

VM3500 Series

4, 6 or 8-CHANNEL, 5-VOLT, THIN-FILM HEAD, READ/WRITE PREAMPLIFIER with MULTIPLE SERVO WRITE CAPABILITY

970801

August, 1997

FEATURES

- **General**
 - Single Power Supply (5 V ± 10%)
 - Power Up/Down Data Protect Circuitry
 - Very Low Power Dissipation (3 mW Typical in Sleep Mode)
 - Reduced Write-to-Read Recovery Time
 - Head Inductance Range = 0.2 – 1 μH (0.54 μH Typical)
 - Write Unsafe Detection
 - Available in 4, 6 or 8 Channels
- **High Performance Reader**
 - Read Gain = 300 V/V Typical
 - Input Noise = 0.5nV/√Hz Typical
 - Low Input Capacitance = 8 pF Typical
- **High Speed Writer**
 - Write Current Range 5 - 25 mA
 - I_W Rise/Fall Times = 3.3 ns ($L_H = 0.54 \mu H, I_W = 10 \text{ mA b-p}$)
 - PECL or TTL Write Data Inputs
 - Multi-Channel Servo Write
 - Write Current Range (Servo) 5 - 20 mA
 - Optional Write Data Flip-Flop

DESCRIPTION

The VM3500 is a high-performance read/write preamplifier designed for use in high-end disk drives. It provides write current control, data protection circuitry, and a low-noise read preamplifier for up to eight channels.

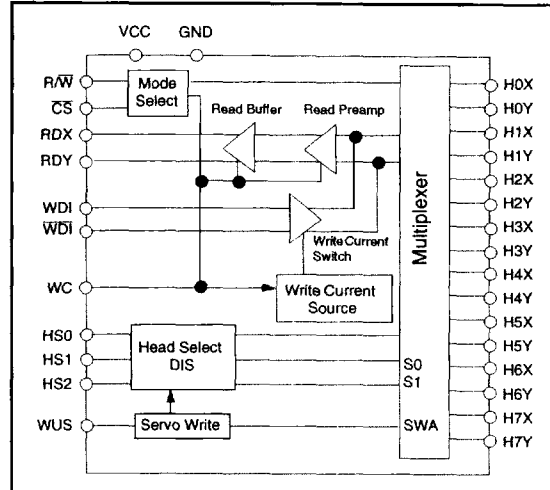
Fault protection is provided so that during power supply sequencing the write current generator is disabled. System write-to-read recovery time is minimized by maintaining the read channel common-mode output voltage in write mode.

Very low-power dissipation from the +5V supply is achieved through use of high-speed bipolar processing and innovative circuit design techniques. When unselected, the device enters a sleep mode, with power dissipation reduced to less than 3mW.

In multi-channel servo write mode, all heads are written simultaneously. The servo mode is activated via the WUS line.

The VM3500 is available in several different packages. Please contact VTC for package availability.

BLOCK DIAGRAM



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ABSOLUTE MAXIMUM RATINGS

Power Supply:	
V_{CC}	-0.3V to +7V
Write Current, I_W	30mA
Input Voltages:	
Digital Input Voltage, V_{IN}	-0.3V to ($V_{CC} + 0.3$)V
Head Port Voltage, V_H	-0.3V to ($V_{CC} + 0.3$)V
WUS Pin Voltage Range, V_{WUS}	-0.3V to +6V
Output Current:	
RDX, RDY: I_O	-10mA
WUS: I_{WUS}	+12mA
Junction Temperature	150°C
Storage Temperature, T_{stg}	-65° to 150°C
Thermal Characteristics, θ_{JA} :	
20-lead SOIC	90°C/W
20-lead SSOP	110°C/W
24-lead SSOP	100°C/W
32-lead VSOP	100°C/W

RECOMMENDED OPERATING CONDITIONS

Power Supply Voltage:	
V_{CC}	+5V ± 10%
Write current, I_W	5 to 25mA
Head Inductance, L_H	0.2 to 1 μH
Junction Temperature, T_J	25°C to 125°C



CIRCUIT OPERATION

The VM3500 addresses up to eight two-terminal thin-film heads, providing write drive or read amplification. Mode control is accomplished with pins \overline{CS} and R/\overline{W} as shown in Table 1. Head selection is accomplished with pins $HS0$, $HS1$ and $HS2$ as shown in Table 2.

