Triple 150mA Linear LED Driver

GENERAL DESCRIPTION

SiLM42280/1/2/3-AQ family devices provide independent triple linear current controller for LED driving (standalone driver or LED cluster). Diagnostic features are provided to meet automotive requirements, together with a communication interface "RUN" to link ICs to generate more than three channels, supporting individual current configuration and independent digital PWM dimming per channel (e.g. for RGB).

Two external configurable operation modes are supported. In the Failure Feedback Mode (FFM), channels are still operating in case of errors with error signalization. And in Single Lamp Mode, all linked SiLM42280/1/2/3-AQ's channels will be turned off in case of errors.

An intelligent power management system is provided using an external shunt resistor to share power distribution between IC package and external heat sink. Hotspot generation can be avoided by flexible heat spreading on the printed board. Internal derating for reference voltage and over temperature shutdown for extreme temperatures higher than 180°C to protect SiLM42280/1/2/3-AQ in case of abnormal operation conditions.

A high voltage capable input ENA can be used to either digitally enable or disable SiLM42280/1/2/3-AQ. In addition, this input may be used as analog reference voltage input for thermal derating.

FEATURES

- Three independent linear current drivers (3*150mA)
- Parallel output operation for up to 450mA
- Low power standby / sleep mode
- Thermal management option per channel
- Operating input voltage range 5V to 25V, max up to 40V
- External reference voltage for derating supported
- PWM dimming (All channels or separate channels)
- Diagnostic functionalities (LED Driver open/short, single LED short, IR configuration open/short, Junction temperature, supply voltage)
- Diagnostic bus to link ICs
- Single LED short threshold configuration
- Selectable Failure Feedback Mode or Single Lamp Behavior
- Package available in SOP16-EP
- AEC-Q100 Qualification

APPLICATION

- Automotive LED Lighting, Rear Lighting
- Turn Indicator Driver
- Medium Current Interior Lighting
- Industrial LED Applications or RGB Drivers

TYPICAL APPLICATION CIRCUIT

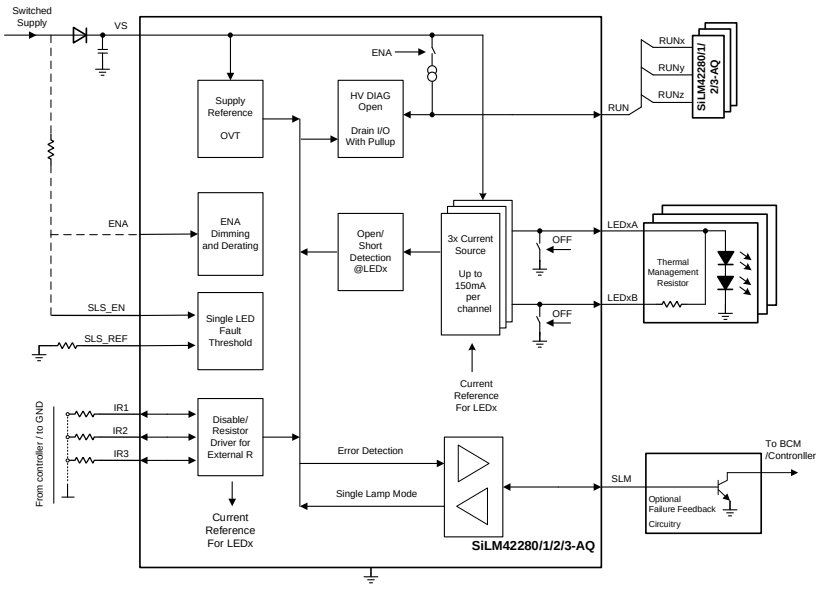

Figure 1. Typical application

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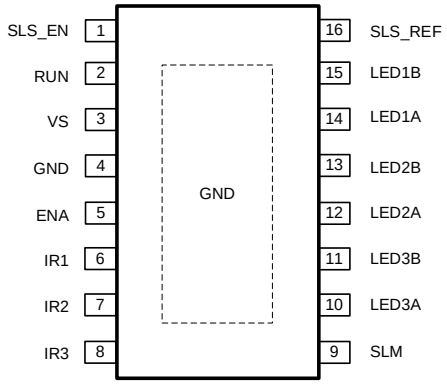
PIN CONFIGURATION

Package	Pin Configuration (Top View) SiLM42280/1/2/3-AQ
SOP16-EP	

PIN FUNCTION DESCRIPTION

Pin		Type [1)]	Function Description
No.	Name		
1	SLS_EN	A_I	SLS_EN: Enable single LED fault detection. When SLS_EN is high, single LED fault detection is enabled. If this function is not used, connect SLS_EN to ground or left it floating.
2	RUN	HV_A_IO	RUN diagnostic bus interface to link SiLM42280/1/2/3-AQ products
3	VS	HV_S	High voltage supply input
4	GND	S	Ground.
5	ENA	HV_A_I	High voltage enable and optional analog reference voltage input
6	IR1	A_IO	Current configuration for Channel 1, digital Input for Channel 1 dimming
7	IR2	A_IO	Current configuration for Channel 2, digital Input for Channel 2 dimming
8	IR3	A_IO	Current configuration for Channel 3, digital Input for Channel 3 dimming
9	SLM	A_IO	Operating mode configuration: When the SLM pin is open, the device works in Single Lamp Mode. When the SLM pin is connected to GND or directly to an external bipolar device, the device works in Failure Feedback Mode. Details see SLM Interface.
10	LED3A	HV_A_O	Bypass output Channel 3, connect to LED directly
11	LED3B	HV_A_O	Priority output Channel 3, connect to LED via thermal shunt
12	LED2A	HV_A_O	Bypass output Channel 2, connect to LED directly
13	LED2B	HV_A_O	Priority output Channel 2, connect to LED via thermal shunt
14	LED1A	HV_A_O	Bypass output Channel 1, connect to LED directly
15	LED1B	HV_A_O	Priority output Channel 1, connect to LED via thermal shunt
16	SLS_REF	A_I	SLS_REF: Single LED short threshold configuration. Connect a resistor between SLS_REF and ground to set the threshold.
	Exposed Pad		Exposed Pad, Connect to ground for thermal connection

Note 1: A = Analog, D = Digital, S = Supply, I = Input, O = Output, B = Bidirectional, HV = High Voltage

ORDERING INFORMATION

Order Part No.	OPEN Diagnostic Threshold	Package	QTY
SiLM42280CN-AQ	7.5V	SOP16-EP	3000/Reel
SiLM42281CN-AQ	9.0V	SOP16-EP	3000/Reel
SiLM42282CN-AQ	10.0V	SOP16-EP	3000/Reel
SiLM42283CN-AQ	15.0V	SOP16-EP	3000/Reel

