Micro Linear

ML6440*

Multi-Standard 8-bit Adaptive Digital Input Comb Filter

GENERAL DESCRIPTION

The ML6440 SmartComb™ is a single-chip, 8-bit digital comb filter that incorporates line delays and adaption algorithms for NTSC and PAL at both CCIR601 and square pixel rates. The ML6440 implements bandsplit filters and a proprietary adaption and decision logic block that allows for optimum combing over a wide range of video sources.
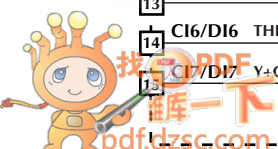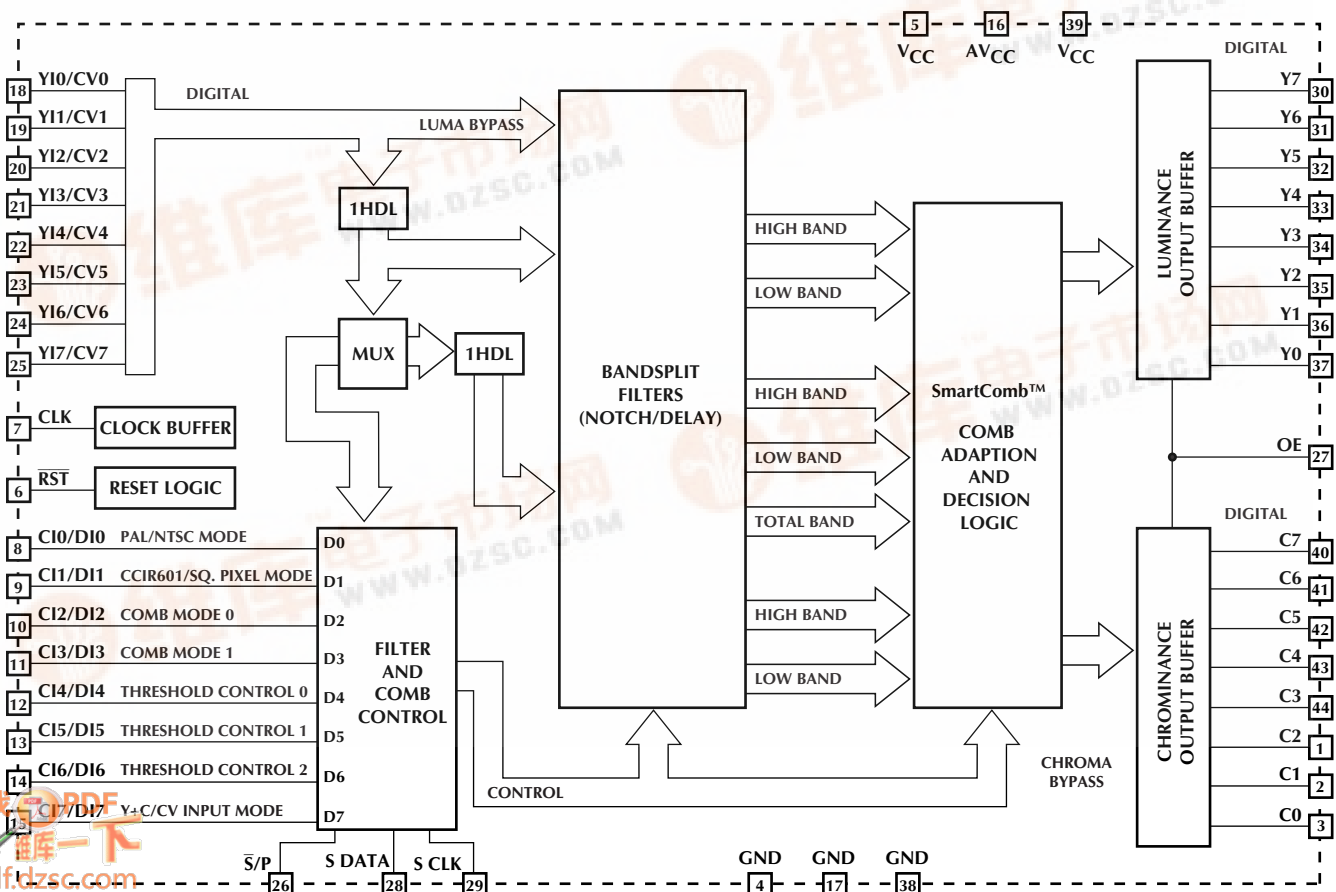
The ML6440 contains all the necessary circuitry to provide high quality combed output of luminance and chrominance in the Y/C format. Internal filters with integrated adaption and compensation circuits provide filtered outputs with optimal video bandwidth and resolution while suppressing cross-color (rainbow), cross-luminance (dot crawl) and other corrupting artifacts that can reduce video compression efficiency.

FEATURES

- SmartComb algorithm for automatic or manual selection adaption thresholds

- 3-line comb with 60+ line frame adjust

- Comb/notch thresholds set dynamically over 60+ lines automatically

- 12-bit processing minimizes truncation errors and maintains signal-to-noise performance

- Optional 8-bit composite or separated Y/C digital inputs

- Applications: digital TV, line doubler, imaging

- Separate comb/notch filter thresholds for Luma and Chroma channels

- Optional pin controls or two-wire serial control interface

- Operating power dissipation less than 700mW

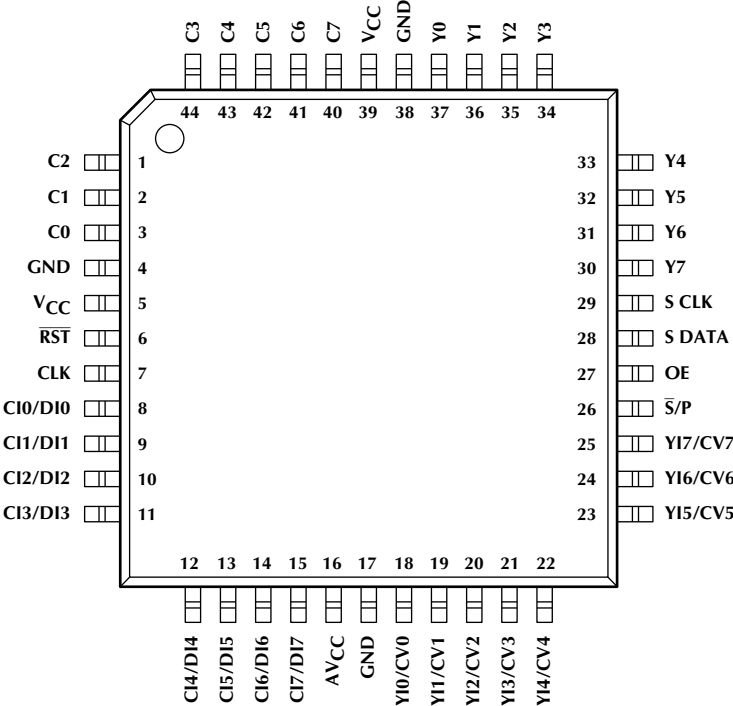- No external components, except diode and caps

BLOCK DIAGRAM

* This Part Is End Of Life As Of August 1, 2000

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PIN CONFIGURATION

ML6440
44-Pin TQFP (H44-14)

Top pins (left to right, 44–34): C3, C4, C5, C6, C7, V_CC, GND, Y0, Y1, Y2, Y3

Left pins (top to bottom, 1–11):
- 1 C2
- 2 C1
- 3 C0
- 4 GND
- 5 V_CC
- 6 RST
- 7 CLK
- 8 CI0/DI0
- 9 CI1/DI1
- 10 CI2/DI2
- 11 CI3/DI3

Right pins (top to bottom, 33–23):
- 33 Y4
- 32 Y5
- 31 Y6
- 30 Y7
- 29 S CLK
- 28 S DATA
- 27 OE
- 26 S̄/P
- 25 YI7/CV7
- 24 YI6/CV6
- 23 YI5/CV5

Bottom pins (left to right, 12–22):
- 12 CI4/DI4
- 13 CI5/DI5
- 14 CI6/DI6
- 15 CI7/DI7
- 16 AV_CC
- 17 GND
- 18 YI0/CV0
- 19 YI1/CV1
- 20 YI2/CV2
- 21 YI3/CV3
- 22 YI4/CV4

