SSI 32R2320/21/22/23/24
3V, 5V, 4-Channel
2-Terminal Read/Write Device

### Advance Information

October 1993

DESCRIPTION

The SSI 32R2320/21/22/23/24 are BiCMOS monolithic integrated circuit designed for use with two-terminal recording heads. They provide a low noise read amplifier, write current control, and data protection circuitry for up to four channels. This family of devices has been designed to support servo bank write, TTL or ECL write data input, and write unsafe output through various bond options. In addition, versions of the devices are available with or without internal damping resistors. When configured with damping resistors, the resistors are switched in during write mode and switched out during read mode. Power supply fault protection is provided by disabling the write current generator during power sequencing. System write to read recovery time is significantly improved by making the read channel outputs high impedance.

The SSI 32R2320/21/22/23/24 require a single 3.0 to 5.5V power supply and are available in a variety of packages. They are hardware compatible with the SSI 32R4610A and SSI 32R2020R Read/Write devices.

FEATURES

- +3.0V - 5.5V voltage supply
- Low power
  - PD = 73 mW Read mode (Nom) (@3.3V supply)
  - PD = 75 μW Idle (Max @ Vcc = 3.3V)
- High Performance:
  - Read mode gain = 250 V/V
  - Input noise = 0.50 nV/√Hz (Nom)
  - Input capacitance = 9 pF (Nom)
  - Write current range = 2-30 mA
- Bond options for:
  - Self switching damping resistance
  - Servo bank write
  - TTL or ECL write data input
  - Write unsafe detection
- Power supply fault protection

BLOCK DIAGRAM

1093 - rev.

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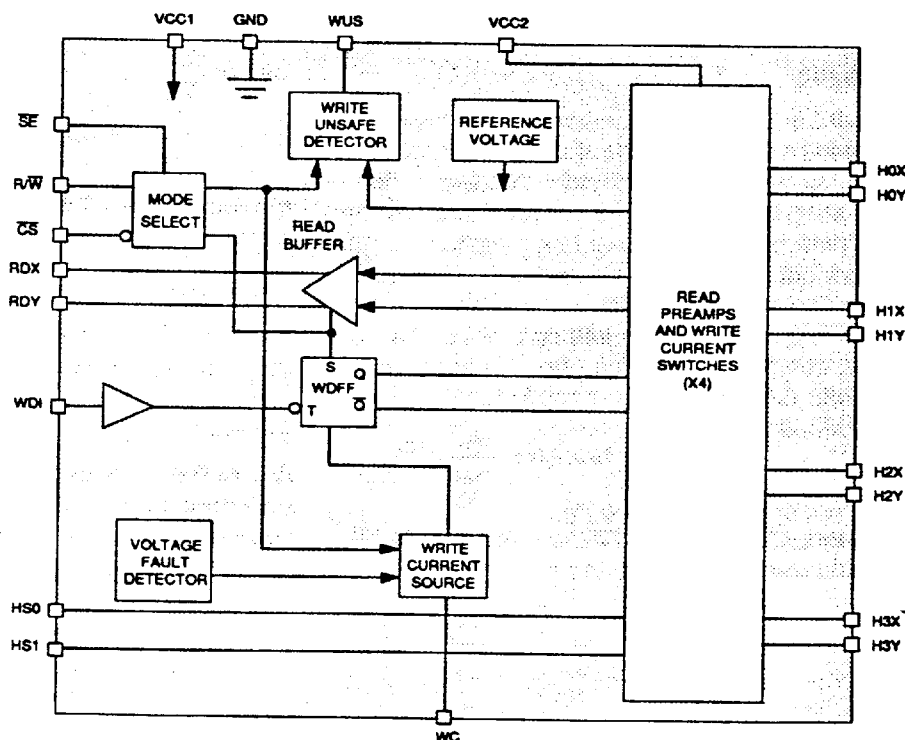
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FUNCTIONAL DESCRIPTION

The SSI 32R2320/21/22/23/24 have the ability to address up to 4 two-terminal heads and provide write drive or read amplification. Mode control and head selection are described in Tables 1 and 2. The TTL inputs R/W̄, C̄S̄ and DMP have internal pull-up resistors. The TTL inputs HS0 and HS1 have internal pull down resistors.