FUNCTIONAL DIAGRAM

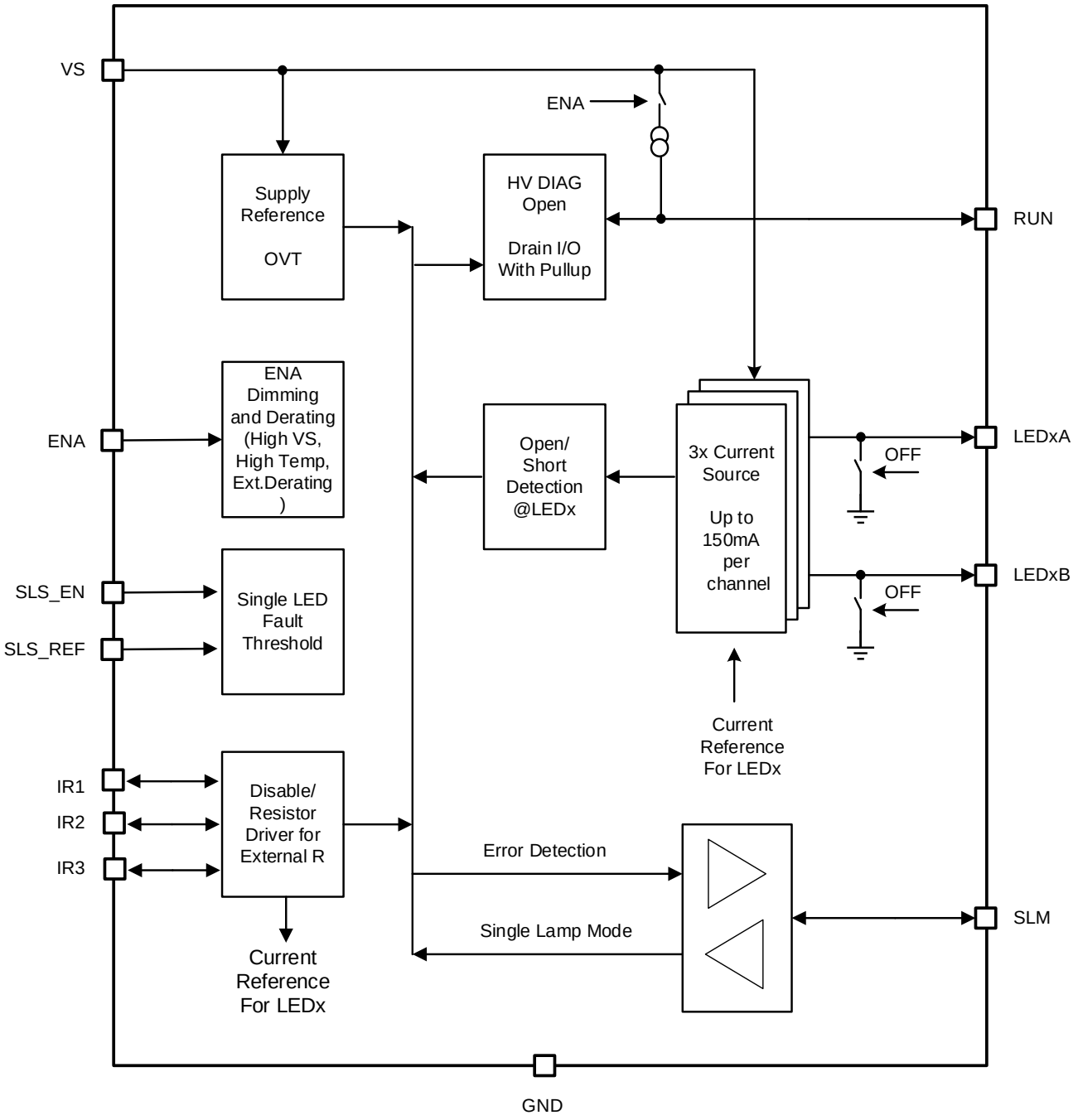


Figure 2. Functional Block Diagram

ABSOLUTE MAXIMUM RATINGS

Symbol	Description	Min	Max	Unit
V_{VS}	VS Pin Voltage	-0.3	40	V
V_{ENA}	ENA Pin Voltage	-0.3	40	V
V_{IRx}	IR1,2,3 Pin Voltage[1]	-0.3	5.5	V
I_{IRx}	IR1,2,3 Pin Current	-1	1	mA
I_{LEDx}	LEDx Current	-170	100	mA
V_{LEDx}	LEDxA/B Pin Voltage	-1	V_{VS}	V
V_{RUN}	RUN Pin Voltage	-0.3	V_{VS}	V
I_{RUN}	RUN Pin Current	-5	5	mA
V_{SLM}	SLM Pin Voltage	-0.3	6.5	V
V_{SLS_REF}	SLS_REF Pin Voltage	-0.3	5.5	V
V_{SLS_EN}	SLS_EN Pin Voltage	-0.3	40	V
T_J	Junction Temperature	-40	150	°C
T_A	Ambient Temperature[2]	-40	125	°C
T_{ST}	Storage Temperature	-40	125	°C
P_{MAX}	Power Dissipation		2.5	W
R_{TH_JC}	Thermal Resistance Junction to Exposed Die Pad[3]		6	°C /W

Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those listed in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. All voltage parameters are absolute voltages referenced to GND.

1) see parameter V_{IR_CLMP} for clamping behavior

2) consider maximum junction temperature and cooling measures to define ambient operating range

3) Typical thermal resistance to EP is R_{TH_JC}=3°C /W (not production tested)

ESD RATINGS

Parameter	Rating
Human Body Model (HBM)	±4000V
Charge Device Model (CDM)	±2000V

RECOMMENDED OPERATING CONDITIONS

Symbol	Description	Min	Typ	Max	Unit
V_{VS_OP}	Recommended operating voltage range	5	14	25	V
P_{OP}	Continuous power dissipation in package			2.2	W
C_{VS_OP}	VS capacitance per SiLM42280/1/2/3-AQ	220	330		nF
R_{IRx}	Nominal value of current selection resistor at IR1,2,3 to GND[1]	9.53		30	kΩ
C_{IRx}	Capacitance at IRx Pin to drive R_{IRx}			100	pF
I_{LEDx}	Typical configured operating current per Channel, sum of LEDxA and LEDxB	48	120	151	mA
f_{PWM}	Dimming frequency at either ENA or IRx[2]	50	200	1000	Hz
t_{PULSE_PWM}	Minimum high/low pulse width in case of PWM Dimming	90			µs
C_{RUN}	Total Capacitance on RUN Bus[3]			1	nF
C_{LEDx}	Capacitance at LEDx driver outputs, LEDxA and LEDxB		6.8	22	nF
L_{LEDx}	Inductance at either LEDxA or LEDxB			1	µH

1) If higher resistive values use, accuracy need take into account. Pay attention to the 'open' state detection limit, I_{IR_OPEN} for IRx configuration.

2) There is an inherent startup delay between rising edge at IRx and current flow, which may influence PWM linearity.

3) High capacitance values are possible but lead to additional delay between rising edge at ENA and startup of LEDx Drivers.

ELECTRICAL CHARACTERISTICS

V_{VS} = 5V to 25V, T_J = -40°C to 150°C and recommended operating range, unless otherwise noted. Typical values are at V_{VS} = 14V and T_J = 25°C. Positive currents flow into the device pins.

Symbol	Description	Condition	Min	Typ	Max	Unit
Supply and Bias						
V_{ENA_ON}	Enable threshold at ENA	V_{ENA} rising	1.1	1.2	1.28	V
V_{ENA_OFF}	Disable threshold at ENA	V_{ENA} falling	0.95	1.06	1.17	V
R_{ENA_PD}	ENA internal pulldown resistor			500		kΩ
V_{VS_ERR}	VS under-voltage release threshold	VS rising	4	4.3	4.6	V
$V_{VS\_ERR\_HYS}$	VS under voltage Hysteresis			312		mV
I_{VS_SLEEP}	VS sleep mode current	V_{VS}= 14V, V_{ENA}=0V, $T_J \leq$ 125°C		13.6	29	µA
$I_{VS\_STBY\_NOM}$	VS current in Standby Mode	V_{ENA}>3V, V_{RUN}< 2V, No error detected		145	217.5	µA
$I_{VS\_STBY\_ERR}$	Average VS Current in "Single Lamp Mode, Counting"	V_{ENA}>3V, IR Open, error detected, SLM open[2]		150	225	µA
I_{GND_OP}	Device current consumption (GND pin current)	all channels regulating in saturation, no error detected, I_{LEDx} = 120mA		1.4	2.1	mA
T_{J_OT}	Over temperature Shutdown	T_J rising	165	185		°C
$T_{J\_OT\_HYS}$	Over temperature recovery hysteresis			20		°C
t_{START}	Initial startup delay of SiLM42280/1/2/3-AQ after first power-up[1]	Initial delay after V_{VS}>V_{VS_ERR}, V_{ENA}>V_{ENA_ON}		36	60	µs
LED Driver						
A_{ILEDx_IIRx}	Current amplification factor between IRx input and LEDx outputs			960		
$Q_{B/(A+B)}$	Ratio of current in LEDxB to total configured current I_{LEDx}	$I_{LEDxB}/(I_{LEDxA}+I_{LEDxB})$, $V_{VS-LEDxA}$>1V	97	99.8		%
$I_{LED\_MAX\_HP}$	LED current tolerance (maximum)	R_{IRx}= 9.53kΩ, V_{VS}=V_{ENA}=14V, $V_{VS-LEDx}$>1V	-161.5	-152.4	-143.3	mA
$I_{LED\_High\_HP}$	LED current tolerance (high)	R_{IRx}= 12kΩ, V_{VS}=V_{ENA}=14V, $V_{VS-LEDx}$>1V	-126.5	-120.7	-114.9	mA
$I_{LED\_Low\_HP}$	LED current tolerance (low)	R_{IRx}= 30kΩ, V_{VS}=V_{ENA}=14V, $V_{VS-LEDx}$>1V	-52	-48.3	-40	mA
V_{LEDxA_DROP}	Drop voltage of bypass outputs LEDxA for 120mA	I_{LEDxA} = 120mA, LEDxB open[3]		248	370	mV