TOP VIEW

PIN DESCRIPTION

PIN	NAME	FUNCTION
1	C2	Chrominance output
2	C1	Chrominance output
3	C0	Chrominance output
4	GND	Digital ground pin
5	V_{CC}	Digital supply pin
6	$\overline{RST}$	Reset input active low. Resets comb logic including the internal data register. Required at power up.
7	CLK	TTL compatible clock reference
8	CI0/DI0	(LSB) Input Chrominance signal (PAL/NTSC control pin in control pin mode: register bit D0)
9	CI1/DI1	Input Chrominance signal (Square Pixel/CCIR control pin in control pin mode: register bit D1)
10	CI2/DI2	Input Chrominance signal. (Comb mode 0 control pin in control pin mode: register bit D2)
11	CI3/DI3	Input Chrominance signal (Comb mode 1 control pin in control pin mode: register bit D3)
12	CI4/DI4	Input Chrominance signal (Adaption Threshold 0 control pin in control pin mode: register bit D4)
13	CI5/DI5	Input Chrominance signal (Adaption Threshold 1 control pin mode: register bit D5)
14	CI6/DI6	Input Chrominance signal (Adaption Threshold 2 control pin mode: register bit D6)
15	CI7/DI7	(MSB) Input Chrominance (Y+C/YI control pin in control pin mode: register bit D7)
16	AV_{CC}	Analog supply pin. Bypass to ground with 1µF ceramic capacitor
17	GND	Ground pin for analog delay line
18	YI0/CV0	TTL compatible (LSB) Input composite video signal or Y in the Y+C bypass mode
19	YI1/CV1	Luma or composite video input signal

PIN	NAME	FUNCTION
20	YI2/CV2	Luma or composite video input signal
21	YI3/CV3	Luma or composite video input signal
22	YI4/CV4	Luma or composite video input signal
23	YI5/CV5	Luma or composite video input signal
24	YI6/CV6	Luma or composite video input signal
25	YI7/CV7	Luma or composite video (MSB) input signal
26	$\overline{S}$/P	Serial/Parallel program mode. If high, allows 8-bit parallel control using the eight digital chrominance input pins. Data clocks in on the positive edge transition. If low, serial port active.
27	OE	Output enable. (Y[7:0] and C[7:0]) If low, outputs high impedance.
28	S DATA	Serial data input
29	S CLK	Serial clock input. Positive-edge clocks.
30	Y7	TTL compatible luminance output (MSB)
31	Y6	Luminance output
32	Y5	Luminance output
33	Y4	Luminance output
34	Y3	Luminance output
35	Y2	Luminance output
36	Y1	Luminance output
37	Y0	Luminance output (LSB)
38	GND	Digital ground pin
39	V_{CC}	Digital supply pin
40	C7	TTL compatible chrominance output (LSB)
41	C6	Chrominance output
42	C5	Chrominance output
43	C4	Chrominance output
44	C3	Chrominance output

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ABSOLUTE MAXIMUM RATINGS

Absolute maximum ratings are those values beyond which the device could be permanently damaged. Absolute maximum ratings are stress ratings only and functional device operation is not implied.

V_{CC} 7V
Analog & Digital I/O .... GND – 0.3V to V_{CC} + 0.3V
Input Current 20µA

Junction Temperature .... 150°C
Storage Temperature Range .... –65°C to 150°C
Lead Temperature (Soldering, 10 sec) .... 260°C
Thermal Resistance (θ_{JA}) .... 67°C/W

OPERATING CONDITIONS

Temperature Range .... 0°C to 70°C
V_{CC} Range .... 4.75V to 5.25V

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, V_{CC} = 5V ±5%, C_L = 50pF, T_A = Operating Temperature Range (Notes 1, 2)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
SUPPLY						
I_{CC}	Supply Current	V_{CC}=5.25V, CLK=14.75 MHz, PAL Square Pixel		60	90	mA
AV_{CC}	Analog Supply Voltage	Recommend Operation		V_{CC}–0.6	V_{CC}–0.4	V
LOGIC						
V_{IL}	Low Level Input Voltage				0.8	V
V_{IH}	High Level Input Voltage		V_{CC} – 1.5			V
I_{IL}	Low Level Input Current				10	µA
I_{IH}	High Level Input Current				10	µA
C_{IN}	Input Capacitance			5		pF
V_{OL}	Low Level Output Voltage	I_{OL} = –2mA			0.4	V
V_{OH}	High Level Output Voltage	I_{OH} = 2mA	V_{CC} – 1.0			V
	Output Current	3-state Mode			10	µA
C_{OUT}	Output Capacitance	3-state Mode		5		pF
SYSTEM TIMING						
f_{CLK}	CLK Input Frequency	Square Pixel PAL		14.75		MHz
		Square Pixel NTSC		12.70		MHz
		CCIR601		13.50		MHz
t_{SU}	Setup Time to Rising CLK Edge	f_{CLK} = 14.75MHz	10			ns
	Clock Low Duration	f_{CLK} = 14.75MHz		30		ns
	Clock High Duration	f_{CLK} = 14.75MHz		45		ns
	Input Rise Time	f_{CLK} = 14.75MHz, 10% to 90%			20	ns
	Input Fall Time	f_{CLK} = 14.75MHz, 90% to 10%			20	ns
	Data Valid after Rising CLK Edge	f_{CLK} = 14.75MHz	20			ns
	3-state Delay Time, Output Enable	f_{CLK} = 14.75MHz		20		ns
	3-state Delay Time, Output Disable	f_{CLK} = 14.75MHz		20		ns
	Output Rise time	f_{CLK} = 14.75MHz, 10% to 90%			20	ns
	Output Fall time	f_{CLK} = 14.75MHz, 90% to 10%			20	ns

ELECTRICAL CHARACTERISTICS (Continued)

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
VIDEO SIGNAL PROCESSING							
	Effective Luminance Bandwidth	NTSC/PAL, Comb On at –3dB			(Note 3)		
		NTSC/CCIR601, Comb Off at –3dB			2.5		MHz
		NTSC/Sq. Pixel , Comb Off at –3dB			2.5		MHz
		PAL/CCIR601 , Comb Off at –3dB			2.5		MHz
		PAL /Sq. Pixel, Comb Off at –3dB			2.5		MHz
	Effective Chrominance Bandwidth Centered at f_{SC}	NTSC/PAL, Comb On at –3dB			(Note 3)		
		NTSC/CCIR601, Comb Off at –3dB			1.0		MHz
		NTSC/Sq. Pixel, Comb Off at –3dB			1.0		MHz
		PAL/CCIR601, Comb Off at –3dB			1.0		MHz
		PAL /Sq. Pixel, Comb Off at –3dB			1.0		MHz
COMB FILTER CHARACTERISTICS							
SNR_C	Signal to Noise Ratio, Chrominance	Spurious Luma Artifact	NTSC 13.5MHz	48			dB
			PAL 12.27MHz	45			dB
SNR_L	Signal to Noise Ratio, Luminance	Spurious Subcarrier Artifact	NTSC 13.5MHz	48			dB
			PAL 12.27MHz	45			dB
	Comb Notch Depth at f_{SC}	NTSC/PAL		–35			dB
	Comb Notch Bandwidth at –30dB				500		kHz

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ELECTRICAL CHARACTERISTICS (Continued)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
SERIAL BUS LOGIC INPUT						
	Low Level Input Voltage		0		0.8	V
	High Level Input Voltage		$V_{CC} - 0.8$		V_{CC}	V
	Low Level Input Current	$V_{IN} = 0V$			1.0	µA
	High Level Input Current	$V_{IN} = V_{CC}$ D			1.0	µA
	Input Impedance	$f_{CLK} = 100kHz$		1		MΩ
	Input Capacitance (C_{IN})			2		pF
SYSTEM TIMING						
	S_{CLK} Frequency (f_{CLOCK})				100	kHz
	Input Hysteresis (V_{HYS})		0.2			V
	Spike Suppression (t_{SPIKE})	Max length for zero response		50		ns
	Power Setup Time to Valid Data Inputs	VCC Settled to Within 1%	10			ms
	Wait Time From STOP to START On S_{DATA} (t_{WAIT})			1.3		µs
	Hold Time for START On S_{DATA} ($t_{HD/START}$)			0.6		µs
	Setup Time for START On S_{DATA} ($t_{SU/START}$)			0.6		µs
	Min LOW Time On S_{CLK} (t_{LOW})		1.3			µs
	Min HIGH Time On S_{CLK} (t_{HI})		0.6			µs
	Hold Time On S_{DATA} ($t_{HD/DATA}$)			5.0		µs
	Setup Time On ($t_{SU/DATA}$)	Fast mode (Note 4)	100			ns
		Slow mode (Note 4)	250			ns
	Rise Time for S_{CLK} & S_{DATA} (t_{LH})			30	300	ns
	Fall Time for S_{CLK} & S_{DATA} (t_{HL})			30	300	ns
	Setup Time for STOP On S_{DATA} ($t_{SU/STOP}$)			0.6		µs

Note 1: Limits are guaranteed by 100% testing, sampling, or correlation with worst case test conditions.

