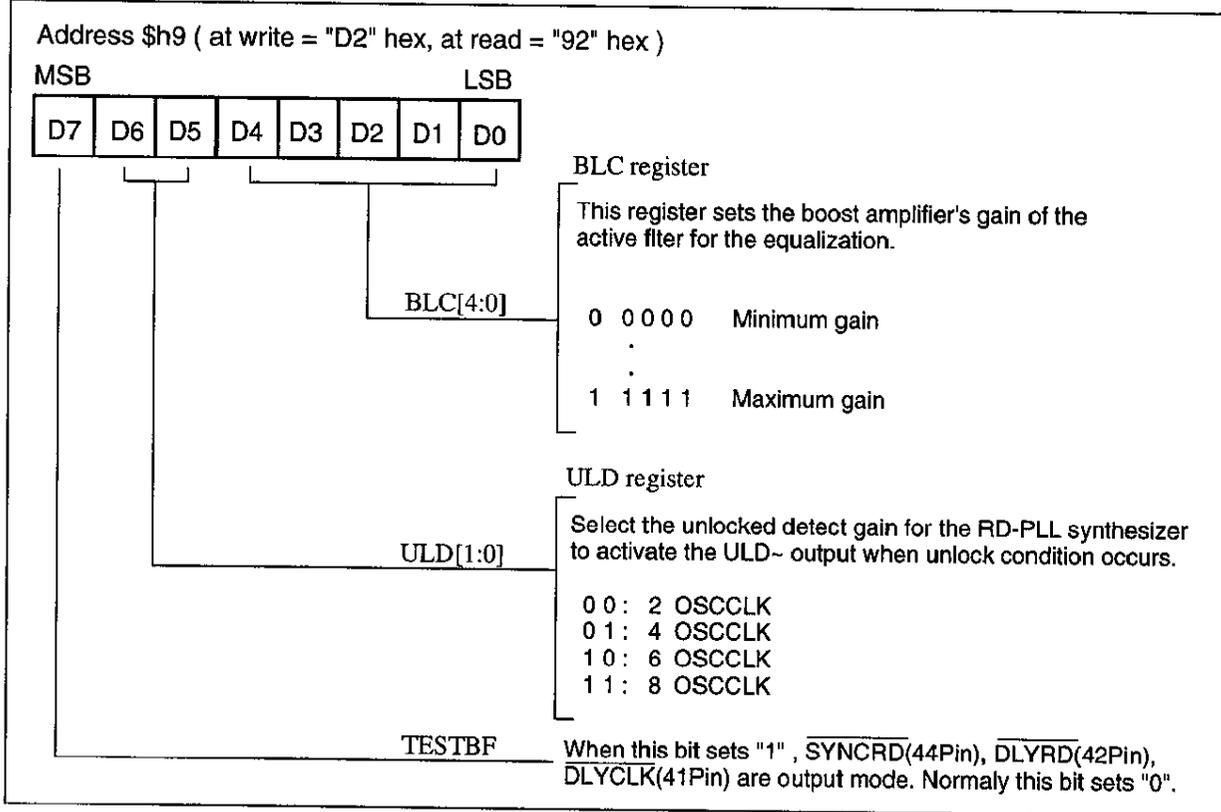


NRZ Data mode select bit (NRZM), Servo Mode AF Cut-Off Frequency Register (CFCB)

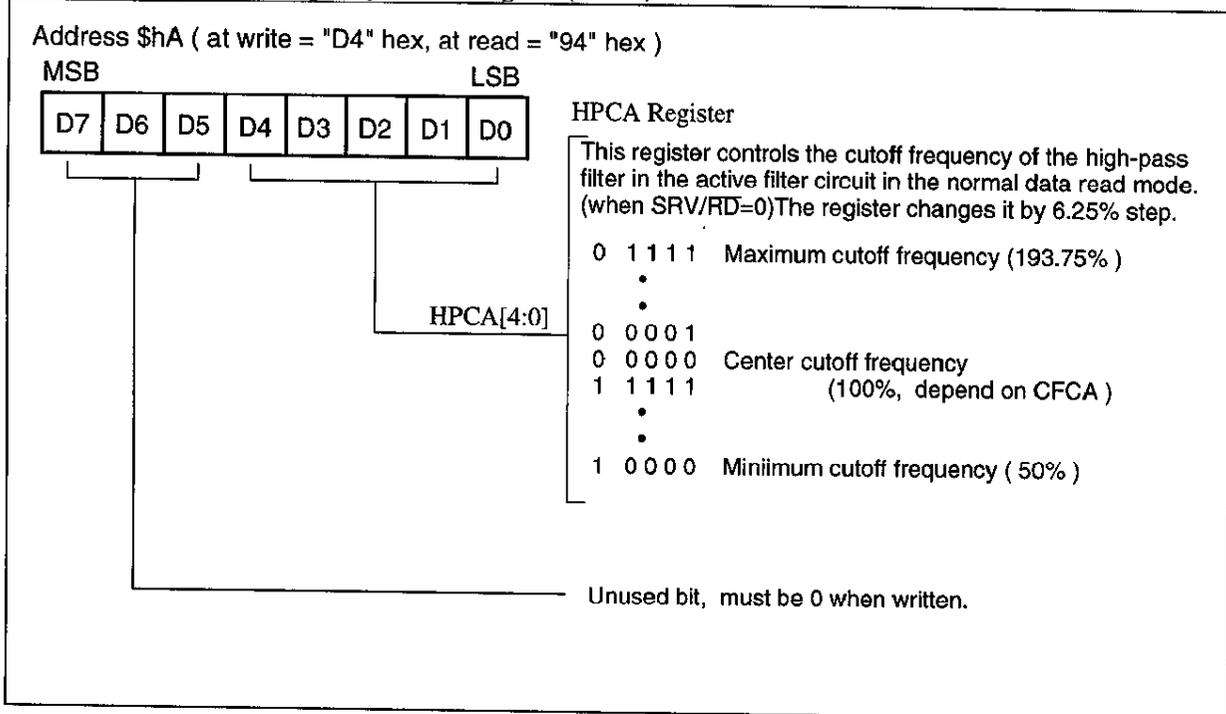


Register Descriptions (cont)

Unlock Detect Register (ULD) and Boost Level Control Register (BLC)

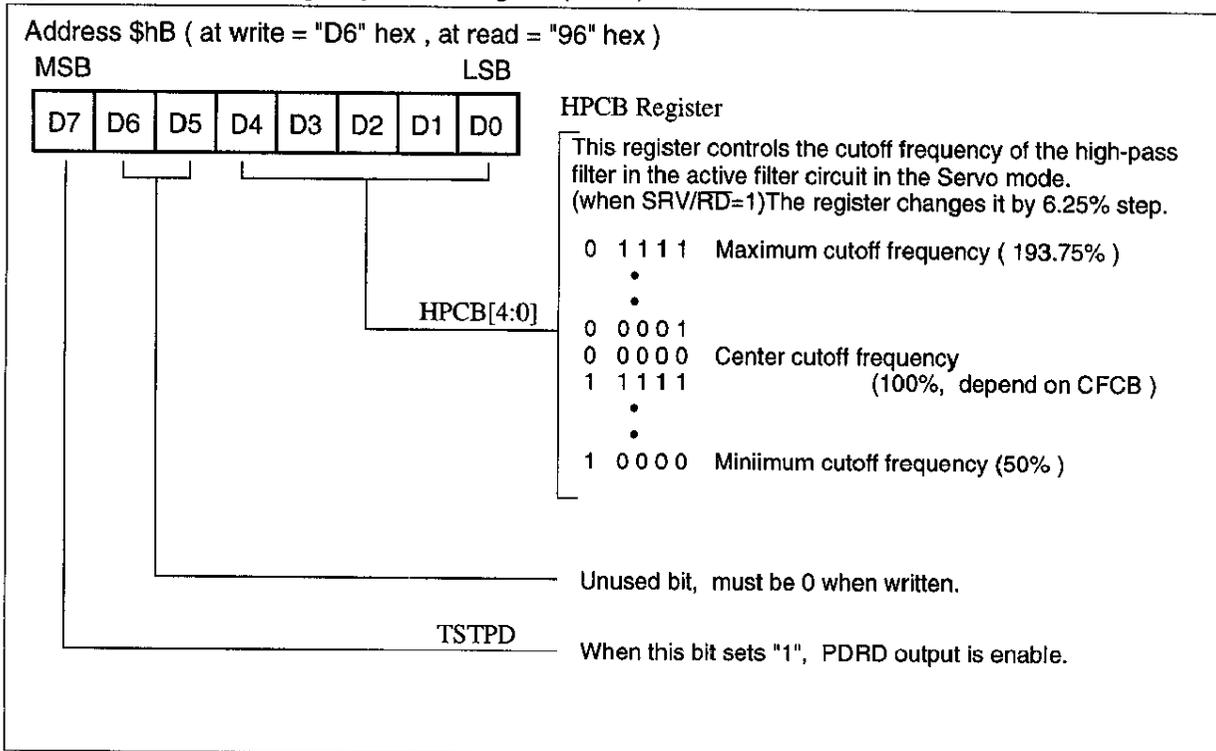


High-Pass Filter Cutoff Frequency Control Register (HPCA)

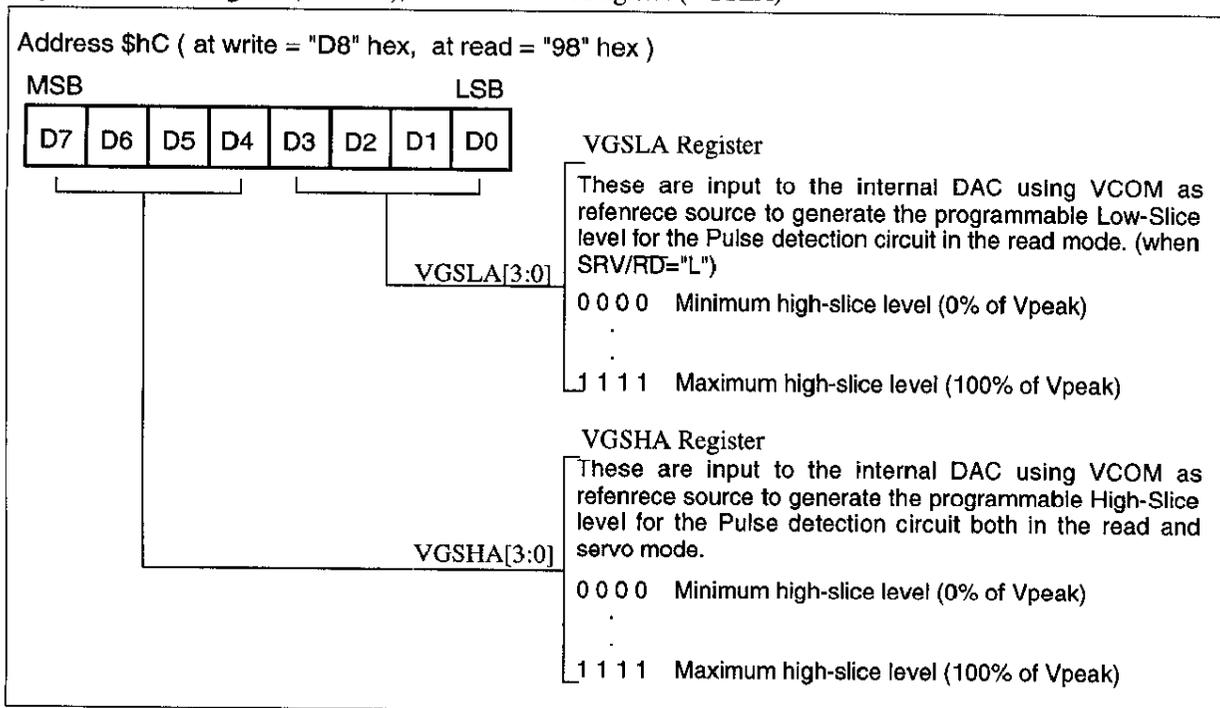


Register Descriptions (cont)

High-Pass Filter Cutoff Frequency Control Register (HPCB)

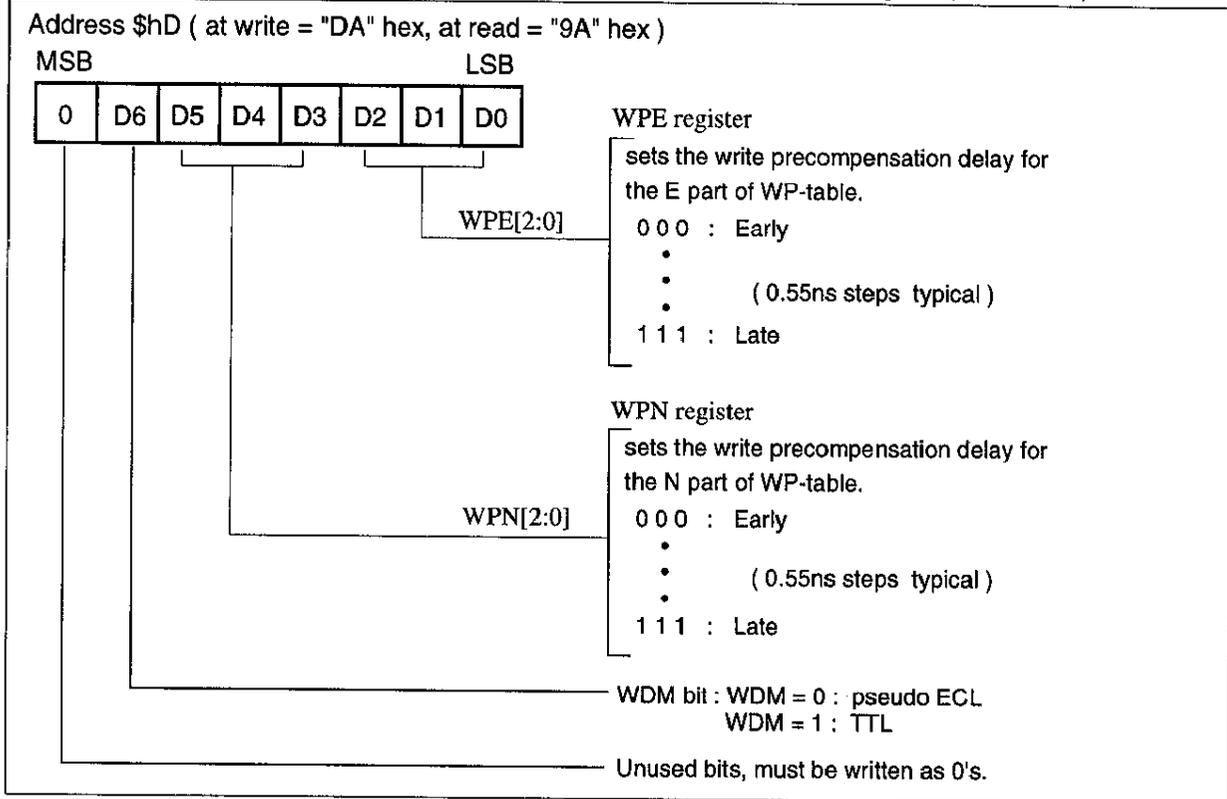


High-Slice Level Register (VGSHA), low-Slice Level Register (VGSLA)

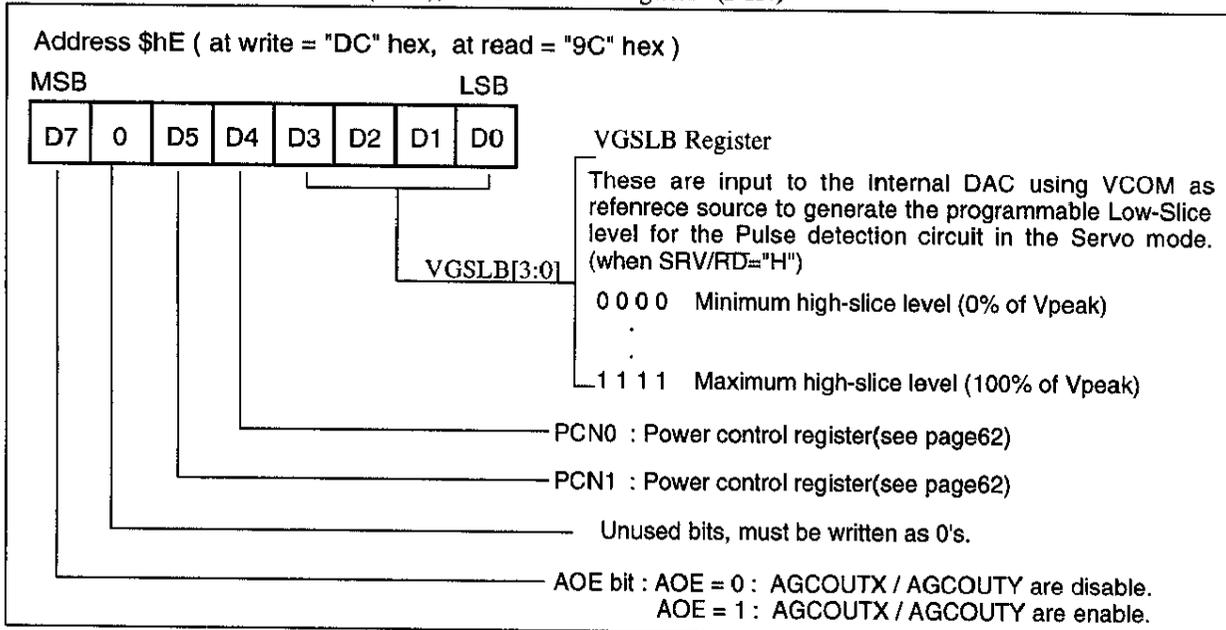


Register Descriptions (cont)

1-7WDOUT output type select bit (WDM), Writeprecompensation delay control register (WPE, WPN)

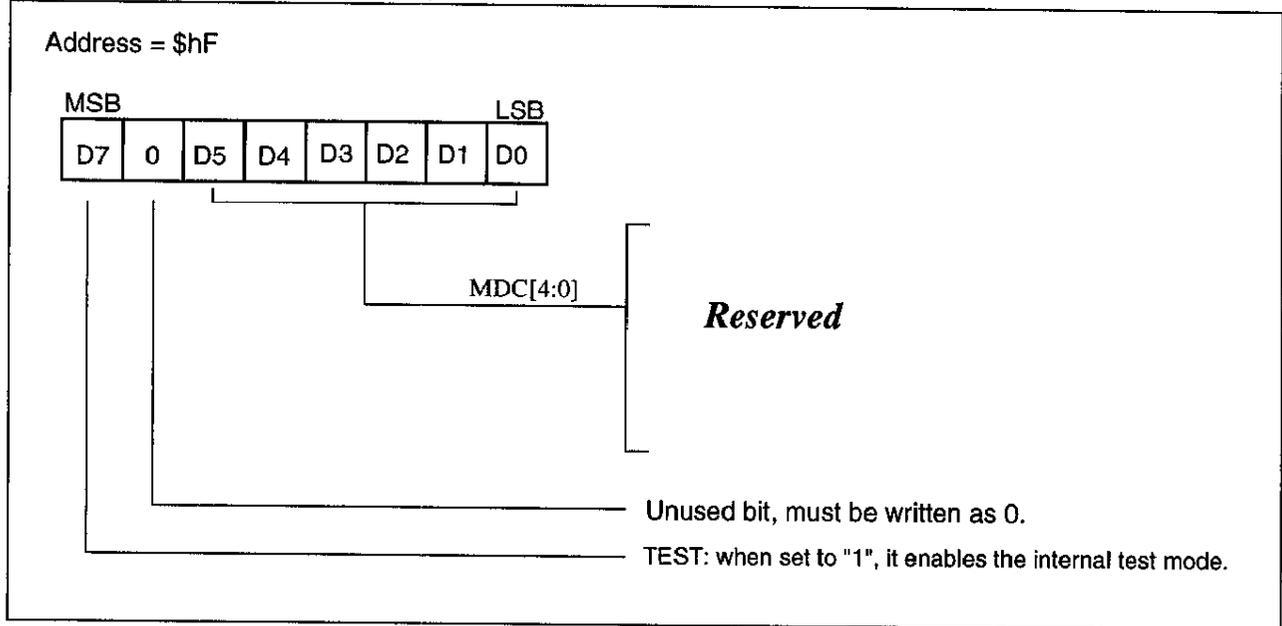


AGCOUTX/Y enable control bit (AOE), Power Control Register (PCN)



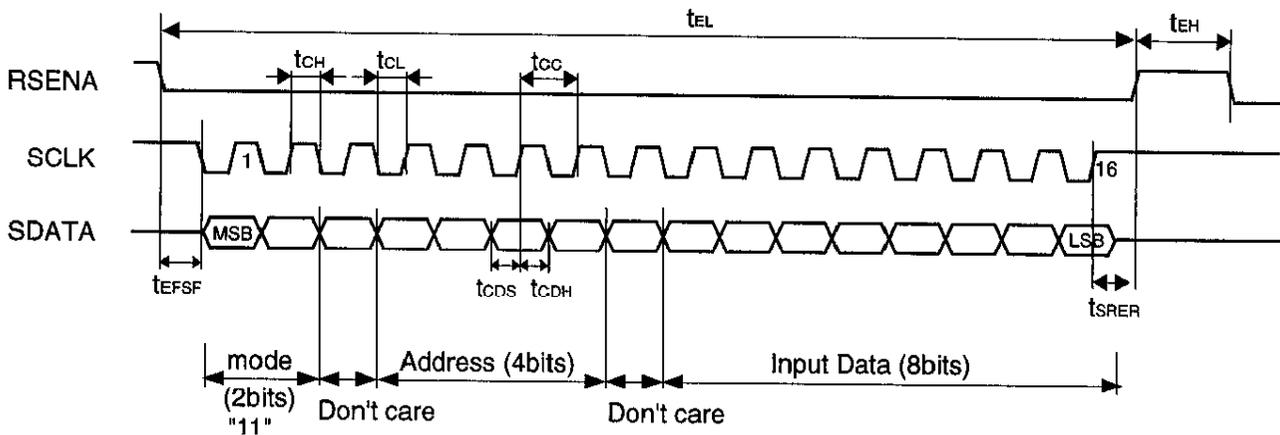
Register Descriptions (cont)

Test Mode Control Register (MDC)



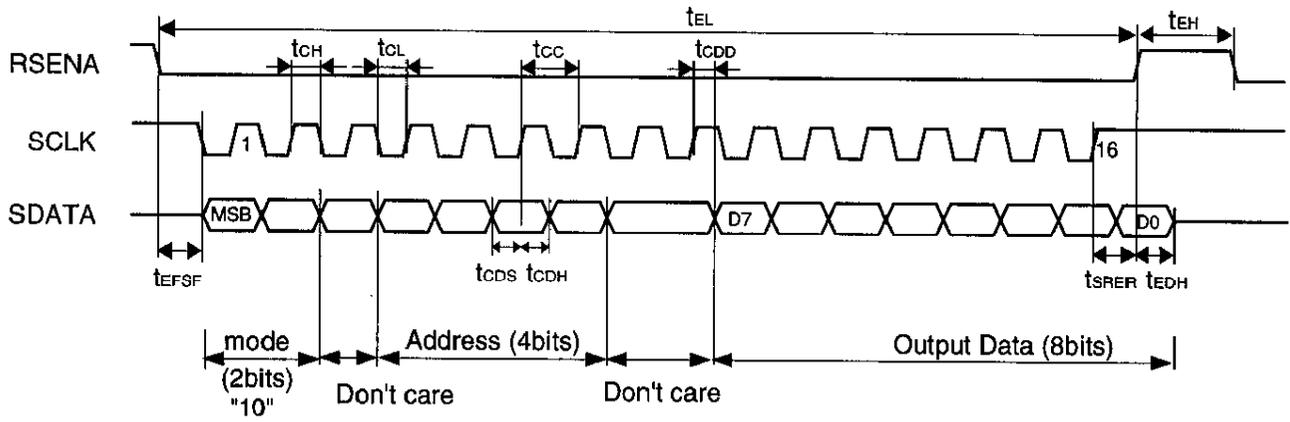
7. Read/Write timing of the control registers

< Write >



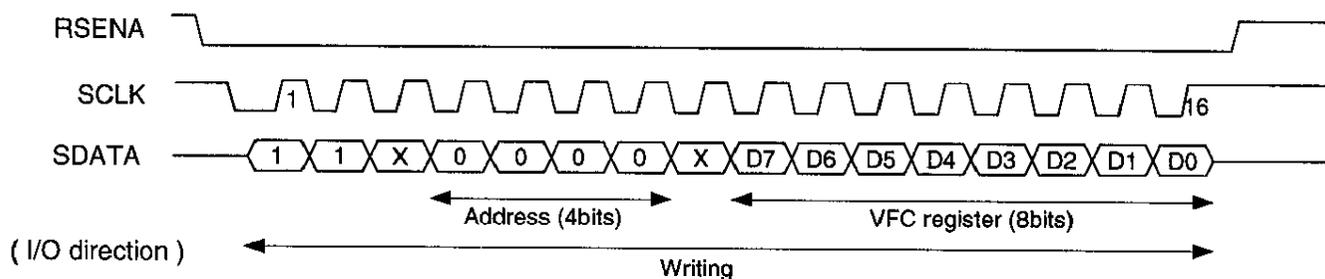
Read/Write timing of the control registers (cont)

< Read >

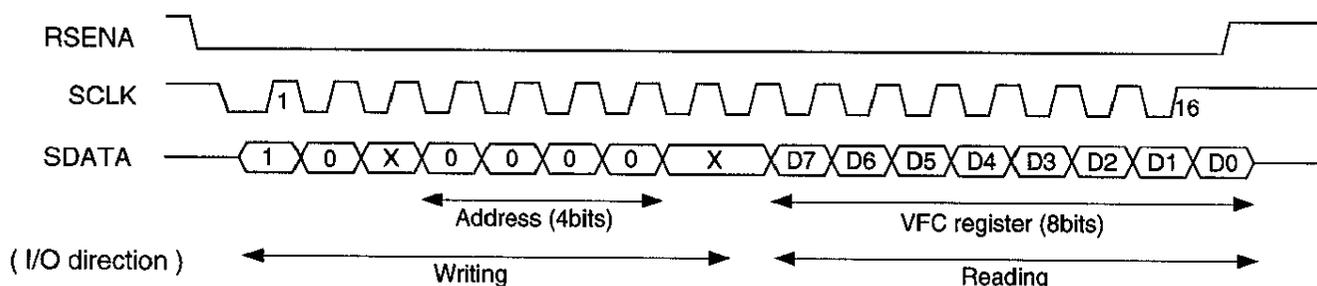


Write and read registers (cont)