Symbol	Description	Condition	Min	Typ	Max	Unit
V_{LEDxB_DROP}	Drop voltage of priority outputs LEDxB for 120mA	I_{LEDxB} = 120mA, LEDxA open[3]		400	649	mV
$R_{LED\_PD\_OFF}$	Total pull down resistance in case of LEDx being turned off	V_{VS}=14V, V_{ENA} = 0V, LEDxA and LEDxB are parallel	8.4	9.6	12	kΩ
IR Driver						
V_{REF_NOM}	Internal nominal reference to drive R_{IRx}	V_{ENA} >3.3V, T_J <T_{J_DERATE}	1.43	1.5	1.57	V
V_{REF_HV}	Internal reference derating in case of high V_{VS}	V_{VS} > 29V		0.9		V
V_{REF_EXT}	Recommended operating range for external reference at ENA[4]		0.6		V_{REF_NOM}	V
N_{ENA_DIV}	Internal divider ratio between ENA and IR in case of external reference voltage	1.2V < V_{ENA}< 3V		2		
V_{VS_DERATE}	Internal reference derating threshold for high V_{VS}	V_{VS} rising	26	28	30	V
$V_{VS\_DERATE\_HYS}$	Hysteresis for voltage Derating threshold			1		V
T_{J_DERATE}	Starting junction temperature for internal reference voltage derating[1]	V_{ENA} > 3.3V		139		°C
dV_{J_DERATE}	Internal reference voltage derating slope[1]	V_{ENA} > 3.3V, T_J>T_{J_DERATE}		-27		mV/K
V_{IR_DIS}	Disable threshold at IRx to disable according LED channel	V_{IR} rising	2.45	2.65	2.86	V
$V_{IR\_DIS\_HYS}$	Hysteresis for IRx disable			60		mV
V_{IR_CLMP}	Zener clamping at IRx[5]	I_{IR} = 100μA	5.25	5.9	6.8	V
I_{IR_PD}	Pull down current in IRx driver for high V_{IR}	V_{IR}= 4V		6		μA
t_{IR_DLY}	Propagation delay between dimming signal at IR and LED driver current flow[1]	V_{ENA} > 3V, V_{IR} falling[6]		5		μs

Symbol	Description	Condition	Min	Typ	Max	Unit
SLM Interface						
I_{SLM_PD}	Pull down current in SLM to drive SLM low	Device nominal operation, V_{SLM} = 0.7V		15		µA
I_{SLM_PU}	Pull up current in SLM to drive SLM high	Error detected in device, V_{SLM} = 0.7V		-250		µA
V_{SLM_HIGH}	Threshold to detect Mode of Operation		1.25	1.5	1.75	V
f_{FFM_PWM}	PWM frequency at SLM for Failure Signalization in FFM	V_{SLM} < V_{SLM_HIGH}, Failure Feedback Mode		3.9		kHz
RUN Interface and Diagnostics						
I_{RUN_PU}	RUN Pin pull up current to VS	V_{VS} = 14V, V_{RUN}= 0V		-40		µA
V_{RUN_ENA}	RUN bus comparator high threshold		2.7	2.94	3.3	V
V_{RUN_STBY}	RUN bus comparator low threshold		2.25	2.55	2.85	V
V_{RUN_HYS}	Hysteresis for RUN thresholds		250	410		mV
t_{RUN_DEL}	RUN state change debouncing[1]	Rising and falling edge		4		µs
V_{RUN_DRV1}	RUN low level, nominal	V_{VS}= 14V, I_{RUN}= 2mA		0.2	0.8	V
V_{RUN_DRV2}	RUN low level, low VS or VS Open	VS Pin open, I_{RUN}= 2mA, T_J < 125°C		1.4	2	V
I_{RUN_LIM}	Current limitation for RUN driving low	V_{RUN} = 5V	10	22		mA
V_{LEDx_SHORT}	LEDx short circuit detection threshold		0.85	1	1.15	V
I_{LEDx_OPEN}	Open detection threshold at LEDx, relative to nominal configured current	R_{IRx}= 12kΩ, V_{ENA} > 3V[7]	27.5	37.5	47.5	%
V_{VS_DIAG1}	Open diagnostic enable threshold at VS for SiLM42280	SiLM42280, V_{VS} rising	6.94	7.5	8.1	V
V_{VS_DIAG2}	Open diagnostic enable threshold at VS for SiLM42281	SiLM42281, V_{VS} rising	8.33	9	9.72	V
V_{VS_DIAG3}	Open diagnostic enable threshold at VS for SiLM42282	SiLM42282, V_{VS} rising	9.26	10	10.8	V

Symbol	Description	Condition	Min	Typ	Max	Unit
V_{VS_DIAG4}	Open diagnostic enable threshold at VS for SiLM42283	SiLM42283, V_{VS} rising	13.89	15	16.2	V
$V_{VS\_DIAG\_HYS}$	Open diagnostic enable hysteresis			0.5		V
I_{IR_OPEN}	IRx pin open diagnostic Threshold	absolute value	7.3	9.5	13.6	µA
I_{IR_SHORT}	IRx pin short circuit diagnostic threshold	absolute value	280	380		µA
t_{ERR_DEB1}	Error tolerance after enabling a channel[8]	V_{ENA}> V_{ENA_ON}, V_{IR}<V_{IR_DIS}		64		µs
t_{ERR_DEB2}	Additional debouncing time in case of Error Detection during Operation[1]	New error detected		4		µs
t_{ERR_REDIAG}	Re-Diagnosis time out in case of error detection	ERR present, SiLM42280/1/2/3-AQ operated undimmed[9]	4.1	5.9	9.1	ms
Single LED Short Detection						
I_{SLS_REF}	Source current on SLS_REF			40		µA
$Ratio_{SLS}$	Ratio between Single LED short voltage and Voltage on the SLS_REF			8		
$V_{SLS\_EN\_H}$	Single LED detection enable threshold high			2		V
$V_{SLS\_EN\_L}$	Single LED detection enable threshold low			1		V

1). Not tested in production
2). In case of LED or IR short circuit, the average input current also depends on the configured current and the re-diagnostic duty cycle.
3). Parallel operation of LEDxA/B is possible to reduce drop voltage
4). 2:1 divider at ENA to IR reference
5). An unused channel may be disabled by connecting to VS via a suitable resistor
6). Disable propagation delay of a channel is typical <1us
7). Threshold is related to nominal current generated at IRx input. This diagnosis is active for V_{VS} higher than V_{VS_DIAGx}
8). Startup of a channel is performed within this time
9). Dimming the erroneous channel resets the according channels re-diagnostic cycle, thus a re-diagnostic is performed with the next enabling of the channel

FUNCTION DESCRIPTION

SiLM42280/1/2/3-AQ family devices provide independent triple linear current controller for LED driving, which can optionally be operated in parallel for higher current requirements. These family members support individual current configuration and independent digital PWM dimming per channel. Various diagnostic features are provided to meet automotive requirements, together with a communication interface named “RUN” to link ICs to generate more than three channels. ICs linked in this way can be operated as a combined cluster of drivers, turning on and off in parallel (e.g. turning all drivers off in case of hardware failures).

LED Driver

High side drivers for LEDx provide the current configured by the according IRx pin, reproducing the IIRx with a typical amplification factor of 960:1.

To handle the high power that is typically generated in linear LED drivers, the SiLM42280/1/2/3-AQ device family offers an advanced power distribution feature. The channels current is regulated as a sum of currents in LEDxA and LEDxB. The priority output LEDxB drives the current as long as the voltage headroom allows to. Afterwards the bypass output LEDxA is activated to deliver the remaining current flow.

IR Driver

The interface IRx is used to configure the current for the corresponding LEDxA/B channel. By connecting the IRx pin with a resistor, R_{IRx}, to GND potential, the current flow out of IRx is multiplied to LEDxA/B by a factor of typical 960:1.

Digital dimming can be applied to IRx by setting $V_{IRX}>V_{IR\_DIS}$. A simple option to control the current is to switch the GND connection of R_{IRx} by a micro-controller port, a low level drives the current out of IRx, the high level disables the according channel.

Various factors influence the reference voltage driven to IR as an output as shown in Figure 3. In nominal case (typical junction temperature, V_{ENA} > 3V), the internal reference is used. The lowest reference applied to the amplifier is used to regulate V_{IR}.