Note 2: Supply voltage fed through 7.5Ω resistor to all V_{CC} pins.

Note 3: No bandlimiting is performed on the signal bandwidth when the comb is in the "on" state.

Note 4: Parameter is luma dependent

FUNCTIONAL DESCRIPTION

The ML6440 is an adaptive digital comb filter that offers automatic self-adjusting or manual thresholds to handle vertical and horizontal contouring during Y/C separation. The ML6440 implements a SmartComb algorithm where full bandwidth video and artifact suppression techniques are used to automatically select suppression thresholds for all video content. Video artifacts such as hanging dots, dot crawl, and cross luminance are dramatically reduced. The algorithm functionally performs a statistical analysis of the video content of over 60 lines. It then calculates and selects the best threshold for artifact reduction at 12-bit resolution.

The ML6440 is a comb for NTSC (525 lines) and PAL (625 lines) with the ability to handle CCIR601 and square pixel sampling rates.

CCIR601 is the existing standard for digitized video of either NTSC or PAL at a 13.5MHz rate, and is used by MPEG encoders and decoders for image compression. The comb algorithms in the comb filter substantially reduce rainbow and dot-crawl artifacts which interfere with efficient image compression.

Square pixel is video digitized at 12.27MHz for NTSC, and 14.75MHz for PAL, so that each sample corresponds to a single pixel in computer displays without the effort or expense of a multi-phase image resizing filter done in hardware or software.

Using the ML6440 comb filter requires no external components for operation. The comb filter can be bypassed to accommodate selection of external S-video signals. The comb filter is controllable via parallel pin or serial interface.

SMARTCOMB OPERATION

The user supplies 8-bit video as either digital Y/C or digital composite video inputs and receives delayed and combed data at the Y/C digital outputs. Use of Y/C input assumes that combing is unnecessary and sends the data through the same delay as the composite video path to prevent shifting of the video position on the screen. This makes the ML6440 useful in source selection such as S-video inputs and composite video. Composite video (CV), applied to the ML6440 with comb operation enabled, permits the separation of luminance and chrominance with minimal artifacts.

The SmartComb controls the application of the comb filter and bandsplit-notch filters on a pixel-by-pixel basis. The digital video image is sampled, and an analysis is performed. SmartComb step 1: looks for differences in the low frequency spectra (vertical detail). SmartComb step 2: searches for changes in phase angle/saturation of the chroma sub-carrier, which represents changes in color in the vertical direction. Finally, SmartComb step 3: an averaging circuit is used as "smoothing function" to eliminate dithering in the horizontal dimension caused by excessive filter switching.

Figure 1 provides a simplified block diagram of the SmartComb architecture. This architecture implements several complex computations to determine the amount of notch vs. comb filtering. Three 8-Bit detectors are used to examine vertical and horizontal detail for luma and chroma signals on a pixel-by-pixel basis for 3-line analysis. These data are then fed into a weighting function to determine the best filtering approach over the existing 3-lines of video. Furthermore, this data is then compared
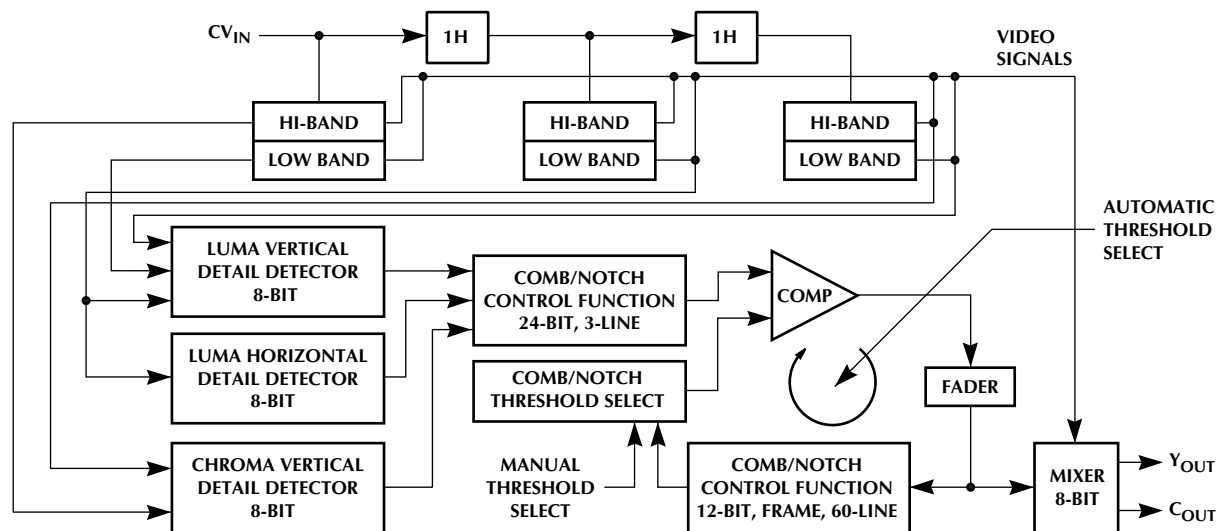

Figure 1. SmartComb Architecture: Simplified Block Diagram

PREAMBLE	DATA ADDRESS (B3)$_{HEX}$	DATA (D[7:0]$_2$)

Table 1. Serial Data Format

BIT	D7	D6	D5	D4	D3	D2	D1	D0
Mode—Function	Y+C or CV Select	Adaption Threshold 2	Adaption Threshold 1	Adaption Threshold 0	Comb Mode 1	Comb Mode 0	Square Pixel/ CCIR601 Select	PAL or NTSC Select
Value	Y+C = 1 CV = 0	AT2 = 0 or 1	AT1 = 0 or 1	AT0 = 0 or 1	CM1 = 0 or 1	CM0 = 0 or 1	Sq. Pixel = 1 CCIR601 = 0	PAL = 1 NTSC = 0
Parallel Mode Input Pin	CI7/DI7	CI6/DI6	CI5/DI5	CI4/DI4	CI3/DI3	CI2/DI2	CI1/DI1	CI0/DI0

Table 2. Control Register Format D[7:0] (Serial or Parallel Mode)

STANDARD/RATE	CCIR601	SQUARE PIXEL
NTSC (f_{SC} = 3.58MHz)	13.5MHz	12.27MHz
PAL (f_{SC} = 4.43MHz)	13.5MHz	14.75MHz

Table 3. Clock Frequency Requirements

ADAPTION THRESHOLD D[6,5,4]	ADAPTION THRESHOLD LEVEL
000	Automatic threshold for minimal comb artifact generation for various video source material.
001	Threshold for computer graphics applications, minimizing dot crawl on bold lettering.
010 to 110	Various degrees of thresholds.
111	Threshold for better reproduction of natural photographic images.