TABLE 1: Mode Select

C̄S̄	R/W̄	S̄Ē	Mode
0	0	1	Write
0	1	X	Read
1	0	X	Idle
1	1	X	Idle
0	0	0	Servo Write

TABLE 2: Head Select

HS1	HS0	Head
0	0	0
0	1	1
1	0	2
1	1	3

WRITE MODE

Taking both C̄S̄ and R/W̄ low selects write mode which configures the device as a current switch and activates the Write Unsafe (WUS) detector circuitry. Head current is toggled between the X and Y side of the selected head on each high to low transition of the Write Data Input (WDI). Note that a preceding Read to Write transition or Idle to Write transition initializes the Write Data Flip-Flop to pass write current into the "X" side of the device. In this case, the Y side is higher potential than the X side. The magnitude of the write current (0-pk) is given by:

$$Iw = Aw \cdot \frac{Vwc}{Rwc} = K/Rwc$$

where Aw is the write current gain.
RWC is connected from pin WC to GND. Note the actual head current Ix, y is given by:

$$Ix, y = \frac{Iw}{1 + Rh/Rd}$$

Where:

Rh = Head resistance plus external wire resistance

Rd = Damping resistance

In Write mode a 350Ω damping resistor is switched in across the Hx, Hy ports.

VOLTAGE FAULT

A voltage Fault detection circuit improves data security by disabling the write current generator during a voltage fault or power startup in Read or Write mode.

WRITE UNSAFE

Any of the following conditions will be indicated as a high level on the Write Unsafe, WUS, open collector output.

- WDI frequency too low
- Device in Read mode
- Device not selected
- Open head
- Head short to ground
- No write current

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WRITE UNSAFE (continued)

WUS is valid in the write current/head characteristic region defined by $5 < Ih \cdot Lh < 50$ mA $\cdot$ μH, and $1 < Rh < 1.25/Ih$. After the fault condition is removed, one negative transition on WDI is required to clear WUS.

READ MODE

The Read mode configures the SSI 32R2320RZ as a low noise differential amplifier and deactivates the write current generator. The damping resistor is switched out of the circuit allowing a high impedance input to the read amplifier. The RDX and RDY output are driven by emitter followers. They should be AC coupled to the load. The HnX, HnY inputs are non-inverting to the RDX, RDY outputs.

Note that in Idle or Write mode, the read amplifier is deactivated and RDX, RDY outputs become high impedance. This facilitates multiple R/W applications (wired-OR RDX, RDY) and minimizes voltage change when switching from Write to Read mode. Note also that the write current source is deactivated for both the Read and Idle mode.

IDLE MODE

Taking $\overline{CS}$ high selects the Idle mode which switches the RDX and RDY outputs into a high impedance state and deactivates the device. Power consumption in this mode is held to a minimum at $\overline{CS}$, input is greater than $(Vcc - 0.3V)$.

PIN DESCRIPTION

NAME	TYPE	DESCRIPTION
HS0, HS1 †	I	Head Select: selects one of four heads
$\overline{CS}$	I	Chip Select: a high inhibits the chip
R/$\overline{W}$ †	I	Read/Write : a high selects Read mode
WUS †	O	Write Unsafe: a high indicates an unsafe writing condition
WDI/$\overline{WDI}$ †	I	Write Data Input: On TTL versions, a negative transition on WDI changes the direction of the current in the recording head. On ECL versions, a positive transition on the WDI (negative transition on $\overline{WDI}$ changes the direction of the current in the recording head. $\overline{WDI}$ is only present on the ECL versions.
H0X - H3X; H0Y - H3Y	I/O	X, Y Head Connections
RDX, RDY †	O	X, Y Read Data: differential read data output
WC		Write Current: used to set the magnitude of the write current
VCC1	I	Power Supply
GND	I	Ground
$\overline{SE}$	I	Servo Enable: A low input on this line enables the servo bank write mode when $\overline{CS}$ and R/$\overline{W}$ are both low.
WUS/SE	I	Write Unsafe/Servo Enable (32R2323/24 only): Under normal operation, a high level output on this pin indicates a write unsafe condition. When this pin is driven externally above VCC and $\overline{CS}$ and R/$\overline{W}$ are both low, servo write mode is activated.
DMP	I	Damping Resistor Enable (32R2322 only): A high (or open) level on this input enables the switchable damping resistor. A low level on this input disables the damping resistor.