Internal pull-up resistors provided on pins \overline{CS} and R/\overline{W} force the device into a non-writing condition if either control line is opened accidentally.

Write Mode

The write mode configures the VM3500 as a write current switch with the write current toggled between the X and Y side of the selected head in response to transitions on the WDI/\overline{WDI} PECL inputs. The write unsafe (WUS) detection circuitry is also activated at this time to drive the output to a low (Safe) condition.

VM3500: Write current is toggled on each low to high transition of WDI/\overline{WDI} . A preceding read operation initializes the write data flip flop (Wdff) so that upon entering the write mode current flows into the "X" port.

VM3500F: For the VM3500F (without the Wdff), the write current polarity is defined by the levels of WDI/\overline{WDI} . For $WDI > \overline{WDI}$, current flows into the "X" port; for $WDI < \overline{WDI}$, current flows into the "Y" port.

An internally-generated 2.5 V reference voltage is present at the WC pin. The write current magnitude is determined by an external resistor connected between the WC pin and ground and is defined by the equation:

$$I_W = \left(\frac{K_W}{R_{WC}} \right) + 0.3mA = \left(\frac{50}{R_{WC}} \right) + 0.3mA \quad (eq. 1)$$

(0-peak ±10%)

Power supply fault protection improves data security by disabling the write current generator during a voltage fault or power-up. Additionally, the write unsafe circuitry will flag any of the conditions below as a high level on the open collector output pin WUS:

- No write current
- WDI frequency too low
- Device in read or sleep mode

Two transitions on pin WDI, after the fault is corrected, may be required to clear the WUS flag.

Multi-Channel Servo Write Mode

In servo write mode, the operation is the same as described above except that all channels are written simultaneously. Servo mode is controlled using the WUS pin.

To initiate servo mode:

1. Enter read mode (bring R/\overline{W} high).
2. Select Head 1 (bring $HS0$ high).
3. Supply 10mA source current into the WUS pin.
4. Enter servo mode (drop the R/\overline{W} line low).

Note: If any other head is selected during servo, the part will exit servo mode and write only the selected head. Unless servo is "formally" exited by removing the 10mA current, servo mode will return whenever head 1 is selected.

To return to normal operations:

1. Enter read mode (bring R/\overline{W} high).
2. Drop the WUS pin (remove the 10 mA current) and return to normal read mode.

Read Mode

The read mode configures the VM3500 as a low-noise differential amplifier. The write current reference remains active to minimize the write/read recovery time. The RDX and RDY outputs are emitter followers and are in phase with the "X" and "Y" head ports. These outputs should be AC-coupled to the load.

The RDX, RDY common-mode voltage is maintained in the write mode, minimizing the transient between the write mode and the read mode, thereby substantially reducing the recovery time delay to the subsequent pulse detection circuitry.

Sleep Mode

In sleep mode (\overline{CS} high), most of the circuit is idle and power dissipation is reduced to 3mW typical.

Table 1: Mode Select

R/\overline{W}	\overline{CS}	MODE
0	0	Write
0	0	Servo*
1	0	Read
X	1	Idle

* See Multi-Channel Servo Write Mode on page 4 for additional detail.