Table 4. Adaption Threshold Bit Table

COMB MODE, D[3,2]	NTSC	PAL
00	Y adaptive, C comb 100% active	Y adaptive, C adaptive
01	Y adaptive, C adaptive	Y adaptive, C comb 100% active
10	Y 100% comb active, C 100% comb active	Y 100% comb active, C 100% comb active *Not recommended due reduced performance*
11	Bandsplitting only (no combing)	Bandsplitting only (no combing)

Table 5. Comb Mode Bit Table

START: A Falling Edge on the S DATA While S CLK is Held High
STOP: A Rising Edge on the S DATA While S CLK is Held High
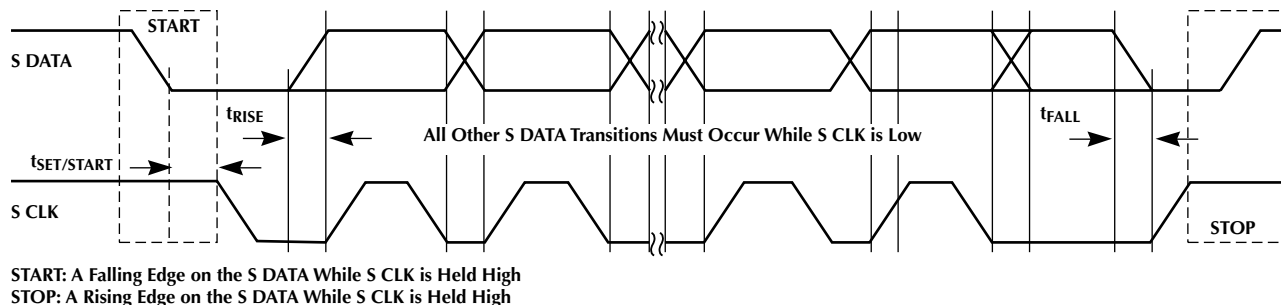
Figure 2. Definition of START & STOP on Serial Data Bus
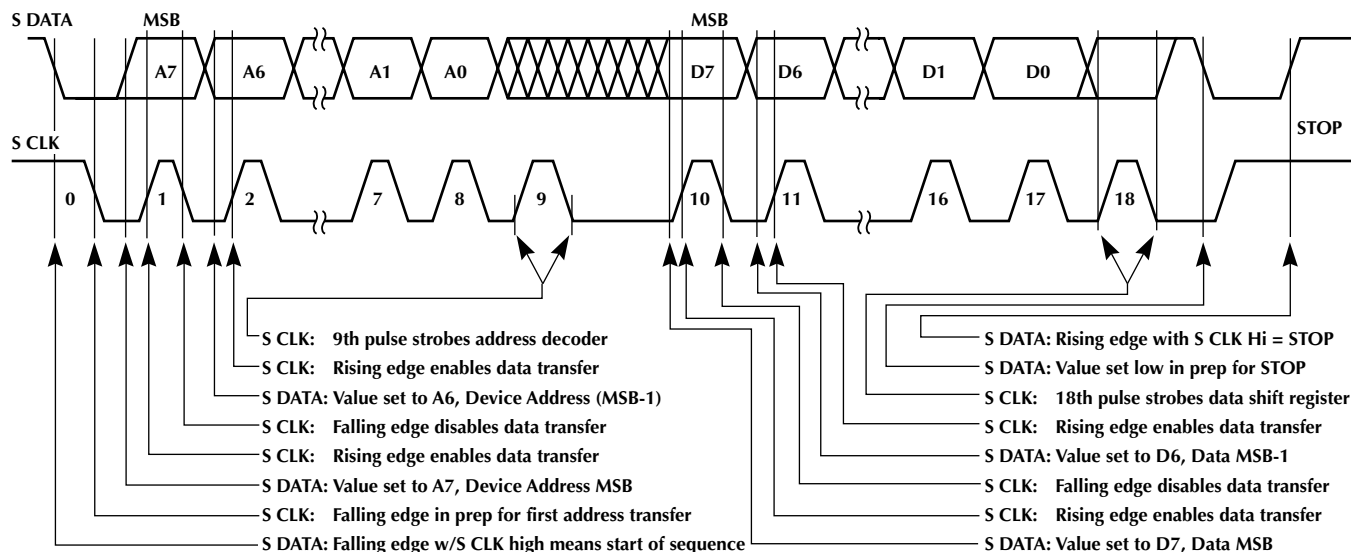
Figure 3. Definition of DATA FORMAT on Serial Data Bus
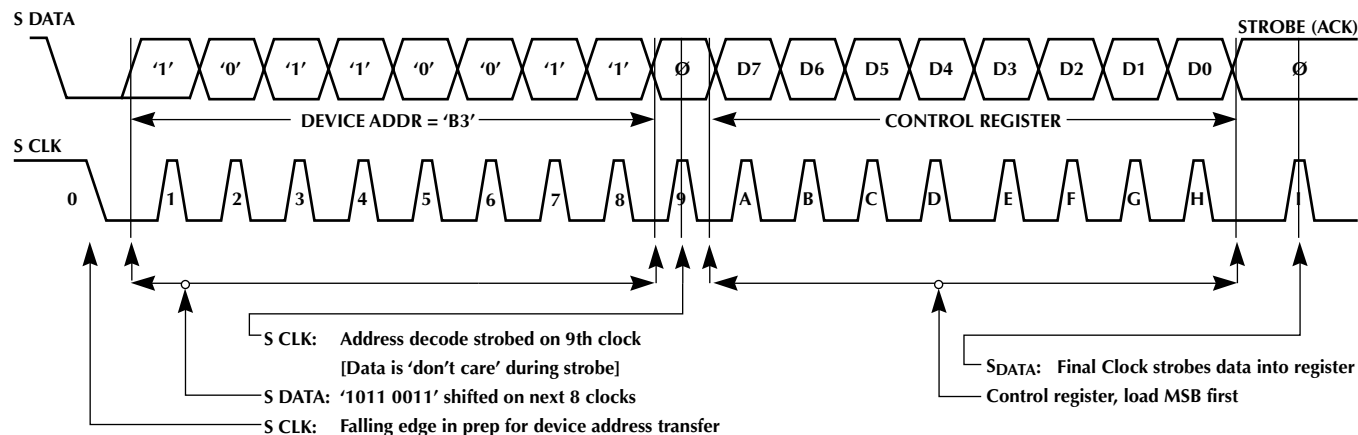
Figure 4. Typical Serial Bus Command

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FUNCTIONAL DESCRIPTION (Continued)

to the video content of the last 60+ lines (frames) of video —a frame weighing function— to determine the best filtering approach of the current video content. Finally, 1 of 7 thresholds can be chosen to adjust either real-time (automatically) by the ML6440 itself or fixed manually by design. An internal 12-bit analysis is used for the filtering algorithm. An additional fader circuit is included to "smooth" the transitions between comb and notch filtering.

In NTSC, every other line of chroma is inverted while there are no changes in luma (assuming there is no change in color between adjacent lines). This permits data to be added from the first stored line of data with the third line of active high-band video data, each with a scaling of 0.25, and add the second stored line of data with a scaling of 0.50. The result contains no chroma, only luma information. Subtracting this information from the high-band signal yields only chroma information.

In PAL, each line of data rotates the phase of the chroma by 90 degrees. Therefore, by adding the first line of stored high-band information from the active third line, the chroma is canceled, leaving only luma information. Once again, this information is subtracted with the appropriate amplitude scaling from the original highband information to yield only chroma.

In bandsplit (notch) filtering and luma peaking, the digital bandsplit filter is used as an alternate filter when the SmartComb algorithm determines that the comb filter output signal would be contaminated with cross chroma artifacts. To maintain a reasonable amount of apparent resolution in the luminance signal, luma peaking is applied. This helps maintain image quality in the portion of the video image where comb filtering would generate artifacts.

The ML6440 SmartComb provides a real-time filtering algorithm solution (automatic mode) for a wide variety of video sources without the shortcomings of using fixed thresholds (manual mode). The automatic threshold tracking circuit responds quickly, adjusting itself in about 1/300th of a second (about 60 lines). The transition from the comb to the digital bandsplit is made with a continuous digital fader to prevents switching glitches.

The bandsplit-notch and comb filters were designed to reduce color bar peak-to-peak dot edge crawl to <7.5% for 75% color bars. Peak-to-peak cross color on the white bar edge was designed to be <1% with 75% color bars.

SERIAL PROGRAM MODE

In Serial Program Mode, the comb filter can be controlled with the serial interface. Control inputs may be clocked in serially with S DATA and S CLK , when $\overline{S}$/P is low. Serial bus transfers require an 8-bit address followed by 8-bits of data for the internal data register. The pattern is described in Tables 1 through 5.

The serial bus control in the ML6440 has one level of addressing followed by control register programming. Figure 2 shows the physical waveforms generated in order to address the ML6440. There are six basic parts of the waveform:

1. Start indication: Clock Cycle 0
2. Device address shifted in: Clock Cycle 1 thru 8
3. Device address strobed /decoded: Clock Cycle 9
4. Data shifted in: Clock Cycle 10 thru 17
5. Data strobed to appropriate register: Clock Cycle 18
6. Stop indication: Clock Cycle 19

PARALLEL PROGRAM MODE

In Parallel Program Mode, the CI/DI[7:0] pins act as programming pins for the internal 8-bit register (D[7:0]) such that CI7/DI7=D7, CI6/DI6=D6, ... CI0/DI0=D0. In the parallel mode, the $\overline{S}$/P serves as a rising edge-triggered strobe pin for the internal registers of D[7:0]. When $\overline{S}$/P goes from low to high, data applied to the inputs (CI/DI[7:0]), is loaded into the internal 8-bit register D[7:0] directly. A transition on the $\overline{S}$/P pin back to low will reactivate the serial mode. If the $\overline{S}$/P is held at a high, the serial mode is inactive.

