GE
Lighting

Infusion™ LED Module

Brighten Your Environment with a Little Twist

APPLICATION GUIDE

imagination at work

Infusion™ LED Module

Fast Connection with a Simple Twist

GE Infusion™ LED Module System

Introduction

The GE Infusion LED module is a game-changing platform, designed to open up new possibilities for the use of long-lasting, controllable, low maintenance LED solutions in retail, hospitality and other environments where the quality of light is critical to the customer/visitor experience.

With a simple twist and lock action, the module can be easily removed and replaced, with no additional hardware necessary. Plus, a selection of optical accessories are available from GE which are also tool-free to attach, allowing for a complete lighting solution.

In addition to offering excellent energy efficiency and long life, the GE Infusion module allows compatible luminaires to use future generations of Infusion LED modules as the technology improves, enabling users to always have the optimum energy efficient solution in their installation.

M1000

M1500

M2000

M3000

M4500

NPM

Features & Benefits

- Easy to replace, no hardware necessary
- 4 color temperatures - 2700K, 3000K, 3500K (not offered in NPM), 4000K
- 5 module series, M1000, M1500, M2000, M3000, M4500 and NPM (Narrow Punch Module) with lumen packages ranging from 800 to 4700 lumens
- Wattage range from 10.5W – 46W
- Standard range with CRI >80 and 4-step MacAdam color consistency
- Infusion Ultra range with high CRI and 2-step MacAdam color consistency
- Long rated life, 50,000 hours L70 with LM-80 data available to support claim
- Runs at constant current DC input - range of compatible drivers on market
- Dimmable via DALI, DMX, 0-10V, leading edge, trailing edge – range of compatible drivers on market
- No mercury or radioactive components, RoHS compliant

Applications

GE Infusion modules can be adopted in new luminaires for track-lighting, recessed down-lighting, and many other types of applications:

- Fashion Retail Display Lighting
- Supermarket Accent Lighting
- Museum & Gallery Lighting
- Bar & Restaurant Lighting
- Commercial Downlighting

GE Infusion™ LED Module System

Modules

Module Series	Product Code	Description	Body Color	CCT [K]	CRI [Ra]	Color Variation (MacAdam Ellipse)	Rated Life (L85) [h] (2)	Drive Current [mA]	Nominal Lumens [lm] (1)	Nominal Watts [W]	LPW*	Nominal Voltage [V]
M1000	19192	M1000/827/W/G4	White	2700	> 80	< 4-steps	50,000	700	1000	10.5	95	15
	19193	M1000/830/W/G4	White	3000	> 80	< 4-steps	50,000	700	1100	10.5	105	15
	19195	M1000/835/W/G4	White	3500	> 80	< 4-steps	50,000	700	1100	10.5	105	15
	19196	M1000/930/W/G4	White	3000	90	< 2-steps	50,000	700	800	10.5	76	15
	19197	M1000/840/W/G4	White	4000	> 80	< 4-steps	50,000	700	1100	10.5	105	15
M1500	19198	M1500/827/W/G4	White	2700	> 80	< 4-steps	50,000	700	1400	14.5	97	20.7
	19200	M1500/830/W/G4	White	3000	> 80	< 4-steps	50,000	700	1500	14.5	103	20.7
	19201	M1500/835/W/G4	White	3500	> 80	< 4-steps	50,000	700	1500	14.5	103	20.7
	19202	M1500/930/W/G4	White	3000	90	< 2-steps	50,000	700	1200	14.5	83	20.7
	19207	M1500/840/W/G4	White	4000	> 80	< 4-steps	50,000	700	1500	14.5	103	20.7
M2000	19209	M2000/827/W/G4	White	2700	> 80	< 4-steps	50,000	1400	2000	21	95	15
	19210	M2000/830/W/G4	White	3000	> 80	< 4-steps	50,000	1400	2100	21	100	15
	19211	M2000/835/W/G4	White	3500	> 80	< 4-steps	50,000	1400	2200	21	105	15
	19214	M2000/930/W/G4	White	3000	90	< 2-steps	50,000	1400	1700	21	81	15
	19215	M2000/840/W/G4	White	4000	> 80	< 4-steps	50,000	1400	2200	21	105	15
M3000	19216	M3000/827/W/G4	White	2700	> 80	< 4-steps	50,000	1400	2800	29.5	95	21.1
	19218	M3000/830/W/G4	White	3000	> 80	< 4-steps	50,000	1400	3000	29.5	102	21.1
	19220	M3000/835/W/G4	White	3500	> 80	< 4-steps	50,000	1400	3000	29.5	102	21.1
	19224	M3000/930/W/G4	White	3000	90	< 2-steps	50,000	1400	2300	29.5	78	21.1
	19225	M3000/840/W/G4	White	4000	> 80	< 4-steps	50,000	1400	3100	29.5	105	21.1
M4500	19226	M4500/827/W/G4	White	2700	> 80	< 4-steps	50,000	1400	4300	46	93	32.9
	19230	M4500/830/W/G4	White	3000	> 80	< 4-steps	50,000	1400	4500	46	98	32.9
	19231	M4500/835/W/G4	White	3500	> 80	< 4-steps	50,000	1400	4600	46	100	32.9
	19307	M4500/930/W/G4	White	3000	90	< 2-steps	50,000	1400	3600	46	78	32.9
	19337	M4500/840/W/G4	White	4000	> 80	< 4-steps	50,000	1400	4700	46	102	32.9
NPM	98471	MP30/827/W/N	White	2700	> 80	< 4-steps	50,000	700	1300	25	52	35.7
	98472	MP30/830/W/N	White	3000	> 80	< 4-steps	50,000	700	1400	25	56	35.7
	98473	MP30/930/W/N	White	3000	> 87	< 2-steps	50,000	700	1100	25	44	35.7
	98474	MP30/840/W/N	White	4000	> 80	< 4 steps	50,000	700	1500	25	60	35.7