† When more that one R/W device is used, signals can be wire OR'ed

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ELECTRICAL SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS
Operation above maximum ratings may permanently damage the device.

PARAMETER		RATING
DC Supply Voltage	VCC1	-0.3 to +7 VDC
	VCC2	-0.3 to +7 VDC
Write Current	Iw	30 mA
Digital Input Voltage	Vin	-0.3 to VCC1 +0.3 VDC
Head Port Voltage	VH	-0.3 to VCC2 +0.3 VDC
Output Current: RDX, RDY	IO	-10 mA
	WUS	+8 mA
Storage Temperature	Tstg	-55 to +150°

RECOMMENDED OPERATING CONDITIONS

PARAMETER		RATING
DC Supply Voltage		3.3 ±10%, 5.0 ±10% VDC
Recommended Head Load Range	Lh	0.3 - 5.0 µH
WUS Operating Range	Iw • Lh	5.0 - 50.0 mA • µH
Head Differential Load Capacitance		15 pF max
Ambient Operating Temperature*		0 - 70 °C

* Derating is required when in Servo Write mode.

DC CHARACTERISTICS
Recommended operating conditions apply unless otherwise specified.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VCC1 Supply Current	Vcc = 3.3V ±10% Read		22.0	30.0	mA
	Vcc = 3.3V ±10% Write		5+1.2 • Iw	9+1.4 • Iw	mA
	Vcc = 3.3V ±10% Servo		6+4.5 • Iw	11+4.7 • Iw	mA
	Vcc = 3.3V ±10% Idle, $\overline{CS}$ = Vcc		3	20	µA
	Vcc = 3.3V ±10% Idle, $\overline{CS}$ = 2.7V		30	200	µA
Power Dissipation	Vcc = 3.3V ±10% Read		73	110	mW
	Vcc = 3.3V ±10% Write		17+4 • Iw	33+5 • Iw	mW
	Vcc = 3.3V ±10% Servo		20+15 • Iw	40+17 • Iw	mW
	Vcc = 3.3V ±10% Idle, $\overline{CS}$ = Vcc		9	75	µW
	Vcc = 3.3V ±10% Idle, $\overline{CS}$ = 2.7V		100	730	µW

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DC CHARACTERISTICS (continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VCC1 Supply Current	Vcc = 5.0V ±10% Read		23.0	32.0	mA
	Vcc = 5.0V ±10% Write		6+1.2 • Iw	10+1.3 • Iw	mA
	Vcc = 5.0V ±10% Servo		7+4.4 • Iw	12+4.7 • Iw	mA
	Vcc = 5.0V ±10% Idle, $\overline{CS}$ = Vcc		5	30	µA
	Vcc = 5.0V ±10% Idle, $\overline{CS}$ = 2.7V		250	450	µA
Power Dissipation	Vcc = 5.0V ±10% Read		115	180	mW
	Vcc = 5.0V ±10% Write		30+6 • Iw	55+7 • Iw	mW
	Vcc = 5.0V ±10% Servo		35+22 • Iw	66+26 • Iw	mW
	Vcc = 5.0V ±10% Idle, $\overline{CS}$ = Vcc		0.03	0.17	mW
	Vcc = 5.0V ±10% Idle, CS = 2.7V		1.25	2.5	mW