CONTROL REGISTER, D[7:0]

The internal register, D[7:0], controls the following functions within the ML6440. Again, this register can be programmed through either a serial or parallel interface. The $\overline{RST}$ acts as a reset pin, forcing all the bits of the
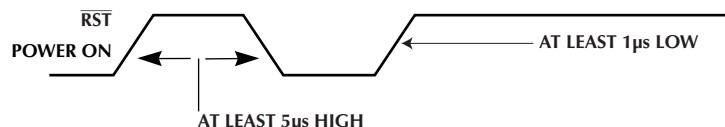

Figure 5: Reset Timing

FUNCTIONAL DESCRIPTION (Continued)

internal data register low (D[7:0]=0) which defaults to automatic combing of NTSC/CCIR601 composite video.

The Y+C/CV selection bit, D7, controls whether Y+C or CV format is the source for the comb filter. Setting this bit low selects the composite input pins, which is combed by default. Setting the bit high selects the Y+C inputs as the source for video (see bypass section). This source is not combed and the Y+C inputs are not activated until the $\overline{S}$/C pin is rising-edge triggered.

Adaption thresholds 2 through 0 are D6 through D4, respectively. These set the adaption behavior from automatic (D[6:4]=000) to one of seven settings ranging from fine tuning of computer graphics to photographic images. See Table 4.

Comb modes 1 and 0, (D3 and D2, respectively) are used to enable and disable adaption separately on Y and C data. For NTSC, if D[3:2]=<00>, then Y is adaptive and C is always combed. For NTSC, if D[3:2]=<01>, both Y and C are adaptive. For PAL, if D[3:2]=<00>, then both Y and C are adaptive. For PAL, if D[3:2]=<01>, then Y is adaptive and C is combed. For NTSC and PAL, if D[3:2]=<10>, then Y and C are forced to comb mode. For NTSC and PAL, if D[3:2]=<11>, then both Y and C are in bandsplit filtering mode only. See Table 5.

The D1 bit sets the choice of data rates between CCIR601 and Square pixel. CCIR601 is active low. Square pixel is active high. The last bit, D0, select the standard, NTSC or PAL. NTSC is active low. PAL is active high. See Table 2.

The remaining pin function controls are independent of the data register: CLK, $\overline{RST}$, and OE. The CLK pin requires a clock at the rates listed in Table 2. Its duty cycle must meet the duration minimum for high and low.

The $\overline{RST}$ pin resets the comb logic including the internal data register on active low but does not clear the line delays. This part requires a timed reset pulse. On power up or at any time a return to automatic combing of NTSC/CCIR601 composite video is required the reset pin must have been high for at least 5 micro seconds. Then taken low for at least one micro second before returning high again to resume normal operation. Neither pulse width nor rise and fall times are critical.

In most applications a microprocessor will be available to provide timing and control waveforms. It will provide this reset pulse and if needed set the appropriate comb filter mode. In non processor systems an R C network can provide this reset pulse. See Figure 5.

CHROMA AND LUMA BYPASS OPERATION

This mode can be activated by setting the internal bit D7 = 1 either through the serial or parallel programming modes. Once the register is set (D7 = 1), the comb filter will look at the inputs for luma on the CV[7:0] pins for a luma bypass to the outputs of the Y[7:0] pins respectively; as well as inputs for chroma on the CI/DI[7:0] pins for a chroma bypass to the outputs of the C[7:0] pins respectively. The comb filter will continue to look at the inputs as long as D7 is set high.

Data presented to the inputs (CI/DI[7:0]) is not interrupted in the color processing path when $\overline{S}$/P is held high or low. Therefore, it is recommended that $\overline{S}$/P activity be limited to sync or blanking intervals in the video to avoid unwanted visual artifacts during register programming.

Clock Timing

Figure 6 depicts digital video input and output timing for valid data.
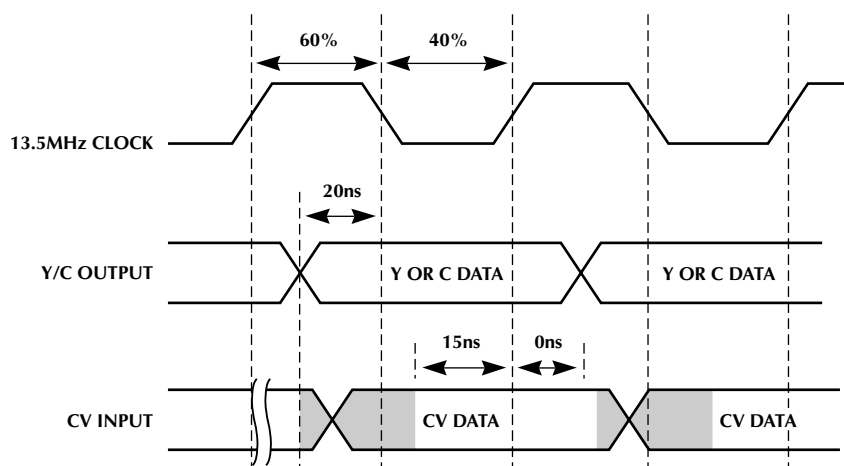
Figure 6: Clock Timing

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TYPICAL APPLICATIONS

Figure 7 depicts an application block diagram of the ML6440. The ML6440 is easy to use in most standard video applications in conjunction with an 8-bit A/D converter or digital data for analog and digital applications. High speed digital layout should be observed. Pay special attention that the outputs are not loaded beyond a 2mA load. An A/D, if used, should have at least seven effective bits at Nyquist rates for good quality video. Please note that startup of the part will require at least two lines to flush out the line delays and about 10 lines for the adaption to adjust. The automatic adaption thresholding should not be discernible in most video applications, but can be defeated with the fixed adaption levels. In applications using video tape recorders the comb may not be effective and can make results worse if time jitter exceeds the clock period 70ns. Jitter of this magnitude would misalign the line delays, making the combing and adaption incorrect. In this case combing should be turned off.

POWER SUPPLY REQUIREMENTS

The AV_{CC} must be fed through a Schottky diode of about 0.4V drop from a 5V supply. Alternately, a 7.5Ω resistor can be used instead of the diode. The AV_{CC} pin also needs a 1µF surface mount capacitor to ground. See Figure 7.

Bypass caps must be within 3mm of the chip pins they bypass. Direct traces are necessary.

Digital Video Values of Sync Tip and Peak White

As recommended by SMPTE and ITU-R BT.601, the minimum value of digitized sync tip is decimal 16. The maximum value of digitized video is decimal 255 (235 recommended is by SMPTE which allows for overshoots in video). Normally, peak white is at 235; this avoids clipping due to overshoots.

Figure 8 presents Micro Linear's entire solution for optimized video application designs. The ML6430 can be used as high performance line lock clock that's capable of

generating horizontal and vertical syncs and a variety of system clocks using common reference frequency crystals. The ML6401 is a low cost A/D converter. The ML6421 is a three channel filter with sinx/x equalization. The ML6424 is a precision filter used as a clamp circuit and anti-aliasing filter. (See Micro Linear's ML6440EVAL for more information)

Test Patterns

When viewing test patterns, the fixed thresholds may give better performance, since the automatic adaptive threshold algorithm was optimized for live video.

There are various specific application uses of the ML6440 SmartComb :

- Large screen TVs
- HDTV
- Video projection
- MPEG encoding
- Video conferencing
- Imaging and video capture
- Format converters
- Time base correctors
- Professional video
- Line doublers and quadrapulers

Figure 9 illustrates the use of the ML6440 in a big screen TV application. In this application, the ML6440 offers automatic self-adjusting thresholds to optimize Y/C separation while minimizing artifacts for a wide variety of live video material without fixed threshold limitations. The ML6440 supports S-video bypass or luma and chroma separation enhancement, simplifying design for high-performance video source selection.