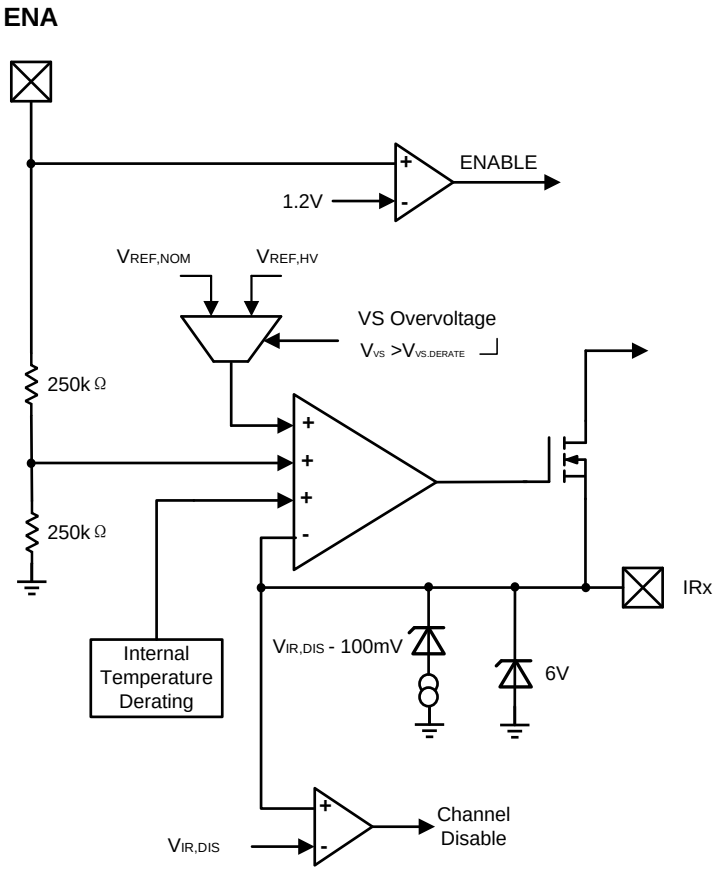


Figure 3. IR Reference

In case that less than three current drivers are needed, the internal clamping as shown in Figure 3 allows to connect the IRx input to VS directly by a resistor of typical 100kΩ. Note that this resistor will contribute to the overall sleep mode or standby current of the application.

Connecting the IRx inputs statically to other supply voltages higher than V_{IR_DIS} is also possible to effectively disable the according channel. The maximum supply voltage to turn IRx off may be restricted by the clamping voltage at this pin, see parameter V_{IR_CLMP}.

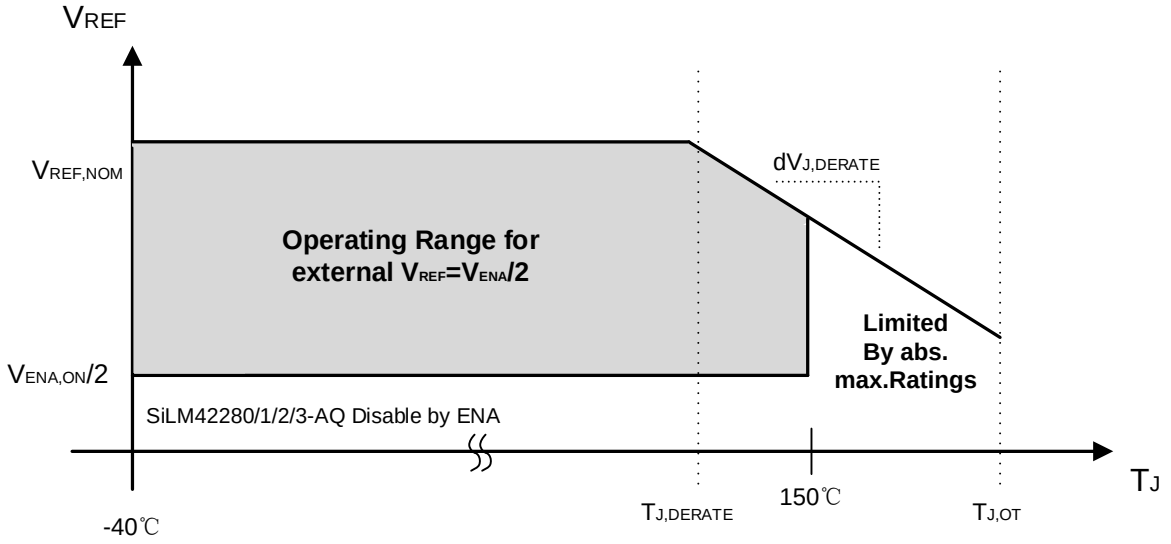


Figure 4. Internal Temperature Derating

The internal reference derating function implemented is rather tolerant to allow external configuration of derating by the user. It typically starts to derate the internal reference at T_J = 139℃, falling with typical -26.7mV/K beyond this temperature. The range of operating SiLM42280/1/2/3-AQ with external reference or external derating is shown in Figure 4.

It is possible to use a temperature dependent resistor divider at ENA to realize an external derating function and shut down. In the range of typical 3V down to V_{ENA_OFF}, the reference voltage to drive IRx is V_{ENA}/2. Falling below V_{ENA_OFF} disables the SiLM42280/1/2/3-AQ and restarting with V_{ENA_ON}.

SLM Interface

The SLM pin can be used to distinguish between Single Lamp Mode or Failure Feedback Mode (FFM). The basic setup of this pin is shown in Figure 5.

Single Lamp Mode is characterized by switching all channels off in case of a single failure on any channel. This behavior allows a network of LEDs to behave in a comparable manner to single bulb lamp. Other SiLM42280/1/2/3-AQ devices should be connected by RUN to each other to allow switching other ICs to standby mode as well. To operate SiLM42280/1/2/3-AQ in single lamp mode, the SLM pin has to be left open, thus the voltage level V_{SLM} exceeds V_{SLM_HIGH}.

Failure Feedback Mode (FFM) is used to provide status feedback to some external circuitry, for example a microcontroller or a body control module. In this mode operation, a failure channel can be indicated, thus the other channels are not affected by the error detection and remain operated. This mode can as well be used in case of applications for which the diagnostics of channels must not affect other channels.

To use SiLM42280/1/2/3-AQ in FFM, it is recommended to use a bipolar external device and connect its base to SLM. The threshold V_{SLM_HIGH} is high enough to detect SLM as being held low by the base-emitter voltage of the external bipolar device.

Note that RUN is switched to low in this case as well, thus a direct connection to other SiLM42280/1/2/3-AQ is not recommended in FFM.

FFM can also be achieved by connecting SLM directly to GND if channels shall be made independent of each other.

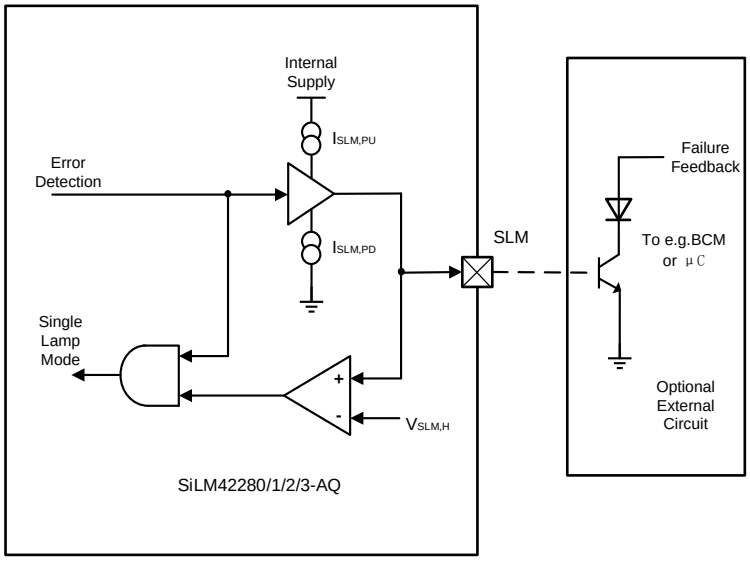


Figure 5. SLM Configuration

During “Active, Failure Feedback Mode”, a 4-bit pulse width modulated (PWM) signal is provided at the SLM output to determine which channels are failing. This protocol is repeated typically every 256µs (typical16µs bit-time), representing the actual ERR[2:0] state at the start of the PWM cycle.