Table 2: Head Selection

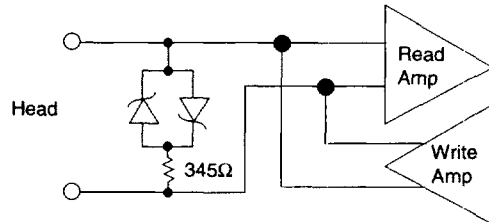
$HS2$	$HS1$	$HS0$	HEAD
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7

PIN DESCRIPTIONS

NAME	I/O	DESCRIPTION
HS0 - HS2	I	Head Selects: Selects one of up to eight heads.
H0X - H7X H0Y - H7Y	I/O	X, Y Head Terminals
WDI, $\overline{\text{WDI}}$	I	Write Data Inputs: PECL input signal; a rising edge toggles direction of head current. (Each transition toggles the direction of head current on the "F" option without the write data flip flop.)
$\overline{\text{CS}}$	I	Chip Select: A high level signal puts chip in sleep mode; a low level awakens chip.
R/ $\overline{\text{W}}$	I	Read/Write select: A high level selects read mode. A low-level selects write mode
WUS/SE	O	Write Unsafe/Servo Enable: (open collector output) A high level indicates a writes unsafe condition. Note: The WUS pin is also used to enter servo mode. See Multi-Channel Servo Write Mode on page 4.
WC		Write Current Adjust: A resistor adjusts level of write current.
RDX-RDY	O	Read Data Output: Differential output data.
VCC		+5 volt supply
GND		Ground

Damping Resistor

Unless otherwise indicated, the VM3500 has damping resistors isolated by Schottky diodes. The diodes effectively remove the resistor from the circuit during the read mode, however during the write mode with the higher level input signal, the resistor provides damping for the write current waveform.



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5V PREAMPS



DC CHARACTERISTICS

Recommended operating conditions apply unless otherwise specified.

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5V PREEMPS

PARAMETER	SYM	CONDITIONS	MIN	TYP	MAX	UNITS
Power Supply Voltage	V_{CC}		4.5	5.0	5.5	V
VCC Supply Current	I_{CC}	Read Mode		$34 + 0.05I_W$	50	mA
		Write Mode, Normal, $I_W = 10\text{mA}$		$34 + 1.05I_W$	60	
		Write Mode, Servo, $I_W = 10\text{mA}$ (4-Channel)		$55 + 4.3I_W$	125	
		Write Mode, Servo, $I_W = 10\text{mA}$ (6-Channel)		$100 + 8.6I_W$	225	
		Write Mode, Servo, $I_W = 10\text{mA}$ (8-Channel)		$100 + 8.6I_W$	225	
		Sleep Mode		0.5	3	
Power Supply Power Dissipation	PD	Read Mode		175	275	mW
		Write Mode, Normal, $I_W = 10\text{mA}$		225	330	
		Write Mode, Servo, $I_W = 10\text{mA}$ (4-Channel)		490	688	
		Write Mode, Servo, $I_W = 10\text{mA}$ (6-Channel)		930	1240	
		Write Mode, Servo, $I_W = 10\text{mA}$ (8-Channel)		930	1240	
		Sleep Mode		3	16.5	
Input High Voltage	V_{IH}		2		$V_{CC} + 0.3$	V
Input Low Voltage	V_{IL}		-0.3		0.8	V
Input High Current	I_{IH}	$V_{IH} = 2.7\text{V}$			80	μA
Input Low Current	I_{IL}	$V_{IL} = 0.4\text{V}$	-160			μA
WDI, $\overline{\text{WDI}}$ Input High Voltage	V_{IH}	Pseudo ECL	$V_{CC} - 1.5$		$V_{CC} - 0.1$	V
WDI, $\overline{\text{WDI}}$ Input Low Voltage	V_{IL}	Pseudo ECL	$V_{IH} - 1.5$		$V_{IH} - 0.25$	V
WDI, $\overline{\text{WDI}}$ Input High Current	I_{IH}	$V_{IH} = V_{CC} - 0.7\text{V}$			100	μA
WDI, $\overline{\text{WDI}}$ Input Low Current	I_{IL}	$V_{IH} = V_{CC} - 1.6\text{V}$			80	μA
WUS Output Low Voltage	V_{OL}	$I_{OL} = 4.0\text{mA}$		0.35	0.5	V
WUS Output High Current	I_{OH}	$V_{OH} = 5.0\text{V}$		13	100	μA
VCC Value for Write Current Turn Off		$I_H < 0.2\text{mA}$	3.3	3.6	4.0	V
WUS Servo Enable	I_{SE}		10	*	20	mA

* The typical value for servo activation is 6 mA. The minimum value at which servo activation is guaranteed is 10 mA.