Figure 10 illustrates the use of the ML6440 in HDTV and NTSC application. In hybrid TV sets, where both NTSC and HDTV will be prevalent, the ML6440 SmartComb can serve as a high-performance Y/C NTSC-separator in a NTSC-HDTV video receiver.

TYPICAL APPLICATIONS (Continued)
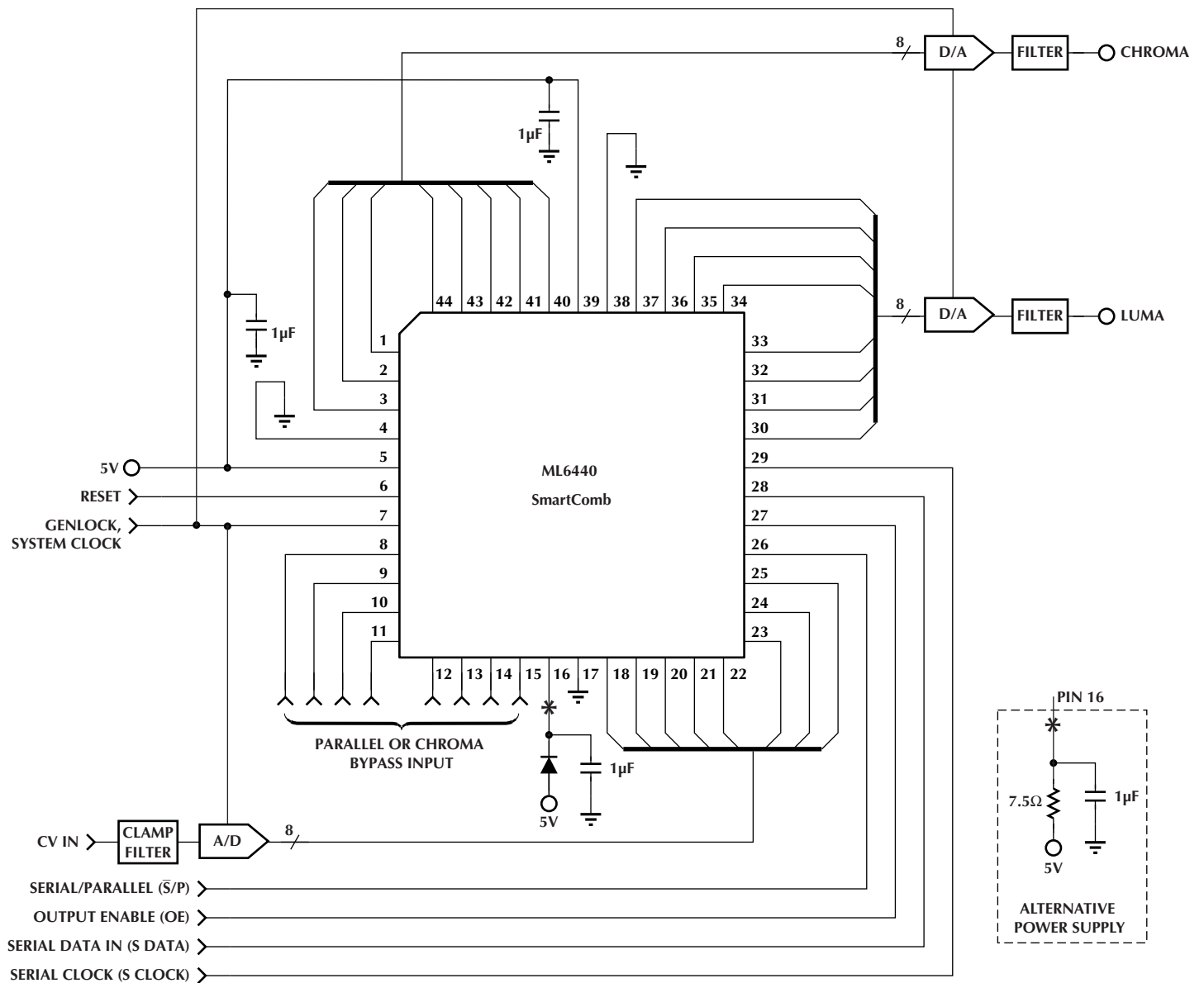
Figure 7. Typical Application Circuit

ML6440

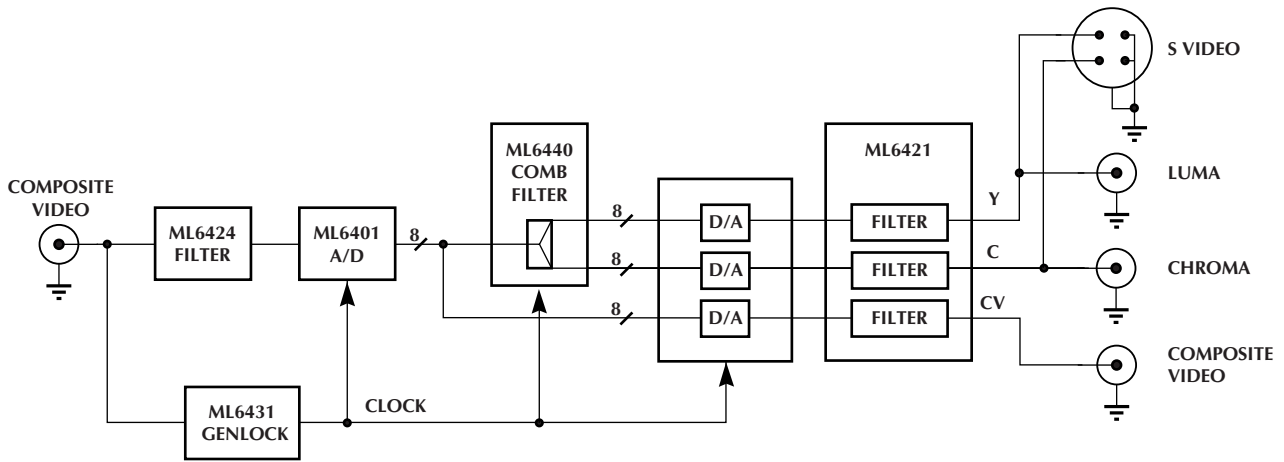## TYPICAL APPLICATIONS (Continued)

Figure 8. Micro Linear Application Solution
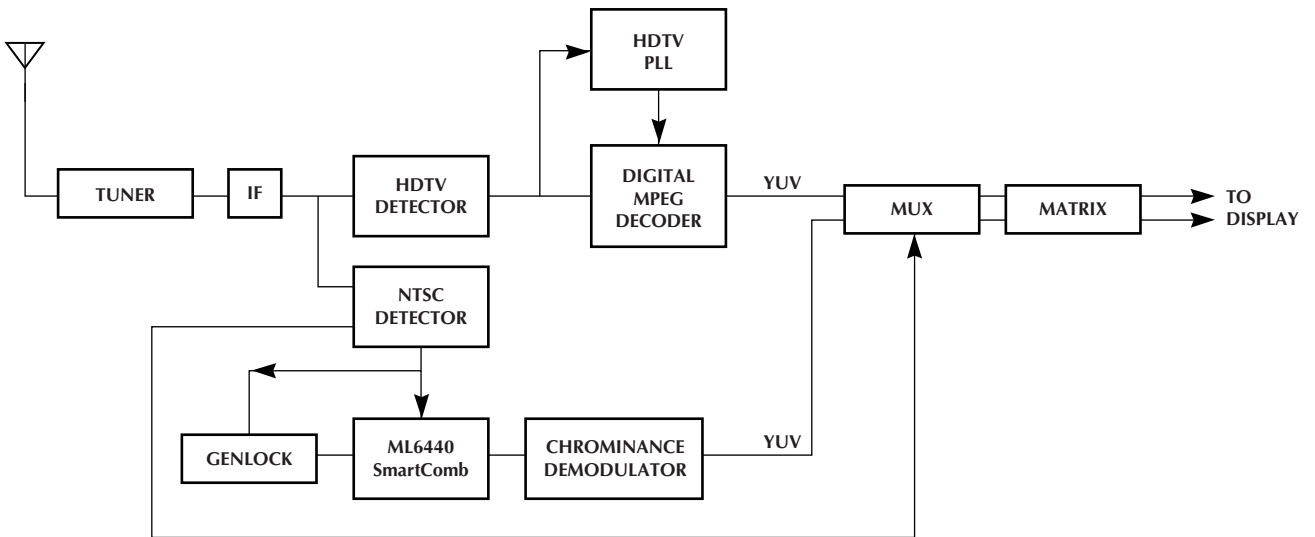