DIGITAL INPUTS

Input Low voltage (VIL)	$\overline{CS}$, R/$\overline{W}$, WDI, HSn and $\overline{SE}$			0.8	VDC
Input High Voltage (VIH)	$\overline{CS}$, R/$\overline{W}$, WDI, HSn and $\overline{SE}$	2.0			VDC
Input Low Current	VIL = 0.4 Vcc = 3.6V	-0.4	-.09		mA
	$\overline{CS}$, R/$\overline{W}$, WDI, $\overline{SE}$ Vcc = 5.5V	-0.4	-0.13		mA
Input High Current	VIH = 2.7V $\overline{CS}$, R/$\overline{W}$, WDI, $\overline{SE}$		0	20	µA
WUS Output Low Voltage (VOL)	Iol = 2 mA max		0.35	0.5	VDC
Input Low Current	HSn and $\overline{SE}$ VIL = 0.4V		10	40	µA
Input High Current	HSn and $\overline{SE}$ VIH = 2.7V		100	400	µA
Input Low Voltage	WD, $\overline{WD}$	Vcc -1.0		Vcc -0.4	V
Input High Voltage	WD, $\overline{WD}$	Vcc -2.0		Vcc -0.8	V
Δ VIN	|WD - $\overline{WD}$|	0.4	0.8		V
Input Low Current	WD, $\overline{WD}$ Vcc = 5V VIH = Vcc - 0.8V		100	200	µA
Input High Current	WD, $\overline{WD}$ Vcc = 5V VIL = Vcc - 1.6V		75	150	µA

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ELECTRICAL SPECIFICATIONS (continued)

WRITE CHARACTERISTICS
Recommended operating conditions apply unless otherwise specirfied.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
VCC1 Fault Voltage	Iw < 0.2 mA		2.5	2.75	VDC
Write Current Gain (Aw)	Iw = 2-5 mA Vcc = 3.3V±10%	19.5	22.0	26.4	mA/mA
	Iw = 5-30 mA Vcc = 3.3V±10%	18.3	20.5	23.0	mA/mA
	Iw = 2-5 mA Vcc = 5.0V±10%	20.6	23.1	28.0	mA/mA
	Iw = 5-30 mA Vcc = 5.0V±10%	19.3	21.7	24.5	mA/mA
Write Current Error	Rwc = 2 kΩ, head to head @ Write mode*	-5		+5	%
	Rwc = 2 kΩ, head to head @ Servo mode*	-5		+5	%
	Rwc = 2 kΩ, Write to Servo	-7		+7	%
Write Current Voltage (VWC)		1.2	1.3	1.4	V
Differential Head Voltage Swing	Open head, $\overline{SE}$ = 1	4.0	4.8		Vpp
	Open head, Vcc = 5V, $\overline{SE}$ = 0	4.0	4.8		Vpp
	Open head, Vcc = 3.3V, $\overline{SE}$ = 0	3.4	4.8		Vpp
Unselected Head Current	AC			1	mA (pk)
	DC			0.1	mA
Head Differential Load Resistance (Rd)	R version	300	400	500	Ω
	non-R version	2400	3000	3600	Ω
WDI Pulse Width	Vil ≤ 0.8V, Vih ≥ 2.0V PWH	5			ns
	$t_f = t_r$ = 1ns PWL	10			ns
Write Current Range (Iw)		2		30	mA

* Error from average of the four heads.

READ CHARACTERISTICS
Recommended operating conditions apply unless otherwise specified. CL (RDX, RDY) < 20 pF, RL (RDX, RDY) = 1 kΩ.

Differential Voltage Gain	Vin = 1 mVpp @1 MHz	200	250	300	V/V
Voltage BW -1dB	|Zs| < 5Ω, Vin = 1 mVpp	20	40		MHz
-3dB		40	80		MHz
Input Noise Voltage	BW = 15 MHz, Lh = 0, Rh = 0		0.50	0.75	nV/√Hz
Differential Input Capacitance	Vin = 1 mVpp, f = 5 MHz		9	14	pF
Differential Input Resistance	Vin = 1 mVpp, f = 5 MHz	500	750	1800	Ω

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READ CHARACTERISTICS (continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Dynamic Range	AC input voltage where gain falls to 90% of its small signal gain value, f = 5 MHz	2	5		mVpp
Common Mode Rejection Ratio	Vin = 0 VDC + 100 mVpp @ 5 MHz	45	60		dB
Power Supply Rejection Ratio	100 mVpp @ 5 MHz on VCC	40	70		dB
Channel Separation	Unselected channels driven with Vin = 0 VDC + 100 mVpp	45	60		dB
Output Offset Voltage	Head shorted	-250		+250	mV
	Head opened	-300		+300	mV
Single Ended Output Resistance	f = 5 MHz		60	100	Ω
Output Current	AC coupled load, RDX to RDY	1.0	2.0		mA
RDX, RDY Common Mode Output Voltage		Vcc-1.0	Vcc-1.35	Vcc-1.70	VDC

SWITCHING CHARACTERISTICS

Recommended operating conditions apply unless otherwise specified. Rwc = 2kΩ, Lh = 1.0 µH, Rh = 30Ω f(Data) = 5 MHz.