WRITE CHARACTERISTICS

Recommended operating conditions apply unless otherwise specified; $L_H = 0.54\mu H$, $R_H = 20\Omega$, $I_W = 10mA$, $f_{DATA} = 5MHz$.

PARAMETER	SYM	CONDITIONS	MIN	TYP (Note 1)	MAX	UNITS
WC Pin Voltage	V_{WC}			2.5		V
I_{WC} to Head Current Gain	A_I			20		mA/mA
Write Current Constant	K_W	$V_{CC} = 5V \pm 10\%$	45	50	55	V
Write Current Range	I_W	$10.64k\Omega > R_{WC} > 2k\Omega$	5		25	mA
Write Current Tolerance	ΔI_W	$V_{CC} \pm 10\%$	-10		+10	%
Write Current Tolerance Servo	ΔI_W	$V_{CC} \pm 10\%$	-14		+14	%
Differential Head Voltage Swing	V_{DH}	Open head @ $V_{CC} = 4.5V$	4.8	5.4		Vp-p
WDI Transition Frequency for Safe Condition	f_{DATA}	WUS = low	1			MHz
Differential Output Capacitance	C_{OUT}				10	pF
Differential Output Resistance	R_{OUT}		3.2			k Ω
Unselected Head Current	I_{UH}	$I_W = 25mA$		0.15	0.5	mA(pk)
RDX, RDY Common Mode Output Voltage	V_{CM}			$V_{CC} - 2.7$		V

Note 1: Typical values are given at $V_{CC} = 5V$ and $T_A = 25^\circ C$.

Servo Write

PARAMETER	SYM	CONDITIONS	MIN	TYP	MAX	UNITS
Write Current Matching Between Channels	ΔI_W	$5mA < I_W < 20mA$			10	%
Duty Cycle (20mA/head)		$T_A = 25^\circ C$, $t_{s-on} < 50ms$			50	%

* The ambient temperature (T_A) and servo-on time (t_{s-on}) limitations are consistent with keeping the peak junction temperature under $125^\circ C$.

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**READ CHARACTERISTICS**Recommended operating conditions apply unless otherwise specified; C_L (RDX, RDY) < 20pF, R_L (RDX, RDY) = 1k Ω .

PARAMETER	SYM	CONDITIONS	MIN	TYP (Note 1)	MAX	UNITS
Differential Voltage Gain	A_V	$V_{IN} = 1\text{mVrms}, 1\text{MHz}$	250	300	350	V/V
Bandwidth	BW	-1dB $ Z_{sl} < 5\Omega$, $V_{IN} = 1\text{mVp-p}$	50	55		MHz
		-3dB $ Z_{sl} < 5\Omega$, $V_{IN} = 1\text{mVp-p}$	90	100		
Input Noise Voltage	e_{in}	$BW = 20\text{MHz}, L_H = 0, R_H = 0$		0.5	0.65	nV/ $\sqrt{\text{Hz}}$
Differential Input Capacitance	C_{IN}	$V_{IN} = 1\text{mVp-p}, f = 5\text{MHz}$		8	12	pF
Differential Input Resistance	R_{IN}	$V_{IN} = 1\text{mVp-p}, f = 5\text{MHz}$	300	750		Ω
Dynamic Range	DR	AC input where A_V is 90% of gain at 0.2mVrms input	2			mV P-P
Common Mode Rejection Ratio	CMRR	$V_{IN} = 100\text{mVp-p @ } 5\text{MHz}$	50			dB
Power Supply Rejection Ratio	PSRR	100mVp-p @ 5MHz on V_{CC}	45			dB
Channel Separation	CS	Unselected channels: $V_{IN} = 20\text{mVp-p @ } 5\text{MHz}$ $V_{IN} = 0$ on selected head	45			dB
Output Offset Voltage	V_{OS}	Steady state read	-300		+300	mV
RDX, RDY Common Mode Output Voltage	V_{OCM}	Read/Write Mode		$V_{CC} - 2.0$		
RDX, RDY Common Mode Output Voltage Difference Between Modes	ΔV_{OCM}		-350		+350	mV
Single-Ended Output Resistance	R_{SEO}	$f = 5\text{MHz}$			35	Ω
Output Current	I_O	AC-coupled load, RDX to RDY	± 1			mA