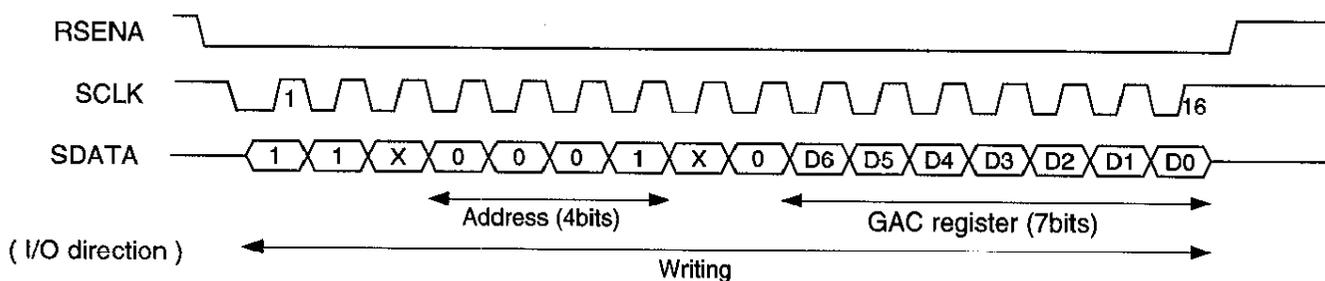
Write to VFC register



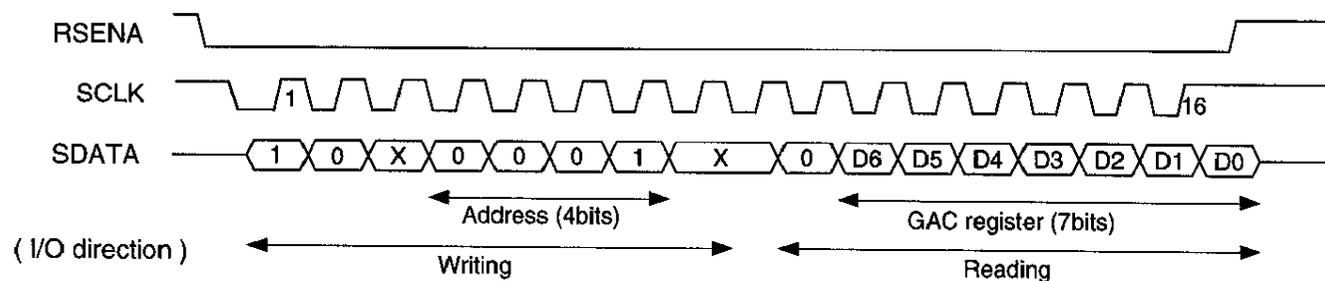
Read from VFC register



Write to GAC register

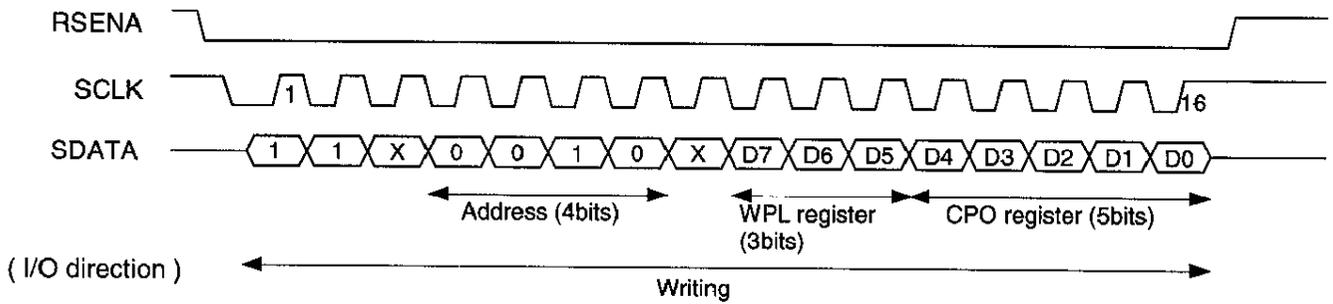


Read from GAC register

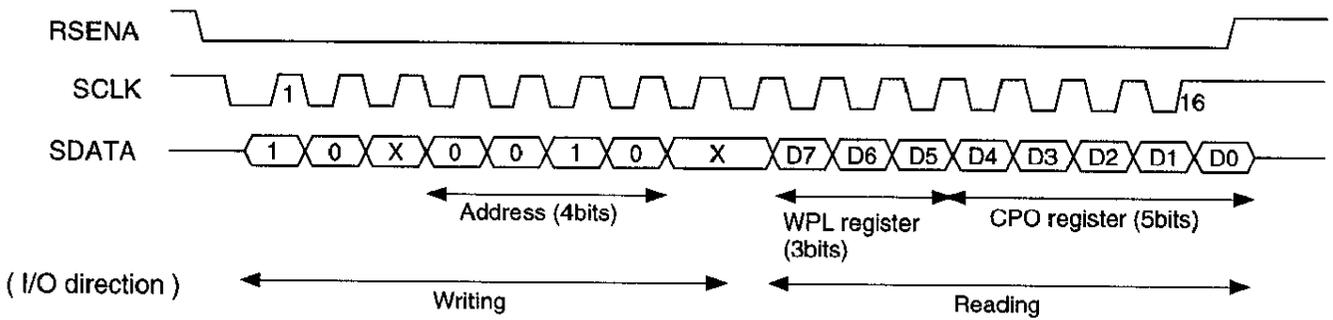


Write and read registers (cont)

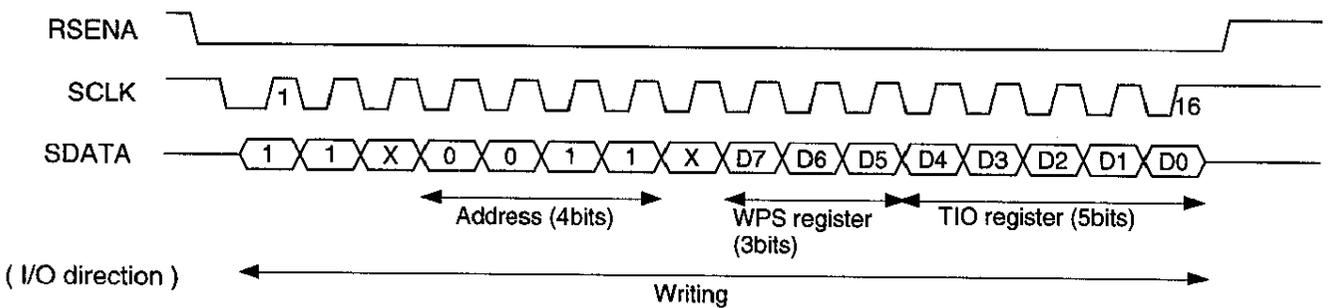
Write to WPL & CPO register



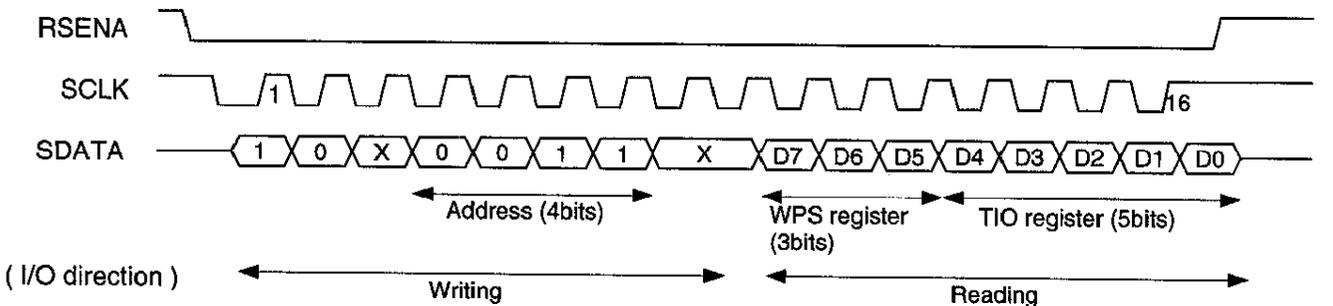
Read from WPL & CPO register



Write to WPS & TIO register

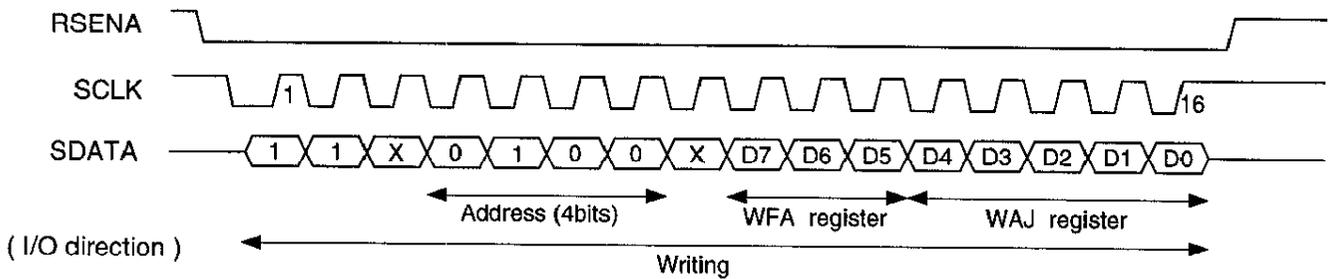


Read from WPS & TIO register

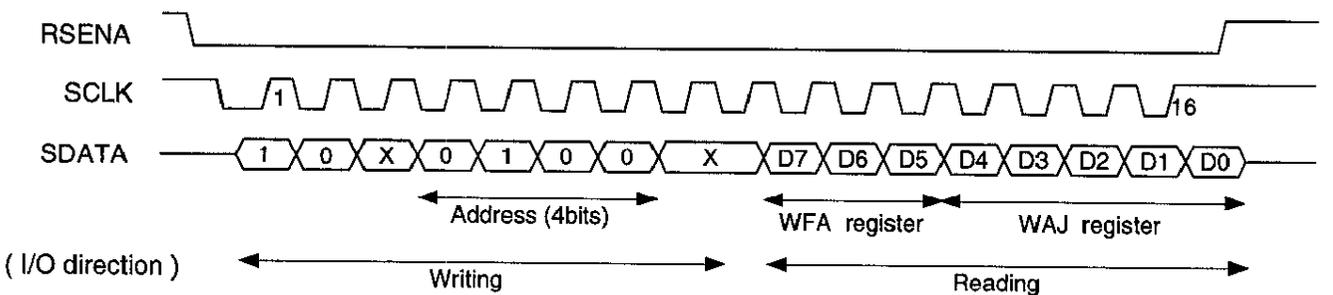


Write and read registers (cont)

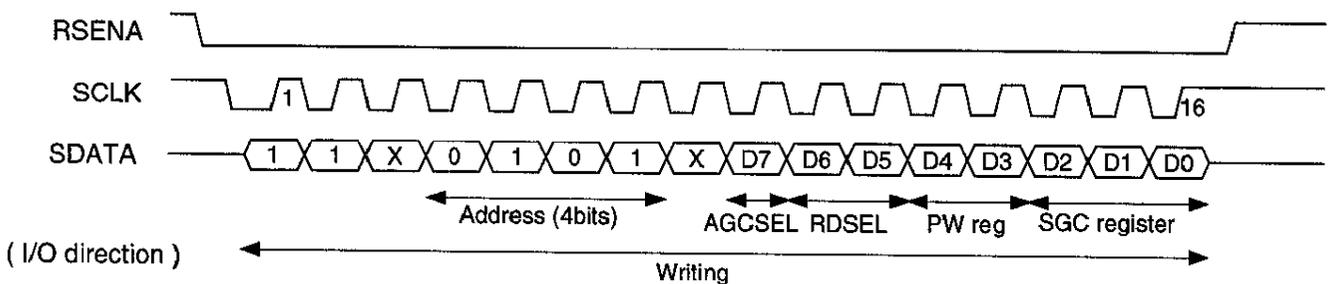
Write to WFA & WAJ register



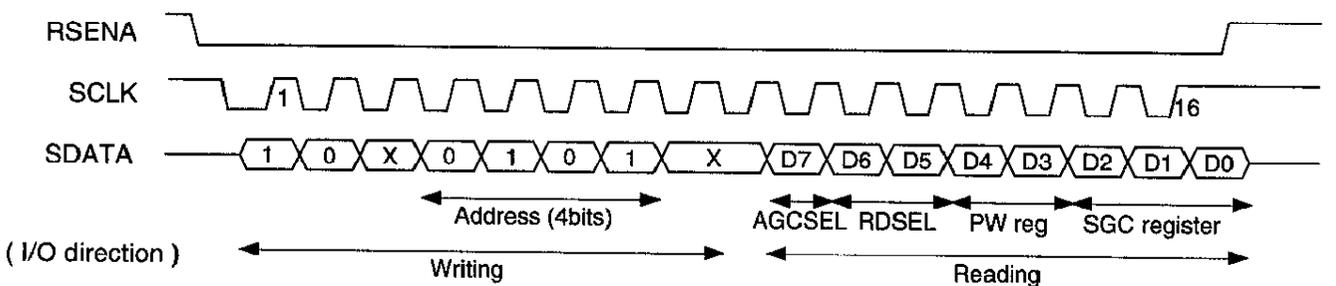
Read from WFA & WAJ register



Write to AGCSEL bit, RDSEL, PW & SGC register

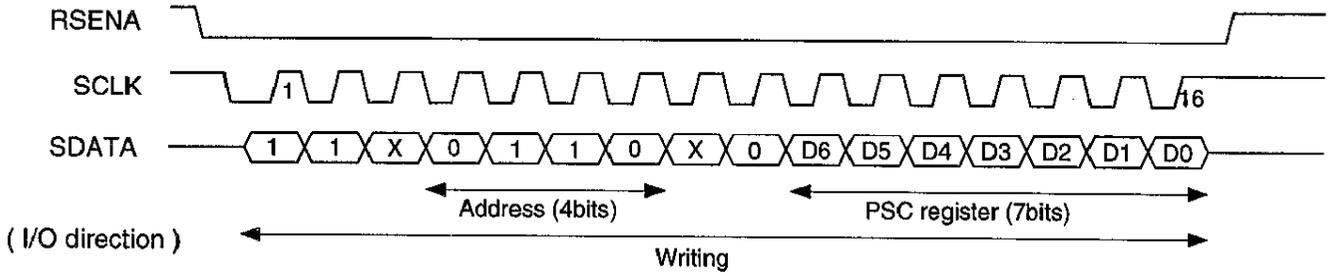


Read from AGS bit, RDS, PW & SGC register

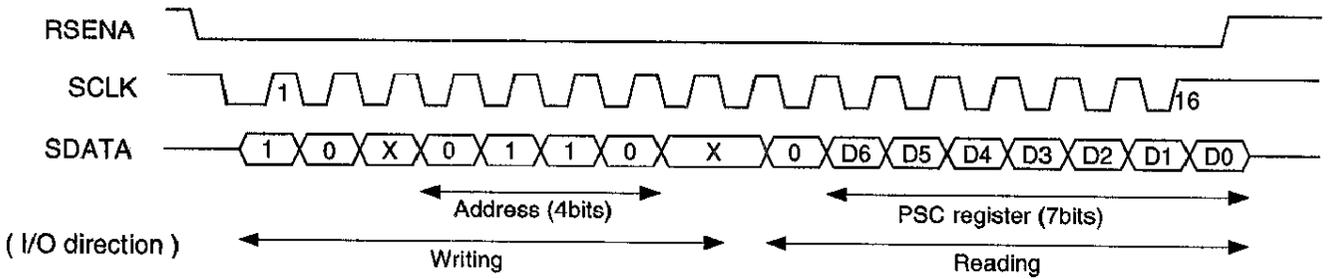


Write and read registers (cont)

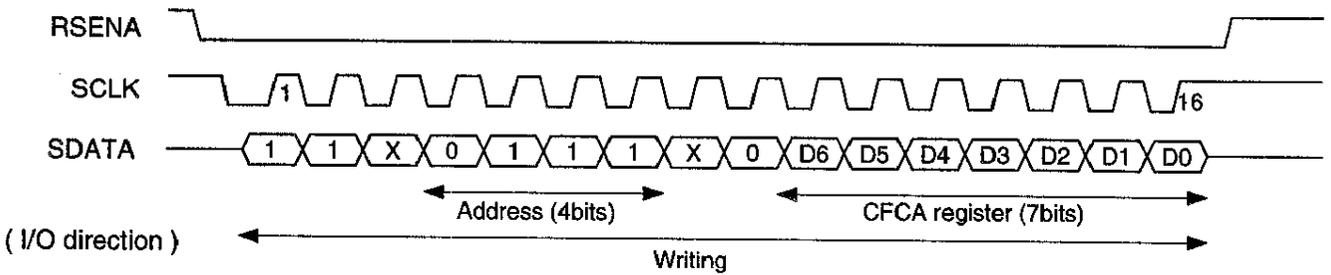
Write to PSC register



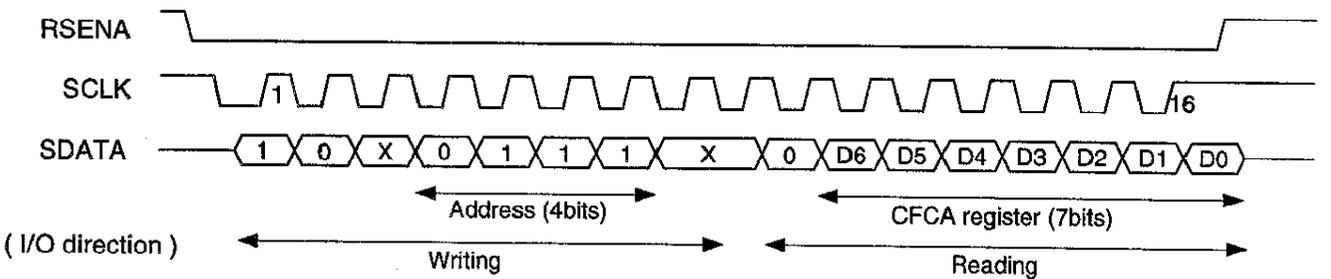
Read from PSC register



Write to CFCA register

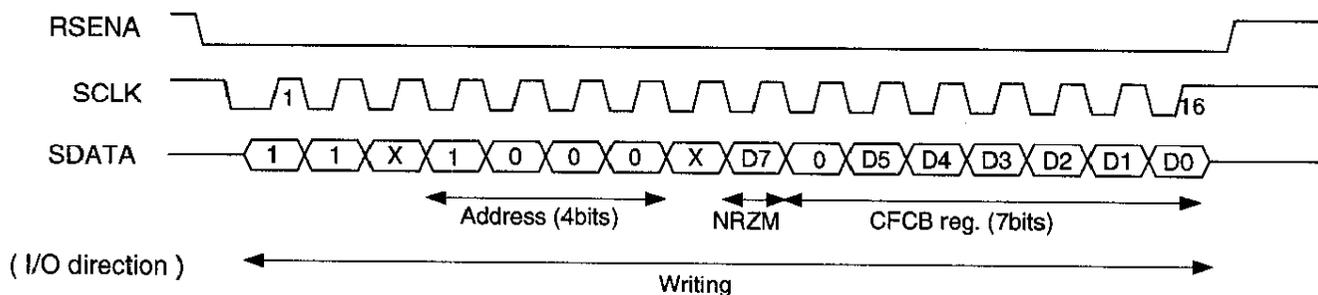


Read from CFC register

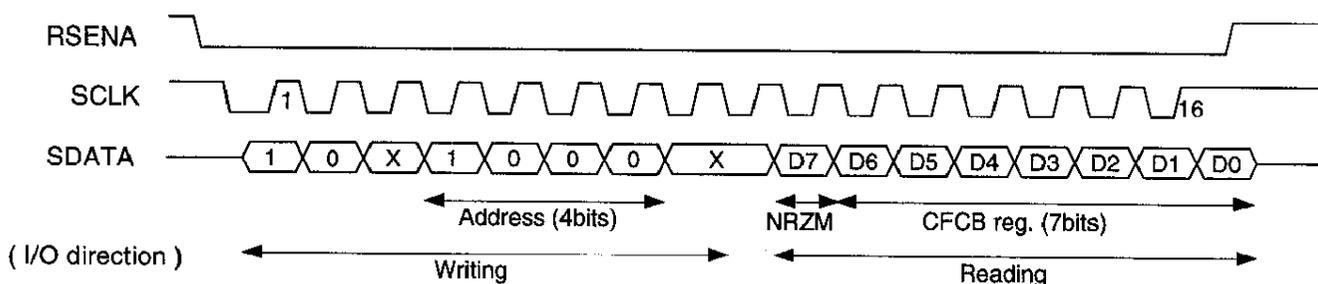


Write and read registers (cont)

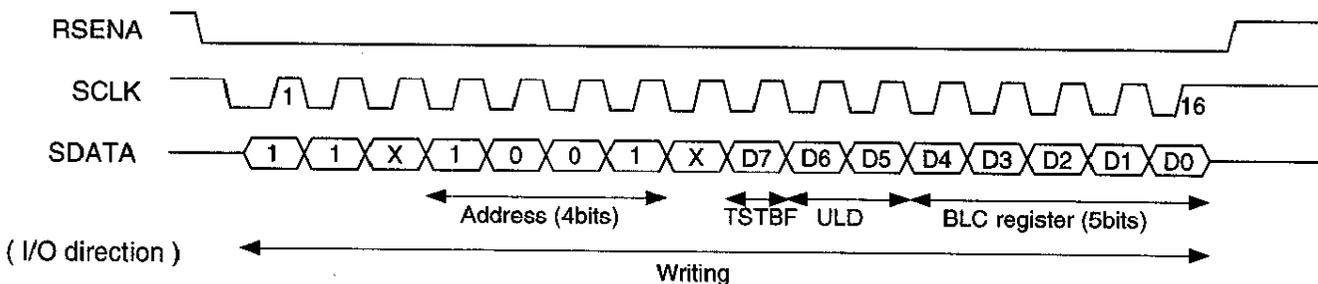
Write to NRZM bit & CFCB register



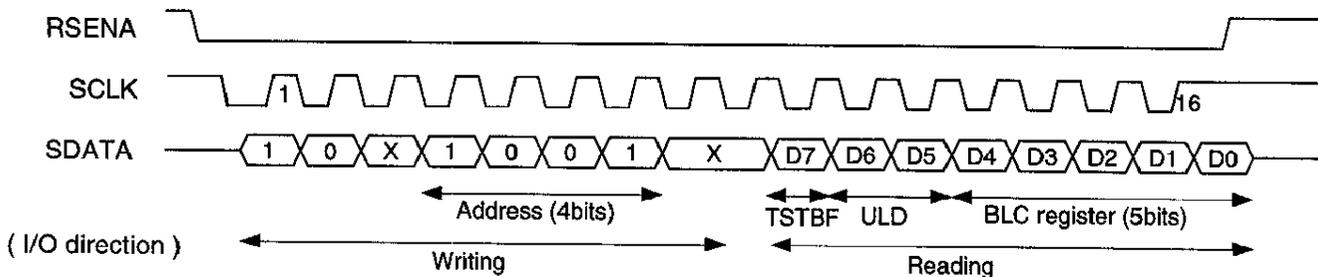
Read from NRZM bit & CFCB register



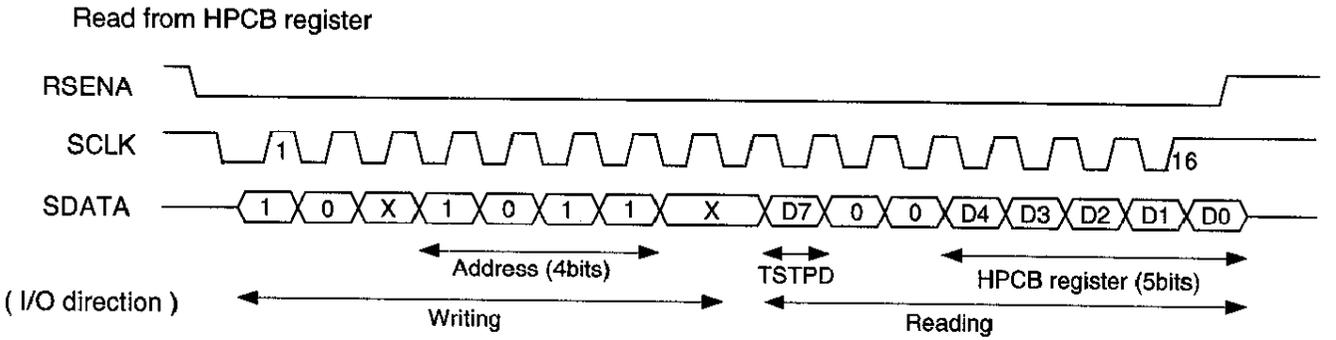
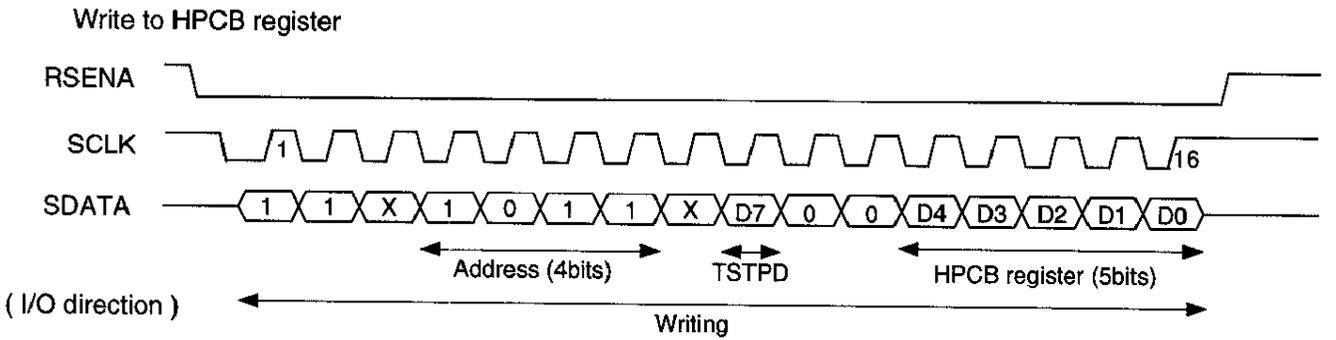
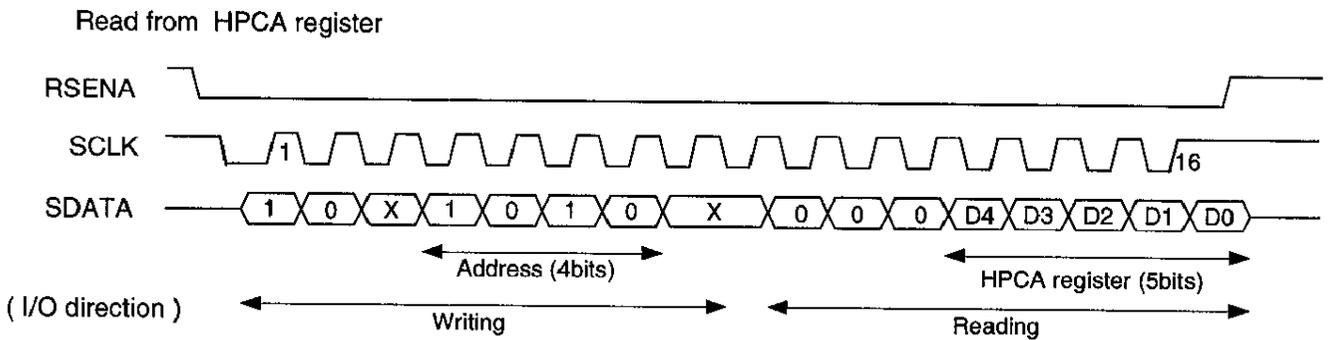
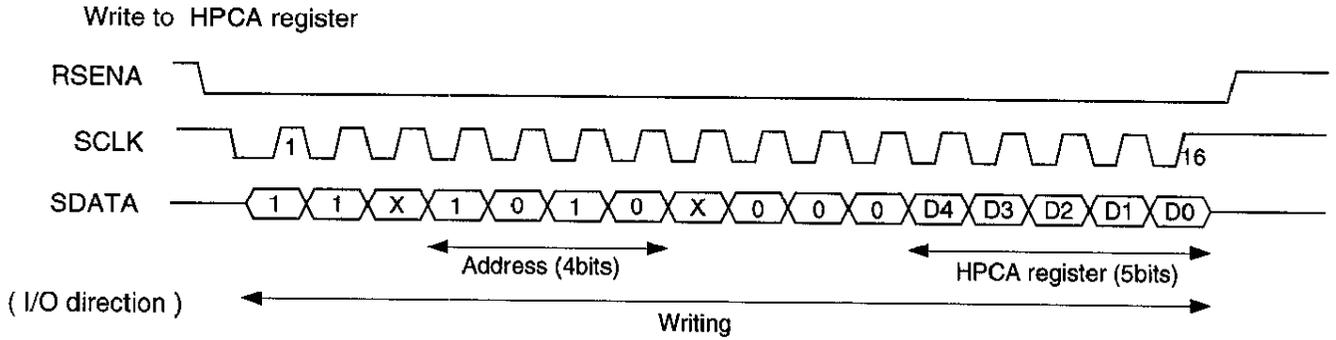
Write to ULD & BLC register



