AHK3296

PowerLinear™

6 Channel 1x Low Dropout LED Driver

General Description

The AHK3296 is a linear current-sink LED driver, capable of driving up to six LEDs at 20.6mA each. Featuring individual low resistance, low drop-out voltage current sinks, the AHK3296 allows the LEDs to be regulated directly from a Lithium Ion/Polymer battery without the need for an additional step-up power supply, thereby reducing the external component count, eliminating switching noise and maximizing efficiency.

AnalogicTech's Simple Serial Control™ (S²Cwire™) interface is used to enable, disable, and set the LED drive current for 32-level linear scale LED brightness control. To minimize the use of external components the LED current is set internally to a maximum of 20.6mA.

The AHK3296 is packaged in a Pb-free, 10-pin SC70JW or 10-pin TDFN2.2x2.2 package and operates over the -40°C to +85°C temperature range.

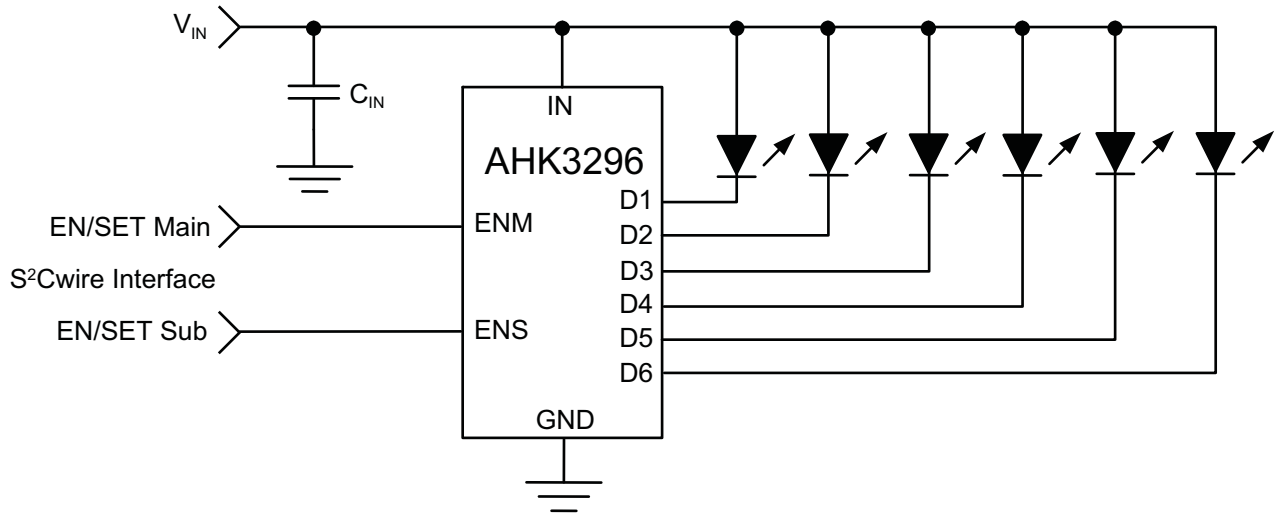
Features

- 2.7V to 5.5V Input Supply Range
- Drives up to 6 LEDs at up to 20.6mA each
- Low-Drop Out, Low Resistance Current Sinks
  - Typically 40.5mV at Full Scale
- Linear LED Output Current Control
  - S²Cwire Interface
    - Single-wire
    - 32 Steps
  - Independent LED Current Control for Main and Sub Group
- ±10% LED Output Current Accuracy
- ±3% LED Output Current Matching
- Low Current Shutdown Mode
- Two Package Options:
  - Low Cost SC70JW-10
  - Low Profile 0.75mm TDFN2.2x2.2-10

Applications

- Entry Level Mobile Phones
- Indicator LEDs
- Keyboard Backlight
- MP3 Players

Typical Application



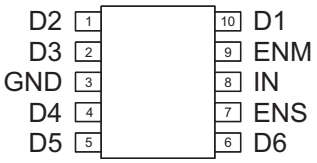
Pin Descriptions

Pinout is preliminary and subject to change during development.

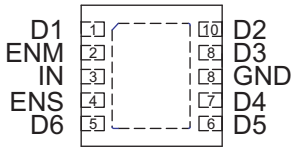
Pin Number		Symbol	Function	Description
SC70JW-10	TDFN2.2x2.2-10			
1	10	D2	O	Backlight LED 2 current sink output. Connect the cathode of LED 2 to D2. If not used, connect D2 to IN.
2	9	D3	O	Backlight LED 3 current sink output. Connect the cathode of LED 3 to D3. If not used, connect D3 to IN.
3	8	GND	I/O	Ground. Connect this pin to the system ground.
4	7	D4	O	Backlight LED 4 current sink output. Connect the cathode of LED 4 to D4. If not used, connect D4 to IN.
5	6	D5	O	Backlight LED 5 current sink output. Connect the cathode of LED 5 to D5. If not used, connect D5 to IN.
6	5	D6	O	Backlight LED 6 current sink output. Connect the cathode of LED 6 to D6. If not used, connect D6 to IN.
7	4	ENS	I	S^2Cwire serial input for the sub group (LED4-LED6). ENS is used for ON/OFF control. ENS is also the data input for the S^2Cwire interface used to control the 32 levels of LED brightness according to the maximum current set internally. Can be connected directly to ENM.
8	3	IN	I	Input power pin. Connect IN to the power source, typically the battery. Bypass IN to GND with a 1μF or larger ceramic capacitor.
9	2	ENM	PI	S^2Cwire serial input for the main group (LED1-LED3). ENM is used for ON/OFF control. ENS is also the data input for the S^2Cwire interface used to control the 32 levels of LED brightness according to the maximum current set internally. Can be connected directly to ENS.
10	1	D1	O	Backlight LED 1 current sink output. Connect the cathode of LED 1 to D1. If not used, connect D1 to IN.
EP				Bottom of package. Connect to large ground plane for good thermal performance

Pin Configuration

SC70JW-10
(Top View)



TDFN2.2x2.2-10
(Top View)



Absolute Maximum Ratings[1]

T_A = 25°C unless otherwise noted.

