### 5. TMS9918A/9928A/9929A ELECTRICAL SPECIFICATIONS

# 5.1 ABSOLUTE MAXIMUM RATINGS OVER OPERATING FREE-AIR TEMPERATURE RANGE (unless otherwise noted)\*

Supply voltage, V <sub>CC</sub>	0.3 to 20 V
All input voltages	0.3 to 20 V
Output voltage	2 to 7 V
Continuous power dissipation	1.3 W
Operating free-air temperature range	0°C to 70°C
Storage temperature range – 5	55°C to +150°C

<sup>\*</sup>Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the Recommended Operating Conditions section of this specification is not implied. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

### 5.2 RECOMMENDED OPERATING CONDITIONS\*

PARAM	METER	MIN	NOM	MAX	UNIT
Supply voltage, V <sub>CC</sub>		4.75		5.25	٧
Supply voltage, VSS			0		٧
	SYNC active	10		12	٧
Input Voltage, V <sub>I</sub> ,	RESET active			0.6	٧
RESET/SYNC pin	SYNC and RESET inactive	3		6	٧
	XTAL1, XTAL2	2.75			٧
High-level input, VIH	All other inputs	2.2			٧
Input voltage, V <sub>I</sub> , EXT VDP pin (TMS9918A only)	SYNC level White level Black level		2.6 3.7 3		V V
Low-level input voltage, V <sub>IL</sub>				0.8	V
Operating free-air temperature, TA		0		70	°C

<sup>\*</sup> All voltage values are with respect to VSS.

# 5.3 ELECTRICAL CHARACTERISTICS OVER FULL RANGES OF RECOMMENDED OPERATING CONDITION (unless otherwise noted)

## TMS9918A/9928A/9929A

	PARAI	METER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
	High-level RAS, CAS, R/W			2.7	3.4		v
	output voltage	All other outputs	I <sub>OH</sub> = 400 μA	2.4	3.2		•
	Low-level	CPU data	I <sub>OL</sub> = 1.2 mA		0.3	0.6	V
VOL	output voltage	DRAM interface	I <sub>OL</sub> = 800 μA			0.6	<b>,</b>
lozh	Off-state outpu applied, D0-D7	t current high-level voltage outputs	V <sub>O</sub> = 5.25 V		1	100	μΑ
İOZL	Off-state output applied, D0-D7	t current high-level voltage outputs	V <sub>O</sub> = 0.4 V		1	-100	μΑ
ΊΗ	High-level inpu	t current	V <sub>I</sub> = 5.25 V, all other pins at 0 V			10	μΑ
IIL.	Low-level input	current	V <sub>I</sub> = 0 V, All other pins at 0 V			-10	μΑ

## TMS9918A Only (Figure 5-1)

17 17 17 17 17 17 17 17 17 17 17 17 17 1	PARAMETER	TEST CONDITIONS	MIN	NOM	MAX	UNIT
V <sub>white</sub>	Video voltage level of white, COMVID		2.8	3.0	3.2 V	
V <sub>black</sub>	Video voltage level of black (blank), COMVID	R <sub>L</sub> = 470 Ω	2.1	2.3	2.5 V	
V <sub>sync</sub>	Video voltage level of sync, COMVID		1.85	2.0	2.1 V	

 $<sup>^{\</sup>dagger}$  All typical values are at VCC  $\,=\,$  5.25 V,  $T_{\mbox{\scriptsize A}}\,=\,25\,^{\circ}\mbox{\scriptsize C}.$ 

# 5.3 ELECTRICAL CHARACTERISTICS OVER FULL RANGES OF RECOMMENDED OPERATING CONDITIONS (unless otherwise noted) (Continued)

## TMS9928A/9929A Only (Figure 5-1)

	PARAMETER	TEST CONDITIONS	MIN	NOM	MAX	UNIT
V <sub>white</sub>	Video voltage level of white, Y, R-Y, B-Y outputs		2.5	3	3.6	٧
V <sub>black</sub>	Video voltage level of black (blank), Y, R-Y, B-Y outputs	R <sub>L</sub> = 470 Ω	. 1.6	2.3	2.5	٧
V <sub>sync</sub>	Video voltage level of sync, Y output		1.2	1.8	2	٧

#### TMS9929A Only

	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V <sub>PS</sub>	Color burst video voltage level with respect to V no color	R-Y output		0.25		٧
V <sub>neg</sub>	Color burst video voltage level with respect to V no color	B-Y output		-0.25		٧

