

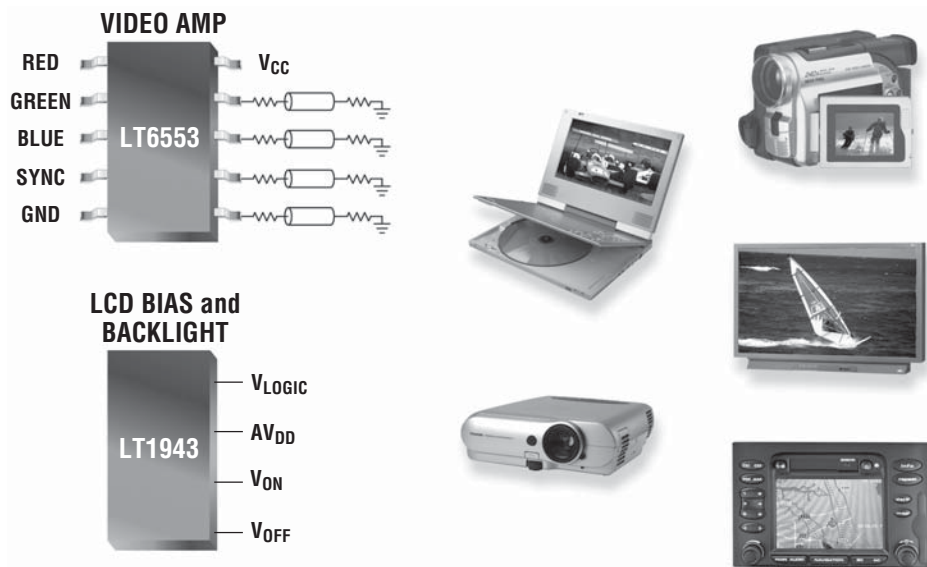
Linear Technology Chronicle

High Performance Analog Solutions from Linear Technology

Vol. 13 No. 2

Focus...

Solutions for Video and Displays



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The convergence of computer and entertainment systems has created a new class of opportunities in digital entertainment. From large screen LCD displays and projectors to camcorders and high-definition televisions, the opportunities for video systems have never been greater.

Whether using composite, s-video or component video, systems require high performance amplifiers for driving cables, adding gain, converting between formats and shaping the video signals. The increasing dimensions of high-definition LCD displays require amplifiers with high gain bandwidth and slew rate to scan the entire screen in one refresh cycle. Low supply voltages present special challenges in video design, forcing amplifiers to accommodate the video signal's relatively large signal swings and high slew rates within limited supply rails.

While LCD displays were once used exclusively for small notebook PC displays, their increasing size and resolution

have seen them displace conventional CRTs in home entertainment and computing applications. These large displays typically require several high performance switching regulators to create the necessary bias voltages. The CCFL tubes used to provide backlighting have their own requirements for power and protection as well. As an added challenge, any power supply circuitry must be small and low profile enough to fit within the space constrained limits of the flat panel LCD.

Linear Technology offers a full range of products for video systems, from amplifiers for driving signals to switching regulators for display biasing. The following pages provide a sample of our products designed specifically for video and display applications.

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Video Amplifiers

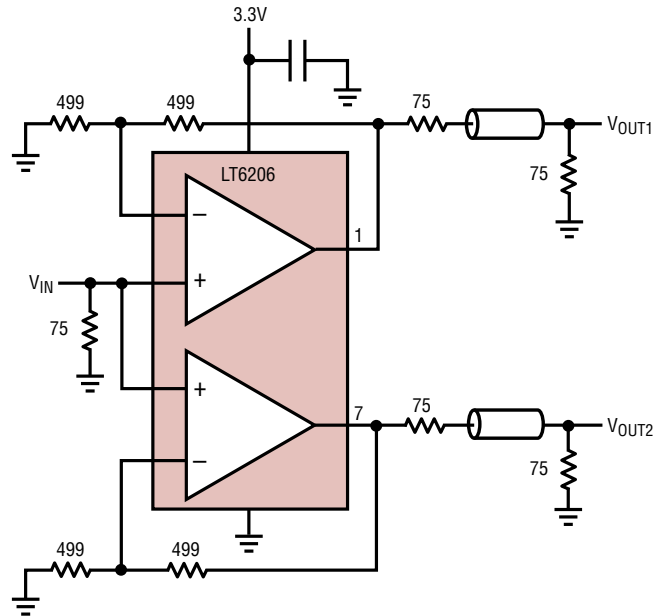
Large video displays require amplifiers that can drive the millions of pixels typical in high resolution systems. Specifications for bandwidth, slew rate and settling time are all critical.