Symbol	Description	Value	Units
V_N	IN, D1, D2, D3, D4, D5, D6 to GND	-0.3 to 6.0	V
V_{EN}	ENM, ENS to GND	-0.3 to VIN +0.3	

Thermal Information[2]

Symbol	Description	Package	Value	Units
Θ_{JA}	Thermal Resistance[3]	SC70JW-10	160	°C/W
		TDFN2.2 x 2.2-10	71.4	
P_D	Maximum Power Dissipation	SC70JW-10	625	mW
		TDFN2.2 x 2.2-10	1.4	
T_J	Junction Temperature Range		-40 to 150	°C
T_A	Operating Temperature Range		-40 to 85	
T_{LEAD}	Maximum Soldering Temperature (at Leads)		300	

1. Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device. Functional operation at conditions other than the operating conditions specified is not implied. Only one Absolute Maximum Rating should be applied at any one time.
2. Mounted on an FR4 board.
3. Derate SC70JW 6.25mW/°C or TDFN 71.4mW/OC above 40°C.

Electrical Characteristics[1]

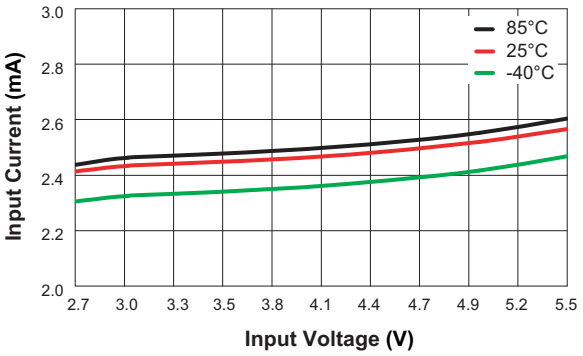
IN = EN = 3.6V, C_{IN} = 1µF; T_A = -40°C to 85°C unless otherwise noted. Typical values are at T_A = 25°C.

Symbol	Description	Conditions	Min	Typ	Max	Units
Power Supply						
V_{IN}	Input Voltage Range		2.7		5.5	V
I_{IN}	Input Operating Current	I_{DX} = 20.6mA (DATA 1) excluding I_{DX}		2.5	4.0	mA
$I_{IN(SHDN)}$	Input Shutdown Current	IN = 5.5V; EN = GND			1	µA
V_{DO}	Current Sink Drop-out Voltage[2]	I_{DX}= 20.6mA (DATA 1)		40.5	125	mV
		I_{DX} = 15.2mA (DATA 16)		36	85	
LED Current Sink Outputs						
$I_{D(MAX)}$	D1 to D6 Current Accuracy	I_{DX} = 20.6mA (DATA 1) at T_A = 25°C	18.54	20.6	22.66	mA
$\Delta I_{D(MAX)}$	D1, D2, D3 (main), D4, D5, D6 (sub) Group Current Matching	I_{DX} = 20.6mA (DATA 1)		±3		%
t_S	Start-up Period	ENM = ENS = IN		150		µs
ENM, ENS and S²Cwire Control						
$V_{EN(L)}$	EN Input Low Threshold				0.4	V
$V_{EN(H)}$	EN Input High Threshold		1.4			V
I_{EN}	EN Input Leakage Current	ENM = EMS = IN = 5V	-1		1	µA
$T_{EN(LOW)}$	EN Serial Interface Low Time		0.3		75	µs
$T_{EN(HI\_MIN)}$	Minimum EN high Time			50		Ns
$T_{EN(HI\_MAX)}$	Maximum EN High Time				75	µs
$T_{EN(OFF)}$	EN Off Timeout				500	µs
$T_{EN(LAT)}$	EN Latch Timeout				500	µs

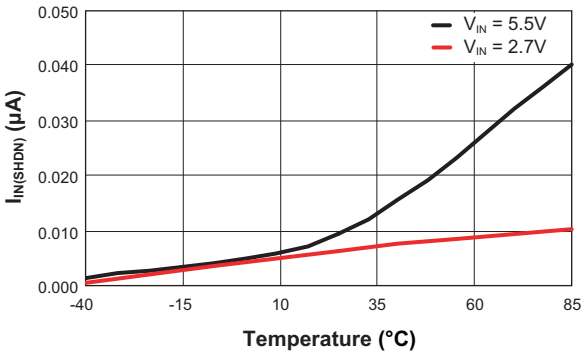
1. The AHK3296 is guaranteed to meet the performance specifications over the -40OC to +85OC operating temperature range and is assured by design, characterization and correlation with statistical process controls.
2. The current sink drop-out voltage is defined as when IDX drops to 90% of its nominal value.

Typical Characteristics

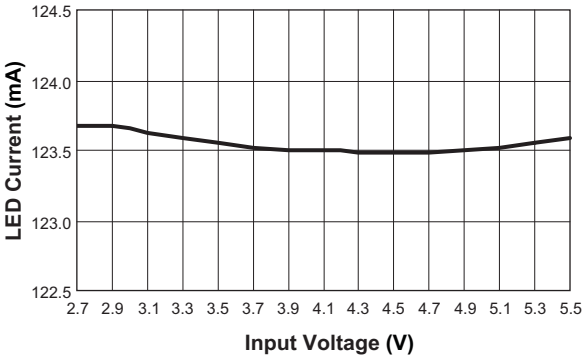
Input Operating Current vs. Input Voltage