### TMS9918A/9928A/9929A (Figure 5-2)

	PARAM	ETER	TEST CONDITIONS	MIN	NOM	MAX	UNIT
	Video voltage o R-Y, B-Y outpu	lifference, white-black, Y,		0.7	1.0		٧
lcc	Average supply	current from VCC	T <sub>A</sub> = 25°C		200	250	mA
		D0-D7				20	
Ci	Input capacitance	All other inputs	unmeasured f = 11 MHz, pins at 0 V			10 10	pF
Co	Output capacita	nce	unmeasured f = 11 MHz, pins at 0 V			20	pF

 $<sup>\</sup>dagger$  All typical values are at VCC = 5.25 V, TA = 25  $^{\circ}\text{C}.$ 

# 5.4 TIMING REQUIREMENTS OVER FULL RANGES OF RECOMMENDED OPERATING CONDITIONS (TMS9918A/9928A/9929A)

CPU - VDP Interface (Figures 5-3 and 5-4)

	PARAMETER	MIN	NOM	MAX	UNIT
t <sub>su(A-RL)</sub>	Address setup time before CSR low		0		ns
t <sub>su(A-WL)</sub>	Address setup time before CSW low		30		ns
th(WL-A)	Address hold time after CSW low		30		ns
t <sub>su</sub> (D-WH)	Data setup time before CSW high		100		ns
th(WH-D)	Data hold time after CSW high		30		ns
t <sub>W</sub> (WL)	Pulse width, CSW low		200		ns
tw(CS-H1)	Pulse width, chip select high (requesting memory access)		8		μs
tw(CS-H2)	Pulse width, chip select high (not requesting memory access)		2		μs

## VDP-VRAM Interface (Figure 5-5 and 5-6)

	PARAMETER	MIN	NOM	MAX	UNIT
t <sub>C</sub>	Memory read or write cycle time	372			ns
t <sub>su</sub> (D-CH)	Input data setup time before CAS high	60			ns
th(CH-D)	Input data hold time after CAS high	0			ns

## External Clock Source (Figure 5-7)

	PARAMETER	М	IN T	ΥP	MAX	UNIT
f <sub>ext</sub>	External source frequency	10	.738098 10.7	386:	35 10.739172	MHz
t <sub>r</sub> /t <sub>f</sub>	External source rise/fall time			10	15	ns
t <sub>wH</sub>	External source high-level pulse width	4	2	47	52	ns
t <sub>WL</sub>	External source low-level pulse width	4	2	47	52	ns
t <sub>pD</sub>	External source phase delay from XTAL1 falling edge to XTAL2 falling edge	4	2	47	52	ns

# 5.5 SWITCHING CHARACTERISTICS OVER FULL RANGE OF RECOMMENDED OPERATING CONDITIONS (TMS9918A/9928A/9929A)

### **CPU-VDP Interface**

	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
TA(CSR)	Data access time from CSR low			100	150	ns
tPVX	Data disable time after CSR high	C <sub>1</sub> = 300 pF		65	100	ns
<sup>t</sup> PVX,A	Data invalid time from address changes			0		ns
fCPUCLK	CPU clock output clock frequency (f <sub>ext</sub> + 3)	- L	3.4	3.58	3.76	MHz
fGROMCLK	GROM clock output clock frequency (f <sub>ext</sub> + 24)		425.12	447.5	469.88	kHz

### VDP-VRAM Interface (Figures 5-5 and 5-6)

	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
t <sub>W</sub>	Pulse width, CAS high		80	100	120	ns
<sup>t</sup> w(CL)	Pulse width, CAS low		220	230	250	ns
<sup>t</sup> w(RH)	Pulse width, RAS high		100	125	150	ns
<sup>t</sup> w(RL)	Pulse width, RAS low		190	210	230	ns
t <sub>w</sub> (W)	Pulse width, write pulse		170	190	210	ns
<sup>†</sup> CA-CL	Delay time, column address to CAS low	C <sub>L</sub> = 50 pF	-10	-2		ns
<sup>t</sup> RA-RL	Delay time, row address to RAS low		25	45	65	ns
<sup>t</sup> d-WL	Delay time, data to R/W low		0	6	20	ns
<sup>‡</sup> WH-CL	Delay time, R/W high to CAS low		25	50	75	ns
tw-cн	Delay time, R/W low to CAS high		120	140	160	ns
tW-RH	Delay time, R/W low to RAS high		60	75	90	ns