Further complicating designs, video systems are often pressed to operate on the lowest possible rail voltages. This is made even more difficult due to the need to accommodate the dynamic offset variation inherent in AC-coupled designs. Traditional op amps require relatively large amounts of output-swing headroom and are therefore impractical for AC coupling at even 5V supplies.

The LT[®]6205/06/07 are single, dual and quad amplifiers designed to operate in video systems with voltage supplies as low as 3V. Featuring 100MHz gain bandwidth product and 400V/μs slew rate, these parts can drive displays with resolutions up to 1024 X 768 pixels. The rail-to-rail outputs swing within 60mV of either supply rail, making the LT6206 suitable for 3V operation requiring the maximum output dynamic range. Features of the parts include:

- **Single supply operation down to 3V**
- **100MHz gain bandwidth, 400V/μs slew rate**
- **Rail-to-rail input and output**
- **Low cost**

Baseband Video Splitter/Cable Driver



Video Amplifiers

Part Number	# Amps	Slew Rate	-3dB Bandwidth	Type	Supply Voltage	Supply Current	Package
LT1818/19	2/4	2500V/μs	400MHz	VFB	4V to 12.6V	10mA	ThinSOT™, SO-8 (LT1818) MS8, SO-8 (LT1819)
LT1259/60	2/3	1600V/μs	90MHz	VFB	4V to 30V	7.5mA	SO-14 (LT1259) SO-16 (LT1260)
LT1395/96/97	1/2	800V/μs	400MHz	CFA	4V to 12V	6.5mA	ThinSOT, SO-8 (LT1395) DFN, SO-8, MS8 (LT1396) SO-14, SSOP-16 (LT1397)
LT1398/99	2/3	800V/μs	300MHz	CFA	4V to 12V	6.5mA	SSOP-16
LT6210	1	700V/μs	200MHz	CFA	3V to 12V	6mA*	ThinSOT
LT6205/06/07	1/2/3	400V/μs	100MHz	VFB	2.7V to 12.6V	5mA	ThinSOT (LT6205) MS8 (LT6206) SSOP-16 (LT6207)
LT6550/51	3/4	340V/μs	110MHz	VFB	3V to 12.6V	10mA	MS10

*The LT6210 offers adjustable supply current from 300μA at 10MHz gain bandwidth to 6mA at 200MHz gain bandwidth.

Video Difference Amplifiers

For video systems driving long cables in noisy environments, a differential amplifier can improve system performance by offering noise immunity and a high common mode rejection ratio.

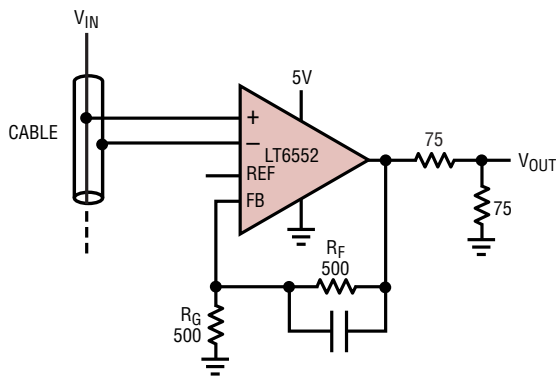
The LT6552 is a wideband difference amplifier offering excellent common mode rejection at high frequencies (CMRR > 60dB at 10MHz). The LT6552 minimizes the effects of high-frequency noise pickup, allowing signals to be sent over long lines without fear of corruption by external noise sources or crosstalk.

The LT6552 features a 75MHz -3dB bandwidth, 600V/μs slew rate and ±70mA output current. A wide supply range of 3V to 12.6V and rail-to-rail outputs make this part well suited for low voltage video applications. The LT6552 is ideal for use as a twisted pair or differential line receiver, coax cable driver, twisted pair to coax cable converter and cable-tap amplifier for loop through connections in a wide variety of video applications. The LT6552 is offered in the space-saving 3mm x 3mm DFN package.