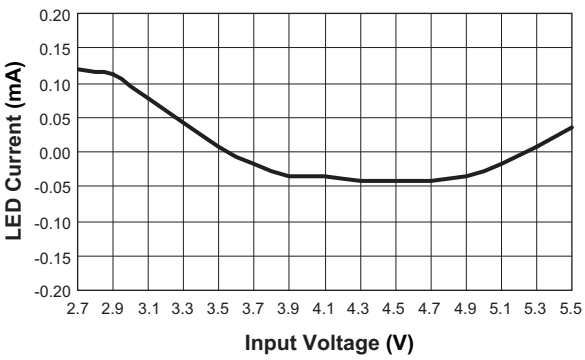
Input Shutdown Current vs. Temperature



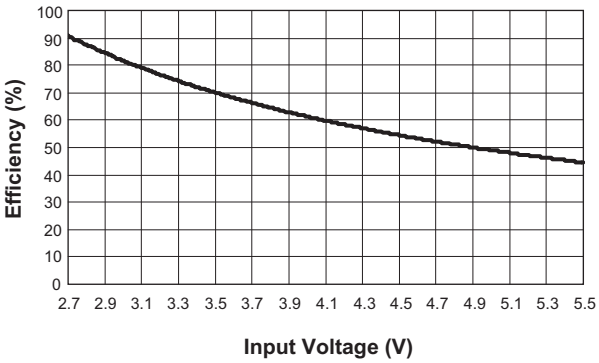
Line Regulation
(20.6mA/ch)



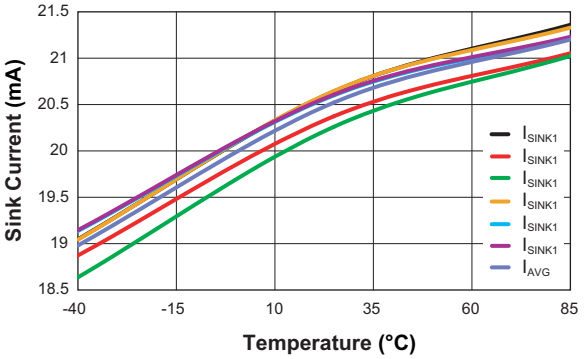
Line Regulation Accuracy
(20.6mA/ch)



Efficiency vs. Input Voltage
(V_F = 2.5V)

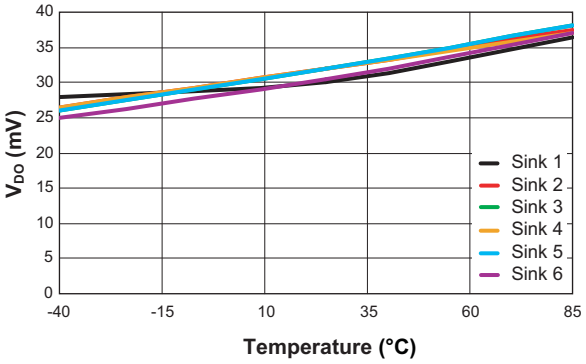


Sink Current Matching

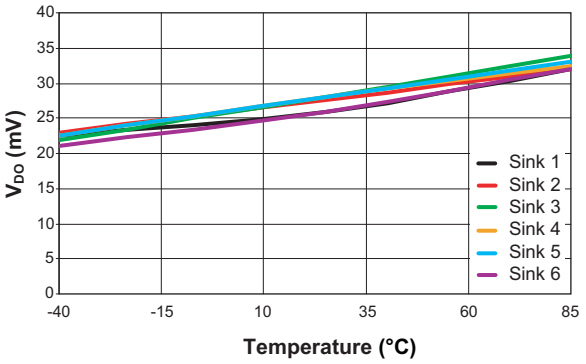


Typical Characteristics

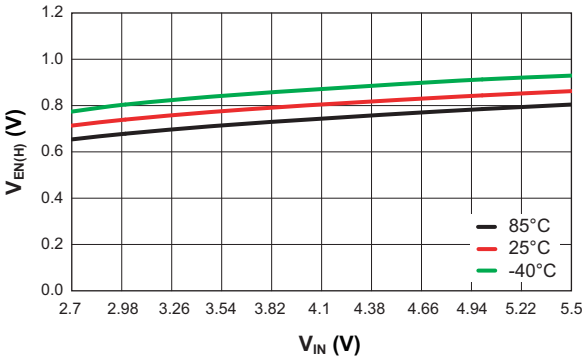
Current Sink Dropout Voltage vs. Temperature (Data = 1)



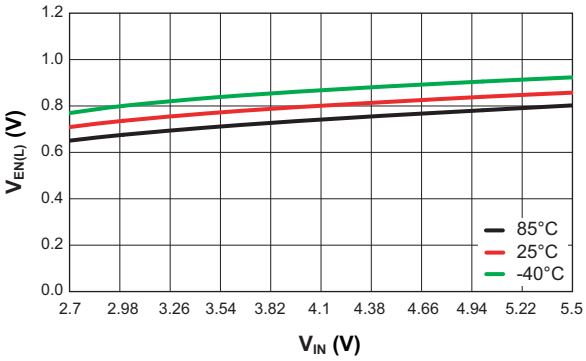
Current Sink Dropout Voltage vs. Temperature (Data = 16)



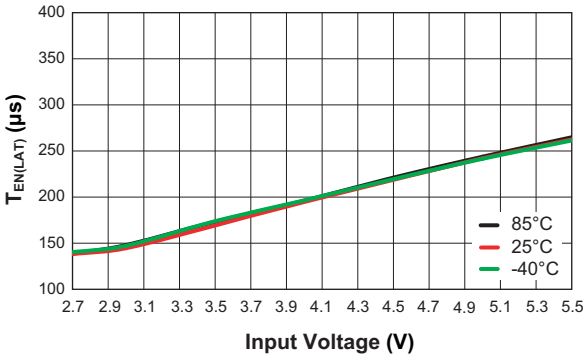
EN Input High Threshold vs. Input Voltage