Note 1: Typical values are given at $V_{CC} = 5\text{V}$ and $T_A = 25^\circ\text{C}$.



SWITCHING CHARACTERISTICS

Recommended operating conditions apply unless otherwise specified; $I_W = 10\text{mA}$, $f_{\text{DATA}} = 5\text{MHz}$, $L_H = 0.54\mu\text{H}$, $R_H = 20\Omega$, C_L (RDX, RDY) $\leq 20\text{pF}$ (see Figures 1 and 2).

PARAMETER	SYM	CONDITIONS	MIN	TYP (Note 1)	MAX	UNITS
R/W Read to Write Delay	t_{RW}	R/W to 90% I_W		0.06	0.15	μs
R/W Write to Read Delay	t_{WR}	R/W to 90% of 100mV, 10 MHz read signal envelope		0.2	0.4	μs
$\overline{\text{CS}}$ Unselect to Select Delay	t_{IR}	$\overline{\text{CS}}$ to 90% I_W or 90% of 100mV, 10MHz read signal envelope			0.6	μs
$\overline{\text{CS}}$ Select to Unselect Delay	t_{RI}	$\overline{\text{CS}}$ to 10% of I_W			0.6	μs
HS0 - HS3 any Head Delay	t_{HS}	HS0 - HS3 to 90% of 100mV, 10MHz read signal envelope			0.6	μs
WUS Safe to Unsafe Delay	t_{D1}		0.6		3.6	μs
WUS Unsafe to Safe Delay	t_{D2}	$I_W = 10\text{mA}$			1.0	μs
Head Current Propagation	t_{D3}	$L_H = 0$, $R_H = 0$, from 50% points			30	ns
Head Current Asymmetry	A_{SYM}	50% duty cycle on WDI, 1ns rise/fall time; $L_H = 0$, $R_H = 0$			0.5	ns
Head Current Rise/Fall Time	t_r/t_f	10% to 90% points, $L_H = 0$, $R_H = 0$, $I_W = 10\text{mA}$		1.0	2.0	ns
		10% to 90% points, $L_H = 540\text{nH}$, $I_W = 10\text{mA}$, $R_H = 20\Omega$		3.3	5.0	

Note 1: Typical values are given at $V_{CC} = 5\text{V}$ and $T_A = 25^\circ\text{C}$.