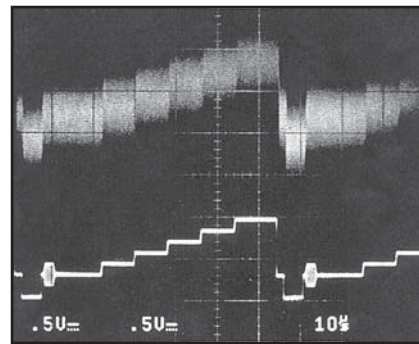
Features of the part include:

- **Differential high impedance inputs**
- **Wide supply range: 3V to 12.6V**
- **75MHz gain bandwidth, 600V/μs slew rate**
- **Small DFN package**

Cable Sense Amplifier with DC Adjust



LT6552 Rescues Video Signal from Noise



Video Difference Amplifiers

Part Number	Slew Rate	-3dB Bandwidth	Supply Voltage	Package	Unity Gain Stable
LT6552	600V/μs	75MHz	3V to 12.6V	DFN	$A_V=2$
LT1194	350V/μs	350MHz	5V to 18V	N8/SO-8	$A_V=10$
LT1193	350V/μs	80MHz	5V to 18V	N8/SO-8	$A_V=2$
LT1187	100V/μs	50MHz	4V to 18V	N8/SO-8	$A_V=2$
LT1189	150V/μs	35MHz	4V to 18V	N8/SO-8	$A_V=10$

Video Buffers

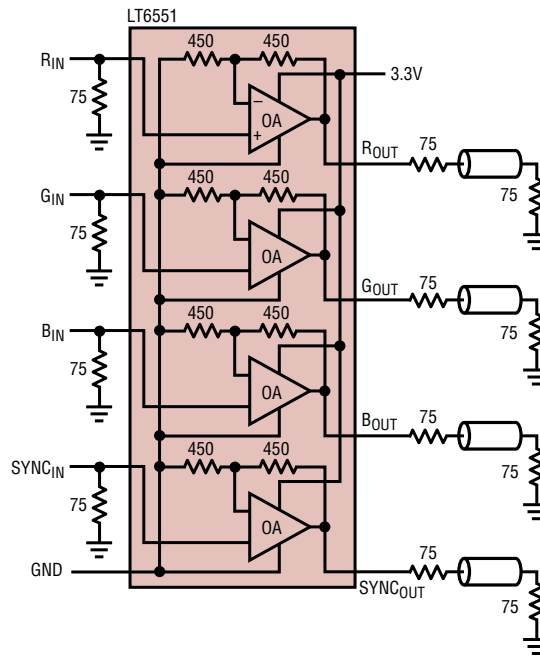
Most video amplifiers drive cables that are series terminated at the source and load terminated at the destination with resistances equal to the cable characteristic impedance (usually 75Ω). This configuration forms a 2:1 resistor divider in the cabling that must be corrected in the driver amplifier. Furthermore, bandwidth and slew rate must be high enough to drive today's large video displays.

The LT6553 video amplifier features a bandwidth of 650MHz and a slew rate of 2500V/μs, making them ideal for RGB video processing on displays with resolutions up to 1600 X 1200 pixels. With internal resistors setting a fixed gain of two, these amplifiers require minimal external circuitry. For lower resolution displays, the LT6550 triple and LT6551 quad video amplifiers provide similar performance at lower speeds. Features of the LT6553 include:

- **650MHz gain bandwidth product, 2500V/μs slew rate for driving 1600 X 1200 displays**
- **Differential gain 0.01%, Differential phase 0.01°**
- **-85dB distortion at 10MHz 2V_{P-P}**
- **Internal resistors for a fixed gain of 2**
- **Small 16-lead SSOP package**

Video multiplexers are required for high speed pixel switching, video signal processing and RGB switching. These key building blocks can be constructed using the high performance amplifiers shown on previous pages or with Linear Technology's family of dedicated video multiplexer ICs.