*LPW = Lumen per Watt
Note: Use in dry location only or in luminaire which is designed and tested to an environmental location appropriate for the intended operating conditions.

Notes:
(1) Lumens are 'hot lumens' measured at steady state at a Tc temperature of 149˚F (65˚C)
(2) Rated life refers to 85% lumen maintenance (L85) for M1000-3000 Modules and 70% lumen maintenance (L70) for M4500 and NPM Modules. Modules are rated to 50,000 hours with supporting LM-80 data. Life testing continues with a view to further upgrades in future. Even higher efficacies can be achieved if modules are run at drive currents lower than the rated value. GE is happy to advise on available permutations to suit particular project requirements.

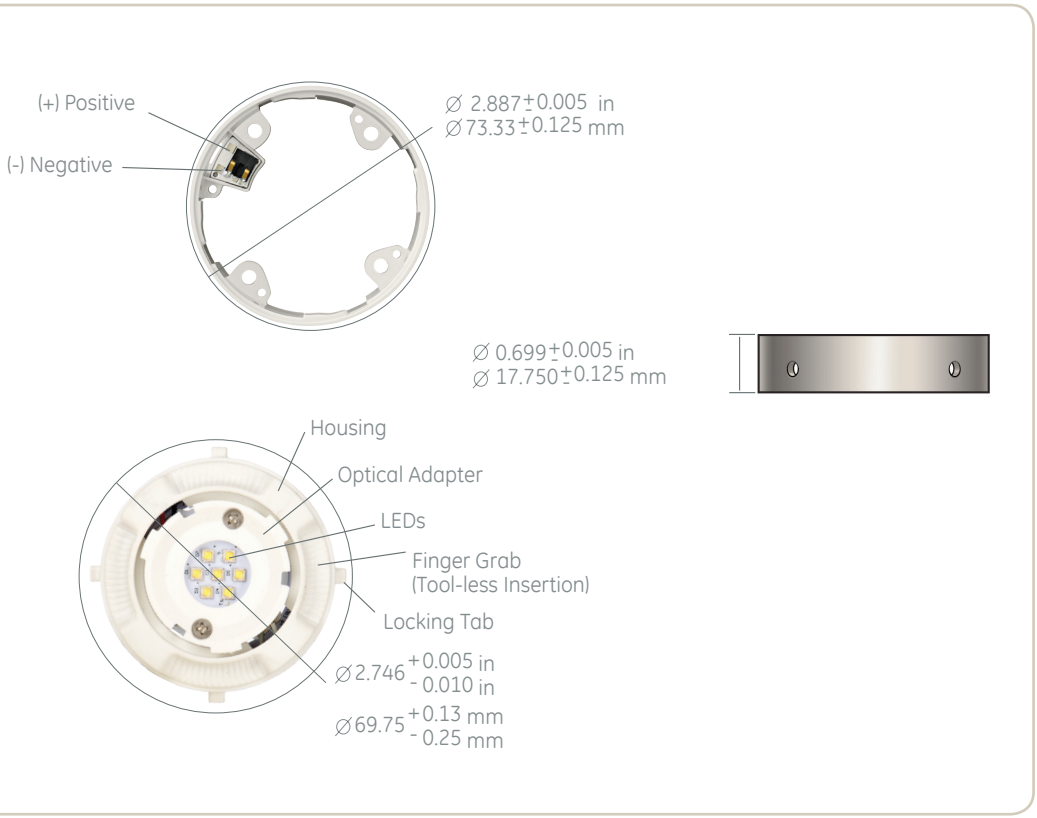
Holders / Collars

Product Code	Description	Body Color	Lead Insulation	Lead Length [mm]
66233	MHOLDERW/PVC600	White	PVC	600
66232	MHOLDERB/PVC600	Black	PVC	600
61450	MACC07HOLDERW	White	No Leads	n/a
78835	MACC07HOLDERB	Black	No Leads	n/a

Notes:
Collars are supplied with and without leads attached.

Line Drawings

Note: Detailed CAD drawings are available on the GE Infusion Module Website at gelighting.com/infusion.