Read from ULD & BLC register

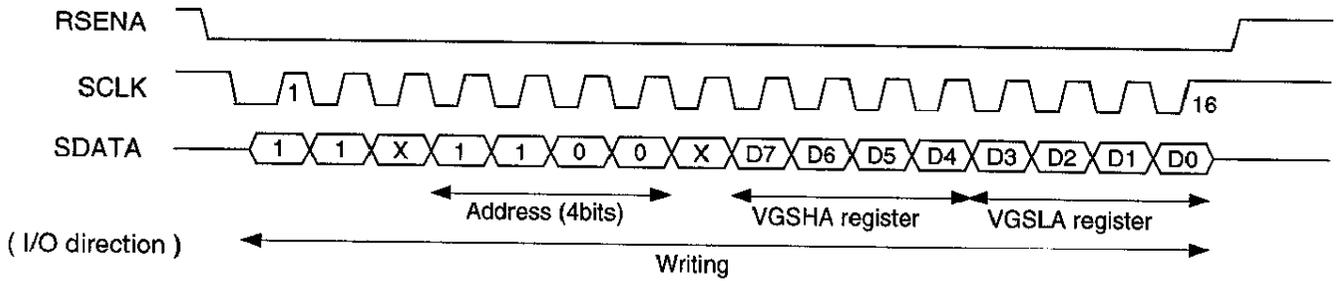


Write and read registers (cont)

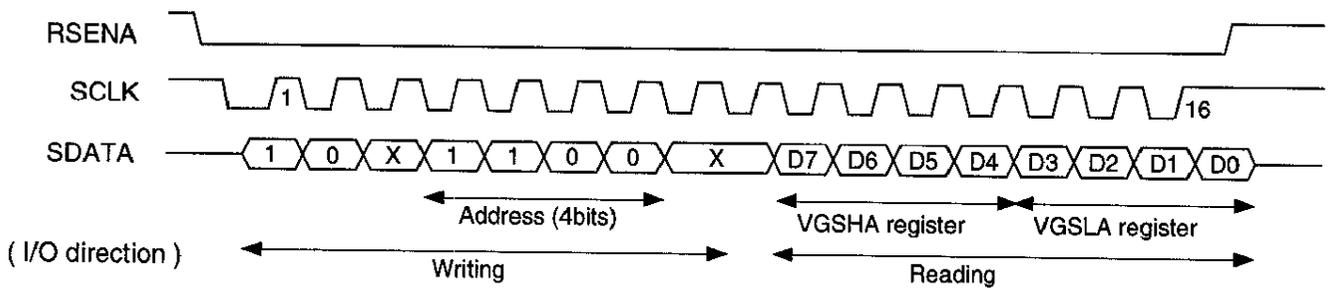


Write and read registers (cont)

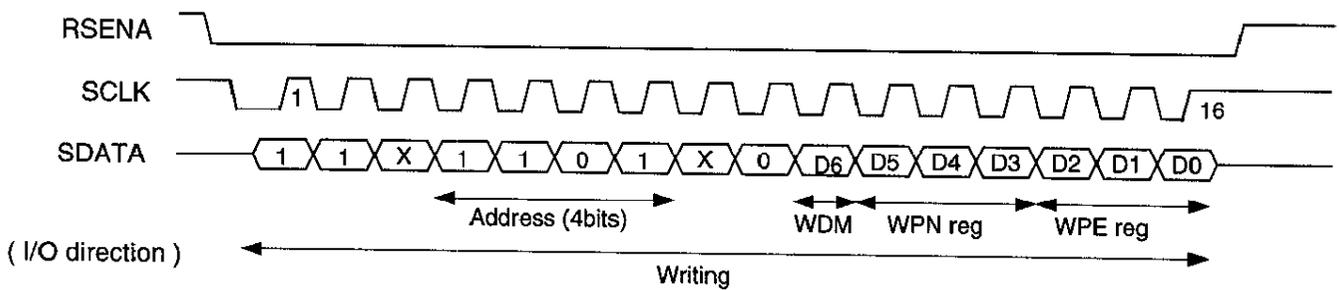
Write to VGSHA & VGSLA register



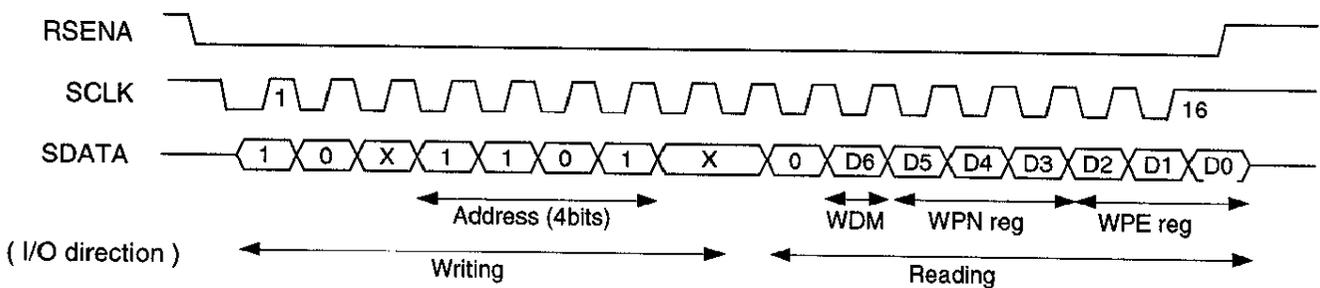
Read from VGSHA & VGSLA register



Write to WDM bit, WPN & WPE register

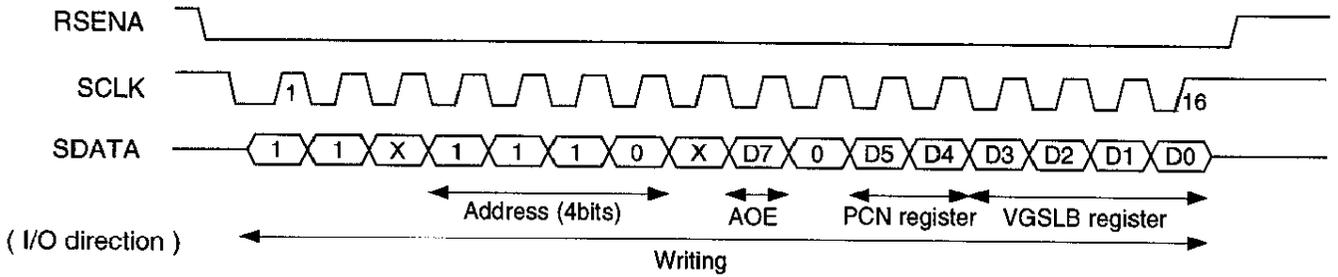


Read from WDM bit, WPN & WPE register

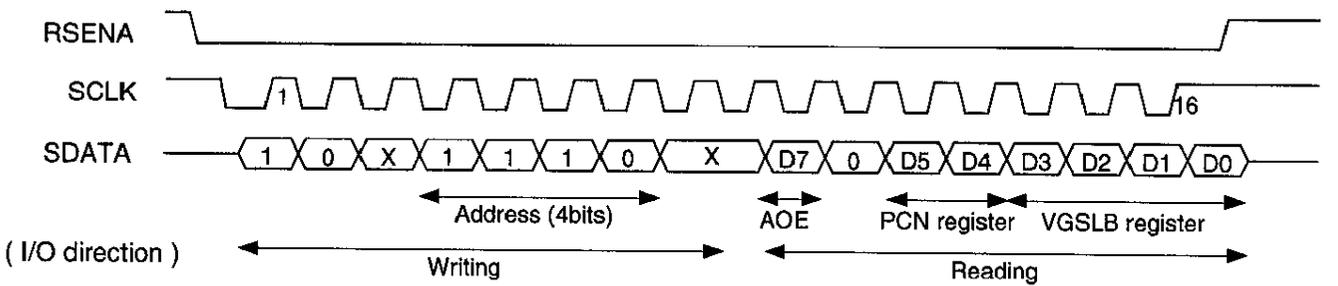


Write and read registers (cont)

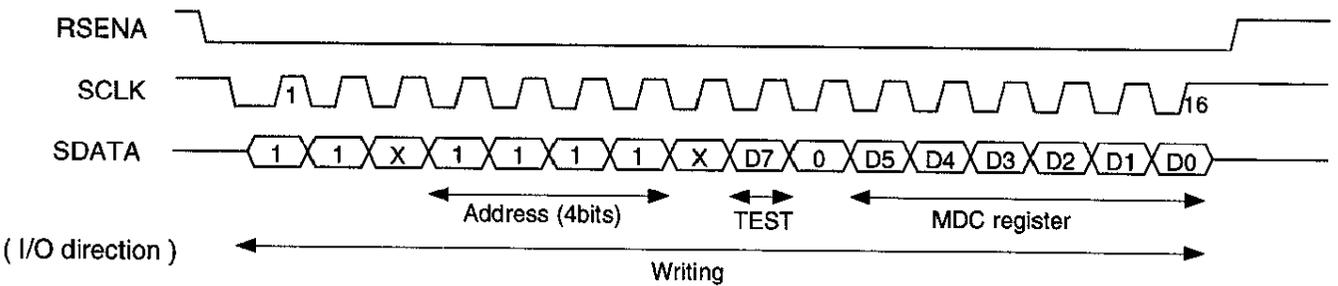
Write to AOE bit, VGSLB & PCN register



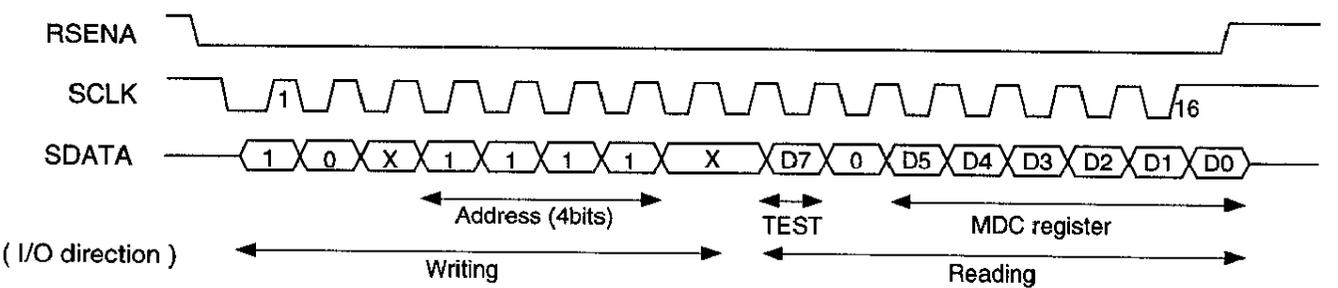
Read from AOE bit, VGSLB & PCN register



Write to MDC register



Read from MDC register



9. 1-7 ENDEC

Encoder and Decoder

The encoder converts an NRZ signal to a (1,7) encoding, and the decoder converts a (1,7) signal back to an NRZ signal. The conversion table is shown in Table4.

The NRZ signal is encoded after being inverted. The inverted NRZ signal is encoded according to the conversion rules shown in figure5.

Therefore the disk controller should input the sequence "0000..." in the sync region. This will be converted to the (1,7) encoding 3T pattern "100100...".

The NRZ signal is encoded after being inverted. For example, if the NRZ data 00 is to be (1,7) encoded, it is first inverted to 11.

Table4 Encoding Table (NRZ to (1,7) Code)

| No. | Last Bit of the Previous (1,7) Code | NRZ Data Bit | | | | (1,7) Code Bits (C2,C3,C4) |
|-----|-------------------------------------|-----------------|---|--------------|---|----------------------------|
| | | Current (D1,D2) | | Next (D3,D4) | | |
| 1 | 0 | 1 | 0 | 0 | X | 1 0 1 |
| 2 | 0 | 1 | 0 | 1 | X | 0 1 0 |
| 3 | 0 | 1 | 1 | 0 | 0 | 0 1 0 |
| 4 | 0 | 1 | 1 | 0 | 0 | 1 0 0 |
| 5 | 0 | 0 | 0 | 0 | X | 0 0 1 |
| 6 | 0 | 0 | 0 | 1 | X | 0 0 0 |
| 7 | 0 | 0 | 1 | 0 | X | 0 0 1 |
| 8 | 0 | 0 | 1 | 1 | X | 0 0 0 |
| 9 | 1 | 0 | 0 | 0 | X | 0 0 1 |
| 10 | 1 | 0 | 0 | 1 | X | 0 1 0 |
| 11 | 1 | 0 | 1 | 0 | 0 | 0 1 0 |
| 12 | 1 | 0 | 1 | 0 | 0 | 0 0 0 |

0 0: Anything other than 0 0
 X : Don't care

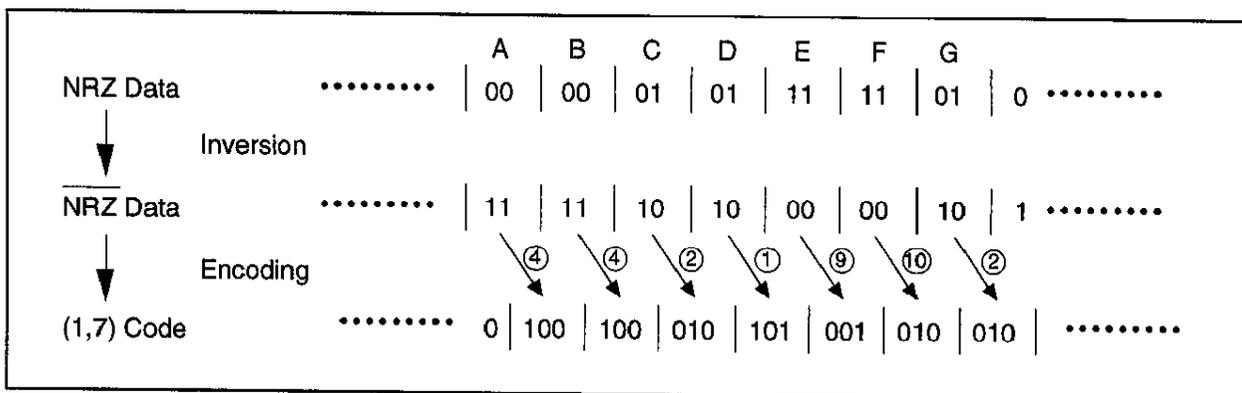


Fig.5 Shows an Example of NRZ to (1,7) Code Conversion.

Next, since the last bit of the previous conversion result A (100) was 0, and the next state of the NRZ data C is 0 ($\overline{C}=10$), the NRZ data B (00) is converted to the (1,7) code 100.

Figure6), since the previous data H was 100 and the next data J is 010, the decoding table gives 11 as the $\overline{\text{NRZ}}$ data. Inverting this gives the NRZ data 00, which is then output.

In decoding the (1,7) code I (=100) to NRZ data (see

Table 5 Decoding Table ((1,7) Code to NRZ)

| No. | (1,7) Code Bits | | | | | | | | | NRZ Data Bit | |
|-----|-----------------|---|---|---------|---|---|------|---|---|--------------|---|
| | Previous | | | Current | | | Next | | | | |
| 1 | X | 1 | 0 | 0 | 0 | 0 | X | X | X | 0 | 0 |
| 2 | X | 0 | 0 | 0 | 0 | 0 | X | X | X | 0 | 1 |
| 3 | X | X | X | 1 | 0 | 0 | X | X | X | 1 | 1 |
| 4 | X | X | 0 | 0 | 1 | 0 | 0 | 0 | X | 1 | 0 |
| 5 | X | X | 0 | 0 | 1 | 0 | 0 | 0 | X | 1 | 1 |
| 6 | X | X | X | 1 | 0 | 1 | X | X | X | 1 | 0 |
| 7 | X | 0 | 0 | 0 | 0 | 1 | X | X | X | 0 | 1 |
| 8 | X | 1 | 0 | 0 | 0 | 1 | X | X | X | 0 | 0 |
| 9 | X | X | 1 | 0 | 0 | 1 | X | X | X | 0 | 0 |
| 10 | X | X | 1 | 0 | 1 | 0 | 0 | 0 | X | 0 | 0 |
| 11 | X | X | 1 | 0 | 1 | 0 | 0 | 0 | X | 0 | 1 |
| 12 | X | X | 1 | 0 | 0 | 0 | X | X | X | 0 | 1 |

0 0: Anything other than 0 0
 X : Don't care

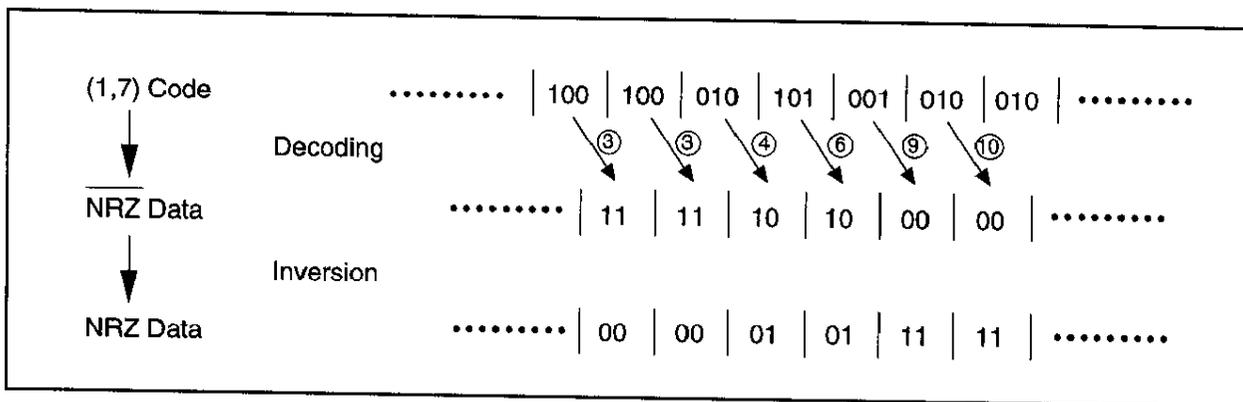
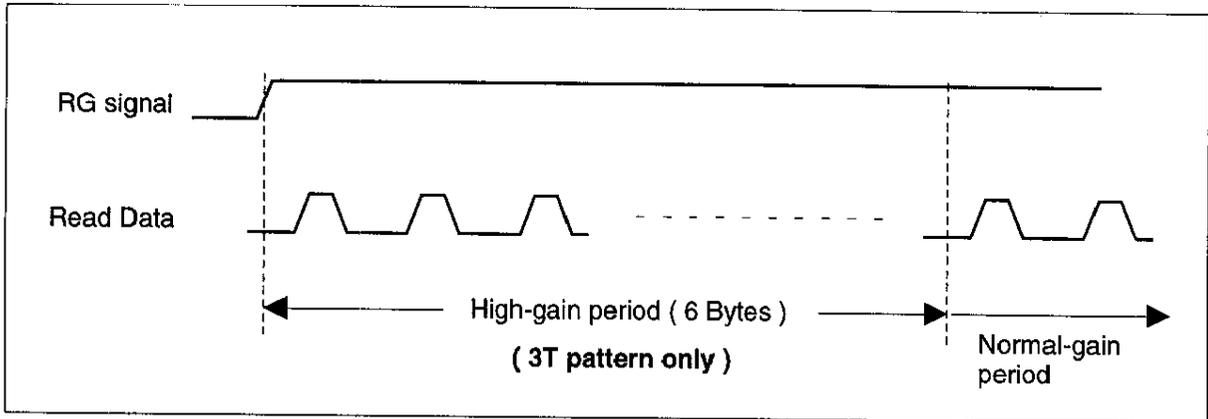


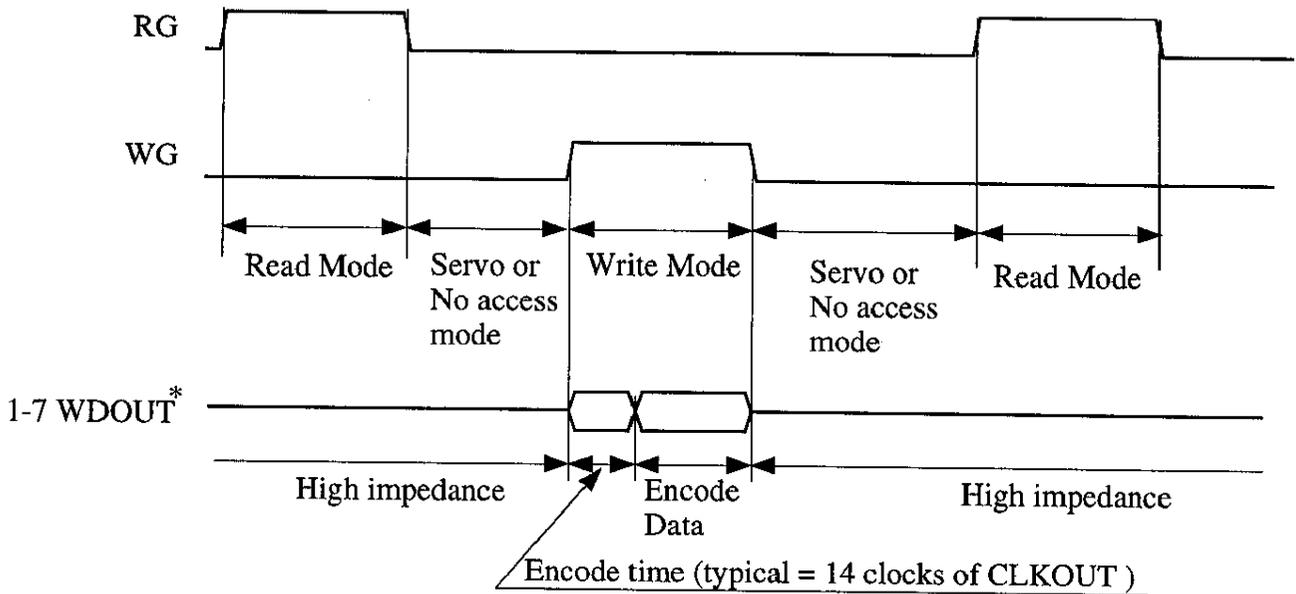
Fig. 6 (1,7) Code to NRZ Decoding Example

10. Sync Field Detection

The high-gain period can be set to last six bytes after the RG signal is goes active.



Read and write mode



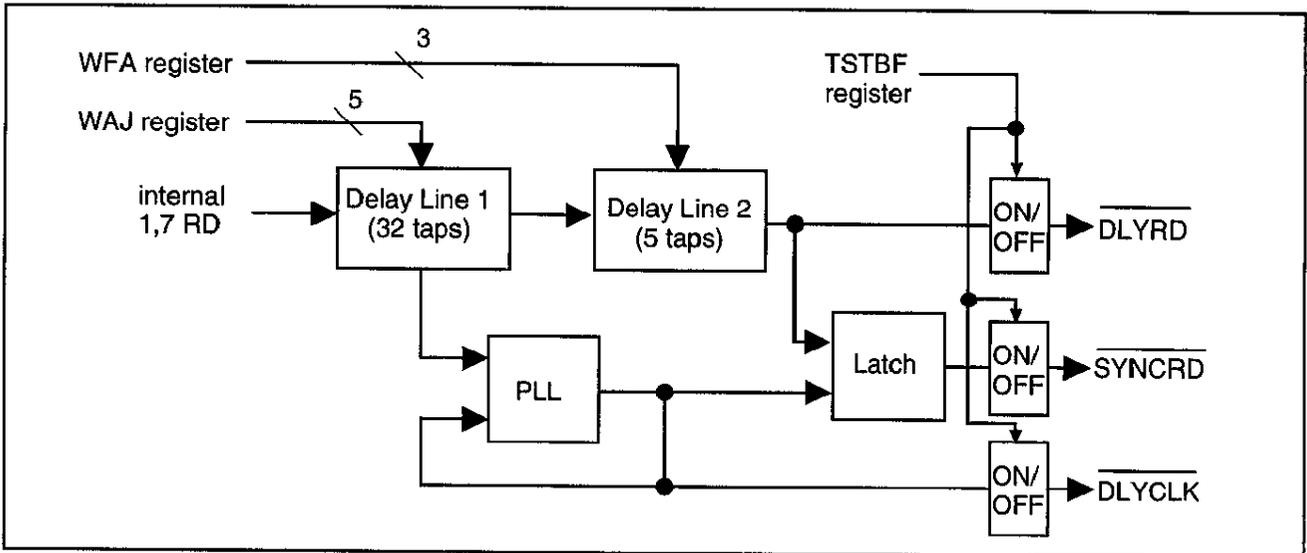
*) 1-7 WDOUT is synchronized rising edge of CLKOUT

11. Window Adjustment Circuit

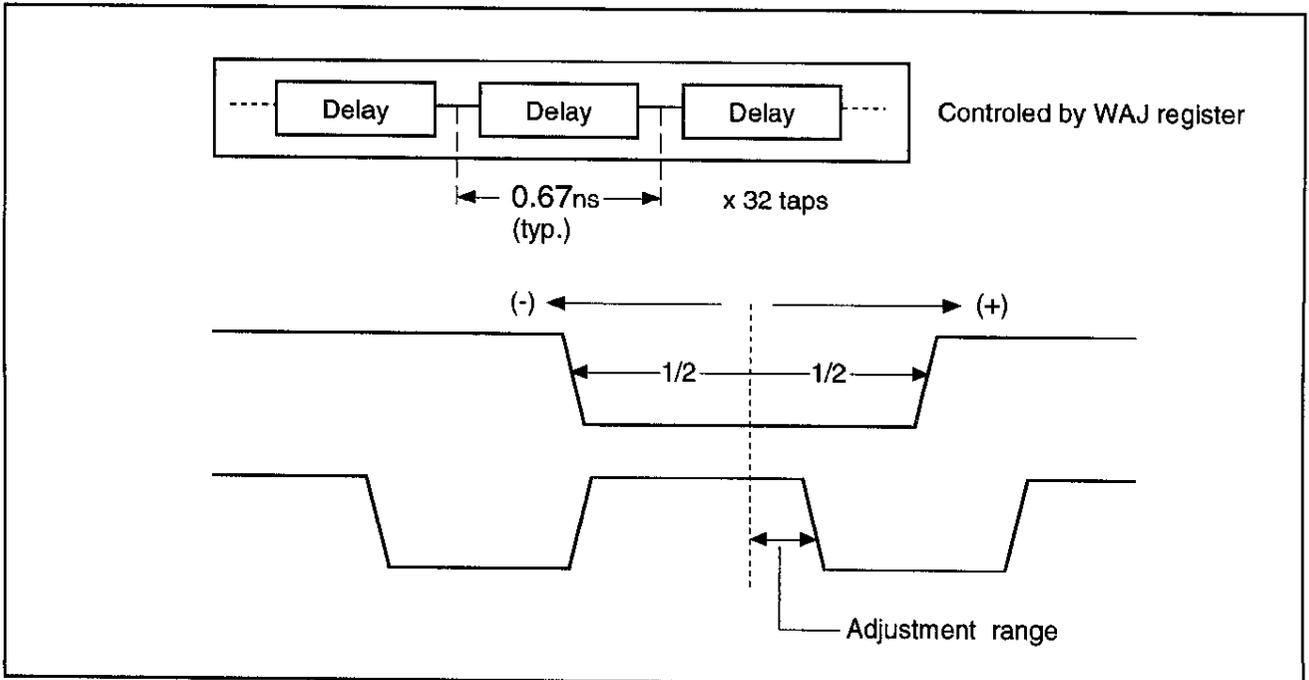
The HD153031RF has two on-chip delay lines for centering the decode window. First delay line has 32 taps for coarse adjustment that can be selected by register WAJ. Second delay line has 5 taps for fine adjustment that can be selected by register

WFA. Centering adjustment can be performed automatically by a microcontroller. This adjustment function can also be used for preshipment window margin test.