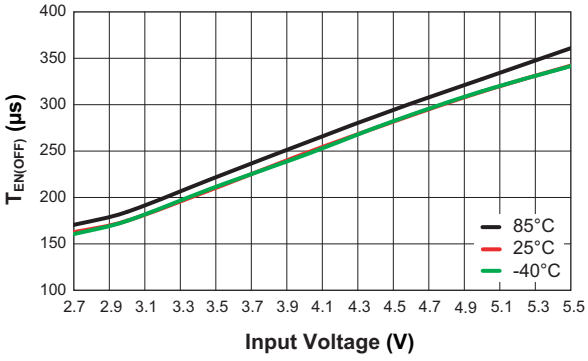
EN Input Low Threshold vs. Input Voltage



EN Latch Timeout vs. Input Voltage

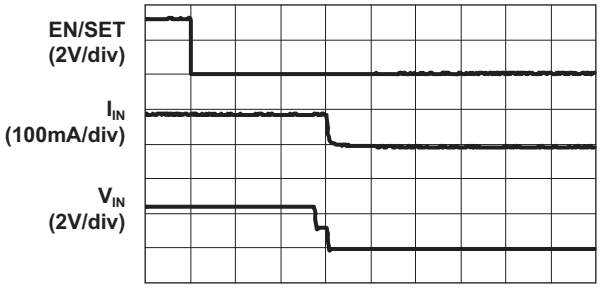


EN Off Timeout vs. Input Voltage

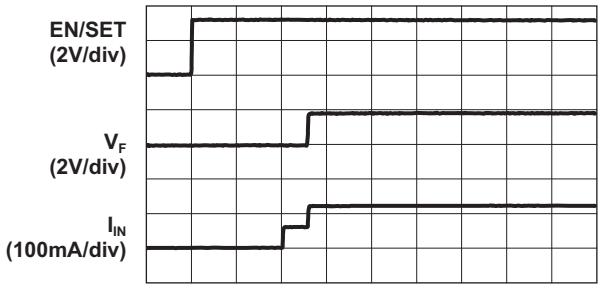


Typical Characteristics

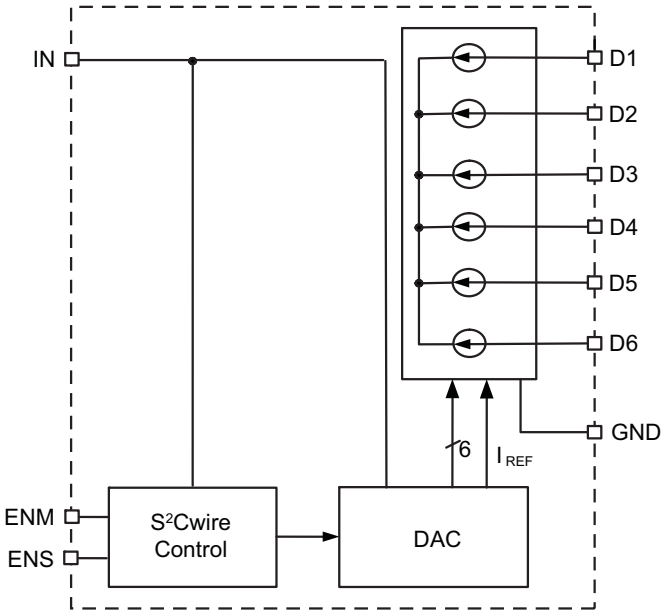
Turn Off
(V_{IN} = 4.5V; 20.6mA/ch)



Startup
(V_{IN} = 4.5V; 20.6mA/ch)



Functional Block Diagram



Functional Description

The AHK3296 is an entry level driver IC, designed to drive up to six white LEDs. The AHK3296 operates directly from a 2.7V to 5.5V power source and enables and controls the current to the LEDs. LED current is individually controlled through integrated current sinks powered from an external power supply. Low resistance and low-drop out voltage current sinks allow the LEDs to operate very close to the input supply voltage, eliminating the need for an additional noisy boost power supplies.

The AHK3296 requires only one external component: one 1μF ceramic input capacitor (C_{IN}). The AHK3296 can drive six constant output sinks (D1 to D6) each with a maximum current of up to 20.6mA which is set internally. AnalogicTech's S²Cwire serial interface enables the AHK3296 and changes the current sink magnitudes for main group (D1-D3) and sub group (D4-D6) through the ENM and ENS pins respectively, thereby changing the LED currents.

S²Cwire Serial Interface

The LED output current of the AHK3296 is controlled by AnalogicTech's S²Cwire serial interface. Since the LED current is programmable, no PWM or additional control circuitry is needed to control LED brightness. This feature greatly reduces the burden on a microcontroller or system IC to manage LED or display brightness, allowing the user to "set it and forget it." With its high-speed serial interface (1MHz data rate), the LED current can be changed quickly and easily. Also the non-pulsating LED current reduces system noise and improves LED reliability. If both the main (D1, D2 and D3) and sub (D4, D5 and D6) groups are to be programmed with the same current level per channel they can share a common GPIO microprocessor port.

The S²Cwire interface relies on the number of rising edges to the ENS and ENM pins to set the registers. A typical write protocol is a burst of ENM and ENS rising edges, followed by a pause with ENM and ENS held high for at least t_{LAT} (500μs). The programmed current is then seen at all current sink outputs. When ENM and ENS are held low for an amount of time longer than t_{OFF} (500μs), the AHK3296 enters into shutdown mode and draws less than 1μA from the input and the internal data register is reset to zero.

The AHK3296 serial interface reduces the LED current on each rising pulse of the enable inputs ENM and ENS. If the AHK3296 is in shutdown, the first rising edge of the ENM turns on all main channels D1-D3 to the maximum current level. The first rising edge of the ENS turns on all sub channels D4-D6 to the maximum current level.. Successive rising edges of ENM decrease the LED current for the main channels (D1-D3) and successive rising edges of ENS decrease the LED current for the sub channels (D4-D6) as shown in Table 1 and Figure 1 for the AHK3296.