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# 5.5 SWITCHING CHARACTERISTICS OVER FULL RANGE OF RECOMMENDED OPERATING CONDITION (TMS9918A/9928A/9929A) (Continued)

TMS9918A Composite video output (Figures 5-8 and 5-9)

	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
<sup>†</sup> CL-CA	Column address valid after CAS low		45	65	85	ns
<sup>t</sup> RL-RA	Row address valid after RAS low		20	25	30	ns
tRL-CA	Column address valid after RAS low		95	110	130	ns
tCL-D	Data valid after CAS low	]	240	260	280	ns
t <sub>RL-D</sub>	Data valid after RAS low	CL = 50 pF	95	110	125	ns
tWL-D	Data valid after R/W low		135	165	195	ns
tCH-WL	Read command valid after CAS high		0			ns
tCL-W	Write command valid after CAS low		270	290	310	ns
tCH-RL	Delay time, CAS high to RAS low	1	45	65		ns
<sup>t</sup> CL-RH	Delay time, CAS low to RAS high	]	150	170	190	ns
tRL-CL	Delay time, RAS low to CAS low		30	40	50	ns

# 5.5 SWITCHING CHARACTERISTICS OVER FULL RANGE OF RECOMMENDED OPERATING CONDITIONS (TMS9918A/9928A/9929A) (Continued)

TMS9918A Composite video output (Figures 5-8 and 5-9)

	PARAMETER	TEST CONDITIONS	MIN TYP	MAX	UNIT
tfi	Fall time, V <sub>black</sub> to V <sub>sync</sub>	R <sub>L</sub> = 470 Q C <sub>L</sub> = 150 pF	10		ns
<sup>t</sup> w(HS)	Pulse width, horizontal sync		4.84	μs	
t <sub>ri</sub>	Rise time, V <sub>sync</sub> to V <sub>black</sub>		20	ns	
tHS-CD	Delay time, sync to color burst		372		ns
tw(CB)	Width, color burst		261		μs
tCB-LB	Delay time, color burst to left border		1.49	μs	
t <sub>r2</sub>	Rise time, V <sub>black</sub> to V <sub>white</sub>		60		ns
tw(LB)	Left border video width		2.42	2.42	
tf2	Fall time, V <sub>White</sub> to V <sub>black</sub>		110	110	
tw(AD)	Width of active display area		47.68		μs
tw(RB)	Right border video width		2.79	2.79	
tRB-HS	Delay time, right border to horizontal sync		1.49		μs μs
tVFB	Vertical front blanking		191.1		μs
tVS	Vertical sync		191.1		μs
V <sub>VBB</sub>	Vertical back blanking		828		μs
t <sub>ABA</sub>	Active plus border area time	]	18.8		ms

NOTE: Fall times depend on external pull-down resistor

# 5.5 SWITCHING CHARACTERISTICS OVER FULL RANGE OF RECOMMENDED OPERATING CONDITION (TMS9918A/9929A) (Continued)

TMS9928A/9929A Y, R-Y, B-Y outputs (Figures 5-10 through 5-13)