High Speed Cable Driver



Video Buffers

Part Number	Channel	-3dB Bandwidth	Slew Rate	Supply Voltage	Package	Max Resolution
LT6553	3	650MHz	2500V/μs	4.5V to 12V	SSOP-16	1600 x 1200
LT6551	4	110MHz	340V/μs	3V to 12.6V	MS10	1024 x 768
LT6550	3	110MHz	340V/μs	3V to 12.6V	MS10	1024 x 768

Video Multiplexers

Part Number	Configuration	Cable Drivers	GBW	Slew Rate	Package	Comments
LT1203	2:1	No	150MHz	180	N8/SO-8	150MHz 2:1 video mux
LT1204	4:1	Yes 1	75	500	N16/SW16	4-input video mux with 75MHz CFA
LT1205	2 x 2:1 or 4:1	No	150	180	SO-16	Dual LT1203
LT1675-1	2:1	Yes 1	250	1100	SO-8/MS8	CFA has fixed gain of 2
LT1675	3 x 2:1	Yes 3	250	1100	GN16	CFA has fixed gain of 2

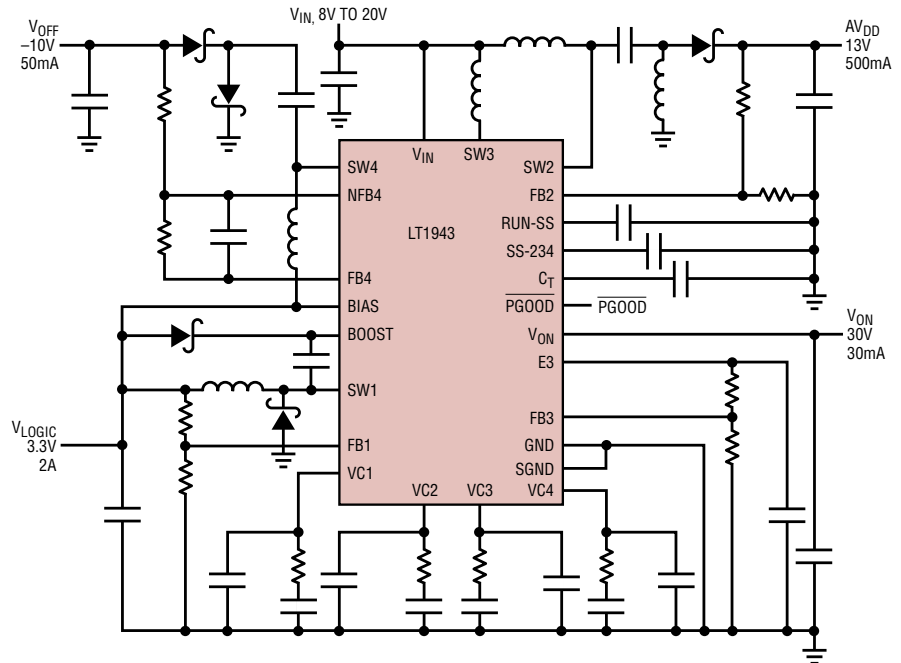
TFT-LCD Bias

CRTs are quickly being replaced by large screen TFT-LCD displays in both computing and entertainment systems. LCD panels typically require up to four separate switching regulators: a high power buck regulator to power V_{LOGIC} , a high power boost regulator to drive the the TFTs ($A_{V_{\text{DD}}}$), a high voltage TFT biasing output (V_{ON}) and an inverter for negative TFT biasing (V_{OFF}).

The LT1943 is a quad output adjustable switching regulator developed specifically for 22" to 42" TFT displays. The part provides all four necessary supplies with an integrated 2.4A buck, 2.6A boost, 300mA boost and 400mA inverter. The LT1943 also integrates several protection features. PanelProtect™ circuitry disables V_{ON} if any of the four outputs are more than 10% below normal operating voltage. This prevents the TFT panel from being exposed to an inrush of V_{ON} current. The LTC1943's high level of integration offers TFT-LCD designers the most compact, high integrated power solution available on the market. Features of the part include:

- Four integrated switching regulators (1 buck, 2 boost, 1 inverting) for complete TFT-LCD biasing solution
- Fixed 1.2MHz operation
- Multiple protection features for expensive TFT panels: PanelProtect circuitry, programmable V_{ON} delay, true output disconnect and soft-start
- TSSOP-28 package