(1) Circuit Configuration



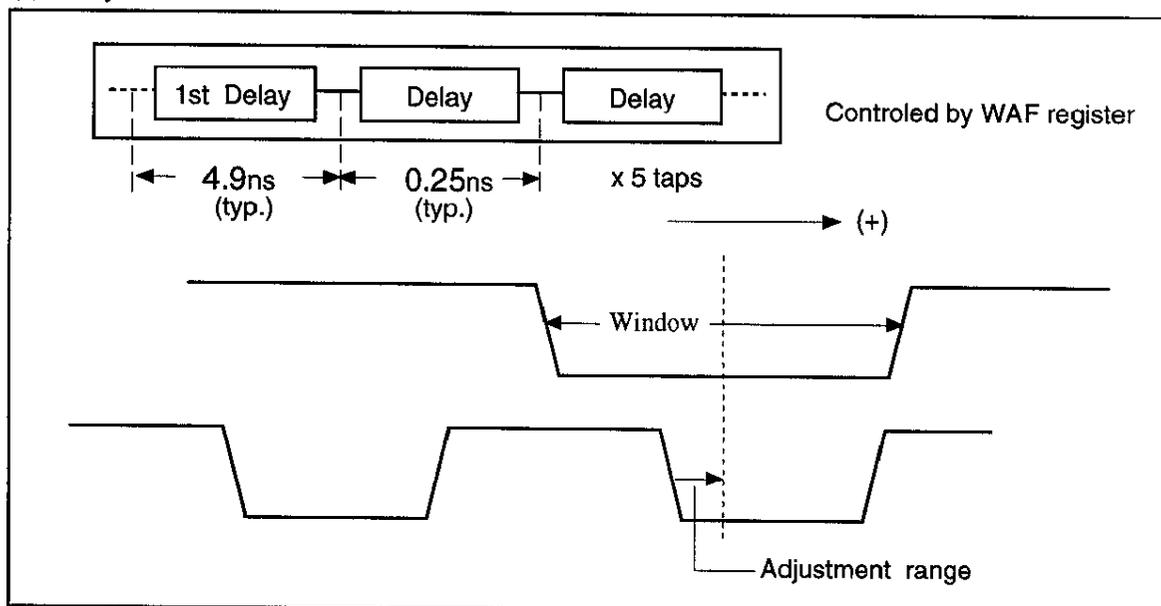
(2) Delay Line 1 (Coarse Window Adjustment)



WAJ Register

| MSB | | | | | LSB | |
|-----|---|---|---|---|----------------------|--|
| 4 | 3 | 2 | 1 | 0 | Delay line 1 tap No. | |
| 0 | 0 | 0 | 0 | 0 | - 16 | |
| | ⋮ | | | | ⋮ | |
| 0 | 1 | 1 | 1 | 0 | - 2 | |
| 0 | 1 | 1 | 1 | 1 | - 1 | |
| 1 | 0 | 0 | 0 | 0 | 0 | |
| 1 | 0 | 0 | 0 | 1 | + 1 | |
| 1 | 0 | 0 | 1 | 0 | + 2 | |
| | ⋮ | | | | ⋮ | |
| 1 | 1 | 1 | 1 | 1 | + 15 | |

(3) Delay Line 2



WAF Register

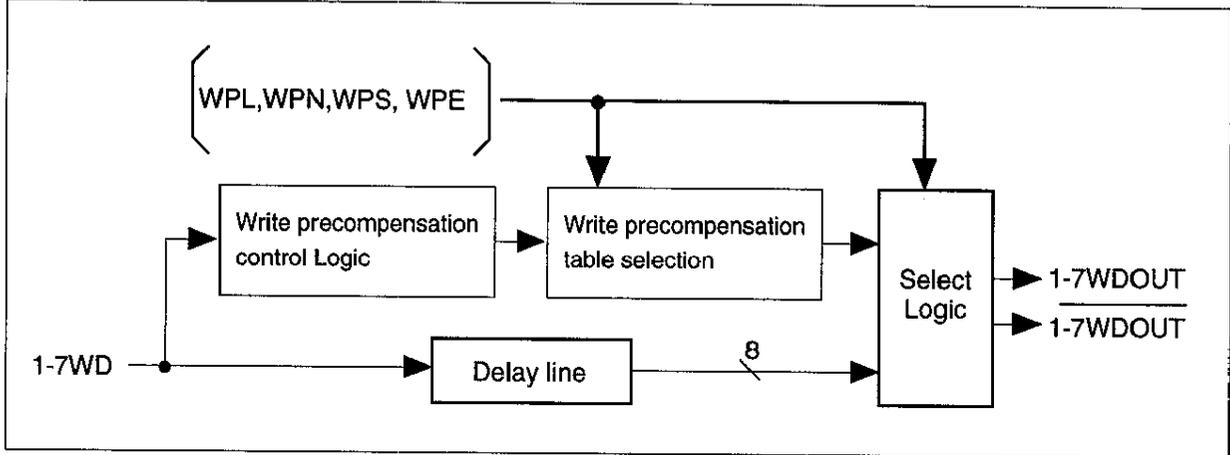
| MSB | | LSB | |
|-----|---|-----|----------------------|
| 2 | 1 | 0 | Delay line 2 tap No. |
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | + 1 |
| 0 | 1 | 0 | + 2 |
| 0 | 1 | 1 | + 3 |
| 1 | 0 | 0 | + 4 |

12. Write Precompensation Circuit

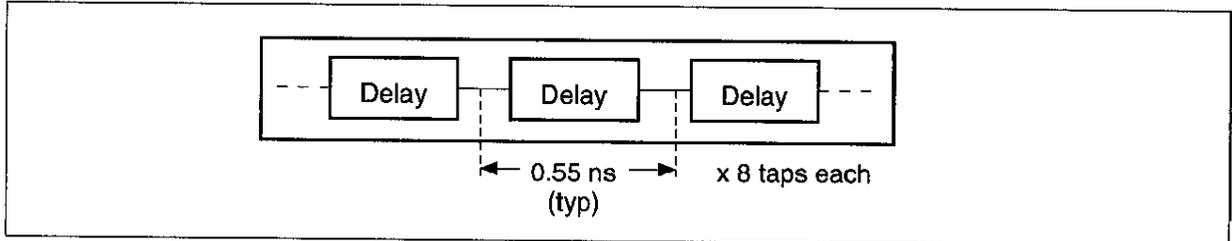
The HD153031RF has a built-in synchronous write precompensation circuit, and the 4 matrix delay levels from the write precompensation table

shown below can be selected independently for the EARLY and LATE sides.

(1) Circuit Configuration

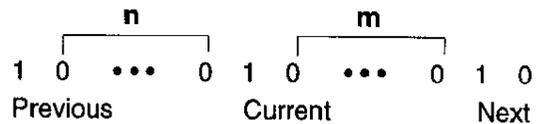


(2) Programmable Delay Line



(3) Table

| n \ m | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|-------|---|---|---|---|---|---|---|
| 1 | N | E | E | E | E | E | E |
| 2 | L | S | S | S | S | S | S |
| 3 | L | S | S | S | S | S | S |
| 4 | L | S | S | S | S | S | S |
| 5 | L | S | S | S | S | S | S |
| 6 | L | S | S | S | S | S | S |
| 7 | L | S | S | S | S | S | S |



n: The number of zeros between the current 1 bit and the previous 1 bit

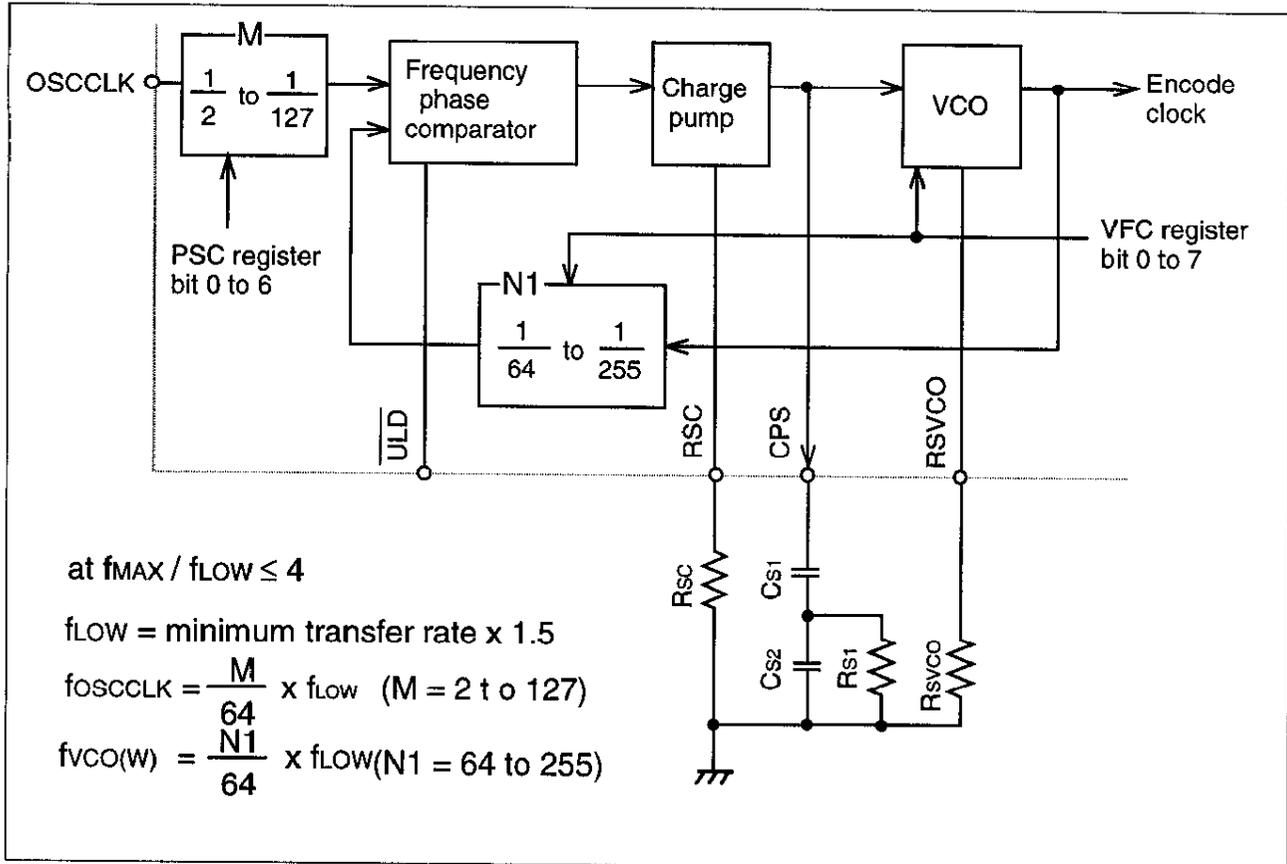
m: The number of zeros between the current 1 bit and the next 1 bit

The precompensation delay time for each the 4 matrix entries in the precompensation table (see Table) can be set independently.

The delay time (8 levels) is selected by the each part of register.

13. Encode Clock Generator's Frequency Synthesizer

Block diagram



Function

- A PLL-type frequency synthesizer generates the encode clock.
- The encode clock frequency can be set by bits 0 to 7 of register VFC to a value $N/64$ times the minimum data transfer rate (innermost track on the disk), where $64 \leq N \leq 255$.
- The lock/unlock function (ULD line) can prevent data from being written when a drive fault occurs.
- Direct, external input of the encode clock (at 1.5 times the transfer rate) is also possible without using the on-chip frequency synthesizer.
- The VCO center frequency can be selected by bits 0 to 7 of register VFC, so a single external resistor RSVCO covers the entire setting range.

Operation

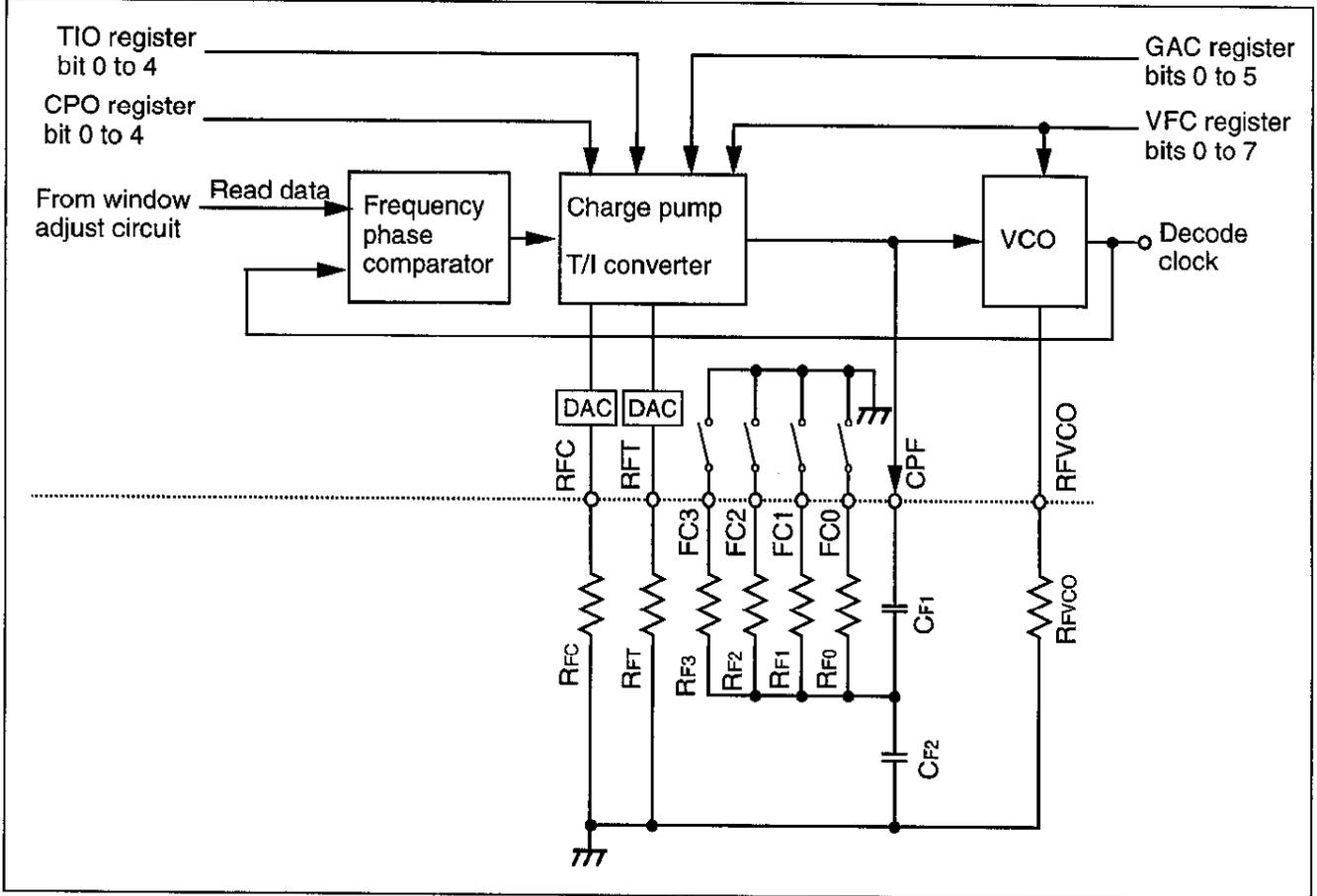
- Input a reference clock to OSCCLK at $(1.5 \cdot M)/64$ times the driver's minimum transfer rate. This signal input to the frequency-phase comparator at $1/M$.
- The VCO clock is divided by $1/64$ to $1/255$, depending on bits 0 to 7 of register VFC, and input to the frequency-phase comparator.

$$2 \leq M \leq 127, 64 \leq N1 \leq 255.$$

$f_{VCO(W)}$: VCO output frequency
 f_{LOW} : Encoder clock frequency corresponding to minimum transfer rate.

14. Decode Clock Generator's VFO

Block diagram



Function

- The phase of the VCO clock is synchronized with the read data from the window adjust circuit.
- The frequency-phase comparator operates in the frequency-phase comparison mode while acquiring phase lock in the sync field, and in phase comparison mode during synchronization in the date field.
- The charge pump and T/I converter circuits both operate while phase lock is being acquired. During synchronization, only the T/I converter operates.
- The VFO is synchronized with the encode clock until the read gate signal (RG) is asserted.
- The VCO center frequency can be changed by

rewriting bits 0 to 7 of the VFC register, so multiple zone recording can be implemented with only a single external resistor(R FVCO).

- The charge pump can select eight levels currents, the reference value of which is controlled by external resistor R FC. Bit 3 to 5 in register GAC selects these eight currents.
- The T/I converter provides one of eight output currents as selected by bits 0 to 2 of register GAC.
- The loop filter attenuation ζ can be selected by bit 6 of register GAC (two selections). Independent settings can be made for high gain and normal gain.

15. Calculation of PLL Constants

I. Encode Clock Generator's Frequency Synthesizer (W-PLL)

1. VCO center frequency f_{ow}

$$f_{ow} = \frac{(6.975 \times 10^9) \cdot N}{R_{svco}} \quad (\text{Hz}) \quad \text{Note1} \quad \dots\dots\dots (I.1)$$

2. VCO gain K_{ow}

$$K_{ow} = (1.056 \times 10^9) \cdot \sqrt{\frac{N}{R_{svco}}} \quad \left(\frac{\text{rad}}{\text{sec} \cdot \text{V}} \right) \quad \dots\dots\dots (I.2)$$

3. Charge pump current ratio N_c

$$N_c = \text{int} \left[16 \cdot \sqrt{\frac{N_1}{N_{1MAX}}} - 8 \right] \quad \dots\dots\dots \text{(When } N_1=N_{1MAX}, \text{ set the } N_c=7) \quad (I.3)$$

Note2: int[] is the integer value calculated by discarding the fractional part of the value.

4. Charge pump current I_{cw}

$$I_{cw} = \frac{5.3}{R_{sc}} \cdot \left(1 + \frac{N_c}{8} \right) \quad (\text{A}) \quad \dots\dots\dots (I.4)$$

5. Characteristic frequency ω_{nw}

$$\omega_{nw} = \sqrt{\frac{K_{ow} \cdot I_{cw}}{2\pi \cdot N_1 \cdot C_{s1}}} \quad \left(\frac{\text{rad}}{\text{sec}} \right) \quad \dots\dots\dots (I.5)$$

6. Attenuation ζ_w

$$\zeta_w = \frac{(C_{s1} + C_{s2})}{2} \cdot R_{s1} \cdot \omega_{nw} \quad \dots\dots\dots (I.6)$$

II. Decode Clock Generator's VFO

1. VCO center frequency f_{or}

$$f_{or} = \frac{(3.375 \times 10^9) \cdot N}{R_{fvco}} \quad (\text{Hz}) \quad \dots\dots\dots (II.1)$$

2. VCO gain K_{or}

$$K_{or} = (1.536 \times 10^9) \cdot \sqrt{\frac{N}{R_{fvco}}} \quad \left(\frac{\text{rad}}{\text{sec} \cdot \text{V}} \right) \quad \dots\dots\dots (II.2)$$

3. Charge pump current I_{CR}

$$I_{CR} = \frac{2.5 \times 10^4}{R_{FC}} \cdot \frac{P}{8} \quad (\text{mA}) \quad \dots\dots\dots (11.3)$$

where $1 \leq P \leq 8$

4. T/I converter current I_{TR}

$$I_{TR} = (3.52 \times 10^3) \cdot \frac{N \cdot L}{500 + R_{FT}} \quad (\mu\text{A}) \quad \dots\dots\dots (11.4)$$

where $0 \leq L \leq 7$

5. Characteristic frequency (high gain) ω_{nRH}

$$\omega_{nRH} = \sqrt{\frac{K_{OR} \cdot \left(\frac{I_{CR}}{6} + I_{TR} \right)}{\pi \cdot C_{F1}}} \quad \left(\frac{\text{rad}}{\text{sec}} \right) \quad \dots\dots\dots (11.5)$$

6. Characteristic frequency (normal gain) ω_{nRN}

$$\omega_{nRN} = \sqrt{\frac{K_{OR} \cdot I_{TR}}{\pi \cdot C_{F1}}} \quad \left(\frac{\text{rad}}{\text{sec}} \right) \quad \dots\dots\dots (11.6)$$

7. Attenuation (high gain) ζ_{RH}

$$\zeta_{RH} = \frac{(C_{F1} + C_{F2})}{2} \cdot \frac{1}{\frac{1}{R_{FA}} + \frac{1}{R_{FB}}} \cdot \omega_{nRH} \quad \dots\dots\dots (11.7)$$

where R_{FA} and $R_{FB} = R_{F0}$ and R_{F1} when GAC register bit 6 = 0
 R_{F2} and R_{F3} when GAC register bit 6 = 1

8. Attenuation (normal gain) ζ_{RN}

$$\zeta_{RN} = \frac{(C_{F1} + C_{F2})}{2} \cdot R_{FA} \cdot \omega_{nRN} \quad \dots\dots\dots (11.8)$$

where $R_{FA} = R_{F0}$ when GAC register bit 6 = 0
 R_{F2} when GAC register bit 6 = 1

Table 15.1 VCO Oscillation Frequency and Transfer Speed for Settings of Register VFC
(at fMAX / fLOW = 3.98)

| N1 | VFC register | | | | | | | | N | VCO oscillation frequency and transfer speed ratio | Example: R _{FVCO} = 3.0 kΩ, R _{SVCO} = 6.2 kΩ | | |
|-----|--------------|---|---|---|---|---|---|---|---|--|---|-------------------------------|--------------------------|
| | MSB | 7 | 6 | 5 | 4 | 3 | 2 | 1 | | | LSB | VCO center frequency (MHz) | Transfer speed (Mbps) |
| 0 | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | |
| 63 | | | | | | | | | | | | | |
| 64 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 1.000 | 18.00 | 12.00 |
| 65 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 16 | 1.016 | 18.28 | 12.19 |
| 66 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 16 | 1.031 | 18.56 | 12.38 |
| 67 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 16 | 1.047 | 18.84 | 12.56 |
| 68 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 17 | 1.063 | 19.13 | 12.75 |
| . | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | |
| 127 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 31 | 1.984 | 35.72 | 23.81 |
| 128 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 2.000 | 36.00 | 24.00 |
| 129 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 32 | 2.016 | 36.28 | 24.19 |
| 130 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 32 | 2.031 | 36.56 | 24.38 |
| . | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | |
| . | | | | | | | | | | | | | |
| 253 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 63 | 3.95 | 71.16 | 47.44 |
| 254 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 63 | 3.97 | 71.44 | 47.63 |
| 255 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 63 | 3.98 | 71.72 | 47.44 |

Table 15.2 Charge pump Output Current Settings in Register GAC

| Bits | GAC register | | | P | Charge pump output current ratio | Example: $R_{FC} = 5.1k\Omega$ |
|------|--------------|---|---|---|----------------------------------|---------------------------------|
| | 5 | 4 | 3 | | | Charge pump output current (mA) |
| 1 | 0 | 0 | 0 | 1 | 1 | 0.613 |
| 2 | 0 | 0 | 1 | 2 | 2 | 1.226 |
| 3 | 0 | 1 | 0 | 3 | 3 | 1.838 |
| 4 | 0 | 1 | 1 | 4 | 4 | 2.451 |
| 5 | 1 | 0 | 0 | 5 | 5 | 3.064 |
| 6 | 1 | 0 | 1 | 6 | 6 | 3.677 |
| 7 | 1 | 1 | 0 | 7 | 7 | 4.289 |
| 8 | 1 | 1 | 1 | 8 | 8 | 4.902 |