tw(HSI)         Pulse width, horizontal sync         4.84         μ           t <sub>r3</sub> Rise time, V <sub>sync</sub> to V <sub>black</sub> 150         n           t <sub>w(BP)</sub> Width, back porch         4.47         μ           t <sub>w(IBI)</sub> Width, left border         2.8         μ           t <sub>w(IBI)</sub> Width, left border         186.24         n           t <sub>w(IP)</sub> Pulse width, pixel         186.24         n           t <sub>w(IADI)</sub> Width, horizontal line         63.695         μ           t <sub>w(IADI)</sub> Width, active display area         47.67         μ           t <sub>r4</sub> Rise time, V <sub>black</sub> to V <sub>white</sub> 75         n           t <sub>r4</sub> Fall time, V <sub>white</sub> to V <sub>black</sub> 50         n           t <sub>w(IRBI)</sub> Width, front porch         2.42         μ           t <sub>w(IRBI)</sub> Width, front porch         1.49         μ           t <sub>w(ICB-I)</sub> Pulse width, pos color burst         2.6         μ           t <sub>w(ICB-I)</sub> Pulse width, pos CB to V no color         1.49         μ           t <sub>w(ICB-IBI)</sub> Delay time, pos CB to left border         1.49         μ           t <sub>w(ICB-IBI)</sub> Pulse width, vertical sync         150 <th></th> <th>PARAMETER</th> <th>TEST CONDITIONS</th> <th>MIN TY</th> <th>P MAX</th> <th>UNIT</th>		PARAMETER	TEST CONDITIONS	MIN TY	P MAX	UNIT
t <sub>γ3</sub> Rise time, V <sub>sync</sub> to V <sub>black</sub> t <sub>w(BP)</sub> Width, back porch  t <sub>w(LBI)</sub> Width, left border  t <sub>w(IDI)</sub> Pulse width, pixel  t <sub>w(ADI)</sub> Width, horizontal line  t <sub>w(ADI)</sub> Width, active display area  t <sub>γ4</sub> Rise time, V <sub>black</sub> to V <sub>white</sub> t <sub>γ4</sub> Fall time, V <sub>white</sub> to V <sub>black</sub> t <sub>w(FP)</sub> Width, front porch  t <sub>w(FP)</sub> Width, front porch  t <sub>γ5</sub> Rise time, V no color to V pos CB  t <sub>w(CB1)</sub> Pulse width, pos color burst  t <sub>γ6</sub> Fall time, V pos CB to V no color  t <sub>w(CB-LBI)</sub> Delay time, pos CB to left border  t <sub>γ6</sub> Rise time, V neg CB to V no color  t <sub>w(VSI)</sub> Pulse width, vertical sync  t <sub>VSI</sub> Vertical sync  t <sub>VABI</sub> Vertical back blanking  t <sub>VABAI</sub> Active area plus border area total	tf3	Fall time, V <sub>black</sub> to V <sub>sync</sub>		1	ns	
tw(BP)         Width, back porch         4.47         μ           tw(LBI)         Width, left border         2.8         μ           tw(P)         Pulse width, pixel         186.24         n           tw(ADI)         Width, horizontal line         63.695         μ           tw(ADI)         Width, active display area         47.67         μ           tr4         Rise time, Vblack to Vwhite         75         n           tw(RBI)         Width, right border         2.42         μ           tw(FP)         Width, front porch         1.49         μ           tr5         Rise time, V no color to V pos CB         1.49         μ           tr6         Fall time, V pos CB to V no color         1.49         μ           tr6         Fall time, V no color to V neg CB         100         n           tr6         Rise time, V neg CB to V no color         1.49         μ           tw(VSI)         Pulse width, vertical sync         465         n           tVFBI         Vertical front blanking         191.09         μ           tVBI         Vertical back blanking         828.04         μ           tVBAAAI         Active area plus border area total         18.70         m	<sup>t</sup> w(HSI)	Pulse width, horizontal sync		4.84		μs
tw(LBI)         Width, left border           tw(P)         Pulse width, pixel         186.24         π           tw(horz)         Width, horizontal line         63.695         μ           tw(ADI)         Width, horizontal line         63.695         μ           tw(ADI)         Width, active display area         47.67         μ           tr4         Rise time, Vblack to Vwhite         75         n           tw(RBI)         Width, right border         2.42         μ           tw(FP)         Width, front porch         RL = 470 Ω         1.49         μ           tw(CB1)         Pulse width, pos color burst         CL = 15 pF         2.6         μ           tf5         Fall time, V pos CB to V no color         1.49         μ           tw(CB-LBI)         Delay time, pos CB to left border         1.49         μ           tr6         Fall time, V no color to V neg CB         100         n           tw(VSI)         Pulse width, vertical sync         150         n           tVFBI         Vertical front blanking         191.09         μ           tVSI         Vertical back blanking         191.09         μ           tABAII         Active area plus border area total         18.70         m <td>t<sub>r</sub>3</td> <td>Rise time, V<sub>sync</sub> to V<sub>black</sub></td> <td></td> <td colspan="2">150</td> <td>ns</td>	t <sub>r</sub> 3	Rise time, V <sub>sync</sub> to V <sub>black</sub>		150		ns