The falling edge at SLM between typical 56.3% and 93.8% represents the ERR[2:0] register status (only for enabled channels since disabled channels or channels without failure are treated as ‘0’ in this PWM, see Table 1. A potential failure flag remains stored internally for re-diagnosis). Furthermore, in case no error is detected by SiLM42280/1/2/3-AQ (e.g. state “Active Mode, Normal Operation”), SLM is continuously driven ‘low’.

If all channels are disabled during FFM by IR dimming, SLM provides a static ‘high’ level (all ERR[2:0] entries are blanked by dimming). If the ‘off’ condition at IR is applied to a channel for typical >64ms, the according entry in ERR[2:0] register will be reset.

For physical layer implementation, make sure the output level is limited to avoid detection of SLM operating mode, for example, by using an external NPN bipolar transistor on each SiLM42280/1/2/3-AQ like shown in Figure 5.

Table 1. PWM Duty Cycle for State “Active, Failure Feedback Mode”

PWM Duty Cycle	ERR[2], Channel LEDx3	ERR[1], Channel LEDx2	ERR[0], Channel LEDx1
100%	0	0	0
93.8%	0	0	1
87.5%	0	1	0
81.3%	0	1	1
75.0%	1	0	0
68.8%	1	0	1
62.5%	1	1	0
56.3%	1	1	1

Note, Digital ‘0’ represents either correct operation at LEDx or disabled channels (V_{IRx}>V_{IR_DIS}).

Here are two examples for the PWM duty cycle and the LED failures.

- Example 1: Channel LEDx2 failure detection (all channels enabled). ERR[2:0] = ‘010’ (no failures blanked by dimming at IRx), and PWM Duty cycle is 87.5%
- Example 2: Channel LEDx2 and LEDx3 failure detection (channel LEDx2 disabled). Since the failure at channel 2 is blanked by dimming, the relevant register value becomes ‘100’, and PWM Duty cycle is 75.0%.

RUN Interface and Diagnostics

Diagnostic features provided in SiLM42280/1/2/3-AQ include the monitoring of

- High resistive IRx drivers for each channel (e.g. in case of “open” connection for any of the connected devices)
- Short circuit at IRx drivers to GND for each channel
- Short circuit of LEDxA/B to GND for each channel (checking for a static threshold of V_{LEDx_SHORT})
- Open LEDxA connections for each channel (SiLM42280/1/2/3-AQ family members provide different open diagnostic enable thresholds, V_{VS_DIAGx}, to enable this monitor, thus avoiding wrong ‘OPEN’ error detection in case that V_{VS} is lower than the forward voltage of the LEDs (V_{LED}).
- Single LED short dection
- Internal junction over temperature (disabling all channels).
- VS voltage monitoring for under voltage (providing defined behavior for slow supply ramping)

The driver “OPEN” detection is relative to the actual current configured at IRx. This detection is active if the supply V_{VS} is higher than V_{VS_DIAGx}, which is a family member specific threshold.

If an error at any of the channels is detected, it is stored for selective re-diagnosis. Dimming at either ENA or V_{IR} does not delete this information. A diagnosis cycle showing removal of the erroneous conditions, VS under-voltage or permanent disable of all failing channels via IR input resets the stored flag(s) to ‘0’.

Erroneous channels can be deactivated and removed from state consideration by setting the according $V_{IRx}>V_{IR\_DIS}$. Once the disable request exceeds a length of typical 64ms (in any mode other than Sleep Mode or VS reset), the channel will no longer be considered for SLM or FFM state. In this way, e.g. a SLM application may be re-enabled (without the erroneous channel).

Re-diagnosis in case of continuous operation is performed on a regular time-basis of t_{ERR_REDIAG} to allow replacement of defect loads / LEDs for such applications.

A loss of VS connection for a single SiLM42280/1/2/3-AQ is propagated via RUN being set to low, as well as for ENA being “low” (e.g. in case of “OPEN” failure at ENA).

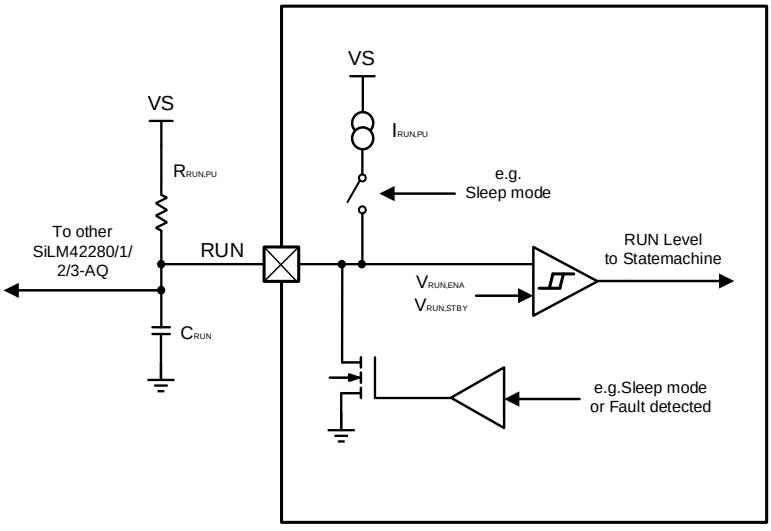
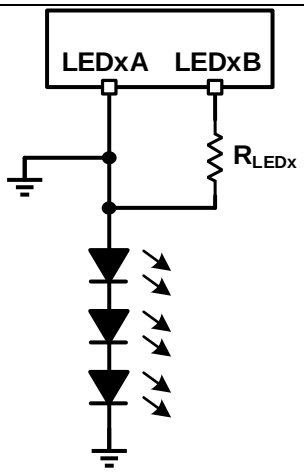
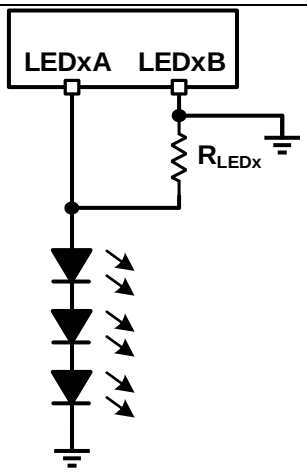
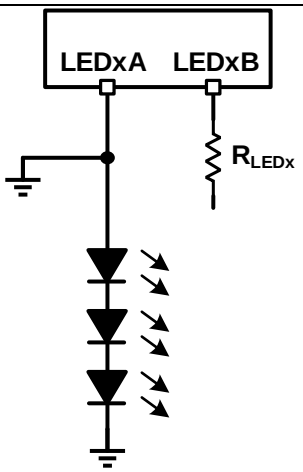
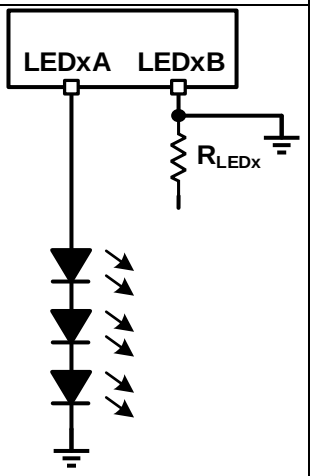
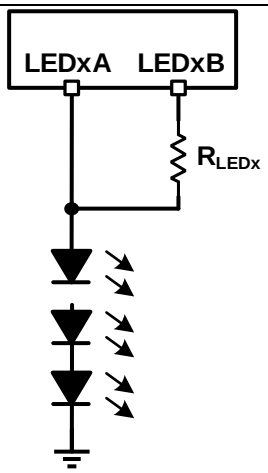
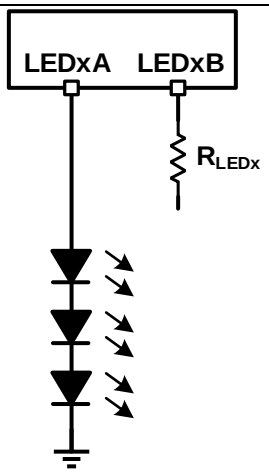
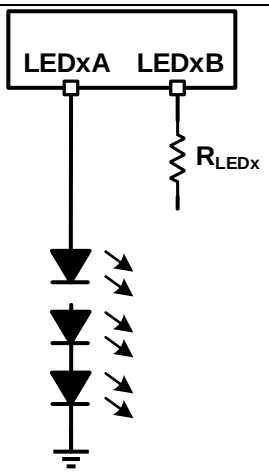
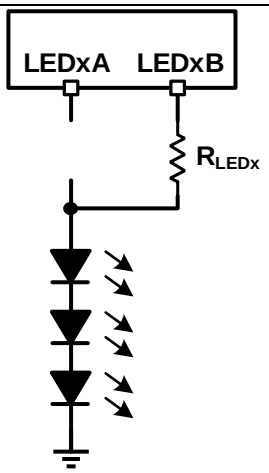
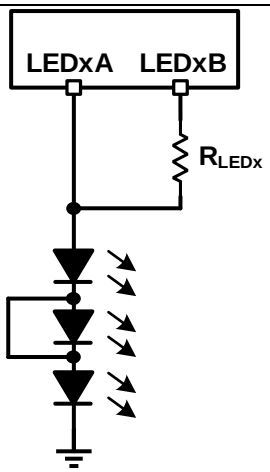
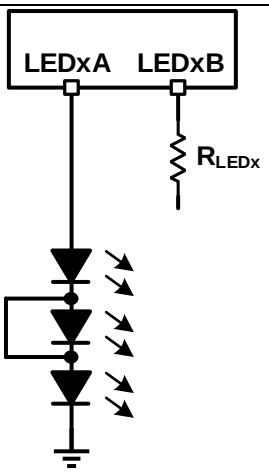
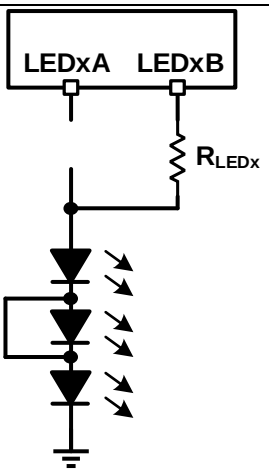
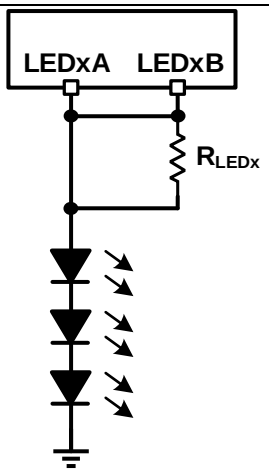