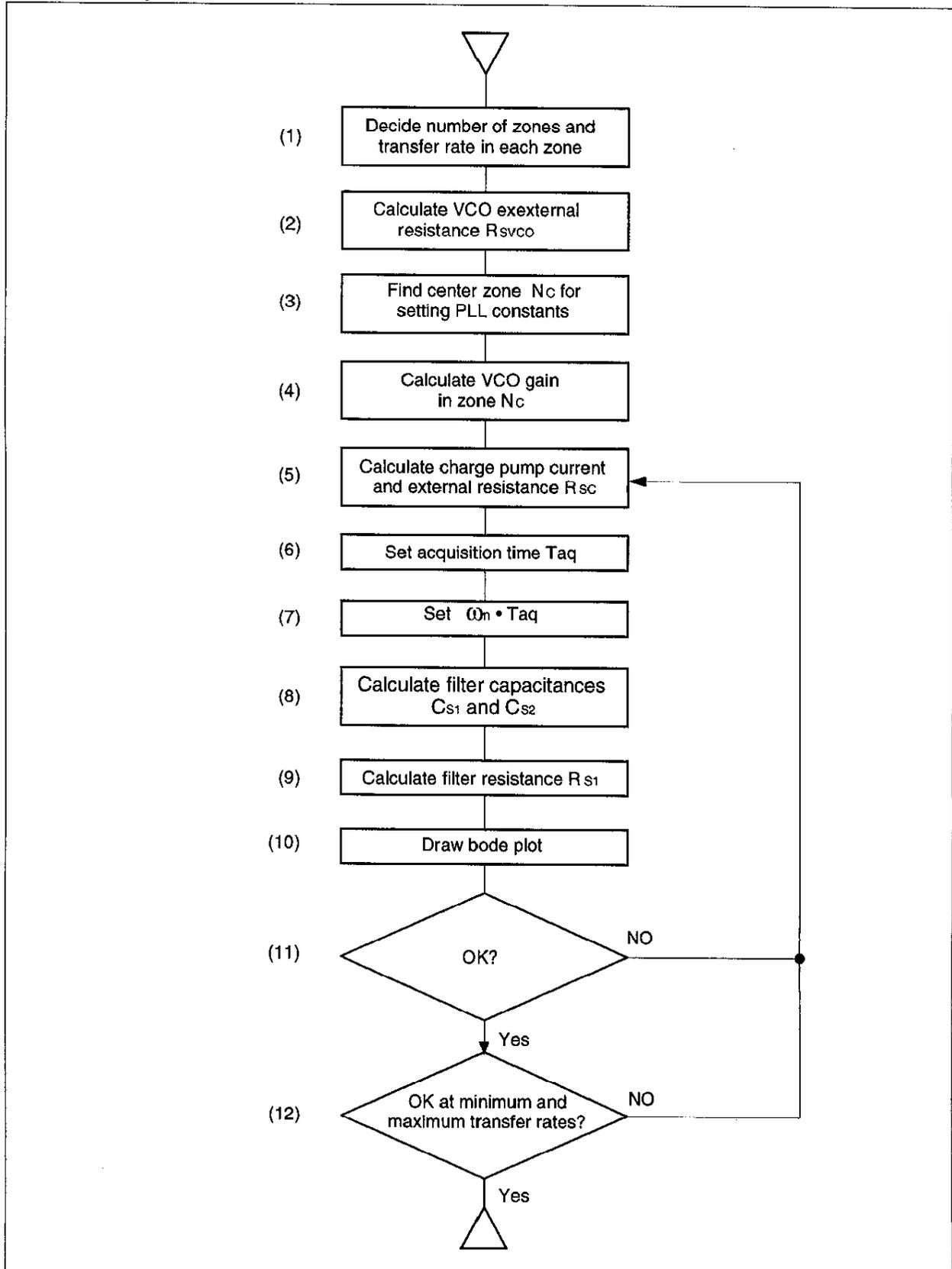
$$I_{CR} = \frac{2.5 \times 10^4}{R_{FC}} \cdot \frac{P}{8} \quad (A)$$

Table 15.3 T/I Output Current Settings in Register GAC

| Bits | GAC register | | | L | T/I output current ratio | Example: $R_{FT} = 12k\Omega$ $N=63$ |
|------|--------------|---|---|---|--------------------------|---|
| | 2 | 1 | 0 | | | T/I output current (μA) |
| 1 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| 2 | 0 | 0 | 1 | 1 | 1 | 17.7 |
| 3 | 0 | 1 | 0 | 2 | 2 | 35.5 |
| 4 | 0 | 1 | 1 | 3 | 3 | 53.2 |
| 5 | 1 | 0 | 0 | 4 | 4 | 71.0 |
| 6 | 1 | 0 | 1 | 5 | 5 | 88.7 |
| 7 | 1 | 1 | 0 | 6 | 6 | 106.5 |
| 8 | 1 | 1 | 1 | 7 | 7 | 124.2 |

$$I_{TR} = (3.52 \times 10^{-3}) \cdot \frac{N \cdot L}{500 + R_{FT}} \quad (\mu A)$$

16. Flowchart of Procedure for Setting Encode Clock Generator's Frequency Synthesizer (W-PLL) Constants



17. Flowchart Explanation (W-PLL)

- (1) Decide number of zones and transfer rate in zone

The HD153031RF uses a frequency synthesizer to generate the reference clock, so the value of the transfer rate is quantized. If the lowest rate corresponds to $N=16$, the available rates are given by the formula:

$$TR_N = TR_{min}, \quad 16 \leq N \leq 63$$

where, TR_N : Transfer rates in different zones
 TR_{min} : Minimum transfer rate (innermost track)

- (2) Calculate VCO external resistance R_{svco}

Use equation (I.1) to calculate the external resistance R_{svco} that makes the VCO oscillate at 1.5 times the minimum transfer rate ($N=16$)

- (3) Find center zone (TR_{cen})

Calculate the midpoint (TR_{cen}) between the minimum transfer rate (TR_{min}) and maximum transfer rate (TR_{max}), and from the zones selected in step (1), find the value of N (N_c) that comes closest to TR_{cen} .

$$TR_{cen} = \frac{TR_{min} + TR_{max}}{2}$$

- (4) VCO gain K_{ow}

Use equation (I.2) to calculate the VCO gain ζ in the center zone ($N=N_c$)

- (5) Charge pump current I_{cw}

Select the charge pump current within the following range:

$$I_{cw} \leq 500 \text{ } (\mu\text{A})$$

Calculate the necessary external resistance R_{sc} from equation (I.4).

- (6) Setting phase-lock acquisition time T_{aq}

Decide the phase-lock acquisition time T_{aq} , considering the change in characteristic frequency from zone to zone and the head seek time.

- (7) Setting $\omega_n \cdot T_{aq}$

Decide $\omega_n \cdot T_{aq}$ the end of the phase-lock acquisition.

(8) Filter capacitances C_{s1} and C_{s2}

Decide the phase-lock acquisition time T_{aq} , considering the change in characteristic frequency from zone to zone and the head seek time. The value used in this data sheet is:

$$T_{aq} = 0.1 \quad (\text{ms})$$

The following formula gives an estimate of the acquisition time:

$$\omega_{nW} \cdot T_{aq} = 2.25$$

Substitute the values of K_{cw} and ω_{nW} into equation (1.5) and combine with the formula above to calculate the filter capacitance C_{s1} . To suppress jitter and allow a phase margin, the following value is recommended for C_{s2} :

$$C_{s2} = \frac{1}{45} \cdot C_{s1}$$

(9) Filter resistance R_{s1}

To ensure loop stability, set the attenuation to approximately:

$$\zeta_{nw} = 1.0$$

Substitute this value into equation (1.6) to calculate the filter resistance R_{s1} .

(10) Bode plot

Calculate the open-loop transfer function $G(s)$ and draw a Bode plot.

(11) OK?

Decide whether the open-loop and closed-loop characteristics are satisfactory.

(12) OK at TR_{min} and TR_{max} ?

Repeat steps (8) and (9) for the minimum and maximum transfer rates.

18. Calculation example of HD153031RF W-PLL Constants

Transfer rate ; 18Mbps , 36Mbps 2 zone

(1) Oscillation frequency $f_{ow} = 36\text{MHz}$, $N=32$

$$R_{svco} = \frac{(6.975 \times 10^9) \cdot 32}{f_{ow}} = 6.2 \text{ k}\Omega$$

(2) VCO gain K_{ow}

$$K_{ow\ 18} = 1.056 \times 10^9 \sqrt{\frac{24}{6.2 \times 10^3}} = 65.7 \text{ Mrad / s} \cdot \text{V}$$

$$K_{ow\ 36} = 1.056 \times 10^9 \sqrt{\frac{48}{6.2 \times 10^3}} = 92.9 \text{ Mrad / s} \cdot \text{V}$$

(3) Charge Pump Current I_{cw}

$$R_{sc} = 20\text{K}\Omega$$

$$I_{cw\ 18} = \frac{5.3}{20 \times 10^3} \left(1 + \frac{1}{8}\right) = 298.1 \mu\text{A} \quad (\text{NC}=1)$$

$$I_{cw\ 36} = \frac{5.3}{20 \times 10^3} \left(1 + \frac{5}{8}\right) = 430.6 \mu\text{A} \quad (\text{NC}=5)$$

(4) ω_n

$$\omega_n \cdot T_{aq} = 2.25$$

$$(\omega_n = 22.5 \text{ Krad / s}) \quad (t_{aq} = 0.1 \text{ ms})$$

$$\omega_{nw\ 18} = \sqrt{\frac{65.7 \times 10^6 \times 298.1 \times 10^{-6}}{2\pi \cdot 96 \cdot C_{S1}}}$$

$$\omega_{nw\ 36} = \sqrt{\frac{92.9 \times 10^6 \times 430.6 \times 10^{-6}}{2\pi \cdot 192 \cdot C_{S1}}}$$

$$C_{S1\ 18} = 64137\text{pF}$$

$$C_{S1\ 36} = 65500\text{pF}$$

$$\therefore C_{S1} = (64137 + 65500) / 2 = 64819 \approx \underline{68000\text{pF}}$$

$$C_{S2} = \frac{1}{45} \cdot C_{S1} = 1440.4$$

$$\therefore C_{S2} \approx \underline{1500\text{pF}}$$

(5) Attenuation ζ_{nw}

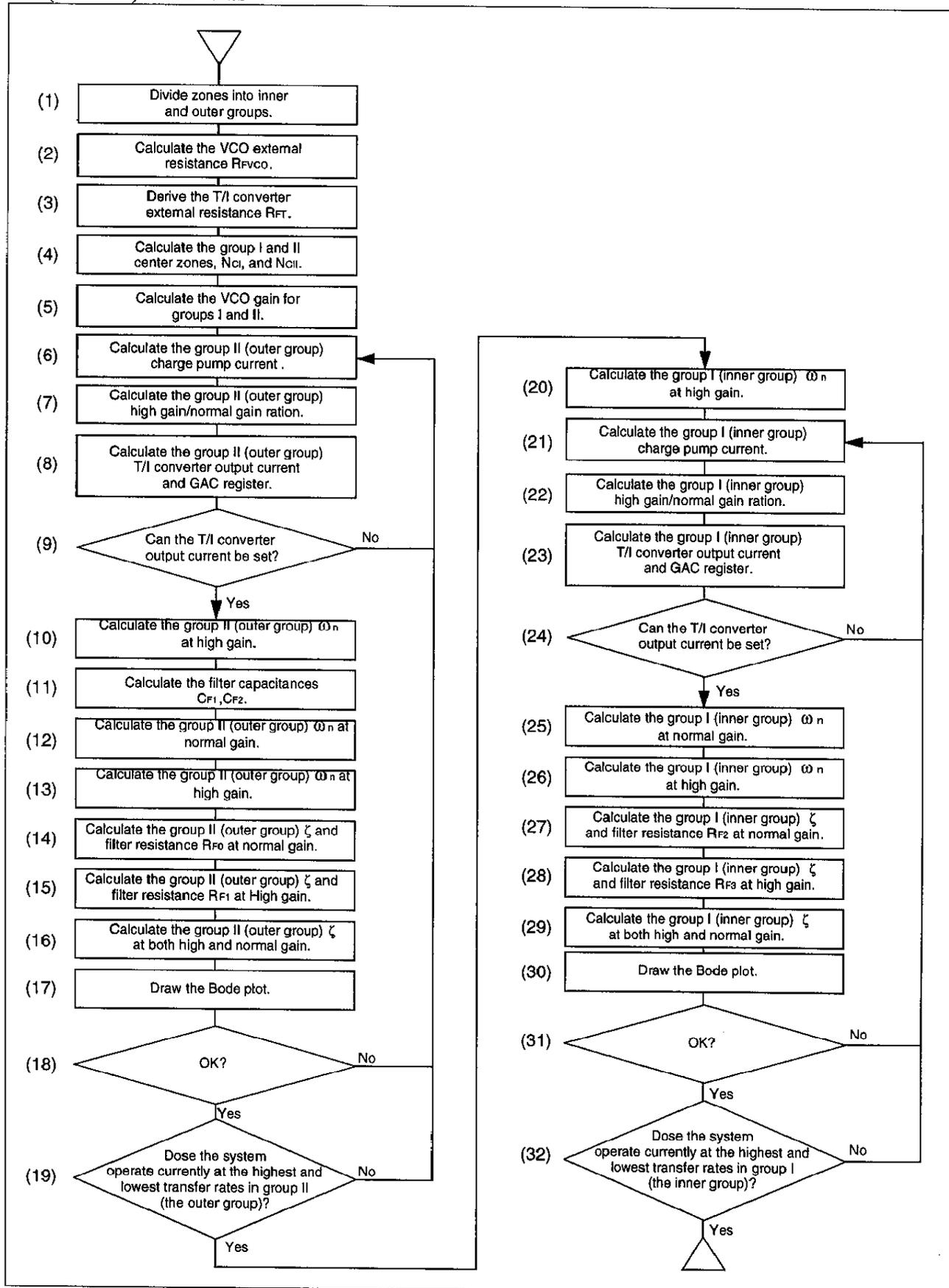
$$\zeta_{nw} = \frac{(68000+1500) \times 10^{-12}}{2} \cdot R_{S1} \cdot \omega_{nw}$$

$$\omega_{nw\ 18} = 21.86 \text{ Krad / s}, \quad \zeta_{nw\ 18} = 0.9875$$

$$\omega_{nw\ 36} = 22.09 \text{ Krad / s}, \quad \zeta_{nw\ 36} = 0.9979$$

$$\therefore R_{S1} \approx \underline{1.3 \text{ k}\Omega}$$

19. Flowchart of Procedure for Setting Decode Clock Generator VFO (R-PLL) Constants



20. Flowchart Explanation (R-PLL)

(1) Divide zones into groups

Divide the zones selected in synthesizer step (1) into two groups (I and II) having equal frequency ranges.

Divide the groups at the following transfer rate TRgr:

$$TRgr = \sqrt{TRmin \cdot TRmax}$$

(2) VCO external resistance R_{FVCO}

Use equation (II.1) to calculate the external resistance R_{FVCO} that makes the VCO oscillate at 1.5 times the minimum transfer rate (N=16)

(3) T/I converter external resistance R_{FT}

Find the R_{FT} values at the minimum transfer rate as shown in Fig1.(R_{FT} vs Data transfer rate).

(4) Center zones TR_{CI} and TR_{CII} of group I and II

Find N_{CI} and N_{CII} in groups I and II by the same method as in synthesizer step (3). See page 42.

(5) VCO gain K_{OR} in groups I and II

Use equation (II.2) to calculate the VCO gain K_{OR} at the center zones (N=N_{CI} and N=N_{CII}) in groups I and II.

(6) Charge pump current I_{CR} in group II

Select the charge pump current level within the following range:

$$I_{CR} \leq 5.0 \quad (\text{mA})$$

Calculate the values for the external resistances R_{FC} and P from equation (II.3). So that the current has the desired value. See Table2 for the relationship between the value of P and GAC register.

(7) High gain/normal gain ratio in group II.

Set the current ratio g_G between high and normal gain.

$$g_G = 16$$

(8) Group II T/I conversion output current I

Determine the value of L(0 ≤ L ≤ 7) using equation (II.4), so that the following equation is satisfied.

$$I_{TR} = \frac{I_{CR}}{6(g_G - 1)}$$

See Table3 for the relationship between the value of L and GAC register.

(9) Analysis

Determine if the T/I converter output current can be set.

(10) Group II High Gain ω_n

After determining the group II center zone N_{CI} phase pull-in time T_{aq} taking into consideration the high gain set time, and determine the high gain characteristic frequency ω_{nRH} using the following equation.

$$\omega_{nRH} \cdot T_{aq} = 2.7$$

(Adjust so that this value is in the range 2 to 4.)

(11) Filter Capacitances C_{F1} and C_{F2}

Calculate the filter capacitance C_{F1} by substituting the high gain characteristic frequency ω_{nRH} calculated in item (10) above in formula II.5.

Also, set the ratio between C_{F1} and C_{F2} taking into consideration high region jitter suppression and phase margin. We recommend deriving C_{F2} using the following equation.

$$C_{F2} = \frac{1}{45} \cdot C_{F1}$$

(Adjust so that this value is in the range 1/20 to 1/100.)

(12) Group II Normal Gain ω_n

Compute the normal gain characteristic frequency ω_{nRN} by substituting the derived value of C_{F1} into formula II.6.

(13) Group II High Gain ω_n

Compute the high gain characteristic frequency ω_{nRH} by substituting the derived value of C_{F1} into formula II.5.

(14) Group II Normal Gain ζ and Filter Resistance R_{F0}

Set the normal gain attenuation ratio ζ_{RN} with stability as the main criteria.

The equation below indicate the recommend value . $\zeta_{RN} \cong 1.0$

Calculate the filter resistance R_{F0} by substituting that value into formula II.8

(15) Group II High Gain ζ and Filter Resistance R_{F1}

Set the normal gain attenuation ratio ζ_{RH} with stability as the main criteria.

The equation below indicate the recommend value . $\zeta_{RH} \cong 0.8$

Calculate the filter resistance R_{F1} by substituting that value into formula II.7.

(16) Group II High Gain ζ and Normal Gain ζ

Calculate the attenuation ratios ζ_{RH} and ζ_{RN} by substituting the values of R_{F0} and R_{F1} into equations II.7 and II.8.

(17) Bode Plot Construction

Compute the open loop transfer function $G(s)$ and construct the Bode plot.

(18) Analysis

Determine if the system is suitable from the open and closed loop characteristics.

(19) Analysis at TRmin and TRmax

Repeat the analysis of item (17) and (18) for group II TRmin and TRmax.

(20) Group I High Gain ω_n

After determining the group I center zone N ci phase pull-in time T_{aq} taking into consideration the high gain set time, and determine the high gain characteristic frequency ω_{nRH} using the following equation

$$\omega_{nRH} \cdot T_{aq} = 3.07$$

(Adjust so that this value is in the range 2 to 4.)

(21) Group I Charge Pump Current I_{CR}

Calculate the charge pump current I_{CR} by substituting the high gain characteristic frequency ω_{nRH} computed in item (20) above into formula II.5.

Here, set the charge pump current level within the following range:

$$I_{CR} \leq 5.0mA$$

Now, derive a value for P using equation II.3 so that the desired charge pump current is achieved. See Table2 for the relationship between the value P and GAC register.

(22) Group I High gain / Normal Gain Ratio

Set the high gain to normal gain current ratio g_G .

$$g_G = 16$$

(23) Group I T/I Converter Output Current I_{TR}

Determine a value of L ($0 \leq L \leq 7$) using equation (II.4) so that the following equation

$$I_{TR} = \frac{I_{CR}}{6(g_G-1)}$$

See Table3 for the relationship between the value L and GAC register.

(24) Analysis

Determine if the T/I converter output current should be set .

(25) Group I Normal Gain ω_n

Calculate the normal gain characteristic frequency ω_{nRN} by substituting the I_{TR} derived above into formula II.6.

(26) Group I High Gain ω_n

Calculate the high gain characteristic frequency ω_{nRH} by substituting the I_{CR} derived above into formula II.5.

(27) Group I Normal Gain ζ and Filter Resistance R_{F2}

Set the normal gain attenuation ration ζ_{RN} with stability as the main criteria. The equation below indicate the recommend value.

$$\zeta_{RN} \cong 1.0$$

Calculate the filter resistance R_{F2} by substituting that value into formula II.8.

(28) Group I High Gain ζ and Filter Resistance R_{F3}

Set the high gain attenuation ration ζ_{RH} with stability as the main criteria. The equation below indicate the recommend value.

$$\zeta_{RH} \cong 0.8$$

Calculate the filter resistance R_{F3} by substituting that value into formula II.7.

(29) Group I High Gain ζ and Normal Gain ζ

Calculate the attenuation ratios ζ_{RH} and ζ_{RN} by substituting the values of R_{F2} and R_{F3} into equations II.7 and II.8.

(30) Bode Plot Construction

Compute the open loop transfer function $G(S)$ and construct the Bode plot.

(31) Analysis

Determine if the system is suitable from the open and closed loop characteristics.

(32) Analysis to determine TR_{min} and TR_{max}

Repeat the analysis of items (30) and (31) for group I TR_{min} and TR_{max} .

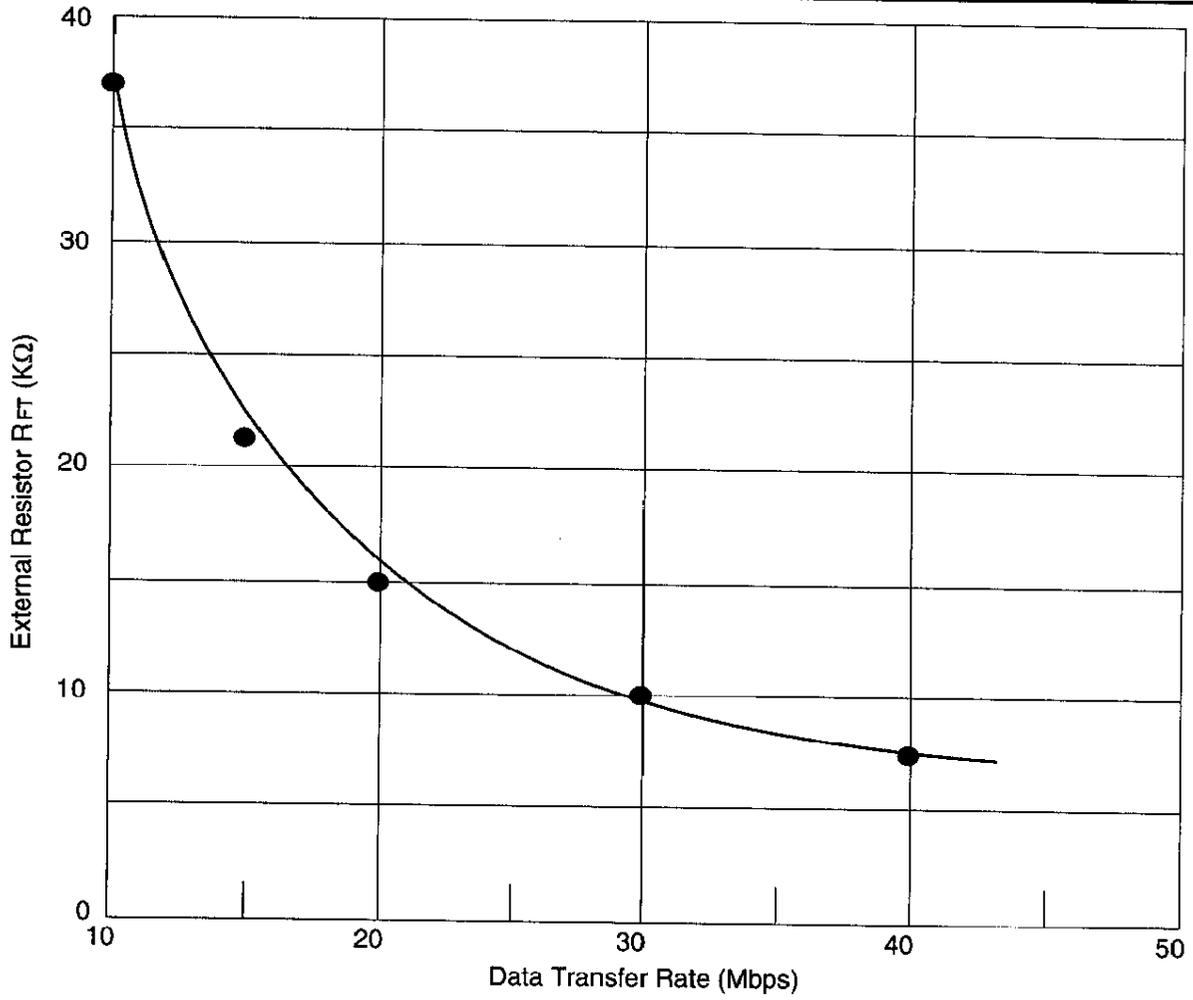


Fig 19.1 T/I Converter Circuit External Resistor R_{FT} vs Data Transfer Rate

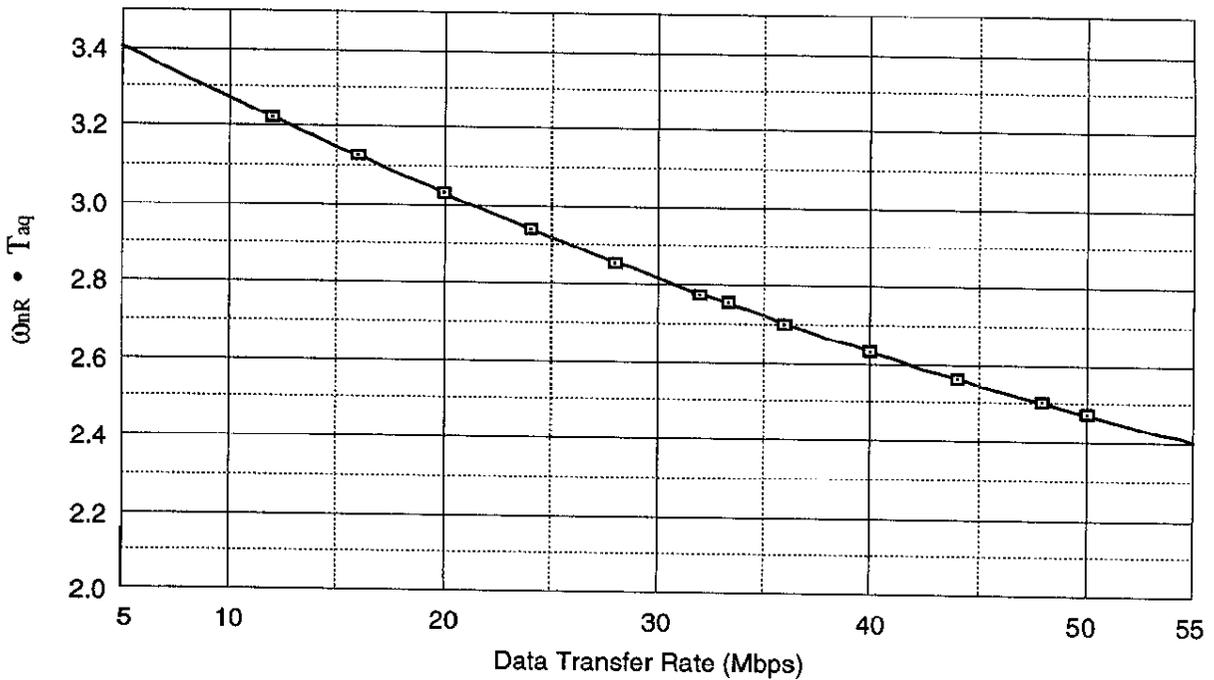


Fig 19.2 $\omega_n R \cdot T_{aq}$ vs Data Transfer Rate (R-PLL)

20. Calculation example of HD153031RF R-PLL Constants

Transfer rate ; 18Mbps , 36Mbps 2 zone

(1) $R_{FVCO} = 3.0K\Omega$ Oscillation frequency = 36MHz

(2) $R_{FT} = 16K\Omega$

(3) VCO Gain K_{OR}

$$K_{OR18} = 1.536 \times 10^9 \sqrt{\frac{24}{3.0 \times 10^3}} = 137.4 \text{ Mrad/s} \cdot V$$

$$K_{OR36} = 1.536 \times 10^9 \sqrt{\frac{48}{3.0 \times 10^3}} = 194.3 \text{ Mrad/s} \cdot V$$

(4) Charge Pump Current I_{CR}

$$R_{FC} = 5.1 K\Omega$$

$$I_{CR36} = \frac{2.5 \times 10^4}{5.1 \times 10^3} \cdot \frac{P}{8}$$

$$I_{CR36} = 4.9 \text{ mA (P=8)}$$

(5) T/I Current I_{TR}

$$I_{TR36} = \frac{4.9}{6 \cdot (16 - 1)} = 54.4 \mu A$$

$$R_{FT} = 16 K\Omega$$

$$I_{TR36} = 3.52 \times 10^3 \cdot \frac{N \cdot L}{500 + R_{FT}}$$

$$\therefore I_{TR36} = 51.2 \mu A (N=48, L=5)$$

(6) $\omega_n \cdot T_{aq36} = 2.7$

$$T_{aq36} = 0.89 \mu s \text{ (6 bytes x 2/3)}$$

$$\omega_{nRH} = 3.03 \text{ Mrad/s}$$

$$C_{F1} = 5600P, \quad C_{F2} = 130P$$

$$\omega_{nRH36} = 3.10 \text{ Mrad/s} \quad \omega_{nRN36} = 0.75 \text{ Mrad/s}$$