tw(P)       Pulse width, pixel         tw(horz)       Width, horizontal line         tw(ADI)       Width, active display area         tr4       Rise time, Volack to Vwhite         tr4       Fall time, Vwhite to Volack         tw(RBI)       Width, right border         tw(FP)       Width, front porch         tr5       Rise time, V no color to V pos CB         tw(CB1)       Pulse width, pos color burst         tr6       Fall time, V pos CB to V no color         tr6       Fall time, V no color to V neg CB         tr6       Rise time, V no color to V neg CB         tr6       Rise time, V no gCB to V no color         tw(VSI)       Pulse width, vertical sync         tVFBI       Vertical front blanking         tVSI       Vertical back blanking         tABAI       Active area plus border area total	t <sub>w(BP)</sub>	Width, back porch		4.	μs	
tw(horz)         Width, horizontal line         63.695         μ           tw(ADI)         Width, active display area         47.67         μ           tr4         Rise time, Vblack to Vwhite         75         n           tr4         Fall time, Vwhite to Vblack         50         n           tw(RBI)         Width, right border         2.42         μ           tw(FP)         Width, front porch         1.49         μ           tr5         Rise time, V no color to V pos CB         CL = 15 pF         2.6         μ           tr5         Fall time, V pos CB to V no color         100         n           tw(CB-LBI)         Delay time, pos CB to left border         1.49         μ           tr6         Fall time, V no color to V neg CB         100         n           tr6         Rise time, V neg CB to V no color         1.49         μ           tw(VSI)         Pulse width, vertical sync         465         n           tVFBI         Vertical front blanking         191.09         μ           tVBBI         Vertical back blanking         328.04         μ           tABAI         Active area plus border area total         18.70         m	tw(LBI)	Width, left border		:	μs	
tw(ADI) Width, active display area  tr4 Rise time, Vblack to Vwhite  tr4 Fall time, Vwhite to Vblack  tw(RBI) Width, right border  tw(FP) Width, front porch  tr5 Rise time, V no color to V pos CB  tw(CB1) Pulse width, pos color burst  tr5 Fall time, V pos CB to V no color  tw(CB-LBI) Delay time, pos CB to left border  tr6 Fall time, V no color to V neg CB  tr6 Rise time, V no color to V neg CB  tr7 Rise time, V no color to V neg CB  tr7 Rise time, V pos CB to V no color  tw(VBI) Pulse width, vertical sync  tvFBI Vertical front blanking  tvSI Vertical back blanking  tABAI Active area plus border area total	t <sub>w(P)</sub>	Pulse width, pixel		186.	ns	
t <sub>r4</sub> Rise time, V <sub>black</sub> to V <sub>white</sub> t <sub>r4</sub> Fall time, V <sub>white</sub> to V <sub>black</sub> t <sub>w(RBI)</sub> Width, right border  t <sub>w(FP)</sub> Width, front porch  t <sub>r5</sub> Rise time, V no color to V pos CB  t <sub>w(CB1)</sub> Pulse width, pos color burst  t <sub>f5</sub> Fall time, V pos CB to V no color  t <sub>w(CB-LBI)</sub> Delay time, pos CB to left border  t <sub>f6</sub> Fall time, V no color to V neg CB  t <sub>r6</sub> Rise time, V no color to V neg CB  t <sub>w(VSI)</sub> Pulse width, vertical sync  t <sub>VFBI</sub> Vertical front blanking  t <sub>VSI</sub> Vertical back blanking  t <sub>ABAI</sub> Active area plus border area total	tw(horz)	Width, horizontal line		63.6	μs	
t <sub>r4</sub> Fall time, V <sub>white</sub> to V <sub>black</sub> t <sub>w(FP)</sub> Width, right border  t <sub>tr5</sub> Rise time, V no color to V pos CB  t <sub>w(CB1)</sub> Pulse width, pos color burst  t <sub>tf5</sub> Fall time, V pos CB to V no color  t <sub>w(CB-LBI)</sub> Delay time, pos CB to left border  t <sub>tf6</sub> Fall time, V no color to V neg CB  t <sub>tr6</sub> Rise time, V no color to V neg CB  t <sub>tr6</sub> Rise time, V no color to V neg CB  t <sub>tr6</sub> Rise time, V no color to V neg CB  t <sub>tr6</sub> Rise time, V neg CB to V no color  t <sub>w(VSI)</sub> Pulse width, vertical sync  t <sub>VFBI</sub> Vertical front blanking  t <sub>VSI</sub> Vertical sync  t <sub>VBBI</sub> Vertical back blanking  t <sub>ABAI</sub> Active area plus border area total	tw(ADI)	Width, active display area		47.	μs	