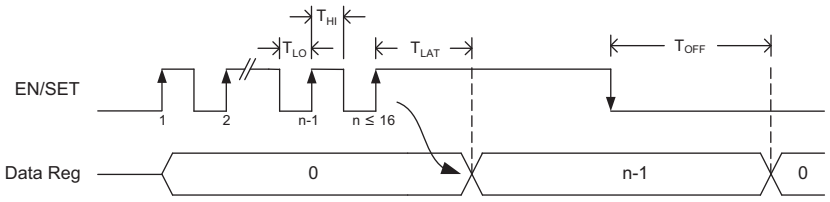


Figure 1: S²Cwire Serial Interface Timing.

Data	ENM, ENS Rising Edges	D1- D6 Output Current (mA)	Data	ENM, ENS Rising Edges	D1-D6 Output Current (mA)
1	1	20.6	17	17	10.0
2	2	19.9	18	18	9.3
3	3	19.3	19	19	8.6
4	4	18.6	20	20	8.0
5	5	17.9	21	21	7.3
6	6	17.3	22	22	6.6
7	7	16.6	23	23	6.0
8	8	15.9	24	24	5.3
9	9	15.3	25	25	4.6
10	10	14.6	26	26	4.0
11	11	13.9	27	27	3.3
12	12	13.3	28	28	2.6
13	13	12.6	29	29	2.0
14	14	11.9	30	30	1.3
15	15	11.3	31	31	0.7
16	16	10.6	32	32	0.3

Table 1: AHK3296 LED Current Settings.

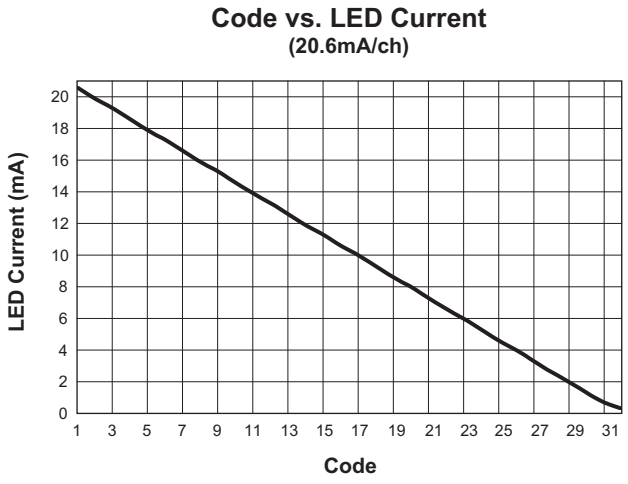


Figure 2: AHK3296 Current Profile.

Applications Information

LED Selection

The AHK3296 is specifically intended for driving white LEDs. However, the device design will allow the AHK3296 to drive most types of LEDs with forward voltage specifications typically ranging from 2.2V to 4.7V depending upon supply voltage. LED applications may include mixed arrangements for display backlighting, keypad display, and any other application that needs a constant current sink generated from a varying input voltage. Since the D1 to D6 constant current sinks are matched within 3% with negligible supply voltage dependence, the constant current channels will be matched regardless of the specific LED forward voltage (V_F) levels. The low dropout current sinks in the AHK3296 maximize performance and make it capable of driving LEDs with high forward voltages. The six channels can be combined to obtain a higher LED drive current without complication.

Shutdown

Since the current switches are the only power supplies for all loads, there is no leakage current when all sink switches are disabled. To activate the shutdown operation, both the ENM and ENS inputs for the AHK3296 should be strobed low for longer than t_{OFF} (500µs). In this state, the AHK3296 typically draws less than 1µA from the input. All registers are reset to 0 in shutdown.

Additional Applications

The current sinks of the AHK3296 can be combined to drive higher current levels through the LEDs. As an example, three LEDs can typically be driven at 61.8mA each by combining the D1-D3 and D4-D6 outputs as shown in Figure 3.

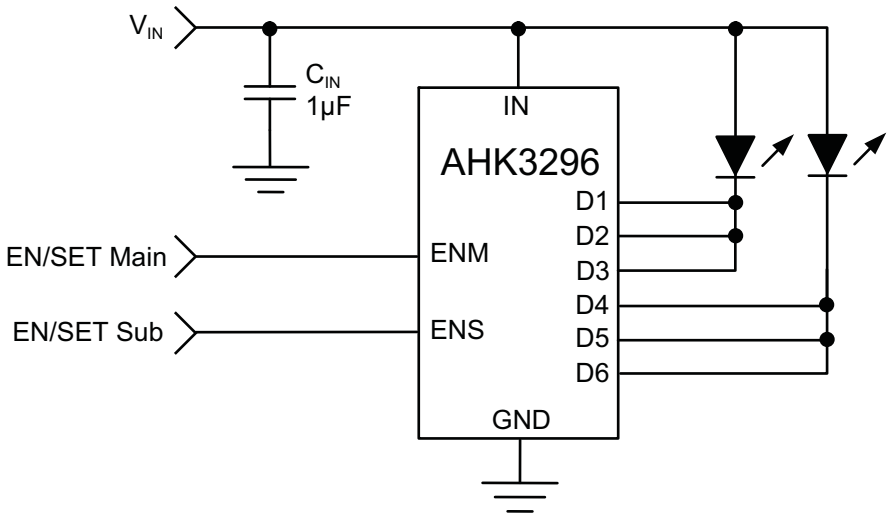


Figure 3: AHK3296 Higher Current Application Circuit.

Capacitor Selection

Careful selection of the external capacitor C_{IN} is important because it will affect turn-on time and transient performance. Optimum performance will be obtained when low equivalent series resistance (ESR) ceramic capacitor is used; in general, low ESR may be defined as less than 100mΩ. A value of 1µF for the input capacitor is a good starting point when choosing a capacitor. If the constant current sinks are only programmed for light current levels then the input capacitor size may be decreased.