Figure 9. Application Diagram: HDTV and NTSC Television
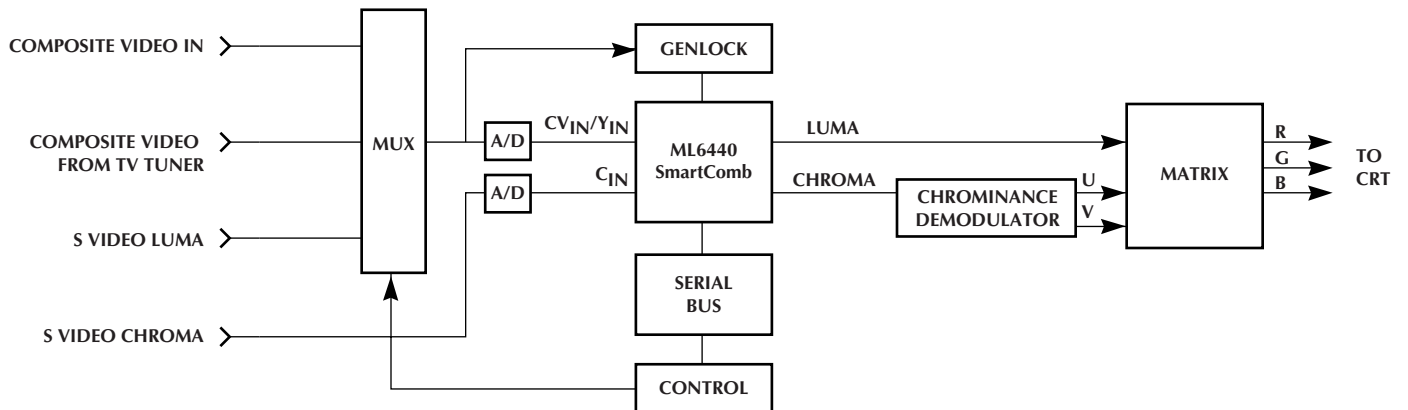

Figure 10. Application Diagram: High-end Television/Monitor

PERFORMANCE DATA

COMB FILTER PERFORMANCE

- Unrestricted Bandwidth. No band-limiting is performed on the signal when the comb is on hence preventing a signal loss.

- High frequency peaking allows for gentle transitions from comb to notch modes.

- Spurious sub-carrier supression by 48dB removes color sub-carrier which otherwise can cause large area dot crawl

NOTCH FILTER PERFORMANCE

- When invoked by adaption threshold logic, hanging dot suppression is 35dB.

ADAPTIVE THRESHOLD PERFORMANCE

- Seven fixed values to select threshold, the 8th value is for automatic self-adjusting threshold mode.

- Adaptive thresholds improve around 10% per threshold level. However, adaptive thresholds can surpass optimum threshold thus causing smearing effects.

- D[6:4] = 000 is the automatic self-adjusting threshold mode. D[6:4] = 001 is the low threshold and D[6:4] = 111 is the highest threshold, D[6:4] = 010 to 110 is therefore the intermediate thresholds.

Figures 11 through 20 show the bandwidth of notch, chroma bandpass, and comb filters for NTSC and PAL video. These curves were taken from a VM700 using a sweep frequency pattern using a TG2000 on the ML6440EVAL board.

Figure 11 shows the NTSC luma filter at CCIR clock rates. This shows significant notch from 3.3MHz to 4MHz sufficient for hanging dot suppression. Figure 12 shows the NTSC chroma bandpass filter for CCIR clock rates where the filter at 3dB ranges from 3MHz to 4.5Mhz. Figure 13 shows the luma notch filter for NTSC for hanging dot suppression for Square Pixel clock rates. This notch ranges from 3.3MHz to 4MHz. Figure 14 shows the NTSC chroma bandpass filter running at Square Pixel clock rates where it at 3dB ranges from 3MHz to 4.5MHz. Figure 15 shows PAL luma response for hanging dot suppression at Square Pixel clock rates where notch ranges from 3.3MHz to 4MHz. Figure 16 shows the response of the PAL chroma bandpass filter where at 3dB down ranges from 3MHz to 4.2MHz. Figure 17 shows the PAL notch filter for luma hanging dot suppression at CCIR clock rates where the notch ranges from 4MHz to 4.3MHz at zero amplitude. Figure 18 shows the bandpass filter for PAL at the CCIR clock rate where at 3dB down ranges from 3.3MHz to 4.7MHz. Figure 19 shows the NTSC luma comb response over a line-to-line in phase frequency sweep to 6MHz for CCIR clock rates. Figure 20 shows the NTSC luma response over a line-to-line in phase frequency sweep to 6MHz for Square Pixel clock rate.
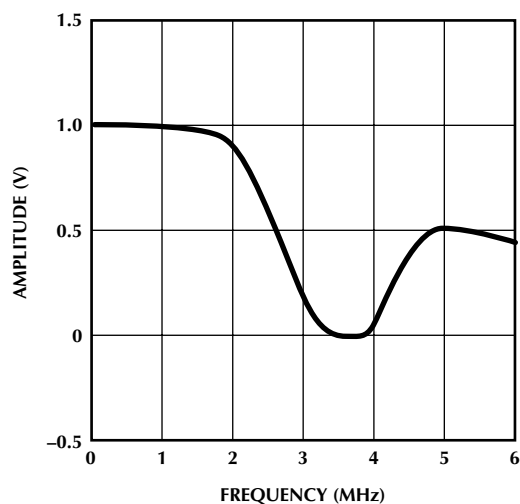
Figure 11. NTSC Luma Notch Filter CCIR
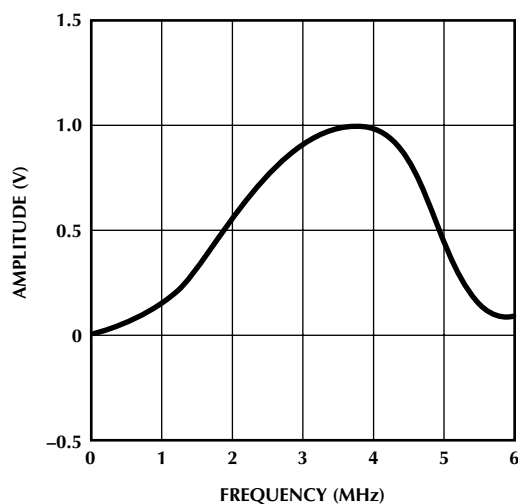
Figure 12. NTSC Chroma Band Phase Filter, CCIR
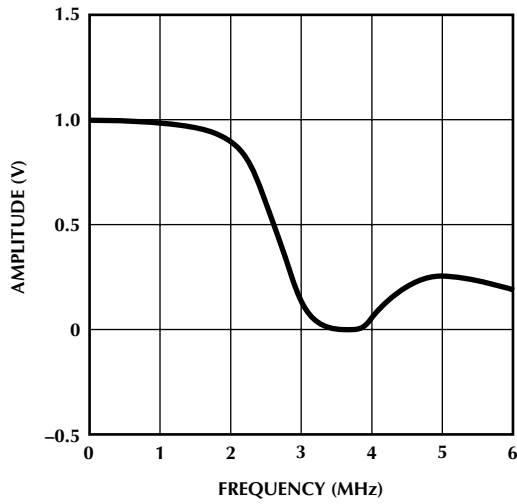
Figure 13. NTSC Luma Notch Filter, Square Pixel
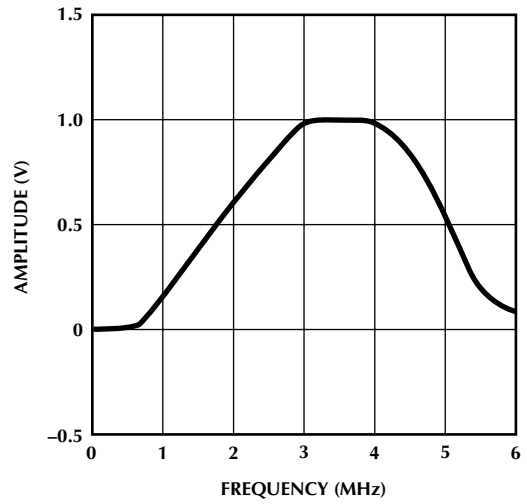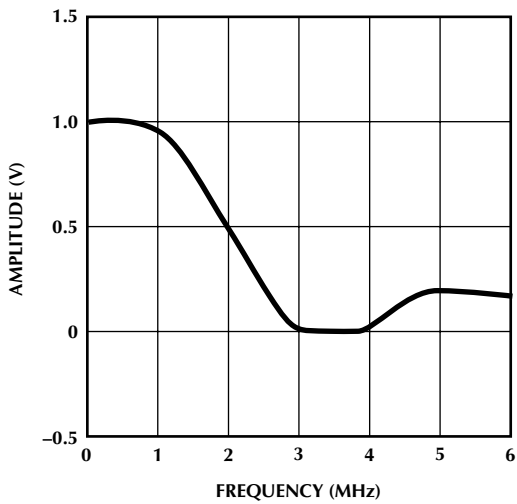
Figure 14. NTSC Chroma Band Pass at Square Pixel Clock
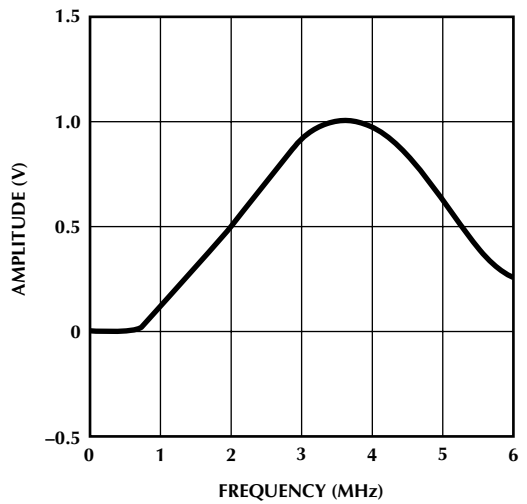
Figure 15. PAL Luma Notch Filter, Square Pixel Clock
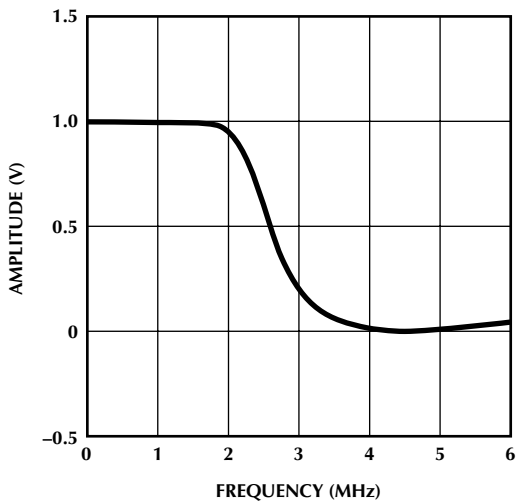
Figure 16. PAL Chroma Band Pass Filter, Square Pixel Clock
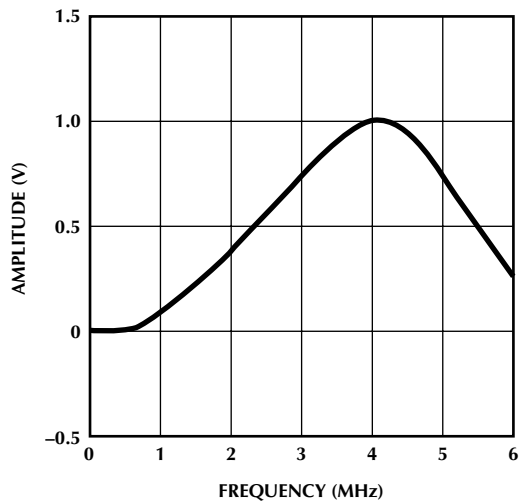
Figure 17. PAL Luma Notch Filter