tw(RBI) Width, right border  tw(FP) Width, front porch  tr5 Rise time, V no color to V pos CB  tw(CB1) Pulse width, pos color burst  tr5 Fall time, V pos CB to V no color  tw(CB-LBI) Delay time, pos CB to left border  tr6 Fall time, V no color to V neg CB  tr6 Rise time, V neg CB to V no color  tw(VSI) Pulse width, vertical sync  tVFBI Vertical front blanking  tVSI Vertical back blanking  tABAI Active area plus border area total	t <sub>r4</sub>	Rise time, V <sub>black</sub> to V <sub>white</sub>			ns	
tw(FP) Width, front porch  tr5 Rise time, V no color to V pos CB  tw(CB1) Pulse width, pos color burst  tf5 Fall time, V pos CB to V no color  tw(CB-LBI) Delay time, pos CB to left border  tf6 Fall time, V no color to V neg CB  tr6 Rise time, V no g CB to V no color  tw(VSI) Pulse width, vertical sync  tVFBI Vertical front blanking  tVSI Vertical back blanking  tABAI Active area plus border area total	t <sub>r4</sub>	Fall time, V <sub>white</sub> to V <sub>black</sub>		50		ns
tr5 Rise time, V no color to V pos CB  tw(CB1) Pulse width, pos color burst  tf5 Fall time, V pos CB to V no color  tw(CB-LBI) Delay time, pos CB to left border  tf6 Fall time, V no color to V neg CB  tr6 Rise time, V no color to V neg CB  tw(VSI) Pulse width, vertical sync  tVFBI Vertical front blanking  tVSI Vertical sync  tVBBI Vertical back blanking  tABAI Active area plus border area total	tw(RBI)	Width, right border		2.42		μs
tr5 Rise time, V no color to V pos CB  tw(CB1) Pulse width, pos color burst  tr5 Fall time, V pos CB to V no color  tw(CB-LBI) Delay time, pos CB to left border  tr6 Fall time, V no color to V neg CB  tr6 Rise time, V neg CB to V no color  tw(VSI) Pulse width, vertical sync  tVFBI Vertical front blanking  tVSI Vertical sync  tVBBI Vertical back blanking  tABAI Active area plus border area total	t <sub>W</sub> (FP)	Width, front porch		1.49		μs
ty(CB1) Pulse width, pos color burst  tf5 Fall time, V pos CB to V no color  tw(CB-LBI) Delay time, pos CB to left border  tf6 Fall time, V no color to V neg CB  tr6 Rise time, V neg CB to V no color  tw(VSI) Pulse width, vertical sync  tVFBI Vertical front blanking  tVSI Vertical sync  tVBBI Vertical back blanking  tABAI Active area plus border area total	t <sub>r5</sub>	Rise time, V no color to V pos CB		150		ns
tw(CB-LBI) Delay time, pos CB to left border  tf6 Fall time, V no color to V neg CB  tr6 Rise time, V neg CB to V no color  tw(VSI) Pulse width, vertical sync  tVFBI Vertical front blanking  tVSI Vertical sync  tVBBI Vertical back blanking  tVBBI Vertical back blanking  tABAI Active area plus border area total	tw(CB1)	Pulse width, pos color burst	C <sub>L</sub> = 15 pF	2.6		μs
tf6 Fall time, V no color to V neg CB  tr6 Rise time, V neg CB to V no color  tw(VSI) Pulse width, vertical sync  tVFBI Vertical front blanking  tVSI Vertical sync  tVBBI Vertical back blanking  tVBBI Vertical back blanking  tABAI Active area plus border area total	t <sub>f5</sub>	Fall time, V pos CB to V no color		100		ns
t <sub>r6</sub> Rise time, V neg CB to V no color  t <sub>w(VSI)</sub> Pulse width, vertical sync  tVFBI Vertical front blanking  tVSI Vertical sync  tVBBI Vertical back blanking  tVBBI Vertical back blanking  tABAI Active area plus border area total	tw(CB-LBI)	Delay time, pos CB to left border		1.49		μs
tw(VSI)       Pulse width, vertical sync       465       n         tVFBI       Vertical front blanking       191.09       μ         tVSI       Vertical sync       191.09       μ         tVBBI       Vertical back blanking       828.04       μ         tABAI       Active area plus border area total       18.70       m	t <sub>f6</sub>	Fall time, V no color to V neg CB		100		ns
tVFBI Vertical front blanking 191.09 μ tVSI Vertical sync 191.09 μ tVBBI Vertical back blanking 828.04 μ tABAI Active area plus border area total 18.70 m	t <sub>r6</sub>	Rise time, V neg CB to V no color		150		ns
tySt Vertical sync 191.09 μ tyBBI Vertical back blanking 828.04 μ tABAI Active area plus border area total 18.70 m	tw(VSI)	Pulse width, vertical sync		465		ns
tyBBI Vertical back blanking 828.04 µ tABAI Active area plus border area total 18.70 m	<sup>‡</sup> VFBI	Vertical front blanking		191.09		μs
t <sub>ABAI</sub> Active area plus border area total 18.70 m	tVSI	Vertical sync		191.09		μs
ADA	tVBBI	Vertical back blanking		828.04		μs
Vertical time 19.91 m	<sup>t</sup> ABAI	Active area plus border area total		18	.70	mS
		Vertical time		19	.91	mS