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5V PREAMPS

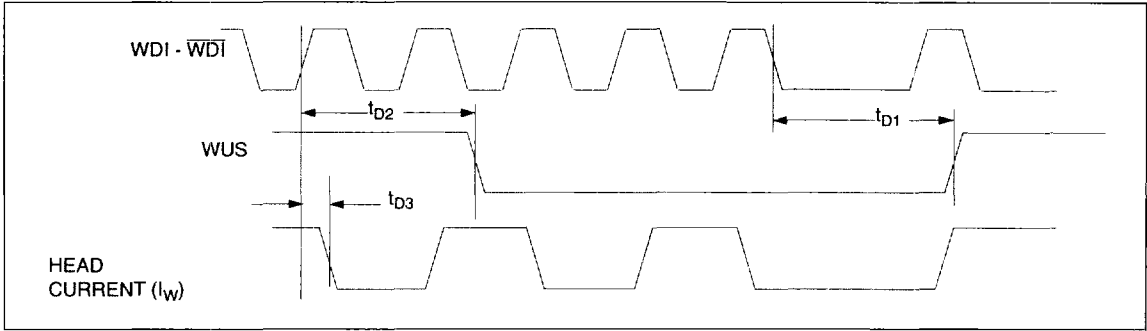


Figure 1: Write Mode Timing Diagram for VM3500

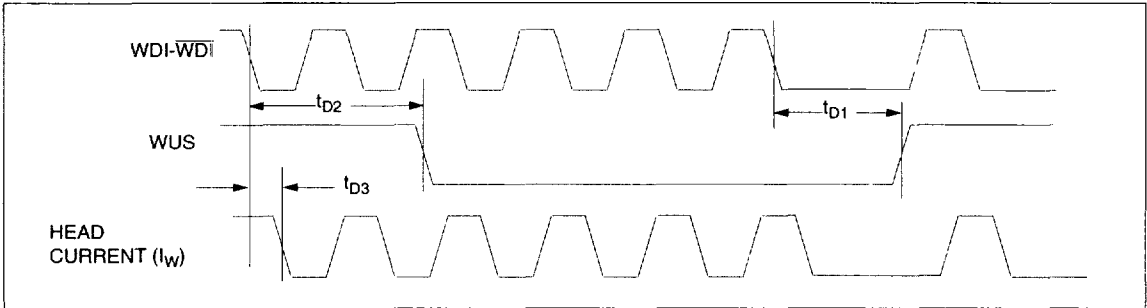
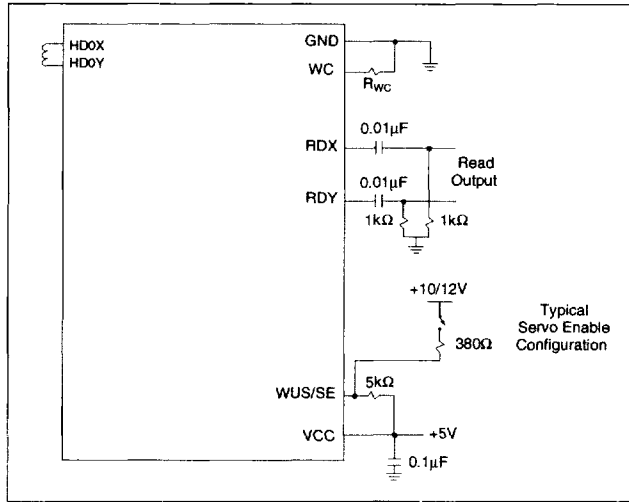


Figure 2: Write Mode Timing Diagram for VM3500F (without write data flip flop)

TYPICAL APPLICATION CONNECTIONS



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Note: The pin placements in the diagram are not meant to be exact and will vary between packages. The connections shown will apply regardless of package variation.

Application Notes:

- For maximum stability, place the decoupling capacitors and the R_{WC} resistor as close to the package pins as possible.
- The voltage at the WUS/SE pin will clamp at two diode drops above VCC.
- The typical servo-enable configuration shown above is presented as an example. Other supply and resistor values are possible, and the supply/resistor symbols shown could be displayed as a 10 mA current source.



List of Specific Part Variations

(described on the following pages)

<i>PART VARIATION</i>	<i>Page Location</i>
VM357830 *	13
VM355830	14
VM355830 (28-lead package)	15
VM356630 *	16
VM355635	17
VM355630	18
VM355435	19
VM355430	20

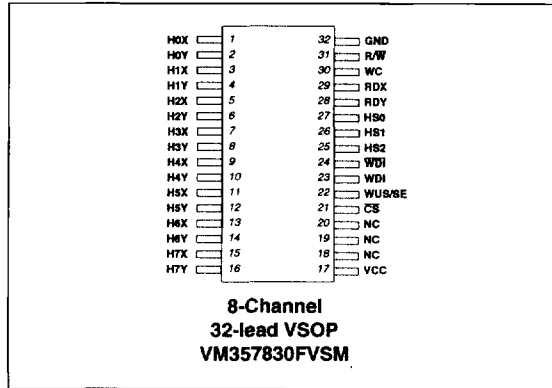
* This part is non-conventional. See the specific page for details.