Capacitor Characteristics

Ceramic composition capacitor is highly recommended over all other types of capacitors for use with the AHK3296. Ceramic capacitors offer many advantages over their tantalum and aluminum electrolytic counterparts. A ceramic capacitor typically has very low ESR, is lower cost, has a smaller PCB footprint, and is non polarized. Since ceramic capacitors are non-polarized, they are not prone to incorrect connection damage.

Equivalent Series Resistance

ESR is an important characteristic to consider when selecting a capacitor. ESR is a resistance internal to a capacitor that is caused by the leads, internal connections, size or area, material composition, and ambient temperature. Capacitor ESR is typically measured in milliohms for ceramic capacitors and can range to more than several ohms for tantalum or aluminum electrolytic capacitors.

Ceramic Capacitor Materials

Ceramic capacitors less than 0.1µF are typically made from NPO or C0G materials. NPO and C0G materials generally have tight tolerance and are very stable over temperature. Larger capacitor values are usually composed of X7R, X5R, Z5U, or Y5V dielectric materials. Large ceramic capacitors (i.e., larger than 2.2µF) are often available in low cost Y5V and Z5U dielectrics, but capacitors larger than 1µF are not typically required for AHK3296 applications.

Capacitor area is another contributor to ESR. Capacitors that are physically large will have a lower ESR when compared to an equivalent material smaller capacitor. These larger devices can improve circuit transient response when compared to an equal value capacitor in a smaller package size.

Evaluation Board User Interface

The user interface for the AHK3296 evaluation board is provided by three buttons and two connection terminals. The board is operated by supplying external power and pressing individual buttons or button combinations. Table 2 indicates the function of each button or button combination. To power-on the evaluation board, connect a power supply or battery to the DC- and DC+ terminals. A red LED indicates that power is applied. The evaluation board is made flexible so that the user can disconnect the enable line from the microcontroller and apply external enable signal. External enable signal must be applied to the EN pin.

When applying external enable signal, consideration must be given to the voltage levels. The externally applied voltage should not exceed the supply voltage that is applied to the IN pins of the device (DC+).

User Interface Functionality

Button(s) Pushed	Description
UP	[Push/Release once] Main channels D1 to D3 are turned on with 0.3mA per channel. With every push/release the current is increased according to Table 1.
UP+CYCLE	[Push/Release once] Sub channels D4 to D6 are turned on with 0.3mA per channel. With every push/release the current is increased according to Table 1.
DOWN	[Push/Release once] Main channels D1 to D3 are turned on with 20.6mA per channel. With every push/release the current is decreased according to Table 1.
DOWN+CYCLE	[Push/Release once] Sub channels D4 to D6 are turned on with 20.6mA per channel. With every push/release the current is decreased according to Table 1.
CYCLE	[Push/Release once] Auto cycling up and down.
UP+DOWN+CYCLE	[Push/Release together once] Reset all buttons.

Table 2: AHK3296 Evaluation Board User Interface.