			MIN	NOM	MAX	UNIT
R/W̄	Read to Write	R/W̄ to 90% of write current; WUS valid		0.3	1.0	µs
	Write to Read	R/W̄ to 90% of 100 mV Read signal envelope		0.4	1	µs
C̄S̄	Unselect to Select	C̄S̄ to 90% of 100 mV 10 MHz Read signal envelope		0.6	2	µs
	Select to Unselect	C̄S̄ to 10% of write current		0.4	1	µs
HS0,1 to any Head		To 90% of 100 mV 10 MHz Read signal envelope		0.2	1	µs
WUS*	Safe to Unsafe (TD1)	Write mode, loss of WDI transitions; Defines max WDI period for WUS operation	0.6	2.0	3.6	µs
	Unsafe to Safe (TD2)	Fault cleared: from first negative WDI transition		0.2	1.0	µs
WDI	Frequency Range	Valid WUS	1.67		25	MHz

* 5 < Iw • Lh < 50 mA • µH, 1 < Rh ≤ 1.25/Iw, WUS available in bonding option.

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SWITCHING CHARACTERISTICS (continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Head Current					
WDI to Ix - Iy (TD3)	Lh = 0, Rh = 0 from 50% points		25	40	ns
Asymmetry	WDI has 1 ns rise/fall time			1.5	ns
Rise/fall Time	10% to 90% points				
	Rwc = 2kΩ, Rh = 0, Lh = 0		2	9	ns
	Rwc = 2kΩ, Rh = 30Ω, Lh = 1μH		14	18	ns
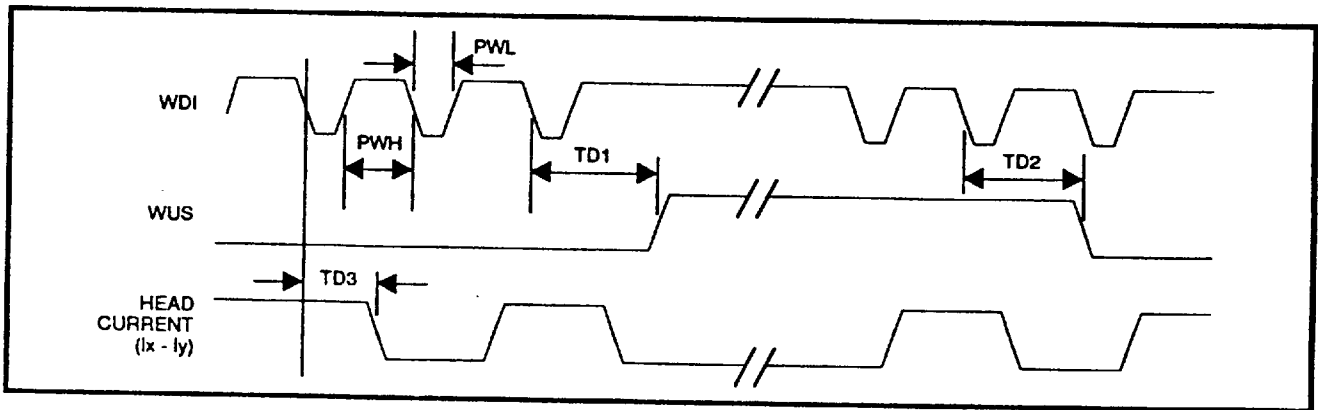
FIGURE 1: Write Mode Timing Diagram

TABLE 1: Device Option Summary

Device #	WDI Type	Servo Enable	Damping Resistor	WUS
32R2320W	TTL	$\overline{SE}$	No	No
32R2320RW	TTL	$\overline{SE}$	350Ω	No
32R2321W	ECL	$\overline{SE}$	No	No
32R2321RW	ECL	$\overline{SE}$	350Ω	No
32R2322RW	TTL	SE	DMP pin	Yes
32R2323W	TTL	WUS/SE	No	Yes
32R2323RW	TTL	WUS/SE	350Ω	Yes
32R2324W	ECL	WUS/SE	No	Yes
32R2324RW	ECL	WUS/SE	350Ω	Yes