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VM357830

8-CHANNEL CONNECTION DIAGRAM



2 - TERMINAL
SV PREAMPS

Note: This part is non-conventional in the following aspects:

- It has an alternate pin-out (\overline{CS} is in a different location).
- It has a bank servo mode where 4 heads are written at a time based on the head selected. (See below.)
- It has a nominal damping resistor value of 250 Ω (Schottky isolated).

Specific CHARACTERISTICS

See the general data sheet for common specification information.

Multi-Channel Servo Write Mode

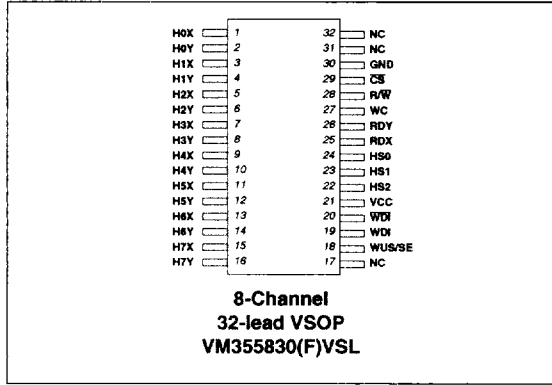
In servo write mode, the operation is the same as described in the general datasheet except that four channels are written simultaneously as shown in the table below.

Table 3: Servo Mode Head Selection

HEAD SELECTED	HEADS WRITTEN
0 or 1	none
2	odd (1,3,5 and 7)
3	even (0,2,4 and 6)

VM355830

8-CHANNEL CONNECTION DIAGRAM



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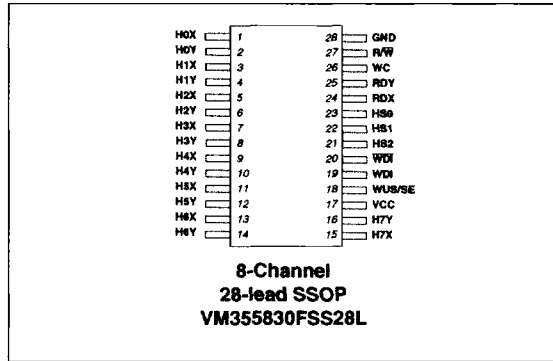
Specific CHARACTERISTICS

See the general data sheet for common specification information.

PARAMETER	SYM	CONDITIONS	MIN	TYP (Note 1)	MAX	UNITS
Differential Voltage Gain	A_V	$V_{IN} = 1\text{mVrms}, 1\text{MHz}$	264	300	336	V/V

VM355830 (28-lead package)

8-CHANNEL CONNECTION DIAGRAM



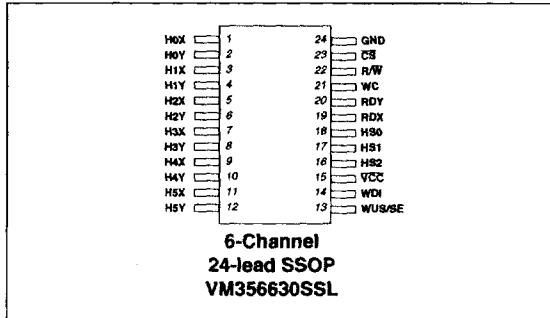
2 TERMINAL
5V PREAMPS

Specific CHARACTERISTICS

See the general data sheet for common specification information.

VM356630

6-CHANNEL CONNECTION DIAGRAM



Note: This part is non-conventional in one aspect:

- It has TTL single-ended write data input.
Write current is toggled on each high-to-low transition of WDI.

Specific CHARACTERISTICS

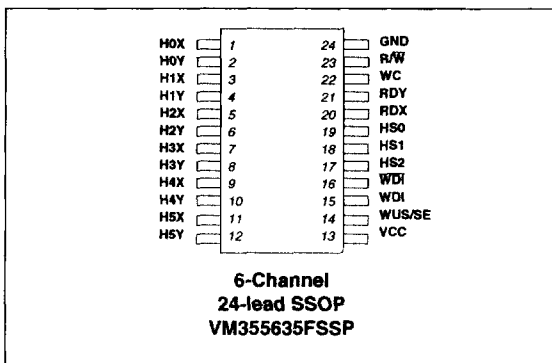
See the general data sheet for common specification information.