Figure 6. RUN Interface

The basic structure of the RUN interface is shown in Figure 6. The purpose of the RUN bus is to form a direct connection to other family members SiLM42280/1/2/3-AQ or local circuitry, preferably on the same PCB. In that case or if RUN is unused, the components C_{RUN} and R_{RUN_PU} may be omitted. They are recommended to protect the bus for additional requirements (e.g. EMC). The interface itself is not suitable for usage in a wiring harness without adequate protective measures.

The limits for usable values for C_{RUN} and R_{RUN_PU} are given by the tolerable delay at startup or from standby together with the current limitation for the RUN interface. Furthermore, R_{RUN_PU} can contribute to sleep mode current consumption due to RUN being driven active low in this case.

LED Fault Summary

Case1	Case2	Case3	Case4
			
LED Short to GND Fault	LED Short to GND Fault	LED Short to GND Fault	LED Short to GND Fault
Case5	Case6	Case6	Case8
			
LED Open Fault	No Fault	LED Open Fault	LED Open Fault
Case5	Case6	Case6	Case8
			
Single LED Short	Single LED Short	LED Open Fault	No Fault

Single LED Fault Detection

The SiLM42280/1/2/3-AQ support single LED fault detection. the SLS_EN pin can be used to enable or disable this function. When the SLS_EN is high, the single LED fault detection is enabled. And when the SLS_EN is floating or connected to ground, the single LED fault detection function is disable.

The SLS_REF is used to program the single LED fault detection threshold. connecting a resistor between SLS_REF and ground to set the threshold.

$$V_{SLS\_FT}[V] = RATIO_{SLS} \times R_{SLS}[\Omega] \times I_{SLS\_REF}[\mu A]$$

Here:

V_{SLS_FT} is the single LED short detection threshold

$RATIO_{SLS}$ is the ratio between Single LED short voltage and the voltage on the SLS_REF, typical is 8

R_{SLS} is the resistor between the SLS_REF and ground.

I_{SLS_REF} is the source current on the SLS_REF, typical is 40μA.

STATE DIAGRAM

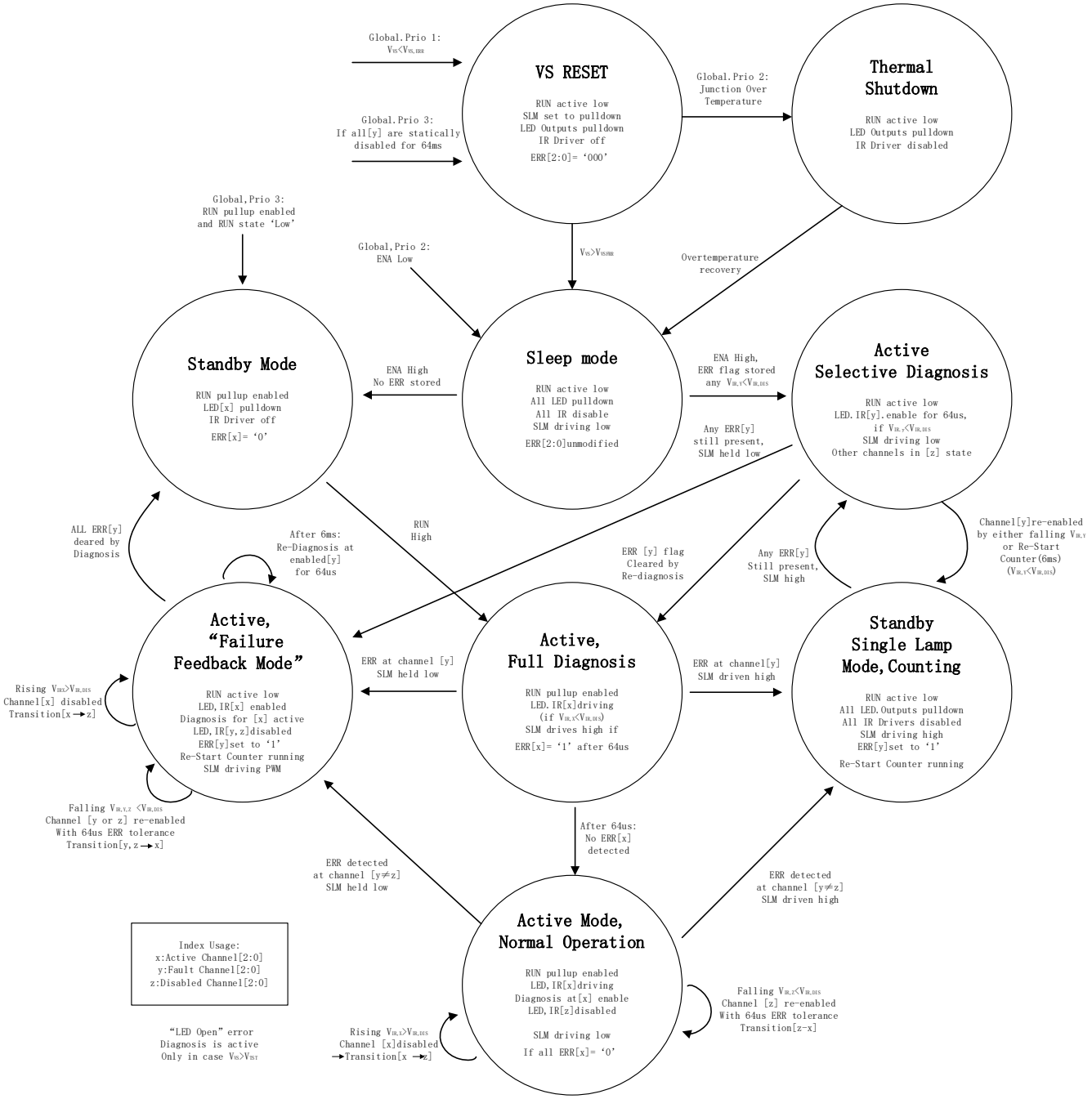


Figure 7. State Diagram of SiLM42280/1/2/3-AQ

APPLICATOIN TOPOLOGIES

Various application topologies and use cases are supported by SiLM42280/1/2/3-AQ.