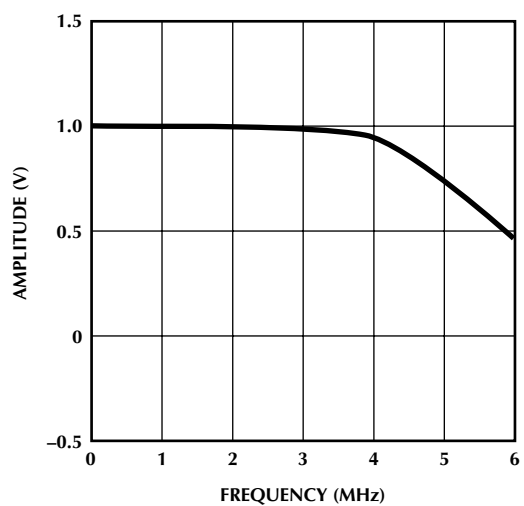**Figure 18. PAL Chroma Pand Pass, CCIR Clock Rate**
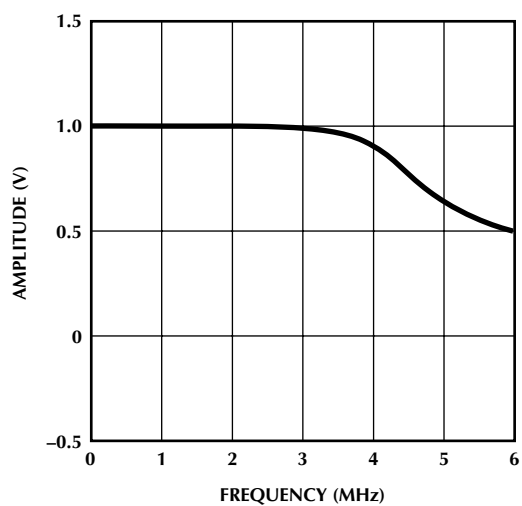
Figure 19. NTSC Comb Luma, CCIR Clock Rate

Figure 20. NTSC Luma Comb, Square Pixel

ML6440

PHYSICAL DIMENSIONS inches (millimeters)

Package: H44-14
44-Pin (14 x 14 x 1mm) TQFP

0.630 BSC
(16.00 BSC)

0.551 BSC
(14.00 BSC)

34

1

PIN 1 ID

0.551 BSC
(14.00 BSC)

0.630 BSC
(16.00 BSC)

23

12

0.039 BSC
(1.00 BSC)

0.014 - 0.020
(0.36 - 0.51)

0° - 7°

0.003 - 0.008
(0.09 - 0.20)

0.018 - 0.030
(0.45 - 0.75)

SEATING PLANE

0.048 MAX
(1.20 MAX)

0.037 - 0.041
(0.95 - 1.05)
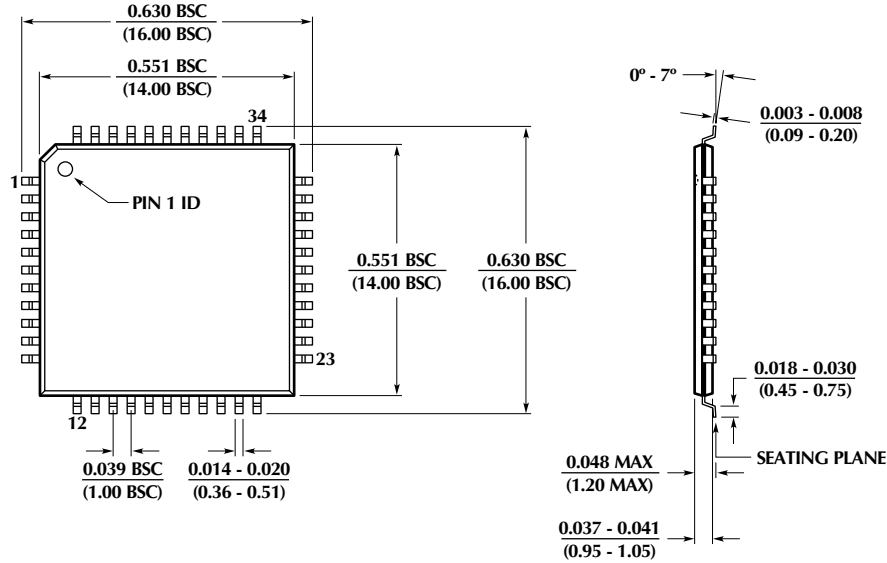
ORDERING INFORMATION

PART NUMBER	TEMPERATURE RANGE	PACKAGE
ML6440CH (EOL)	0°C to 70°C	44 Pin TQFP (H44-14)