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VM355635

6-CHANNEL CONNECTION DIAGRAM



2 - TERMINAL
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Specific CHARACTERISTICS

See the general data sheet for common specification information.

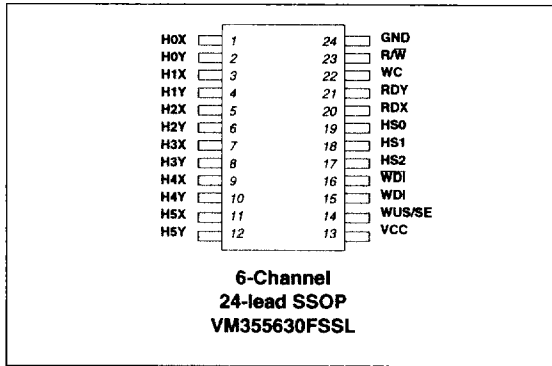
- 350 V/V read gain.

PARAMETER	SYM	CONDITIONS	MIN	TYP (Note 1)	MAX	UNITS
Differential Voltage Gain	A_V	$V_{IN} = 1\text{mVrms}, 1\text{MHz}$	292	350	408	V/V
Differential Input Capacitance	C_{IN}	$V_{IN} = 1\text{mVp-p}, f = 5\text{MHz}$		10	14	pF
Single-Ended Output Resistance	R_{SEO}	$f = 5\text{MHz}$			50	Ω



VM355630

6-CHANNEL CONNECTION DIAGRAM



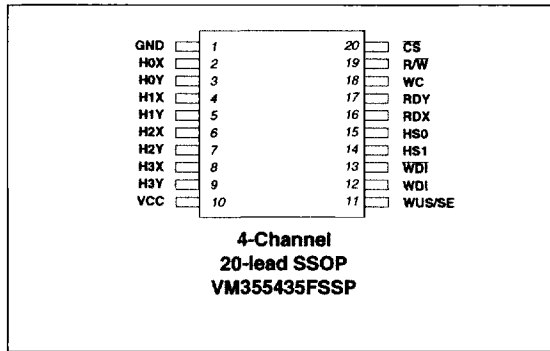
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5V PREAMP'S

Specific CHARACTERISTICS

See the general data sheet for common specification information.

VM355435

4-CHANNEL CONNECTION DIAGRAM



2 - TERMINAL
5V PHEA01'S

Specific CHARACTERISTICS

See the general data sheet for common specification information.

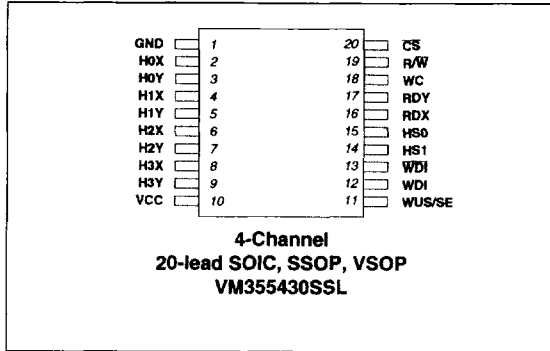
- 350 V/V read gain.

PARAMETER	SYM	CONDITIONS	MIN	TYP (Note 1)	MAX	UNITS
Differential Voltage Gain	A_V	$V_{IN} = 1mV_{rms}, 1MHz$	292	350	408	V/V
Differential Input Capacitance	C_{IN}	$V_{IN} = 1mV_{p-p}, f = 5MHz$		10	14	pF
Single-Ended Output Resistance	R_{SEO}	$f = 5 MHz$			50	Ω



VM355430

4-CHANNEL CONNECTION DIAGRAM



2 - TERMINAL
5V PREAMPS

Specific CHARACTERISTICS

See the general data sheet for common specification information.