Quad Output TFT-LCD Power Supply



Multiple Output Regulators for LCD Bias

Part Number	Power Supplies	V_{IN} Range	V_{OUT} Max	Switching Frequency	Package
LT1943	2.4A buck 2.6A boost 300mA boost 400mA inverter	4.5V to 22V	40V	1.2MHz	TSSOP-28
LT1947	1.1A boost 10mA boost 10mA inverter*	2.7V to 8V	30V	3MHz	MS10
LT1945	350mA buck 350mA boost	1.2V to 15V	36V	C.O.T.	MS10
LT1944	350mA boost 350mA boost	1.2V to 15V	36V	C.O.T.	MS10
LT1940	1.4A buck 1.4A buck	3.6V to 25V		1.1MHz	TSSOP-16

*External level shift charge pump required

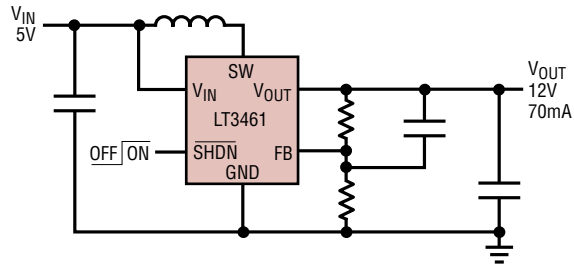
Integrated Boost Converters for LCD Bias

For providing the high voltages typically required for TFT-LCD biasing, Linear Technology offers a wide range of high performance boost regulators. Even in large screen LCD panels, solution size is critical to fitting the biasing electronics within the low profile of the display.

The LT3460 offers a solution for providing boost voltages of up to 36V from a tiny SC70 package. Switching at 1.3MHz allows the use of tiny, low profile capacitors and inductors. The LT3461 offers similar output power but adds an integrated Schottky diode. Features of the parts include:

- **300mA switch current**
- **High 1.3MHz switching frequency**
- **Tiny SC70 package (LT3460)**
- **Integrated Schottky (LT3461)**

5V to 12V, 70mA Step-Up DC/DC Converter



Single Output Boost Regulators for LCD Bias

Part Number	Switch Current	V _{IN} Range	V _{OUT} Max	Switching Frequency	Q Current	Features	Package
LT3464	85mA	2.3V to 10V	34V	COT	25uA	Integrated Schottky, output disconnect	ThinSOT
LT1615	300mA	1.2V to 15V	36V	COT	20uA	Burst Mode [®] operation	ThinSOT
LT3461	300mA	2.5V to 16V	38V	1.3MHz	2.8mA	Integrated Schottky	ThinSOT
LT3460	300mA	2.5V to 16V	36V	1.3MHz	2mA	Small size	SC70/ThinSOT
LT1613	550mA	1V to 10V	36V	1.4MHz	3mA	Low noise	ThinSOT
LT1930/A	1A	2.6V to 16V	34V	1.2/2.4MHz	4.2mA	High freq	ThinSOT
LT3467	1.1A	2.4V to 16V	40V	1.3MHz	1mA	Soft-start	ThinSOT
LT1946/A	1.5A	2.5V to 16V	36V	1.2/2.7MHz	3.2mA	High power	MS8

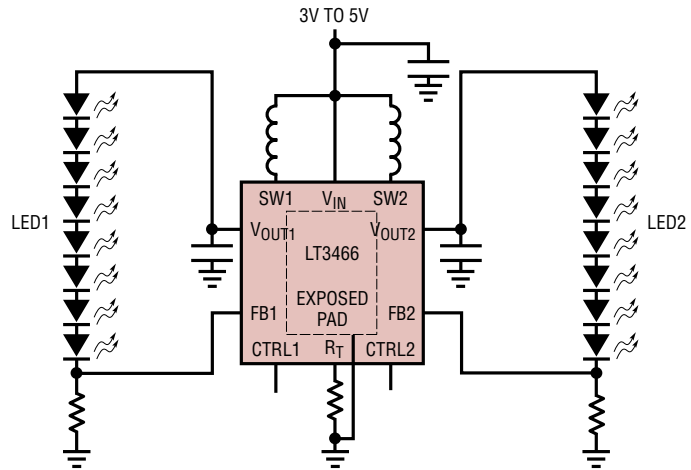
White LED Backlight

While once found only in small, handheld devices such as cell phones, white LEDs for backlighting are finding homes in ever larger displays for home entertainment, automotive, portable computing and industrial applications.