NOTE: Fall times depend on external pull-down resistor.

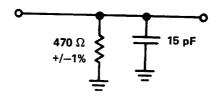


FIGURE 5-1 — LOAD CIRCUIT FOR COMVID (ALL DEVICES) AND R-Y, Y, B-Y SWITCHING CHARACTERISTICS (TMS9928A/9929A)

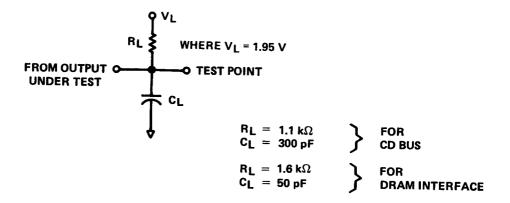


FIGURE 5-2 - LOAD CIRCUITS FOR ALL OUTPUTS EXCEPT COMVID, R-Y, Y, B-Y

#### WRITE CYCLE

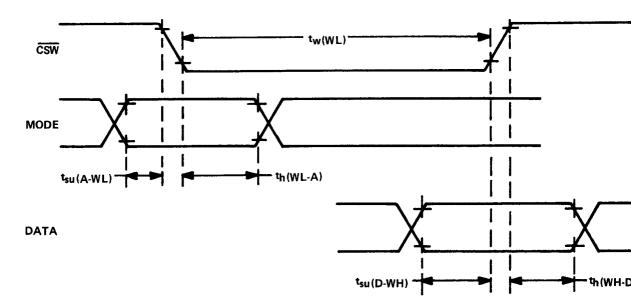
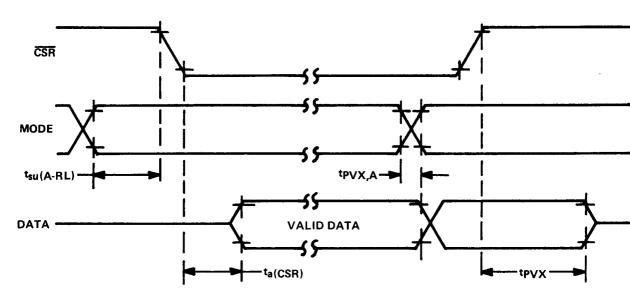


FIGURE 5-3 — CPU-VDP WRITE CYCLE FOR TMS9918A/9928A/9929A

### **READ CYCLE**



NOTE: All measurements are made at 10% and 90% points.