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PACKAGE PIN DESIGNATIONS
(Top View)

32R2320 Package Options

GND ☐	1		16	☐ $\overline{CS}$
H0X ☐	2		15	☐ R/$\overline{W}$
H0Y ☐	3		14	☐ WC
H1X ☐	4		13	☐ RDY
H1Y ☐	5		12	☐ RDX
VCC ☐	6		11	☐ HS0
N/C ☐	7		10	☐ WDI
$\overline{SE}$ ☐	8		9	☐ WUS
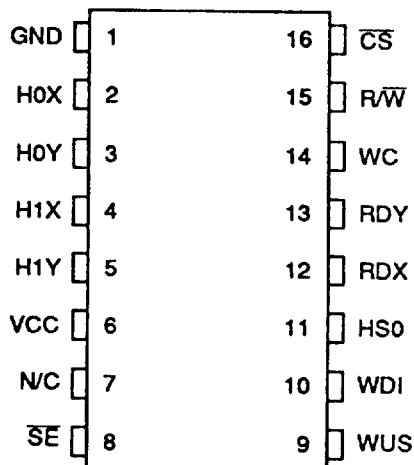
16-Pin Packages:

32R2320RW-2CL (SOL)
32R2320W-2CL (SOL)
32R2320RW-2CN (SON)
32R2320W-2CN (SON)

GND ☐	1		20	☐ $\overline{CS}$
H0X ☐	2		19	☐ R/$\overline{W}$
H0Y ☐	3		18	☐ WC
H1X ☐	4		17	☐ RDY
H1Y ☐	5		16	☐ RDX
H2X ☐	6		15	☐ HS0
H2Y ☐	7		14	☐ HS1
H3X ☐	8		13	☐ N/C
H3Y ☐	9		12	☐ WDI
VCC ☐	10		11	☐ $\overline{SE}$
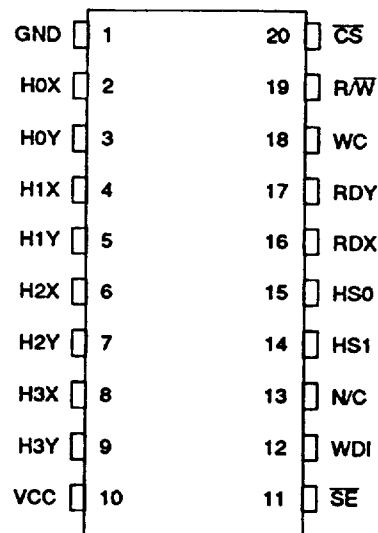
20-Pin Packages:

32R2320RW-4CL (SOL)
32R2320W-4CL (SOL)
32R2320RW-4CV (VSOP)
32R2320W-4CV (VSOP)
32R2320RW-4CVT (VTSOP)
32R2320W-4CVT (VTSOP)

> CAUTION: Use handling procedures necessary
> for a static sensitive component.