Basic Application Topology

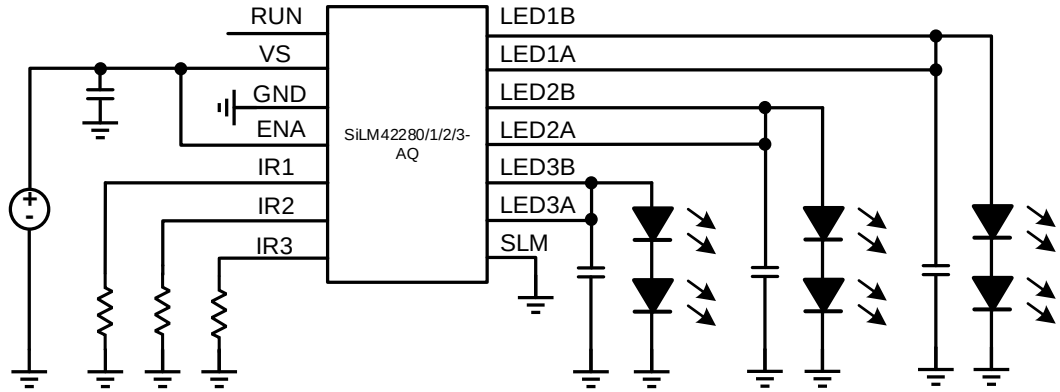


Figure 8. Basic Topology

Figure 8 shows the basic topology application. The basic features are

- Permanent operation of all LED strings
- Individual current configuration for each LED String
- Channels diagnostic does not interfere between channels (FFM mode used - see SLM pin and RUN pin open)
- Capacitors at the LED loads are used to improve PSRR of the circuit

Basic Micro-Controller RGB Application

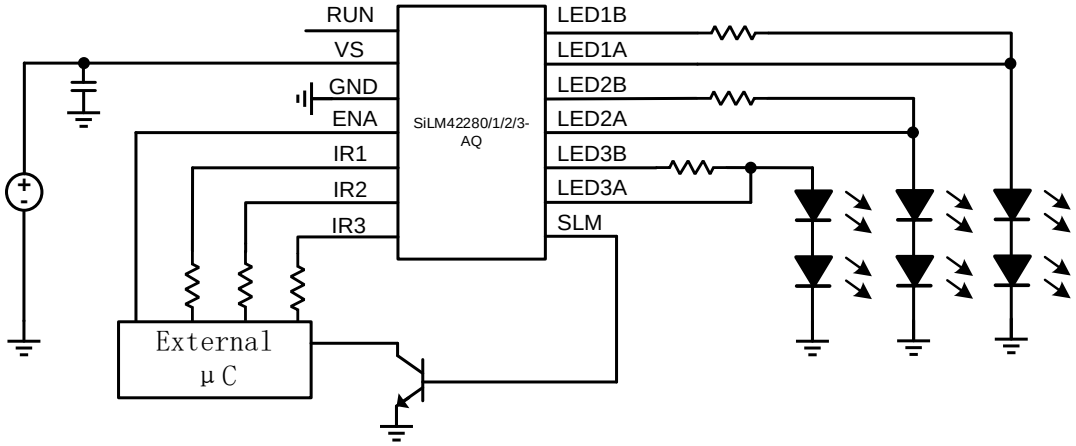


Figure 9. Micro-Controller RGB Topology

RGB driving is possible using the individual current configuration per channel of the LEDs via IR. An additional Micro-Controller drives the resistors to GND (enable of channel) or to its supply (disable of channel).

- External controller provides color mixtures by dimming at either IR1,2,3 or ENA.
- Optionally, instead of digital signals, an analog reference can be generated by the controllers DAC to the ENA pin.
- Diagnostic feedback is provided from SLM by failure-feedback mode, indicating potential issues for a channel via PWM signal.

In this way, redundancy can be built for the colors, compensating a single channel fail with another LED string.

Application with Single LED Short Detection

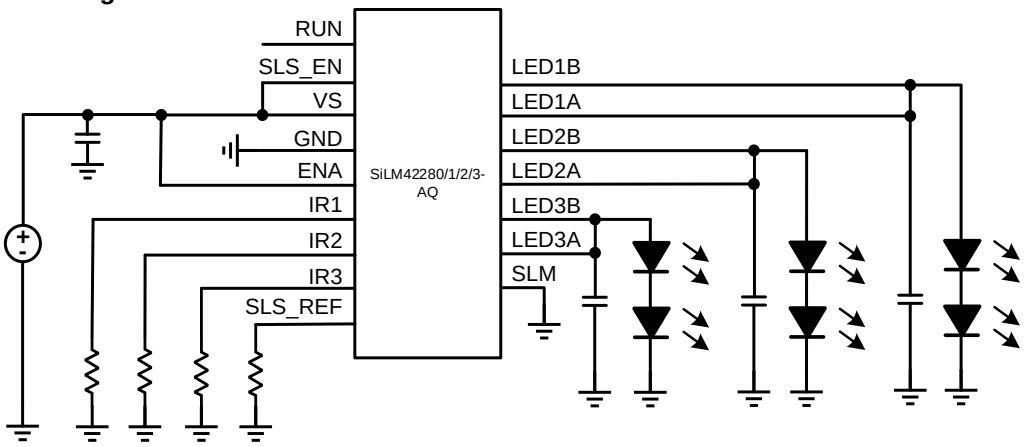


Figure 10. Single LED Short Detection Enabled Topology

Figure 10 shows the single LED short detection enable topology application. The features are

- SLS_REF to set the single LED short detection voltage.
- Capacitors at the LED loads are used to improve PSRR of the circuit

Six Channel Cluster and Supply Dimming

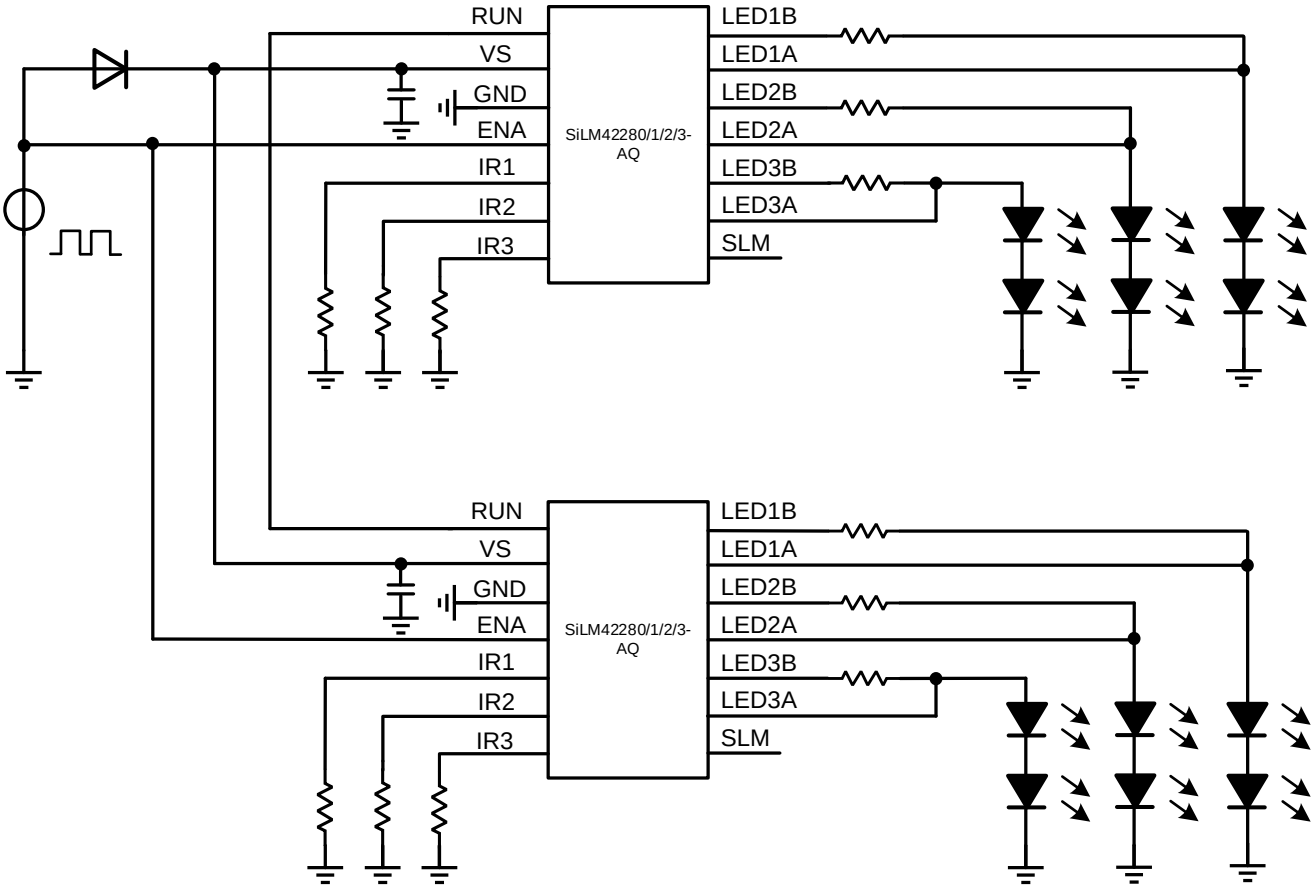


Figure 11. Six Channel Cluster Application

Figure 11 shows a six-channel cluster that has following features:

- Digital Dimming via supply line is possible. ICs remain powered by reverse polarity protection and input capacitors, consuming only very low sleep mode currents.