(7) $\zeta_N = 1.0$, $\zeta_H = 0.8$

$$R_{F2} = 470 \Omega, \quad R_{F3} = 110 \Omega$$

$$\zeta_N = 1.01, \quad \zeta_H = 0.79$$

(8) $\omega_n \cdot T_{aq18} = 3.07$

$$T_{aq18} = 1.78 \mu s \text{ (6 bytes x 2/3)}$$

$$\omega_{nRH18} = 1.72 \text{ Mrad/s}$$

(9) Charge Pump Current I_{CR}

$$I_{CR18} = \frac{6\pi C_{F1} \cdot \omega_{nRH18}^2}{K_{OR18}} - 6I_{TR} = 1.96 \text{ mA}$$

$$\therefore I_{CR18} = 1.84 \text{ mA (P=3)}$$

(10) T/I Current I_{TR}

$$I_{T18} = 20.48 \mu A \quad (N=24, L=4)$$

$$\omega_{nRH18} = 1.60 \text{ Mrad/s}$$

$$\omega_{nRN18} = 0.40 \text{ Mrad/s}$$

(11) $\zeta_N = 1.0$, $\zeta_H = 0.8$

$$R_{F0} = 910 \Omega$$

$$R_{F1} = 220 \Omega$$

$$\zeta_N = 1.04$$

$$\zeta_H = 0.81$$

21. Example of HD153031RF PLL's external parts (18/36Mbps)

(A) W-PLL

$$R_{svco} = 6.2K\Omega$$

$$R_{sc} = 20K\Omega$$

$$C_{s1} = 68000pF$$

$$C_{s2} = 1500pF$$

$$R_{s1} = 1.3 k\Omega$$

| Register Value | |
|-----------------|-----------|
| 18Mbps | 36Mbps |
| VFC = 0110 0000 | 1100 0000 |
| SGC = 0100 0001 | 0100 0101 |

(B) R-PLL

$$R_{fvco} = 3.0 k\Omega$$

$$R_{fc} = 5.1 k\Omega$$

$$R_{ft} = 16 k\Omega$$

$$C_{f1} = 5600pF$$

$$C_{f2} = 130pF$$

$$R_{f3} = 110 \Omega$$

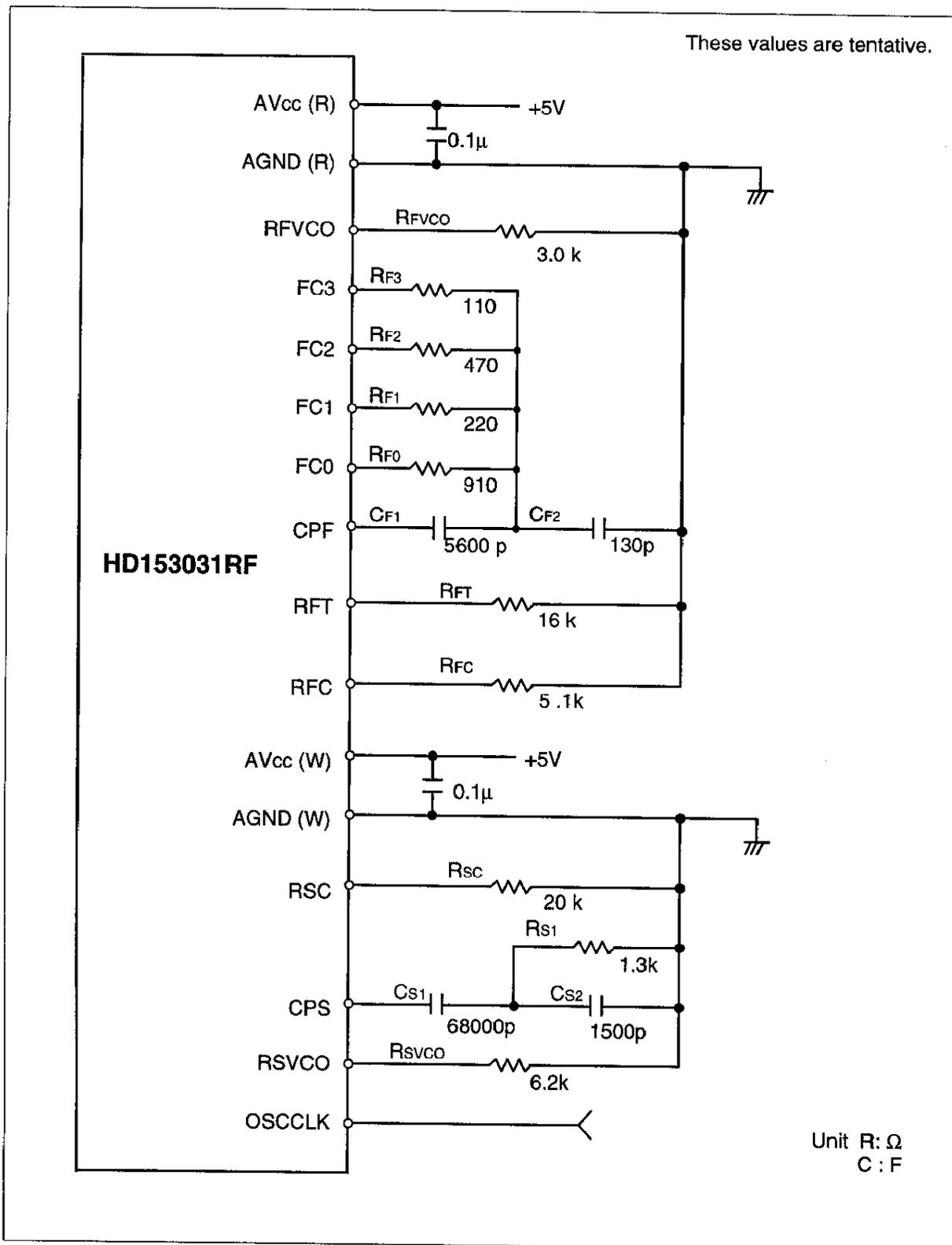
$$R_{f2} = 470 \Omega$$

$$R_{f1} = 220 \Omega$$

$$R_{f0} = 910 \Omega$$

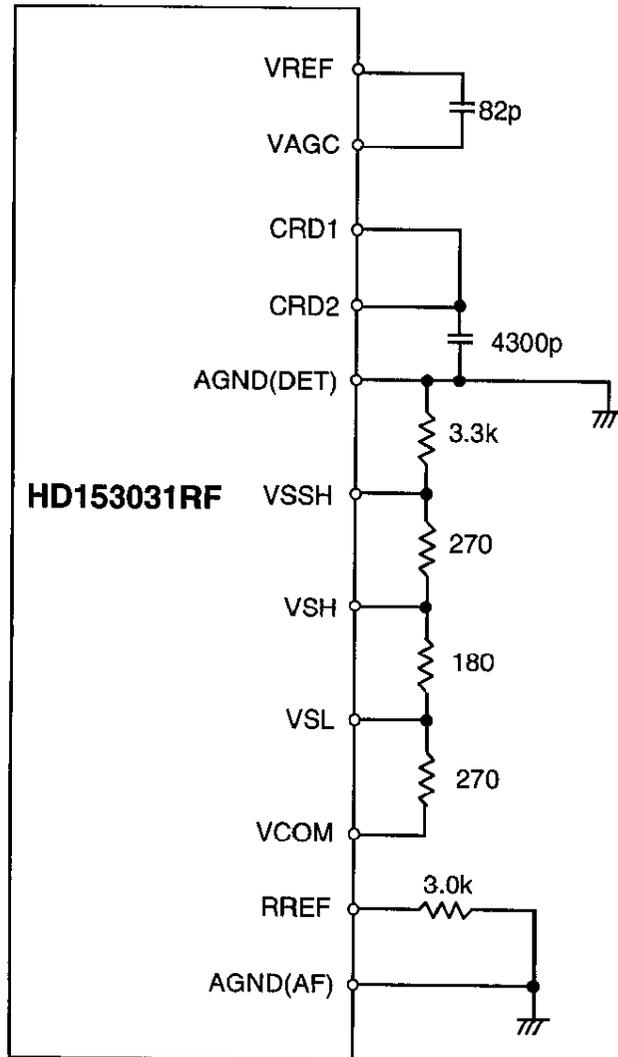
| Register Value | |
|-----------------|-----------|
| 18Mbps | 36Mbps |
| VFC = 0110 0000 | 1100 0000 |
| GAC = 0001 0100 | 0111 1101 |

22. Example of External Components Connected to the Read PLL and Write PLL



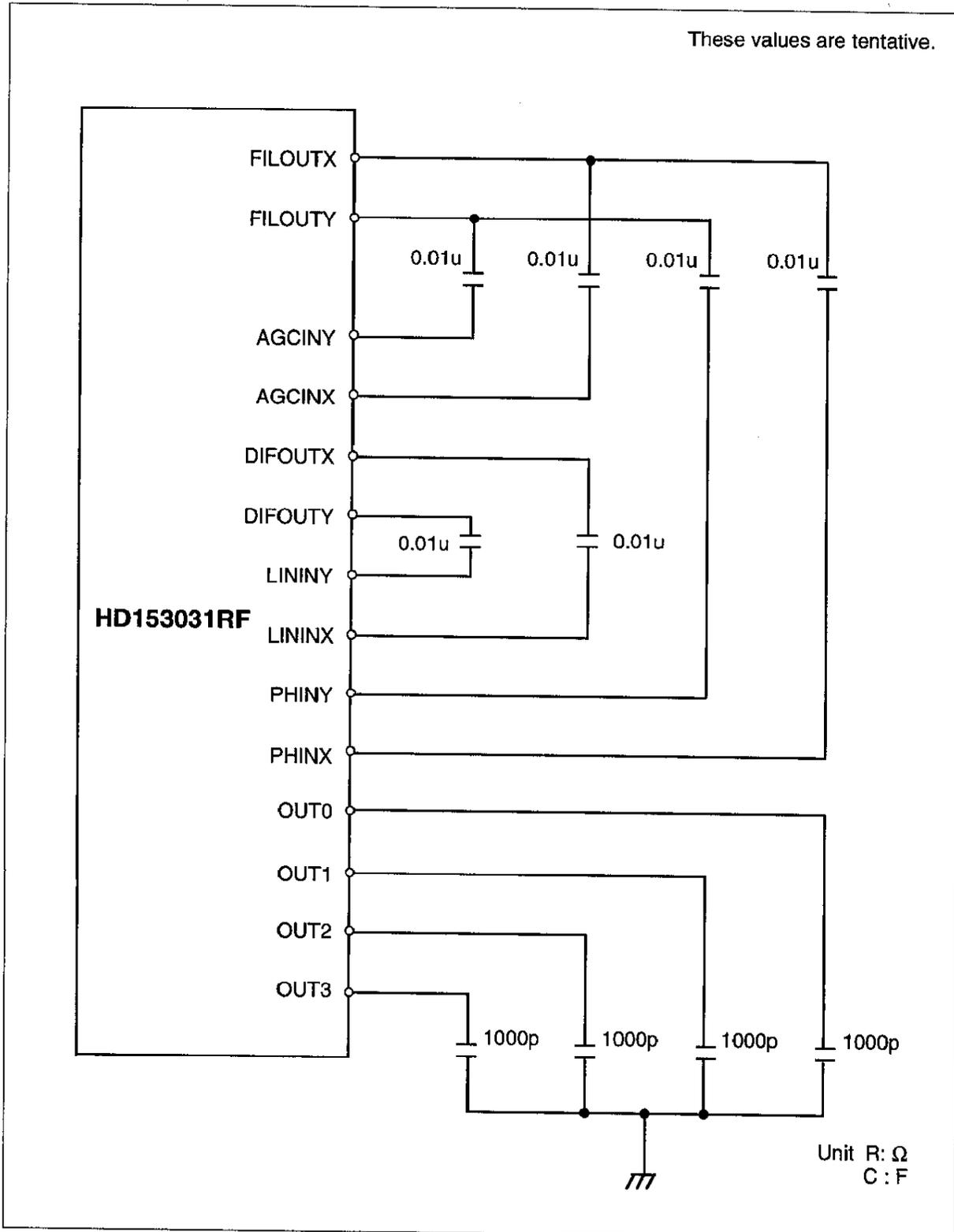
23. Example of External Components Connected to the RPD

These values are tentative.



Unit R: Ω
C: F

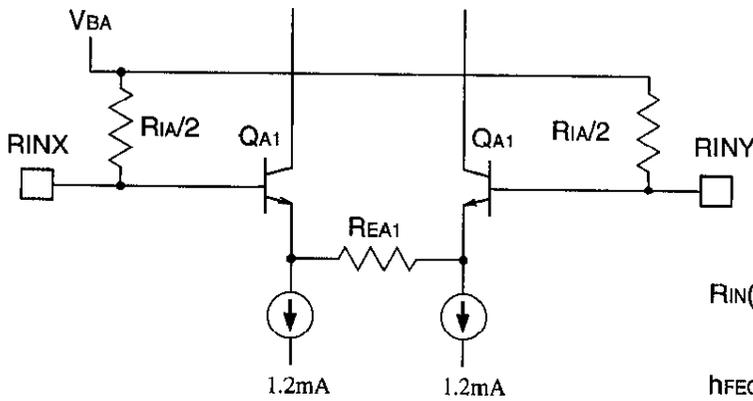
24. Example of External Components Connected to the RPD



25. Input/Output impedance of the Read Pulse Detector's amplifiers

■ AGC amplifier

Input impedance



| | |
|-------------|---------------|
| $R_{IA/2}$ | 1.5k Ω |
| R_{EA1} | 167 Ω |
| R_{EQ1} | 21.4 Ω |
| h_{FEQA1} | 100 |

$$R_{IN(AGC)} = R_{IA/2} // h_{FEQA1} \times (R_{EQ1} + R_{EA1}/2)$$

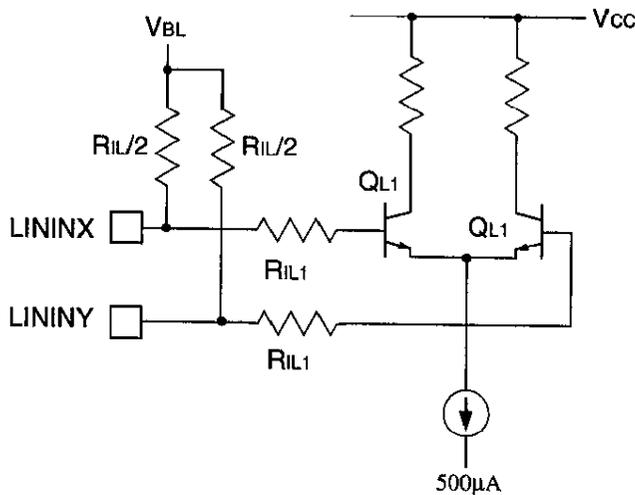
$$= 1.5k\Omega // 10.49k\Omega$$

$$= 1.31k\Omega$$

h_{FEQA1} : h_{FE} of Q_{A1}
 R_{EA1} : Emitter resistance of Q_{A1}

■ LIN amplifier

Input impedance



| | |
|-------------|---------------|
| $R_{IL/2}$ | 4.5k Ω |
| R_{IL1} | 100 Ω |
| R_{EQL1} | 103 Ω |
| h_{FEQL1} | 100 |

$$R_{IN(LIN)} \cong R_{IL/2} // \{ R_{IL1} + h_{FEQL1} \times R_{EQL1} \}$$

$$\cong 3.14k\Omega$$

h_{FEQL1} : h_{FE} of Q_{L1}
 R_{EQL1} : Emitter resistance of Q_{L1}

26. AGC(Automatic Gain Control) amplifier circuit

The AGC amplifier is a three-stage differential amplifier. The first stage has variable gain and the second and third stages have fixed gain. The AGC block consists of the first and second gain

stages. The output of the active filter (FILOUT and DIFOUT) stage is the third gain stage of the AGC block.

Active Filter Block Diagram

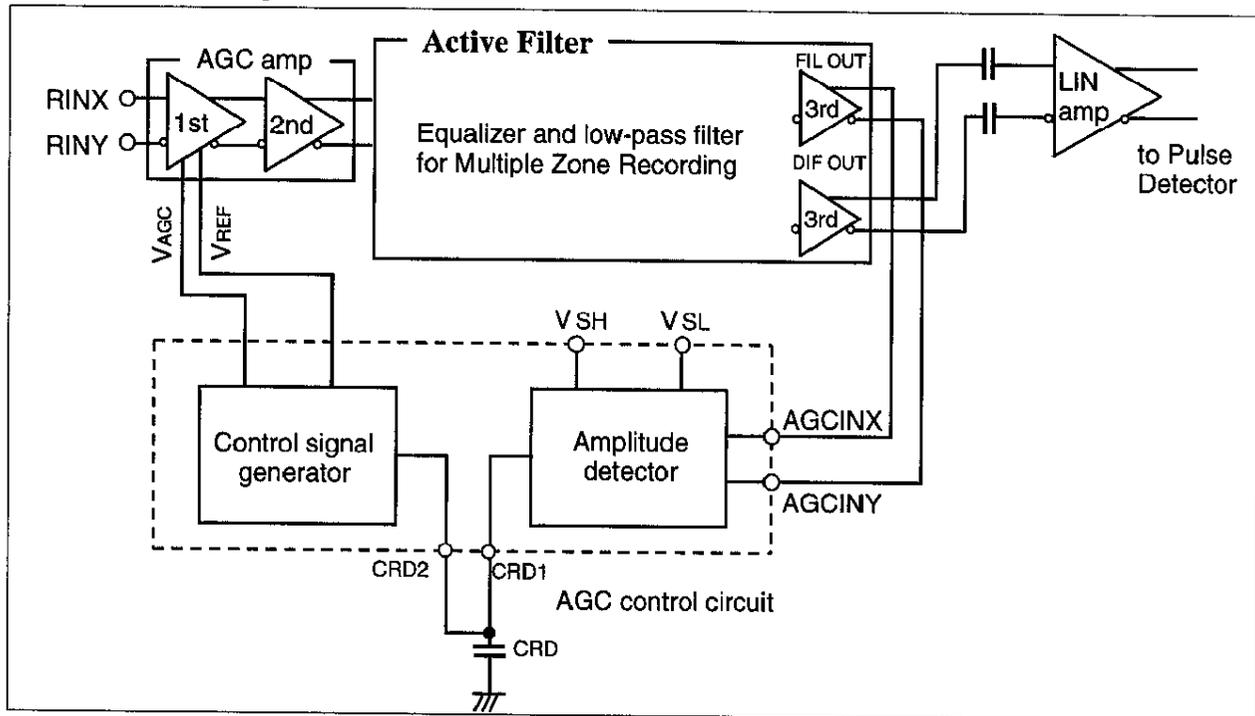


Fig.2 Active Filter Block Diagram

The first-stage gain can be controlled in the range from $-\infty$ to approximately 15 dB by an amplitude control signal (VAGC) from the AGC control circuit. The first-stage gain is given by the following formula.

$$A_v = K_1 \cdot \left(\frac{1}{1 + \exp(qV_c/kT)} \right)$$

$K_1 = 5.62$

$V_c = V_{AGC} - V_{REF}$

q: unit electrical charge

k: Boltzmann constant

T: absolute temperature

The second-stage amplifier has fixed gains of 6dB.

The third-stage amplifier within the Active filter has fixed gains of 20dB (at the outputs of FILOUT).

The AGC full gain is $112V/V (= 41 \text{ dB})$.

The AGC amplifier gain control system is shown in figure 2. The AGC amplifier output is amplified by the post-amplifier and buffer amplifier, then passed through a low-pass filter. The low-pass filter output is connected to the differentiating amplifier, and is also feedback to the AGC control circuit. Here it is compared with reference voltages (V_{SH} and V_{SL}) that are set externally, then the external capacitor (C_{RD}) is charged or discharged. The charging/discharging of the external capacitor varies the control signal V_{AGC} which directly affects the gain of the AGC amplifier. The final amplitude V_P (of the AGCINX and AGCINY waveforms) in this control system can be calculated from the following equations, assuming sine waveforms:

$$T_1 \times I_{ch} = T_2 \times I_{dis} \quad (26-1)$$

$$T_1 = \left(1 - \frac{2}{\pi} \sin^{-1} \frac{V_{COM} - V_{SH}}{V_P}\right) \times T \quad (26-2)$$

$$T_2 = \left(1 - \frac{2}{\pi} \sin^{-1} \frac{V_{COM} - V_{SL}}{V_P}\right) \times T \quad (26-3)$$

From equations (26-1), (26-2), and (26-3):

$$\begin{aligned} \sin^{-1} \frac{V_{COM} - V_{SH}}{V_P} - \frac{I_{dis}}{I_{ch}} \sin^{-1} \frac{V_{COM} - V_{SL}}{V_P} \\ = \frac{\pi}{2} \left(1 - \frac{I_{dis}}{I_{ch}}\right) \end{aligned} \quad (26-4)$$

The final amplitude of the AGC amplifier loop is determined mainly by V_{SH} bias level. If appropriate values are set for V_{SL} , I_{ch} and I_{dis} , then from the preceding equations the final differential peak voltage V_{PDF} is:

$$V_{PDF} = 4 (V_{COM} - V_{SH}) \times m \quad (26-5)$$

where $m = 1.02$ to 1.04

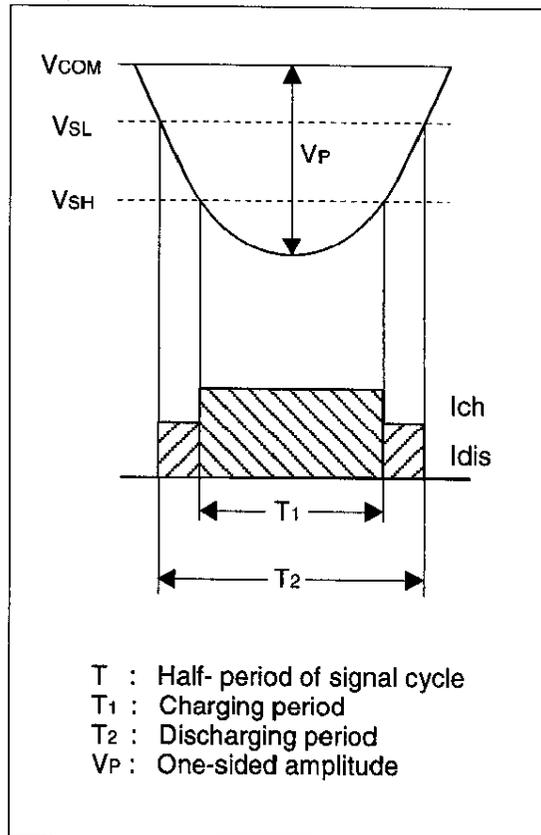
$$V_{COM} = \frac{4}{5} V_{CC}$$

The preceding V_{PDF} is determined by the signal waveform, the output dynamic range of the amplifiers, and other factors. An appropriate value is $V_{PDF} = 1.7V \pm 0.1V$. Accordingly, $(V_{COM} - V_{SH})$ should be from $0.2V$ to $0.3V$. V_{SL} should normally be about:

$$V_{COM} - V_{SL} = 0.67 (V_{COM} - V_{SH}) \quad (26-6)$$

The value must be determined from the resolution specifications, however. The procedure is to determine V_{SH} and V_P from equation (26-4), then

Amplitude



set $I_{ch} = 1.0mA$ and $I_{dis} = 0.2mA$ to determine V_{SL} . Attenuation of signal amplitudes internal to the disk drive with respect to signal amplitudes external to the disk drive must be considered. For example, from equation (26-5), $(V_{COM} - V_{SH}) = 0.239V$ and $m = 1.03$ gives $V_{PDF} = 0.985V$, and from equation (26-4), $(V_{COM} - V_{SL}) = 0.10V$, but if the input amplitude is instantaneously attenuated from its previous value to a new value that is not larger than $(V_{COM} - V_{SL})$, the amplitude recovery time might be excessively long. Next, it is necessary to consider the relationship of the recovery time to the charge-discharge capacitor C_{RD} . The C_{RD} capacitance should be close to the following value:

$$C_{RD} = \frac{200000}{\text{Transfer rate (Mbps)}} \text{ (pF)} \quad (26.7)$$

The write-to-read recovery time t_R is then :

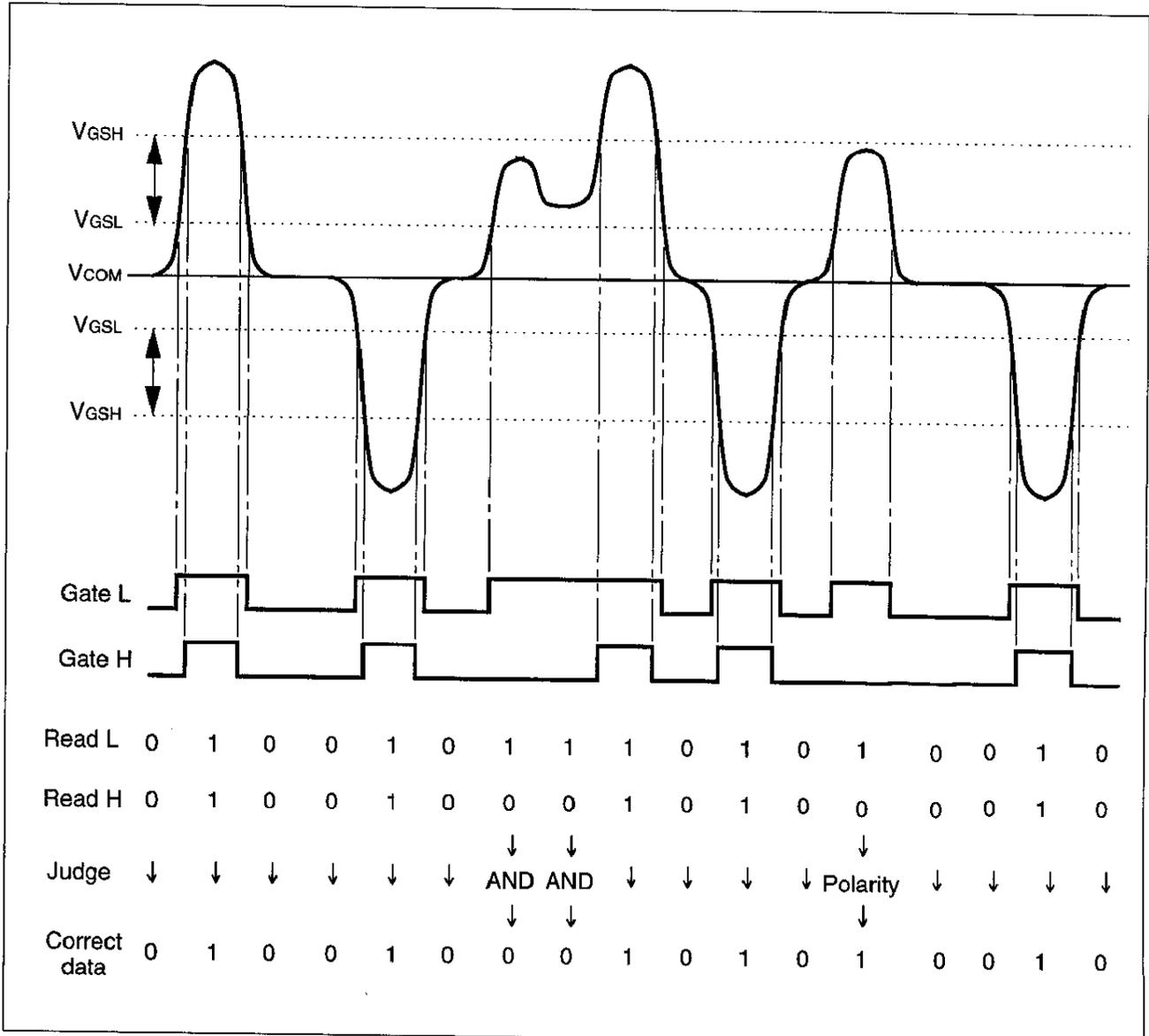
$$t_R = 200 \times C_{RD} \text{ (seconds)} \quad (26.8)$$

27. Gate Generator Circuit

A gate signal is used to gate the read signal near its peak value to remove incorrect read pulse. This gate signal is created by the gate generator circuit. The principle is to ensure that the read pulse crosses two programmable slice levels before being gated out as PDRD signal. For normal read mode, shifter and logic are used to qualify pulses that crosses only the low slice level or multiple peaks that would require polarity checking. The two slice levels VGSL and VGSH are set by writing to the

VGSH and VGSL 4-bit registers. The High slice level is programmed to covered 0% to 100% of the VSH level and the Low slice level would covered 0% to 100% of the VSH. In servo mode, if one pulse is missing because it is not meeting the Low slice level, the next qualifying pulse will be disqualified as well.