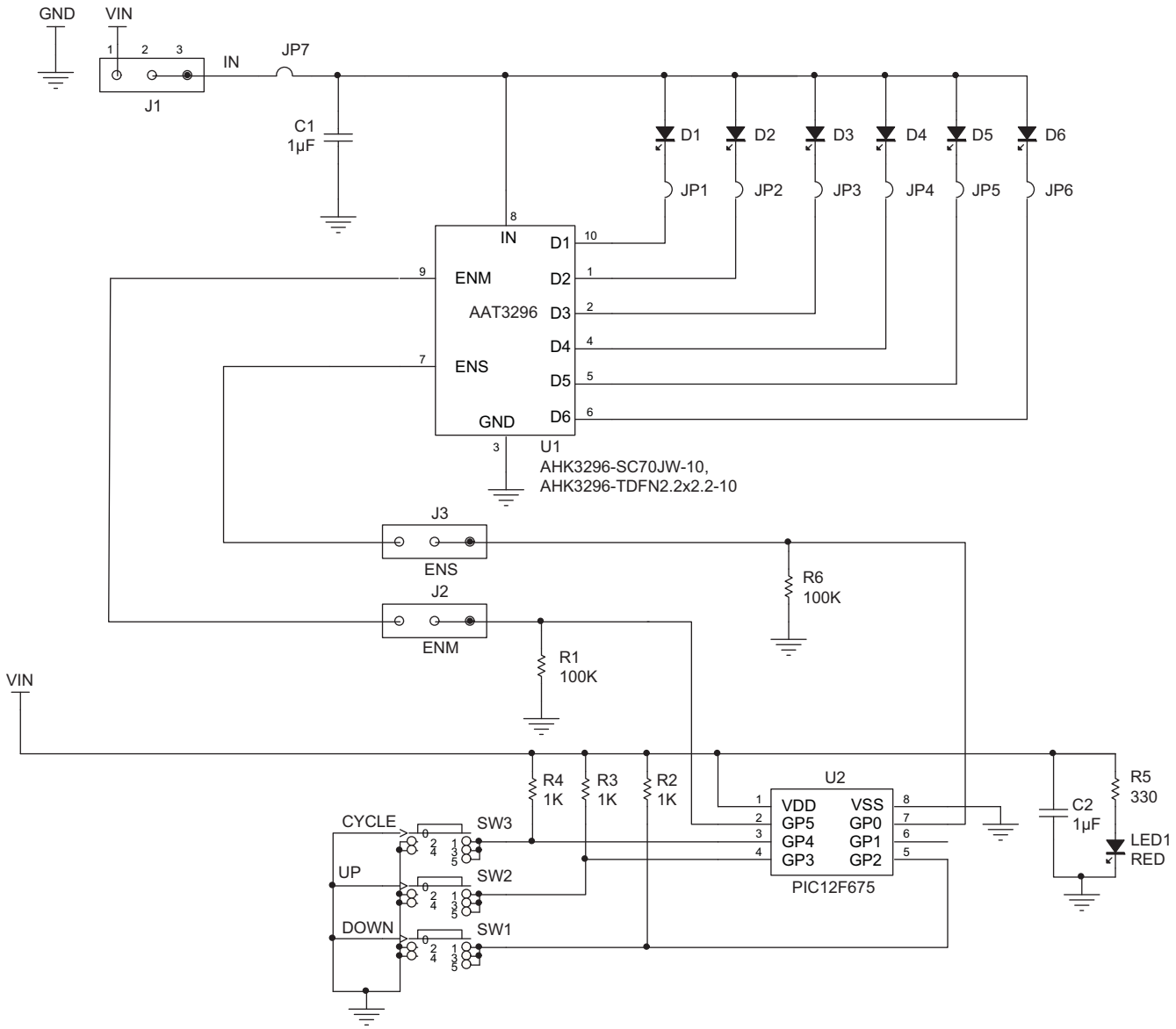


Figure 4: AHK3296IJQ and AHK3296IDH Evaluation Boards Schematic.

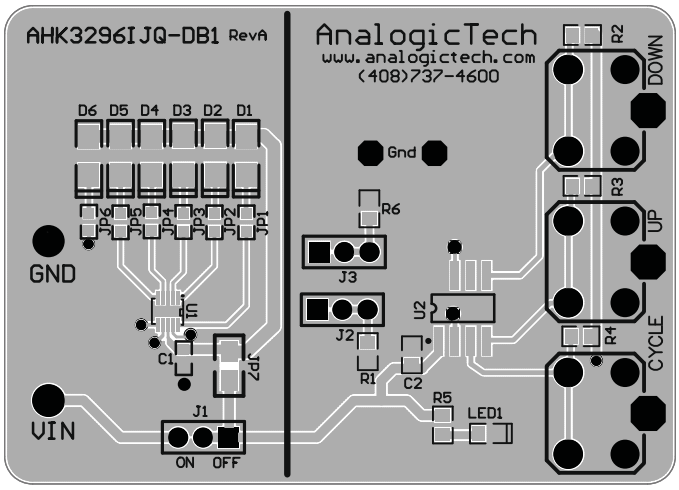


Figure 5: AHK3296IJQ Evaluation Board Top Side Layout.

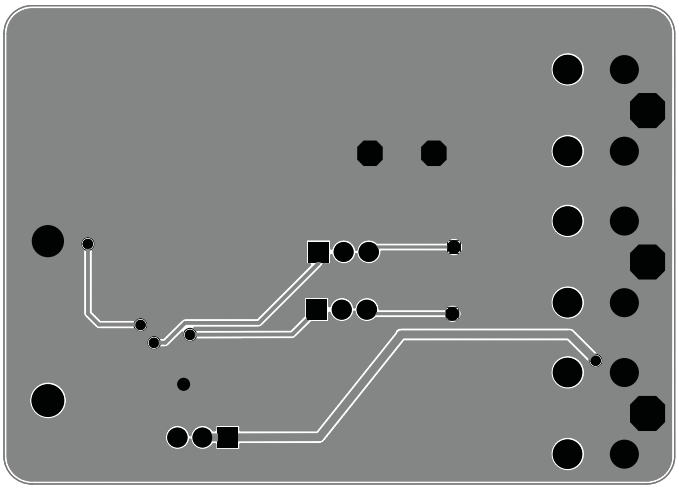


Figure 6: AHK3296IJQ Evaluation Board Bottom Side Layout.

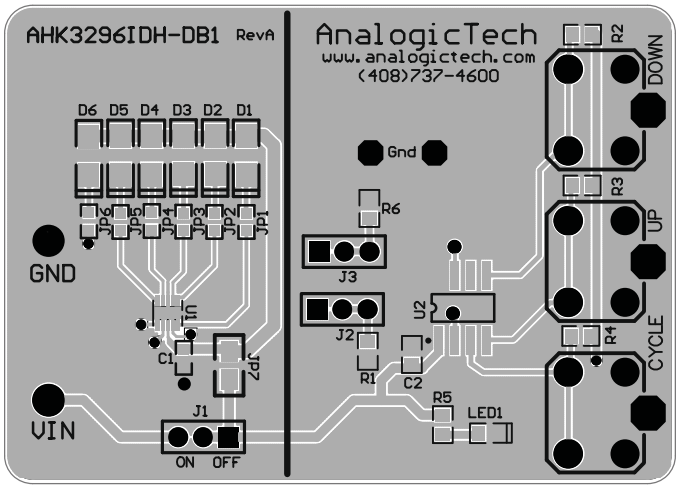


Figure 7: AHK3296IDH Evaluation Board Top Side Layout.

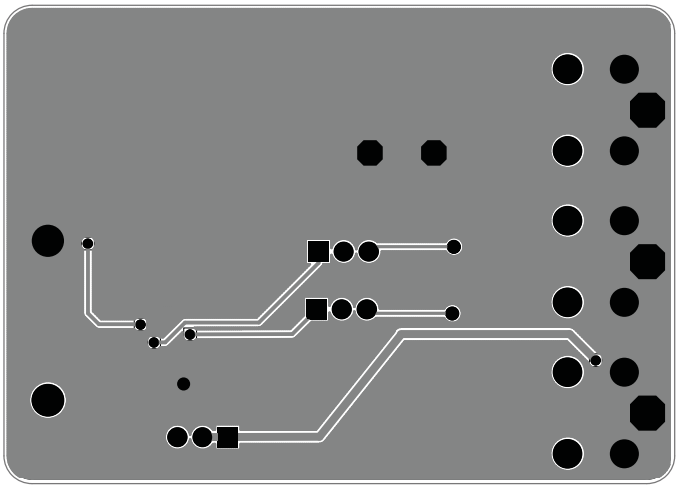


Figure 8: AHK3296IDH Evaluation Board Bottom Side Layout.