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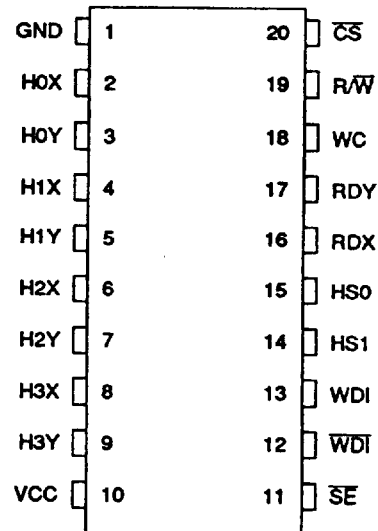
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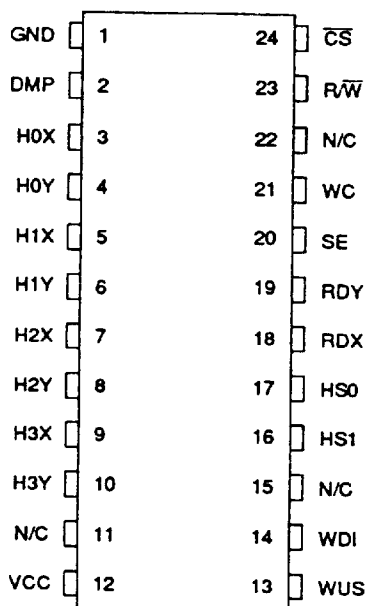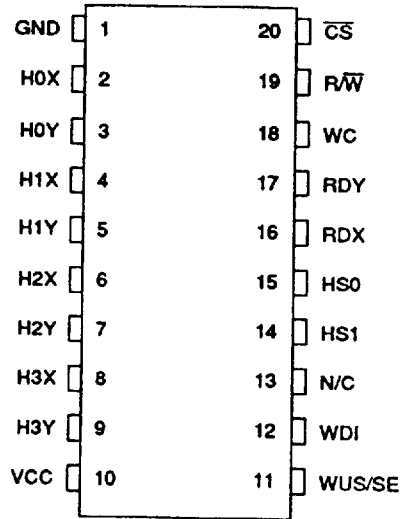## 32R2321 Package Options
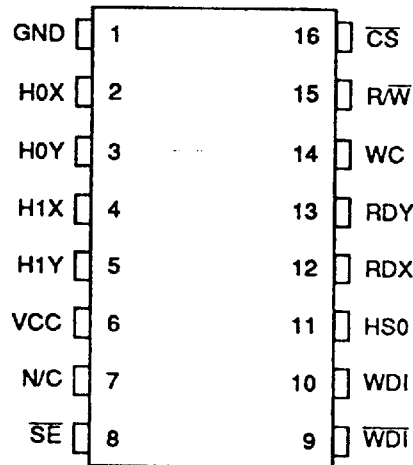
16-Pin Packages:

32R2321RW-2CL (SOL)
32R2321W-2CL (SOL)
32R2321RW-2CN (SON)
32R2321W-2CN (SON)

20-Pin Packages:

32R2321RW-4CL (SOL)
32R2321W-4CL (SOL)
32R2321RW-4CV (VSOP)
32R2321W-4CV (VSOP)
32R2321RW-4CVT (VTSOP)
32R2321W-4CVT (VTSOP)

32R2322 Package Options

24-Pin Packages:
32R2322RW-4CVT (VTSOP)

CAUTION: Use handling procedures necessary
for a static sensitive component.

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PACKAGE PIN DESIGNATIONS (continued)
(Top View)

32R2323 Package Options

GND	1		20	$\overline{CS}$
H0X	2		19	R/$\overline{W}$
H0Y	3		18	WC
H1X	4		17	RDY
H1Y	5		16	RDX
H2X	6		15	HS0
H2Y	7		14	HS1
H3X	8		13	N/C
H3Y	9		12	WDI
VCC	10		11	WUS/SE

20-Pin Packages:

32R2323RW-4CV (VSOP)
32R2323W-4CV (VSOP)

32R2324 Package Options

GND	1		20	$\overline{CS}$
H0X	2		19	R/$\overline{W}$
H0Y	3		18	WC
H1X	4		17	RDY
H1Y	5		16	RDX
H2X	6		15	HS0
H2Y	7		14	HS1
H3X	8		13	WDI
H3Y	9		12	$\overline{WDI}$
VCC	10		11	WUS/SE
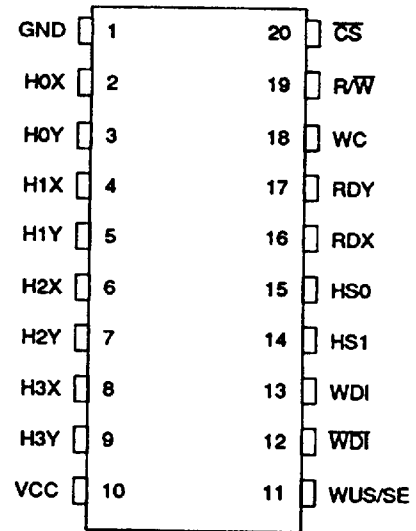
20-Pin Packages:

32R2324RW-4CV (VSOP)
32R2324W-4CV (VSOP)

CAUTION: Use handling procedures necessary for a static sensitive component.

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