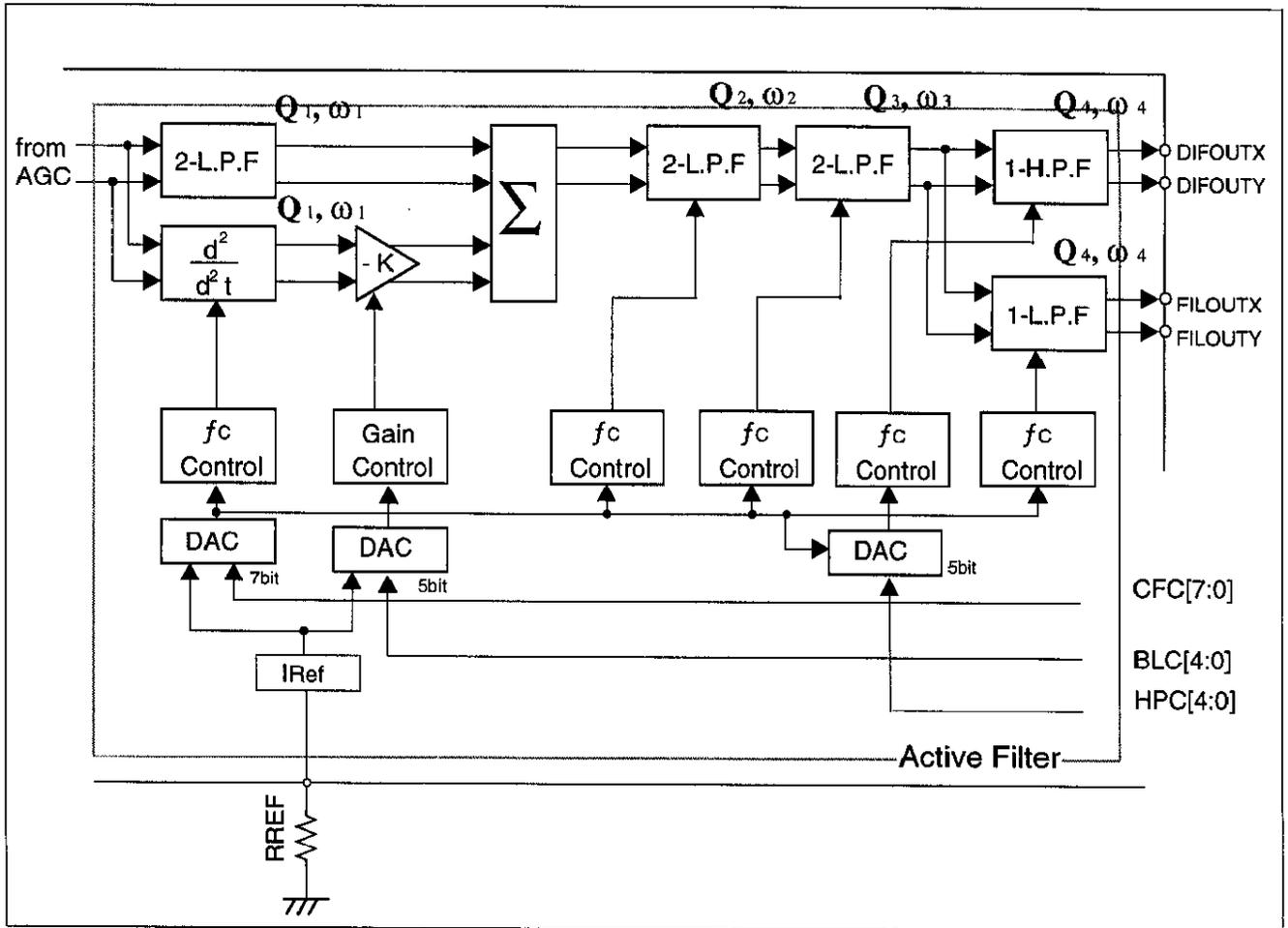
Principal of Gate Generation Circuit.



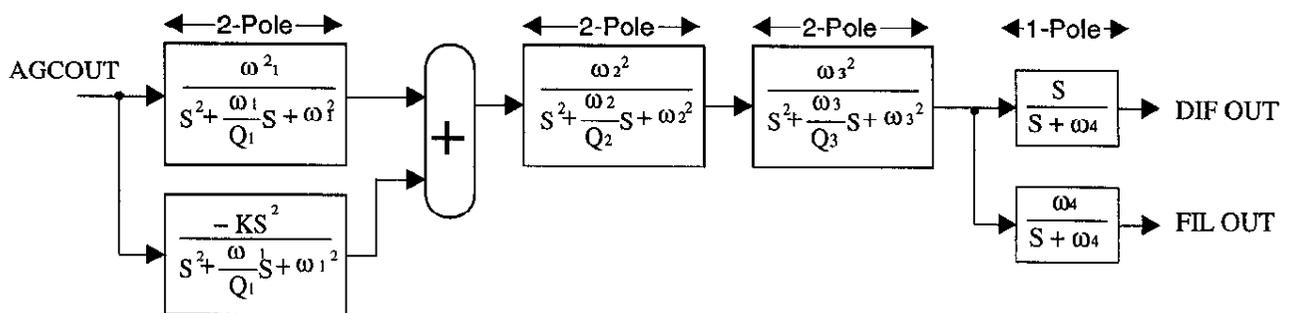
28. Active Filter

Active Filter consists of equalizer and electronic filter. Electronic filter is 7-pole, Bessel-type, low-pass filter and can be used in multiple zone recording (MZR) design. Cut-off frequency of filter is set by writing to register CFC. Writing to the HPC register will set the

high-pass cut-off frequency of the differential amplifier. The equalizer is double differentiation pulse sliming equalization. The Boost level is set by writing to register BLC.



Transfer function



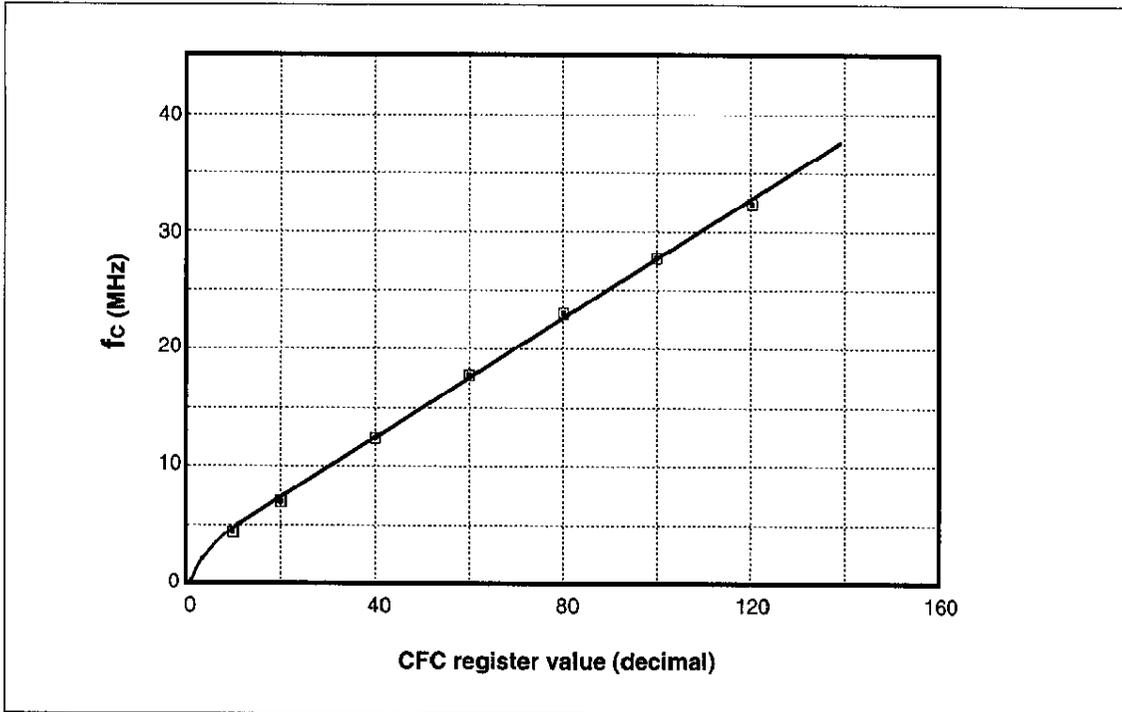


Fig 28.1 f_c vs CFC register

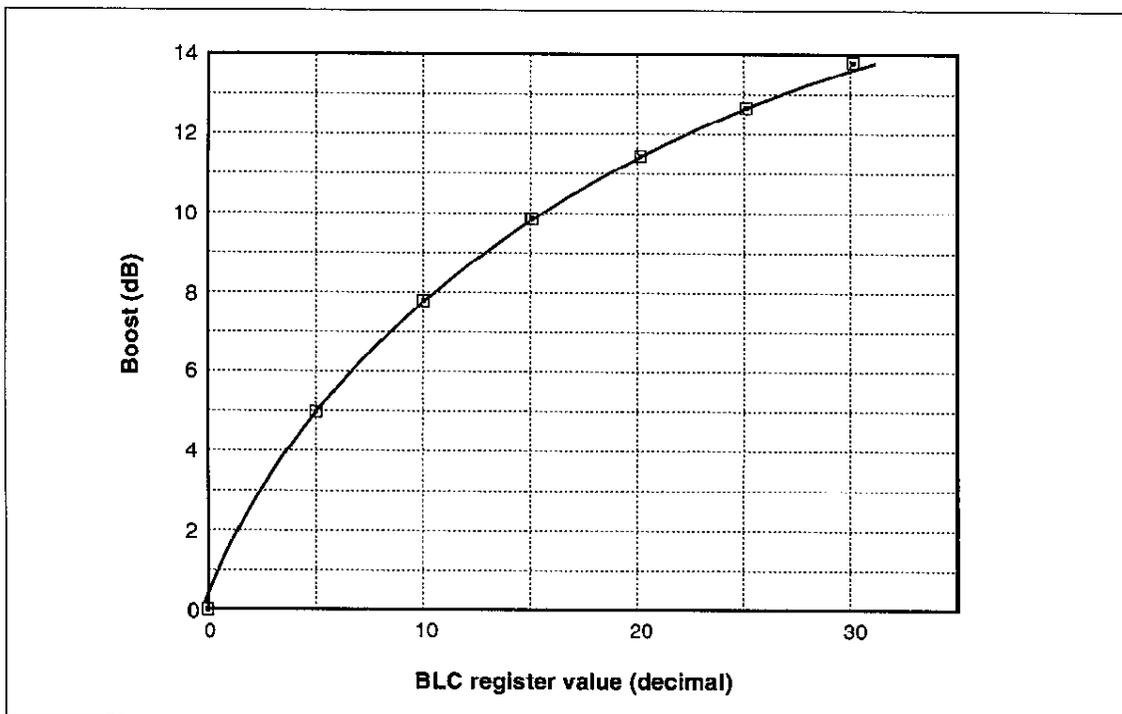


Fig 28.2 Boost vs BLC register

Normalized Constant of 7-pole Bessel filter

| Parameter | Normalized constant ($\omega_c = 1$) |
|------------------|--|
| ω^2 | 2.94930 |
| ω_1 / Q_1 | 3.22597 |
| ω^2 | 3.32507 |
| ω_2 / Q_2 | 2.75939 |
| ω^2 | 4.20534 |
| ω_3 / Q_3 | 1.82031 |
| ω_4 | 1.68536 |

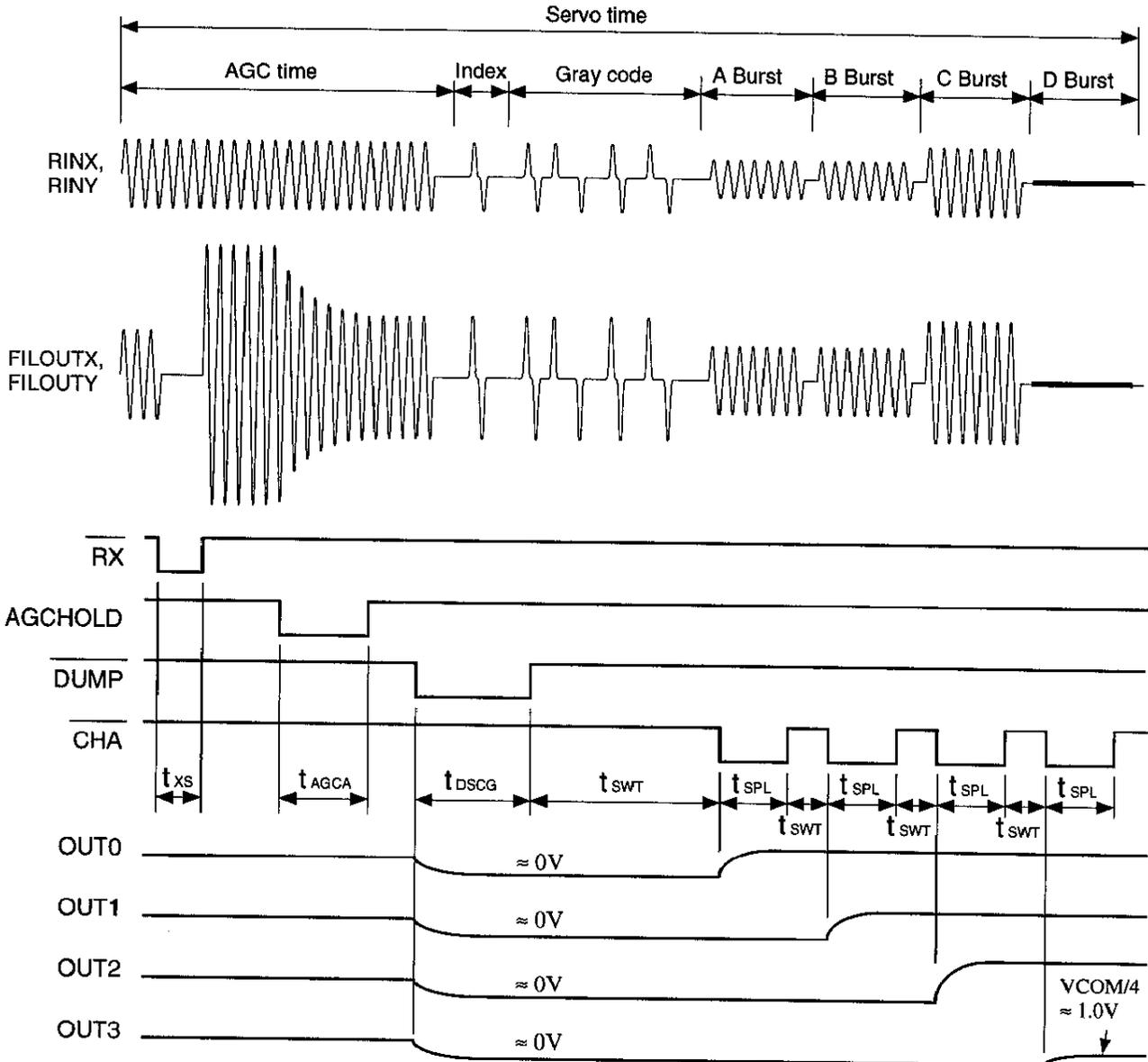
29. Idle input pin for power saving:

With the mode control register(PCN), there are four different modes of operation as shown: 11 = Sleep, 10 = Power Save, 00 = Normal (full power).The modes are defined as followed:

- a) When bit5,4 = 00 : **Normal** mode. All circuitries should be powered.
- b) When bit5,4 = 11 : **Sleep** mode. Everythings powered down except the I/O and the logic section of the chip.
- c) When bit5,4 = 10 : **Power Save** mode. In this mode, the Idle/Servo-pin will select which of the two power save modes to be used. If Idle = 1 then Idle mode is selected and all modules will be powered down except for the I/O, logic, and the bias circuitries.. If Idle/Servo = 0 then Servo mode will be selected and all blocks will be kept on except the clock synthesizer (WR PLL) and the synchronizer (RD PLL).

| Mode | PCN Reg. | $\overline{I/S}$ | I/O | Logic | Bias | RD | WR | AGC | AF | RPD | PH |
|--------------|----------|------------------|-----|-------|------|-----|-----|-----|----|-----|----|
| | Bit5, 4 | pin | | | | PLL | PLL | | | | |
| Normal | 00 | X | ON | ON | ON | ON | ON | ON | ON | ON | ON |
| Power Save { | Servo | 10 | 0 | ON | ON | ON | | | ON | ON | ON |
| | Idle | 10 | 1 | ON | ON | ON | | | | | |
| Sleep | 11 | X | ON | ON | | | | | | | |

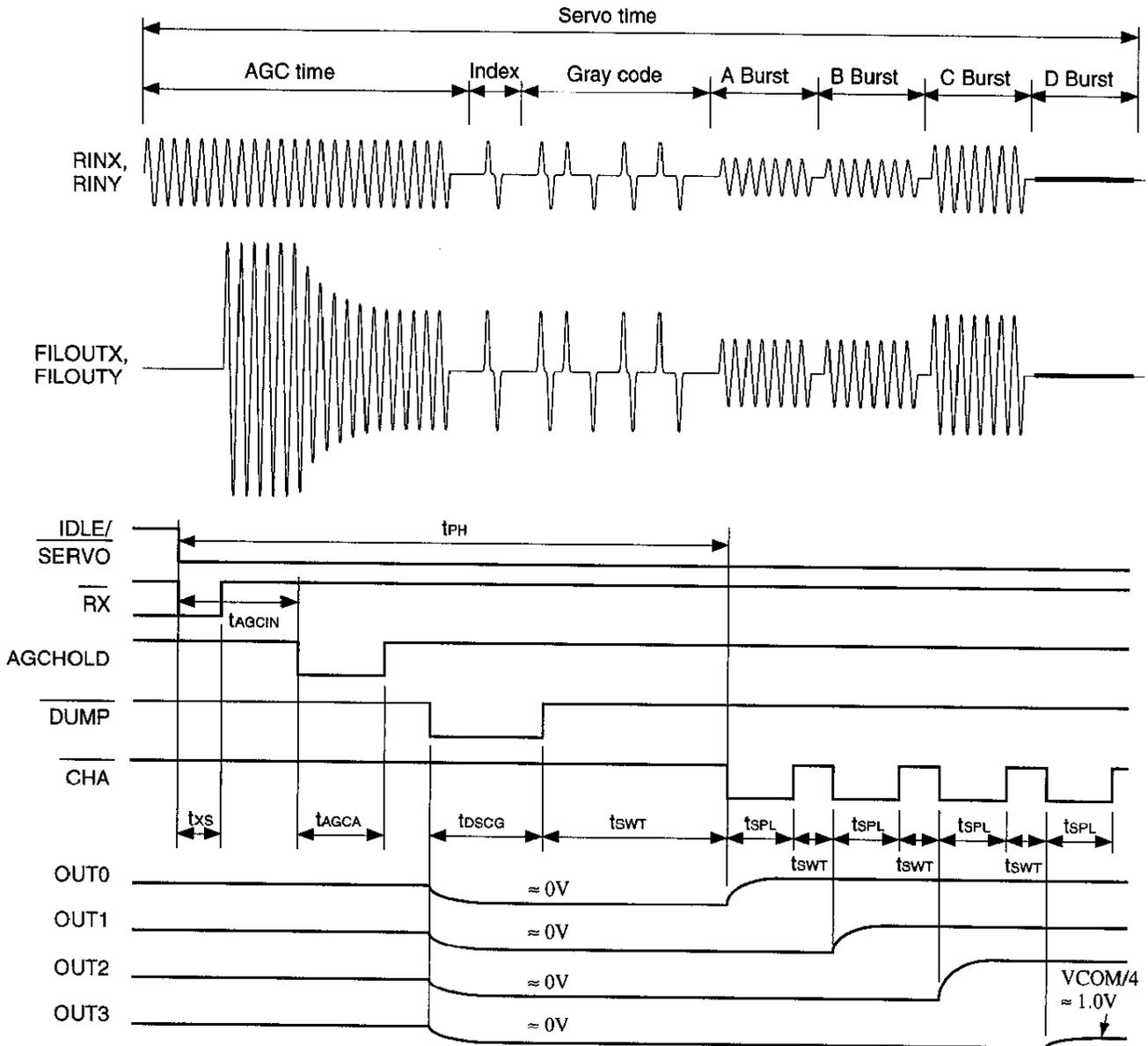
30. Example of the Normal to Servo mode waveform



When D Burst is no signal coming out.

| Symbol | min | typ | max | unit | Conditions |
|------------|-----|-----|-----|---------|------------------|
| t_{XS} | 150 | | | ns | |
| t_{AGCA} | | | 2 | μs | CRD=3300pF |
| t_{DSCG} | | | 2 | μs | COU0~COU3=1000pF |
| t_{SWT} | 200 | | | ns | |
| t_{SPL} | 2 | | | μs | |

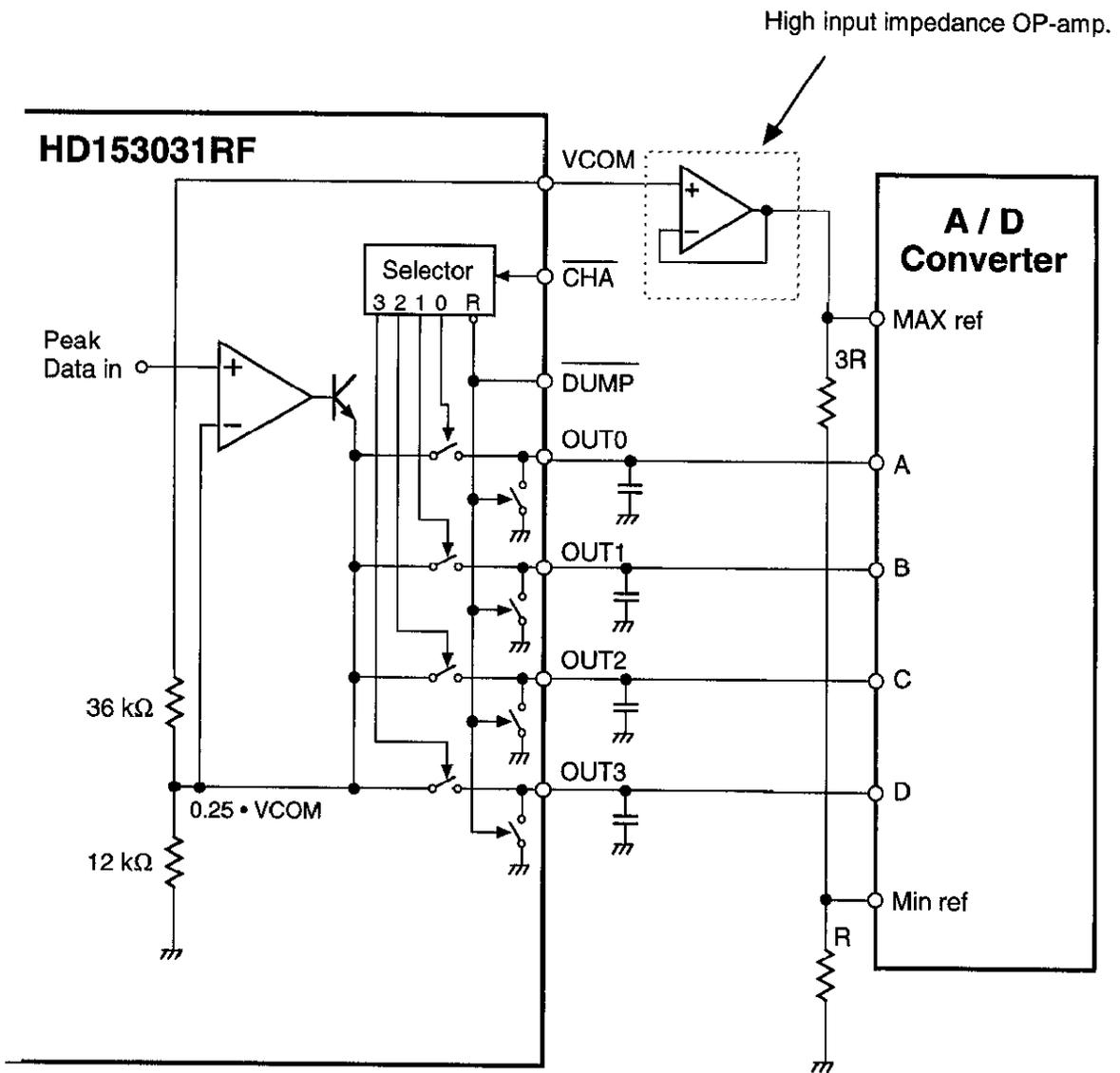
31. Example of the Idle to Servo mode waveform



When D Burst is no signal coming out.

| Symbol | min | typ | max | unit | Conditions |
|-------------|-----|-----|-----|---------|---------------------------------|
| t_{XS} | 4 | | | μs | $C_{AGCIN}=2200pF$ |
| t_{AGCA} | | | 5 | μs | $CRD=3300pF$ |
| t_{DSCG} | | | 2 | μs | $C_{OUT0} \sim C_{OUT3}=1000pF$ |
| t_{SWT} | 200 | | | ns | |
| t_{SPL} | 2 | | | μs | |
| t_{PH} | 60 | | | μs | $C_{PHIN}=2200pF$ |
| t_{AGCIN} | 10 | | | μs | $C_{AGCIN}=2200pF$ |