AAT3296 Evaluation Board Component Listing

Component	Part Number	Description	Manufacturer
U1	AHK3296IJQ, AHK3296IDH	Six Channel LED Driver; SC70JW-10 or TDFN2.2x2.2-10 Packages	AnalogicTech
U2	PIC12F675	8-bit CMOS, Flash-Based µC; 8-pin PDIP Package	Microchip
CYCLE, UP, DOWN	PTS645TL50	Switch Tact, SPST, 5mm	ITT Industries
R5	Chip Resistor	330Ω, 1%, 1/4W; 0603	Vishay
R1, R6	Chip Resistor	100KΩ, 5%, 1/4W; 0603	Vishay
R2, R3, R4	Chip Resistor	1KΩ, 5%, 1/4W; 0603	Vishay
C1, C2	GRM185R60J105KE21	1µF, 6.3V, X7R, 10%, 0603	Murata
LED1	CMD15-21SRC/TR8	Red LED; 0603	Chicago Miniature Lamp
J1, J2, J3	PRPN401PAEN	Conn. Header, 2mm zip	Sullins Electronics
JP1, JP2, JP3, JP4, JP5, JP6	Chip Resistor	0Ω, 5%, 1/4W; 0603	Vishay
JP7	Chip Resistor	0Ω, 5%, 1/2W; 0805	Vishay
D1, D2, D3, D4, D5, D6	LW M673	Mini TOPLED White LED; SMD	OSRAM

Table 4: AHK3296IJQ and AAT3296IDH Evaluation Boards Bill of Materials (BOM).

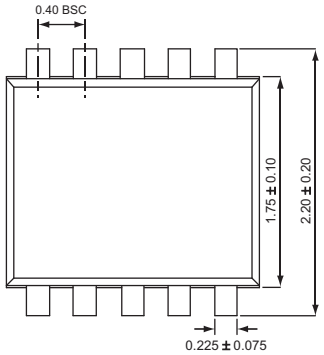
Ordering Information

Package	Part Marking[1]	Part Number (Tape and Reel)[2]
SC70JW-10	C2XYY	**AHK3296IJQ-T1**
TDFN2.2x2.2-10	D7XYY	**AHK3296IDH-T1**

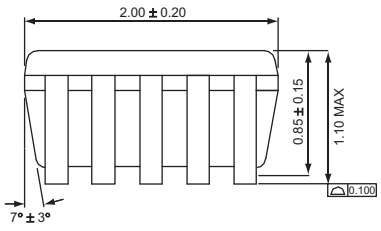
All AnalogicTech products are offered in Pb-free packaging. The term "Pb-free" means semiconductor products that are in compliance with current RoHS standards, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. For more information, please visit our website at http://www.analogictech.com/aboutus/quality.php.

Package Information

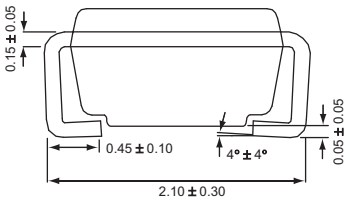
SC70JW-10



Top View



Side View

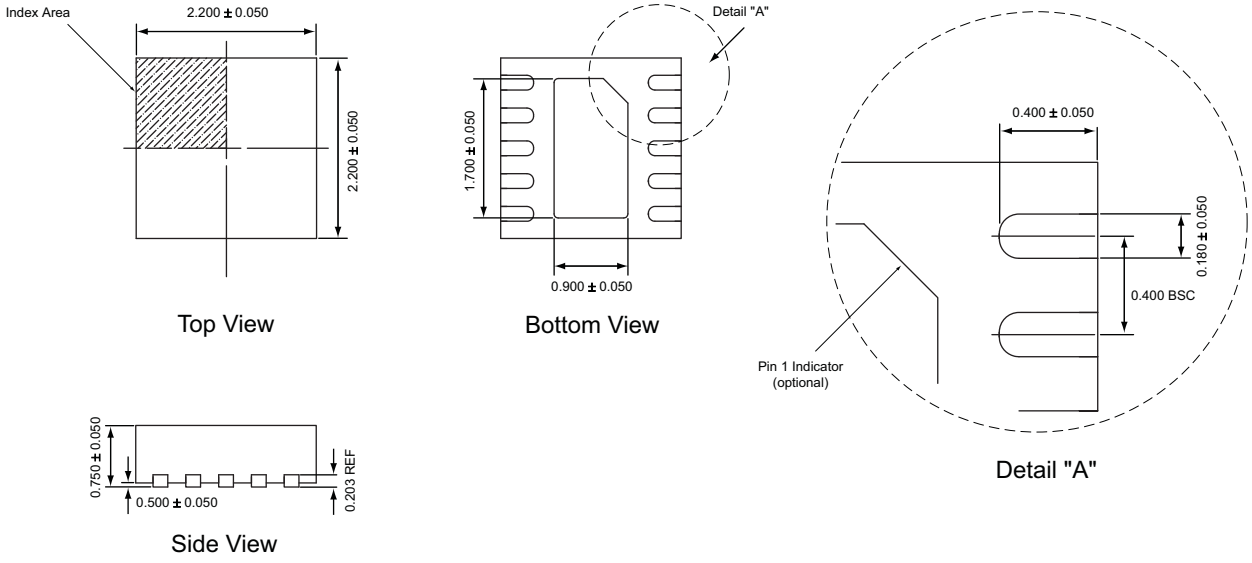


End View

All dimensions in millimeters.

1. XYY = assembly and date code.
2. Sample stock is generally held on part numbers listed in BOLD.

TDFN2.2x2.2-10[1]



All dimensions in millimeters.

1. The leadless package family, which includes QFN, TQFN, DFN, TDFN and STDFN, has exposed copper (unplated) at the end of the lead terminals due to the manufacturing process. A solder fillet at the exposed copper edge cannot be guaranteed and is not required to ensure a proper bottom solder connection.

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