FIGURE 5-4 - CPU-VDP READ CYCLE FOR TMS9918A/9928A/9929A

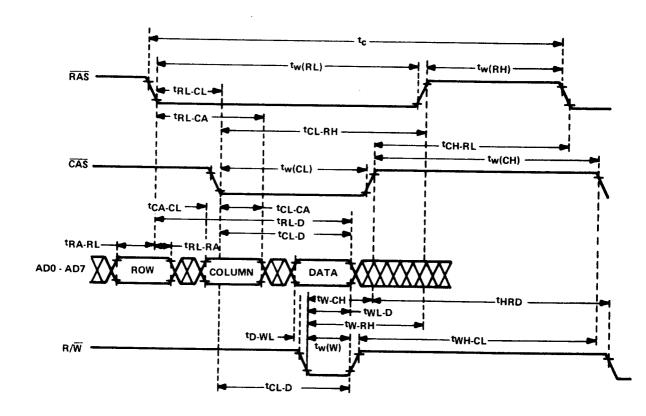


FIGURE 5-5 - VRAM WRITE CYCLE

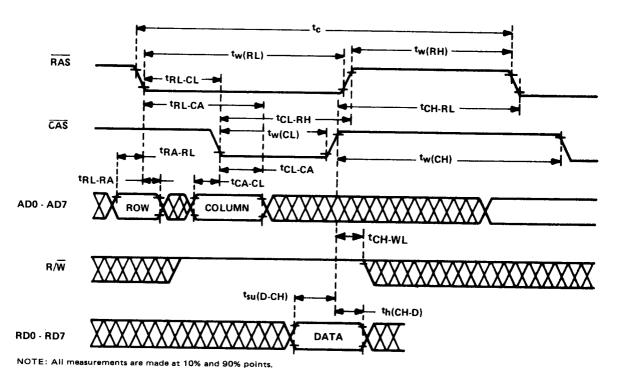
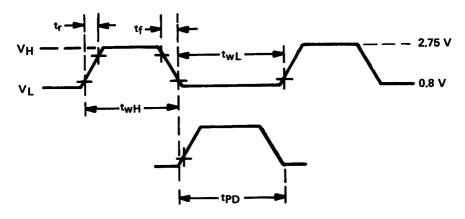


FIGURE 5-6 - VRAM READ CYCLE



NOTE: All measurements are made at 10% and 90% points.

FIGURE 5-7 — EXTERNAL CLOCK TIMING WAVEFORM

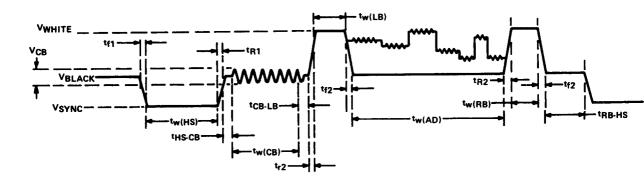


FIGURE 5-8 - TMS9918A COMVID HORIZONTAL TIMING

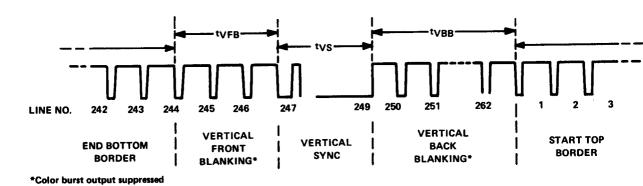


FIGURE 5-9 — TMS9918A VERTICAL TIMING

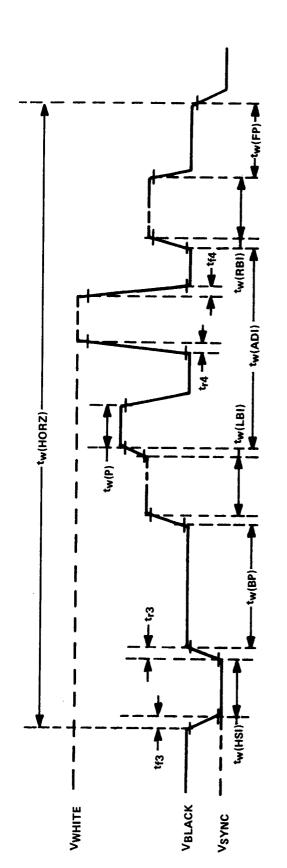
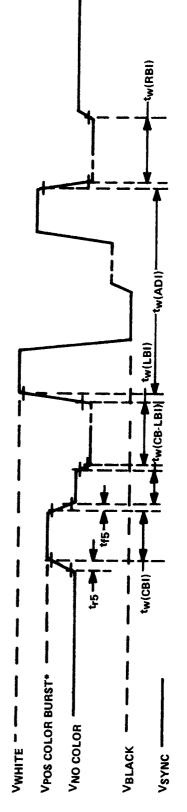


FIGURE 5-10 - TMS9928A/9829A Y HORIZONTAL TIMING



\*Absent for the TMS9928A

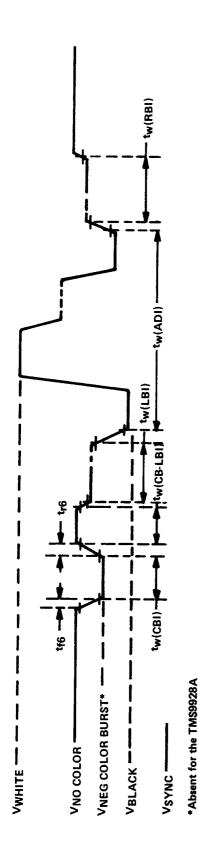


FIGURE 5-12 - TMS9828A/9829A B-Y HORIZONTAL TIMING