(2) High input impedance Digital to Analog Converter application



33. Absolute Maximum Ratings (Ta=25 °C)

| Description | Symbol | Ratings | Unit | Applicable pins |
|-----------------------|--------|---------------|------|---|
| Supply voltage | Vcc | 7 | V | DVcc,AVcc(PH),AVcc(W),AVcc(R) AVcc(AF),AVcc(AGC),AVcc(RPD) |
| Input voltage | Vi | - 0.3 to 5.5 | V | Note1 |
| Output voltage | Vo | 5.5 | V | Note2 |
| Operating temperature | Topr | 0 to 70 | °C | |
| Storage temperature | Tstg | - 55 to + 125 | °C | |

Note1: OSCCLK, RESET, IDLE/SERVO, RSENA, SCLK, SDATA, DUMP, CHA, SHORT, RX, AGCHOLD, RG, SRV/RD, NRZRD/WD0(Write mode), NRZRD/WD1(Write mode), WG, AME

Note2: SDATA, AMF, ULD, PDRD, DLYCLK, DLYRD, SYNCRD, RRCLK, CLKOUT1-7WDOUT, 1-7WDOUT, NRZRD/WD0(Read mode), NRZRD/WD1(Read mode)

34. Electrical Characteristics (Ta=0 to + 70°C, unless otherwise specified Vcc = 5.0V ± 10%)

| Item | Symbol | min. | typ. | max | Unit | Conditions | Applicable Pins | Note |
|-------------------------------|------------------|-----------|----------|----------|------|------------------------------------|-----------------|------|
| Supply Voltage | Vcc | 4.5 | 5 | 5.5 | V | | * 4 | |
| Operating Temperature | Ta | 0 | 25 | 70 | °C | | | |
| Transfer Rate | | 10 | | 36 | Mbps | | | |
| Current Consumption | Icc(read) | | | 240 | mA | 5.5V 36Mbps | * 4 | |
| | | | | 200 | mA | 5.5V 24Mbps | * 4 | |
| | Icc(write) | | | 240 | mA | 5.5V 36Mbps | * 4 | |
| | | | | 200 | mA | 5.5V 24Mbps | * 4 | |
| | Icc(servo) | | | 170 | mA | 5.5V 36Mbps | * 4 | |
| | Icc(idle) | | | 15 | mA | 5.5V | * 4 | |
| | Icc(sleep) | | | 13 | mA | 5.5V | * 4 | |
| TTL High Level Input Voltage | V _{IH} | 2.2 | | | V | Vcc=4.5V | * 1 | |
| TTL Low Level Input Voltage | V _{IL} | | | 0.80 | V | Vcc=4.5V | * 1 | |
| TTL High Level Output Voltage | V _{OHT} | 2.4 | | | V | I _{OH} =-400 μA, Vcc=4.5V | * 2 | |
| TTL Low Level Output Voltage | V _{OLT} | | | 0.5 | V | I _{OL} =4mA, Vcc=4.5V | * 2 | |
| ECL High Level Output Voltage | V _{OHE} | Vcc -0.95 | Vcc -0.8 | | V | Ta=25°C, RL=510 Ω | * 3 | |
| ECL Low Level Output Voltage | V _{OLE} | | Vcc -1.8 | Vcc -1.6 | V | Ta=25°C, RL=510 Ω | * 3 | |
| Input Current | I _{IH} | | | 20 | μA | Vcc=5.5V, Vi=2.7V | * 1 | |
| | I _{IL} | | | -400 | μA | Vcc=5.5V, Vi=0.4V | * 1 | |
| Output Short Current | I _{OS} | -20 | | -120 | mA | Vcc=5.5V | * 2 | |
| Input Clamp Voltage | V _{IK} | | | -1.5V | V | Vcc=5.5V | * 1 | |

* 1: OSCCLK, RESET, IDLE/SERVO, RSENA, SCLK, SDATA, DUMP, CHA, SHORT, RX, AGCHOLD, RG, SRV/RD, NRZRD/WD0 (Write mode), NRZRD/WD1 (Write mode), WG, AME
 * 2: SDATA, AMF, UL, PDRD, DLYCLK, DLYRD, SYNCRD, RRCLK, CLKOUT, 1-7WDOUT (TTL), 1-7WDOUT (TTL), NRZRD/WD0 (Read mode), NRZRD/WD1 (Read mode)
 * 3: 1-7WDOUT (ECL), 1-7WDOUT (ECL)
 * 4: DVcc, AVcc (PH), AVcc (W), AVcc (R), AVcc (AF), AVcc (AGC), AVcc (RPD)

35. Encoder/Decoder (Ta=25°C, Vcc=5V, 36Mbps)

| Item | Symbol | min | typ | max | unit | conditions | Applicable pins |
|-----------------------------|-------------------|-------|--------|-------|-------|------------|-----------------------|
| NRZRD set-up time(serial) | t _{SNRS} | 9.0 | | | ns | | NRZRD/WD0 |
| NRZRD set-up time(parallel) | t _{SNRP} | 15.0 | | | ns | | NRZRD/WD0,1 |
| NRZRD hold time(serial) | t _{HNRS} | 8.0 | | | ns | | NRZRD/WD0 |
| NRZRD hold time(parallel) | t _{HNRP} | 18.0 | | | ns | | NRZRD/WD0,1 |
| NRZWD set-up time(serial) | t _{SNWS} | 8.0 | | | ns | | NRZRD/WD0 |
| NRZWD set-up time(parallel) | t _{SNWP} | 21.0 | | | ns | | NRZRD/WD0,1 |
| NRZWD hold time(serial) | t _{HNWS} | 0 | | | ns | | NRZRD/WD0 |
| NRZWD hold time(parallel) | t _{HNWP} | 0 | | | ns | | NRZRD/WD0,1 |
| Decode time | t _{DD} | | 14 | 16 | RRCLK | | NRZRD/WD0 |
| Encode time | t _{ED} | | 12 | 14 | RRCLK | | 1-7WDOUT, 1-7WDOUT |
| Write Precomp time step | | 0.28 | 0.55 | 0.82 | ns | Not tested | |
| Write Precomp time width | | ± 2.0 | ± 3.85 | ± 5.7 | ns | ± 7steps | |

36. Register (Ta=25°C, Vcc=5V)

| Item | Symbol | min | typ | max | unit | conditions | Applicable pins |
|---|-------------------|------|-----|-----|------|------------|-----------------|
| RSENA "L" time | t _{EL} | 1650 | | | ns | | RSENA |
| RSENA "H" time | t _{EH} | 50 | | | ns | | RSENA |
| RSENA falling edge to the first SCLK falling edge | t _{EFSF} | 50 | | | ns | | SCLK |
| SDATA set up time | t _{CDS} | 10 | | | ns | | SDATA |
| SDATA hold time | t _{CDH} | 10 | | | ns | | SDATA |
| The last SCLK rising edge to RSENA rising edge | t _{SRER} | 50 | | | ns | | RSENA |
| SCLK cycle time | t _{CC} | 100 | | | ns | | SCLK |
| SCLK "H" time | t _{CH} | 40 | | | ns | | SCLK |
| SCLK "L" time | t _{CL} | 40 | | | ns | | SCLK |
| SDATA output delay | t _{CDD} | | | 20 | ns | | SDATA |
| SDATA output hold time | t _{EDH} | 5 | | | ns | | SDATA |

37. Synchronizer (Ta=25°C, Vcc=5V)

| Item | Symbol | min | typ | max | unit | conditions |
|---|--------|--------------|----------------|----------------|---------------|-------------------------------|
| Read VCO center frequency 1 | fvco1 | 34.2 | 36 | 37.8 | MHz | RFVCO=3k, Register VFC=80 Hex |
| Phase lock acquisition time 1 | | — | — | 6 | Byte | 6 NRZ bytes period at 24Mbps |
| Capture range 1 | | ±15 | — | — | % | at 24Mbps |
| Lock range 1 | | ±15 | — | — | % | at 24Mbps |
| Read VCO gain 1 | | 126 | 160 | 194 | Mrad / sec •V | RFVCO=3k, Register VFC=80 Hex |
| Read VCO upper limit clamping frequency 1 | | — | 48 | — | MHz | RFVCO=3k, Register VFC=80 Hex |
| Read VCO lower limit clamping frequency 1 | | — | 27 | — | MHz | RFVCO=3k, Register VFC=80 Hex |
| Read VCO center frequency 2 | fvco2 | 67.5 | 71.5 | 75.5 | MHz | RFVCO=3k, Register VFC=FF Hex |
| Phase lock acquisition time 2 | | — | — | 6 | Byte | 6 NRZ bytes period at 36Mbps |
| Capture range 2 | | ±15 | — | — | % | at 36Mbps |
| Lock range 2 | | ±15 | — | — | % | at 36Mbps |
| Read VCO gain 2 | | 174 | 220 | 266 | Mrad / sec •V | RFVCO=3k, Register VFC=FF Hex |
| Read VCO upper limit clamping frequency 2 | | — | 95 | — | MHz | RFVCO=3k, Register VFC=FF Hex |
| Read VCO lower limit clamping frequency 2 | | — | 53 | — | MHz | RFVCO=3k, Register VFC=FF Hex |
| Window margin loss | | 0 | | 3 | ns | at any data rate |
| Window adjust tap | | 0.34 | 0.67 | 1.0 | ns | Not tested |
| Window adjust width | | +5.5 -5.9 | +10.0 -10.7 | +14.5 -15.5 | ns | +15step, -16step |
| Window fine adjust tap | | 0.12 | 0.25 | 0.5 | ns | Not tested |
| Read VCO maximum oscillate frequency | | 90 | 108 | — | MHz | RFVCO=1k, Register VFC=80 Hex |
| Decode window center accuracy | | -4.2 | | 0.6 | ns | at 24Mbps |
| T/I offset accuracy | | -1.8 | | 5.0 | μA | at 24Mbps |
| C/P offset accuracy | | -15 | | +15 | % | at GAC=20Hex |
| Oscillation Start Voltage | | | | 4.0 | V | Ta=25°C, fosc ≥ 100KHz |

38. Synthesizer (Ta=25°C, Vcc=5V)

| Item | Symbol | min | typ | max | unit | conditions |
|--|--------|------|------|------|----------------|---------------------------------|
| Write VCO center frequency | fwvco | 67.5 | 71.5 | 75.5 | MHz | RSVCO=6.2k, Register VFC=FF Hex |
| Write VCO upper limit clamping frequency | | — | 86 | — | MHz | RSVCO=6.2k, Register VFC=FF Hex |
| Write VCO lower limit clamping frequency | | — | 56.8 | — | MHz | RSVCO=6.2k, Register VFC=FF Hex |
| Phase lock acquisition time | | — | — | 1 | ms | tested at 24Mbps,36Mbps |
| Capture range | | ±10 | — | — | % | tested at 24Mbps,36Mbps |
| Lock range | | ±10 | — | — | % | tested at 24Mbps,36Mbps |
| VCO frequency step | | — | 1.0 | — | % | at fMAX / fLOW = 2.55 |
| VCO gain | | 84 | 106 | 128 | Mrad / sec • V | RSVCO=6.2k, Register VFC=FF Hex |
| Max frequency | | 80 | — | — | MHz | RSVCO=2.3k, Register VFC=80 Hex |

39. RPD & PH (Ta=25°C, Vcc=5V)

| Item | Symbol | min | typ | max | unit | conditions | Applicable pins |
|---------------------------------------|--------|------|---------------|------|------|--------------------------|---------------------|
| Max peak-peak Input signal | | | | 2.0 | Vpp | differential inputs | PHINX/Y |
| PDRD pulse width | | 4.5 | 9 | 13.5 | ns | at 36Mbps, PW[1:0]=00 | |
| PDRD pulse rise time | tr | 0.5 | 2 | 4 | ns | CL=15pF,20%-80% | Not tested |
| PDRD pulse fall time | tf | 0.5 | 2 | 4 | ns | CL=15pF,80%-20% | Not tested |
| P/H output voltage swing | | 2.0 | 2.3 | 2.6 | V | fin=6.5MHz, Vin=2Vpp ** | |
| P/H output leakage current | | -0.2 | 0 | +0.2 | μA | | OUT0 ~ OUT3 |
| P/H Channel Offset | | -50 | 0 | +50 | mV | | OUT0 ~ OUT3 |
| P/H Reference Voltage | | | VCOM x 25% | | V | PHINX/Y=0Vpp | OUT0 ~ OUT3 |
| P/H Discharge time | tdSCG | | | 2.0 | μS | COUT0 ~ COUT3 =1000pF | OUT0 ~ OUT3 DUMP |
| P/H Sampling time (CHA = "L" time) | tsPL | 2.0 | | | μS | | CHA |
| CHA Switching time | tswT | 200 | | | ns | | CHA |

** : differential input for PHINX and PHINY.

40. Active Filter (Ta=25°C, Vcc=5V)

| Item | Symbol | min | typ | max | unit | conditions |
|----------------------------|--------|------|-----|-----|-------|--|
| Filter cutoff frequency | fc | 5 | | 25 | MHz | |
| fc Accuracy | fca | - 15 | | +15 | % | |
| Filter boost level | Fb | 0 | | 10 | dB | |
| Filter boost Accuracy | Fba | - 1 | | 1 | dB | Fb = 10dB |
| Output dynamic range | | 1.5 | 1.8 | 2.0 | Vpp | diff. outputs, THD < 1% Not tested |
| Output noise(normal) | | | 3 | 5.5 | mVRms | Not tested |
| Output noise(differential) | | | 6 | 10 | mVRms | Not tested |
| Group delay variation (0) | | 0 | | 5 | ns | fc=9MHz f=0.2fc to fc Boost=0dB, Not tested |
| | | 0 | | 5 | ns | fc=9MHz f=0.2fc to fc Boost=6dB, Not tested |
| Group delay variation (1) | | 0 | | 5 | % | fc=5MHz to 9MHz (f=0.2fc to fc Boost=0dB) Not tested |
| Power noise rejection | PSRR | 45 | | | dB | AGC+Active Filter Not tested |
| Common mode rejection | CMRR | 40 | | | dB | AGC+Active Filter fin=1MHz |

Condition 1: fc =18MHz, range = 0.2fc to fc, measured from AGCOUTX/Y to FILOUTX/Y.

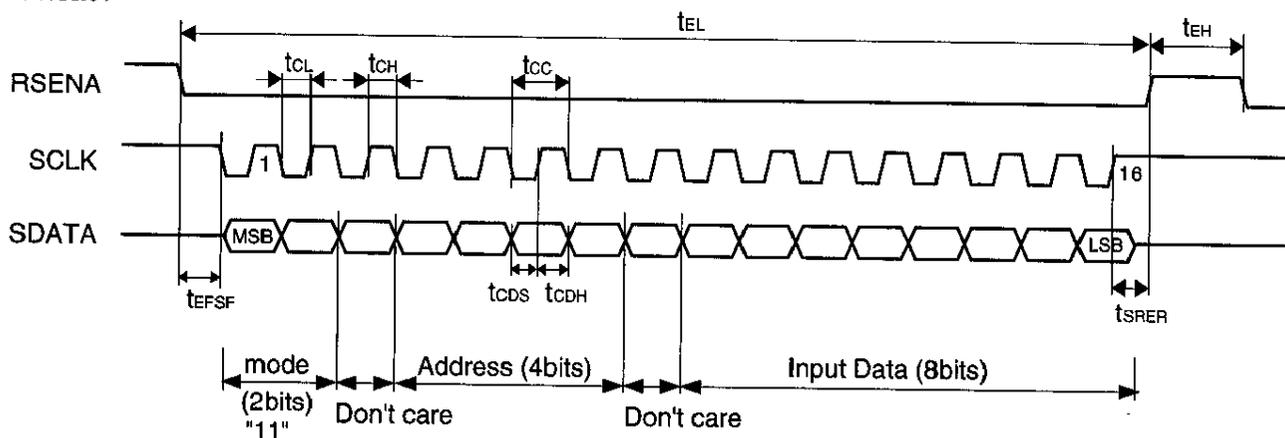
41. AGC (Ta=25°C, Vcc=5V)

| Item | Symbol | min | typ | max | unit | conditions |
|------------------------------------|--------|-----|-----|-----|------------------------|---|
| AGC max gain | | 39 | 41 | | dB | RINX/Y to FILOUTX/Y |
| AGC min gain | | | | 0 | V/V | RX=Low |
| Input dynamic range | | 20 | | 100 | mV | Distortion <1% Not tested |
| Band width(-3dB) | Bw | 50 | | | MHz | Not tested |
| Output DC offset | Voff | | 100 | 200 | mV | AGCOUTX/Y |
| Input noise(max gain) | | | 5 | 15 | nV/ $\sqrt{\text{Hz}}$ | Not tested |
| Write to read recovery time | twrr | | 1 | 2 | μs | write(RX=L) to read cycle CRD=3300pF |
| Read recovery time | trr | | | 5 | μs | recovery from max gain |
| Idle to Servo AGC Recovery time | tAGC | | 7 | 10 | μs | CAGCIN=2200pF |
| Idle to Servo P/H Recovery time | tPH | | 40 | 60 | μs | CPHIN=2200pF |
| Sleep to Servo Recovery time | | | | 1 | ms | |

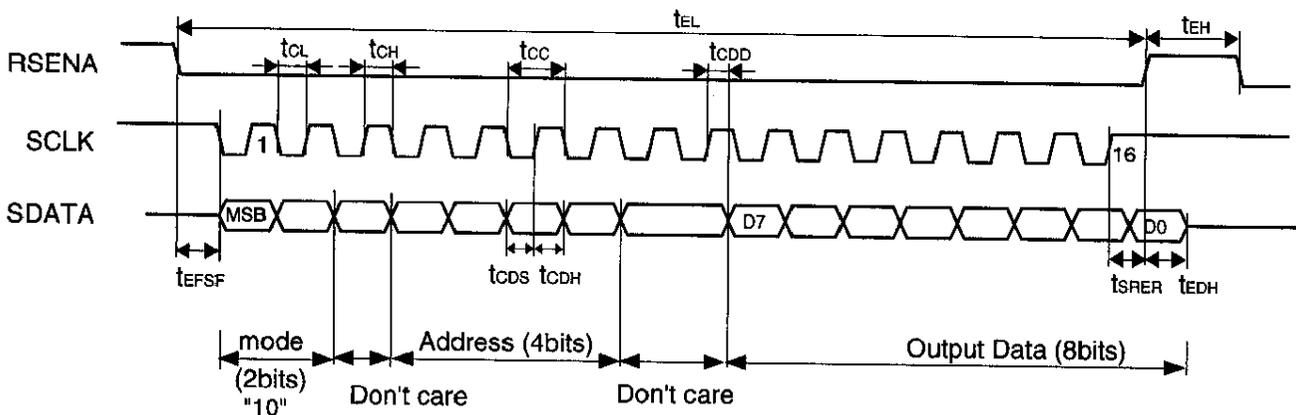
42. AC Timing Chart

(1) Register read / write

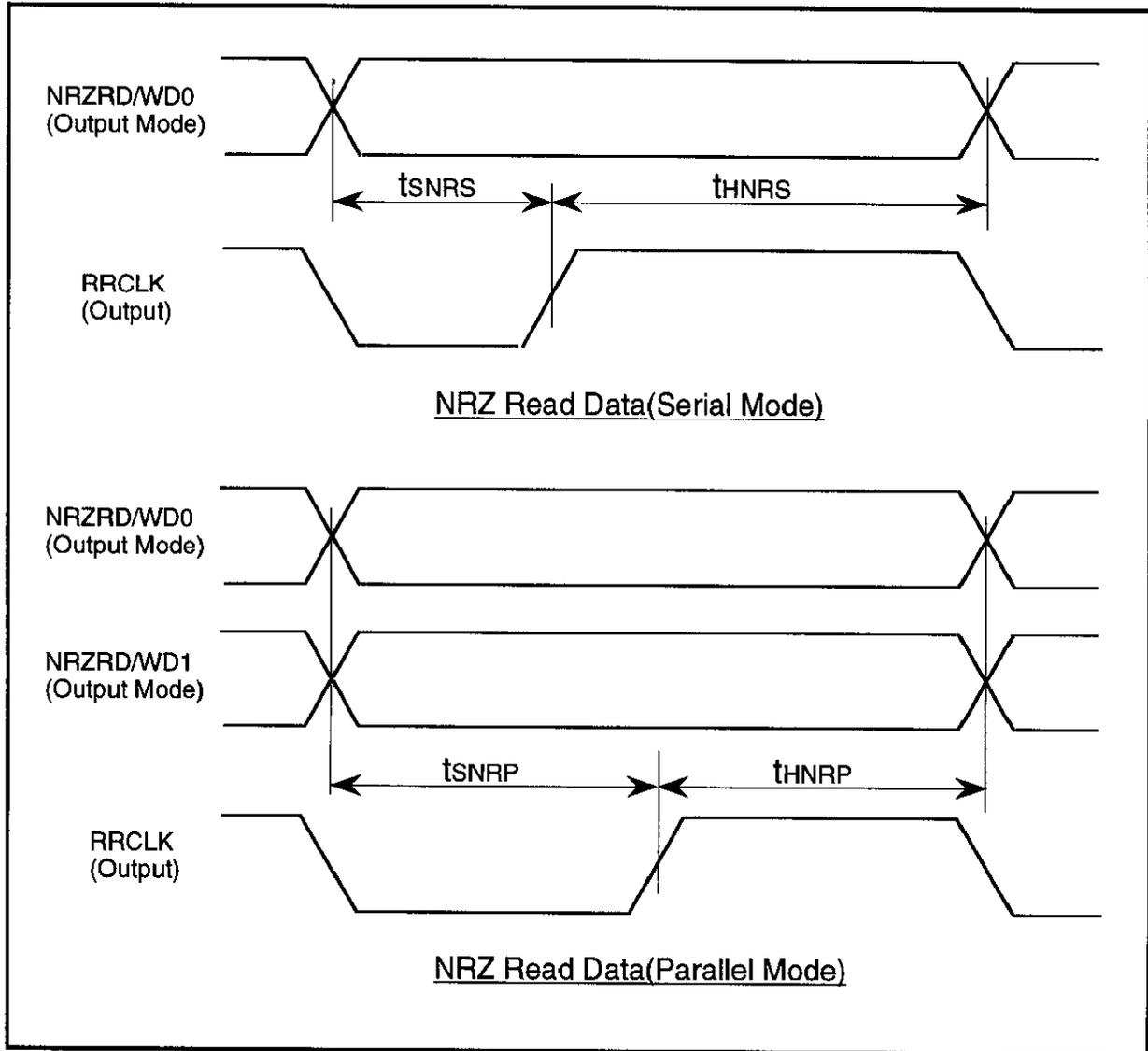
< Write >



< Read >

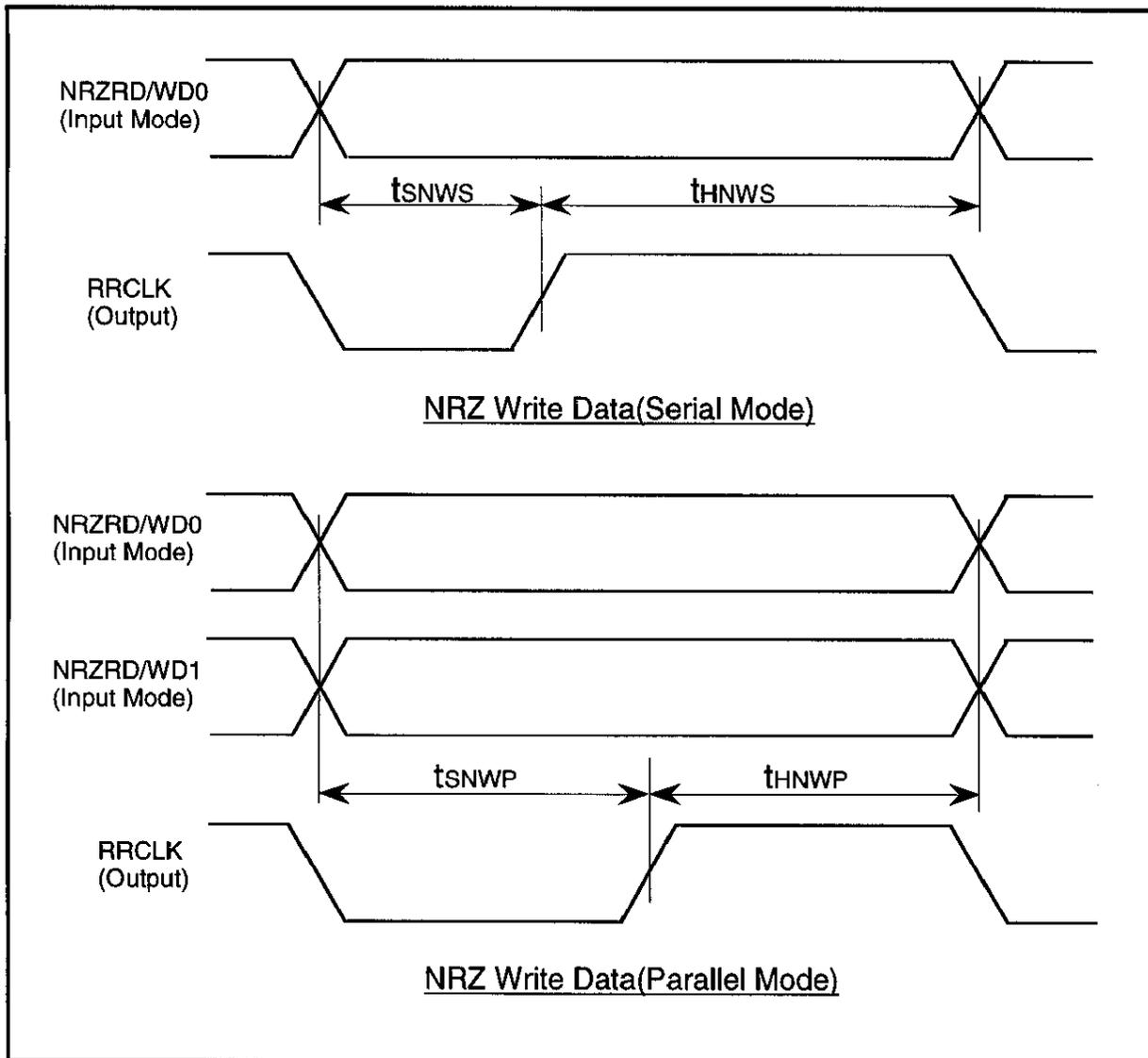


(2) Read for NRZ data



Note1: When data transfer rate is 36Mbps(Serial Mode),NRZ and RRCLK Output is 36MHz .
 RRCLK clock duty "L":"H" =1:2.
 When data transfer rate is 36Mbps(Parallel Mode),NRZ and RRCLK Output is 18MHz .
 RRCLK clock duty "L":"H" =1:1

(3) Write for NRZ data



Note2: When data transfer rate is 36Mbps(Serial Mode), RRCLK Output is 36MHz .
 RRCLK clock duty "L":"H" =1:2.
 When data transfer rate is 36Mbps(Parallel Mode), RRCLK Output is 18MHz .
 RRCLK clock duty "L":"H" =1:1