- Single Lamp Mode (SLM) is configured, deactivating all LEDs in case of a single channel failure on any LED Output. RUN connection is used to propagate the information between ICs, immitating the failing behavior of a bulb if necessary.
- Thermal management resistors are applied to distribute the power on the PCB

Thermal Management and Parallel Operation

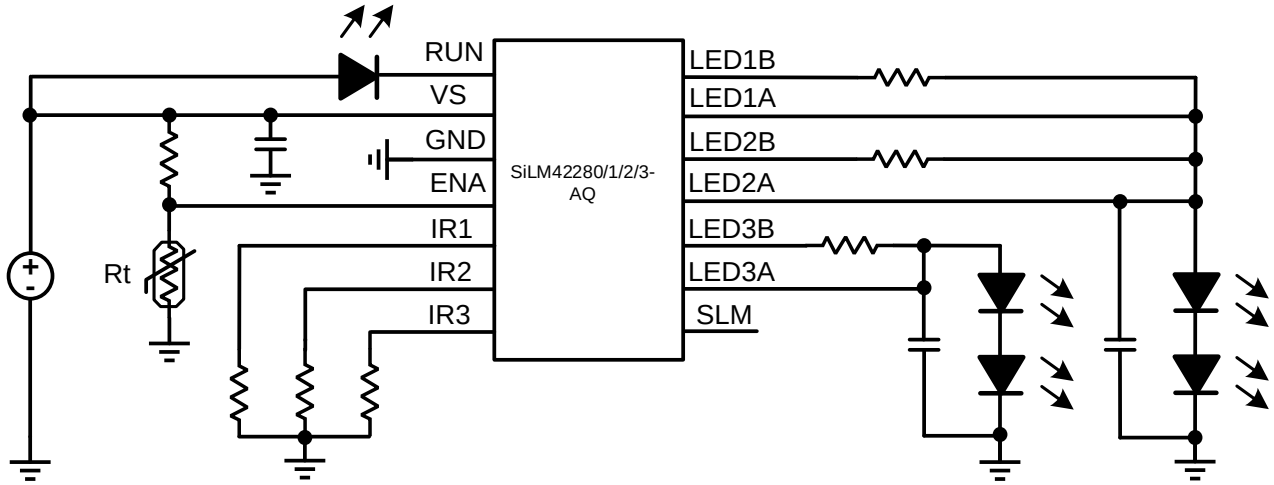
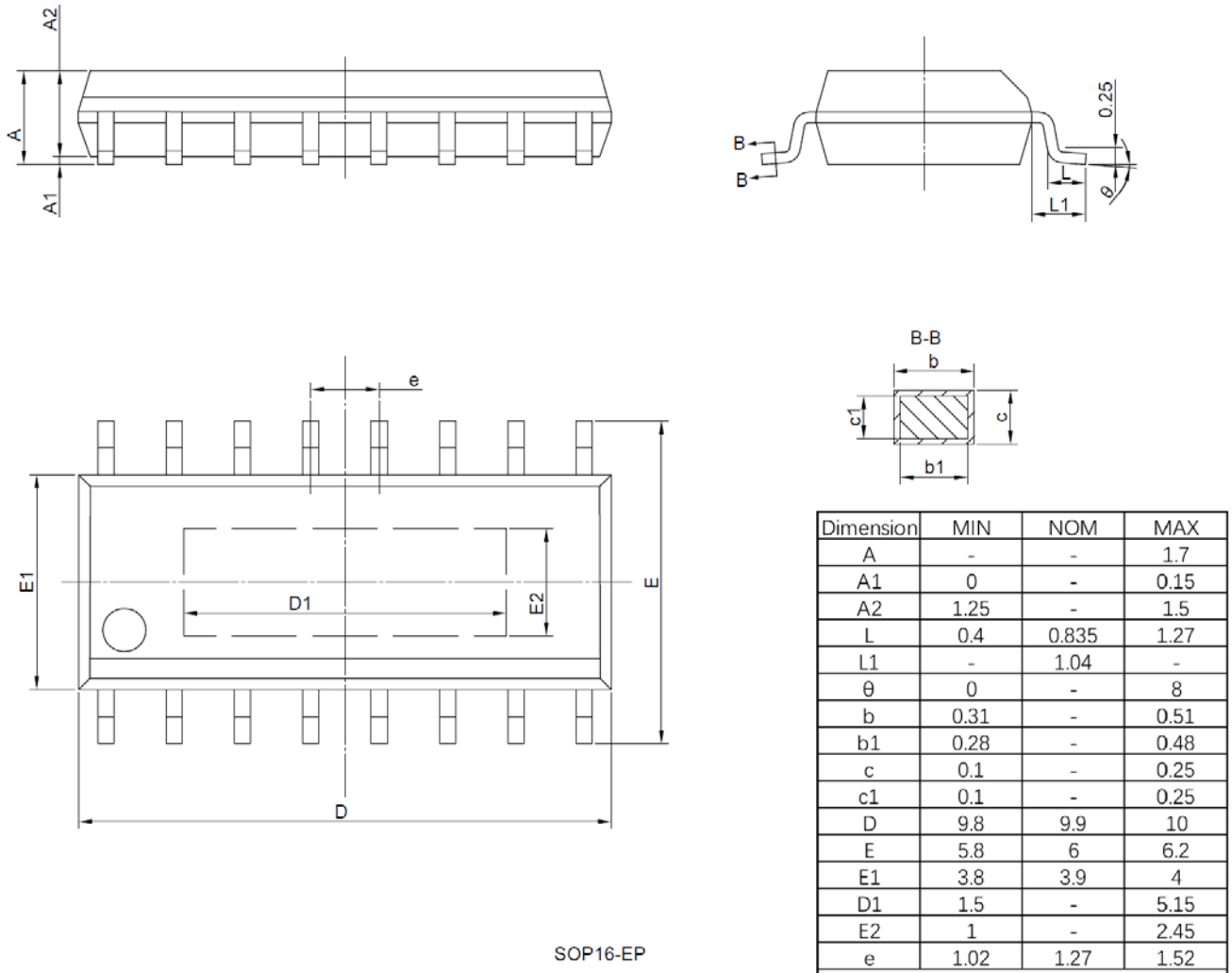


Figure 12. Thermal Optimization Application

Figure 12 shows a thermal optimization application. In this setup more thermal handling options are presented:

- Thermal shunts at LEDxB are used for power distribution on the PCB
- Temperature depending divider at ENA provides derating, if the divided voltage falls below the internal reference of SiLM42280/1/2/3-AQ
- Parallel operation of two channels to increase output current
- A fail-indicator LED is connected to RUN, which may be useful to identify defect PCBs
- Capacitors parallel to loads improve PSRR and thus the life-time of the LEDs in case of e.g. ESD events

PACKAGE CASE OUTLINES



Dimension	MIN	NOM	MAX
A	-	-	1.7
A1	0	-	0.15
A2	1.25	-	1.5
L	0.4	0.835	1.27
L1	-	1.04	-
θ	0	-	8
b	0.31	-	0.51
b1	0.28	-	0.48
c	0.1	-	0.25
c1	0.1	-	0.25
D	9.8	9.9	10
E	5.8	6	6.2
E1	3.8	3.9	4
D1	1.5	-	5.15
E2	1	-	2.45
e	1.02	1.27	1.52
Unit : mm			

Figure 13. SOP16-EP Outline Dimensions

REVISION HISTORY

Note: page numbers for previous revisions may differ from page numbers in current version

Page or Item	Subjects (major changes since previous revision)
Datasheet Rev 1.0: 2023-12-15	
Whole document	Initial release