The LT3466 is a dual, full function white LED step-up converter capable of driving two strings of up to 10 LEDs each. Driving the LEDs in series provides inherent brightness and color matching and eliminates the need for ballast resistors or factory calibration. Features of the part include:

- **Two independent boost regulators with integrated Schottky diodes**
- **Input voltage from 2.7V to 24V**
- **Fixed frequency operation up to 2MHz**
- **Independent dimming control**
- **Small 3mm x 3mm DFN package**

Li-Ion Powered Driver for 16 White LEDs



Boost Regulator LED Drivers

Part Number	V _{IN} Min	V _{IN} Max	V _{OUT} Max	I _{sw} Max	# LEDs	Frequency	Package
LT3466	2.7V	24V	42V	420mA	2 x 10	2MHz	3mm x 3mm DFN
LT1618	1.6V	18V	34V	1.5A	20	1.4MHz	MS10
LT1932	1V	10V	34V	400mA	8	1.2MHz	ThinSOT
LT1615	1.2V	15V	34V	300mA	8	PFM	ThinSOT
LT3465/A	2.7V	16V	30V	400mA	6	1.2/2.7MHz	ThinSOT
LT1937	2.5V	10V	34V	320mA	4	1.2MHz	ThinSOT, SC70

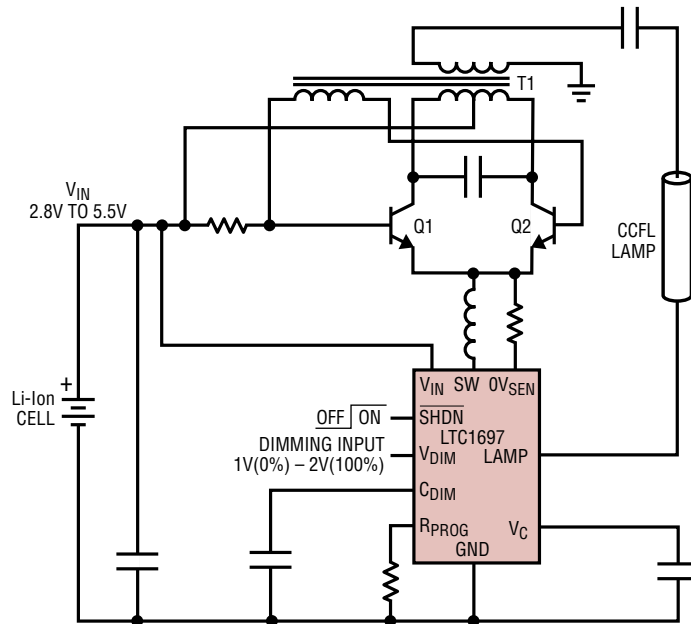
CCFL

Cold Cathode Fluorescent Lamps (CCFL) are commonly used to backlight the TFT-LCD displays found in many computing, entertainment and automotive display systems. Typically a 1W to 20W inverter is required to drive the CCFL and illuminate the LCD. Additionally, the inverter must supply the wide dimming range required for high performance displays and provide safety features to prevent catastrophic failure.

The LT1697 offers a small, inexpensive way to control a single 1W CCFL lamp ideal for portable and automotive applications. The part implements synchronous PWM control with an internal 1A MOSFET switch. Extremely accurate lamp current limits maintain the lamp lifetime and reliability. Features of the part include:

- **Integrated 1A switch**
- **2.7V to 5.5V input voltage range**
- **Adjustable PWM dimming**
- **Small MS10 package**

CCFL Power Supply



CCFL Drivers

Part Number	V _{IN} Min	V _{IN} Max	Switch Current	Frequency	I _Q	I _{SHDN}	Package
LT1697	2.7V	5.5V	1A	300kHz	440µA	1µA	MS10
LT1768	8V	24V	1.50A	350kHz	8mA	100µA	SSOP-16
LT1786F	3.5V	30V	0.90A	100kHa	6mA	5µA	SO-16
LT1186	3.5V	30V	0.90A	200kHa	6mA	5µA	SO-16
LT1184	3V	20V	1.20A	200kHz	9mA	3µA	SO-16
LT1182/83	3V	30V	1.2/0.625A	200kHz	9mA	3µA	SO-16

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