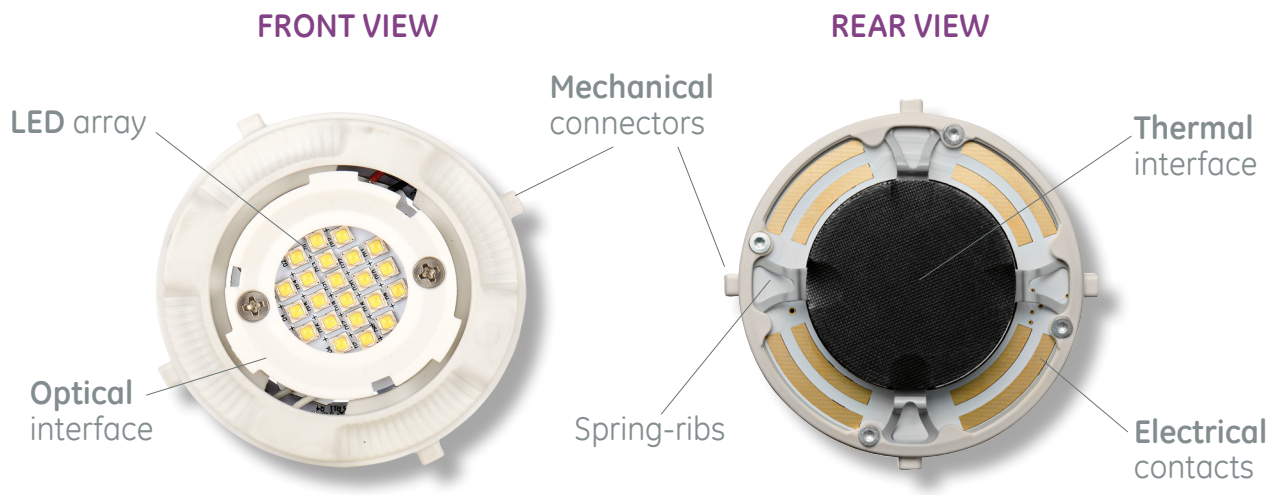
GE Infusion™ LED Module System

About Infusion LED Modules

The GE Infusion LED module is comprised of a printed circuit board (PCB) with an array of high power LEDs. The size of the array varies depending on the lumen output and wattage of the module. However, the external dimensions and form factor of each module are the same, so they fit the same collar.

The PCB is connected to a thermal interface which is attached to the main body of the module by a set of springs. A thermal pad is attached to the thermal interface to provide excellent thermal transfer to an external heat sink.

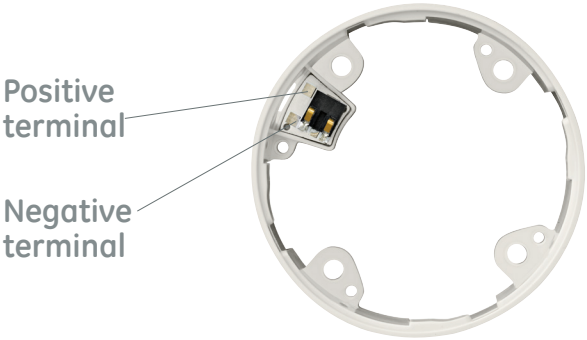
The module also has electrical connectors and mechanical tabs to allow for three key interfaces (thermal, electrical, mechanical) to be connected with one single twist action.



Mechanical Attachment

The attachment collar is used to connect the module to the heat sink and the external driver. The heat sink should ideally be anodized to maximize the effectiveness of thermal management. The collar can be mechanically attached to the heat sink using the provided screw holes on the bottom and side of the collar. A heat pad is provided on the thermal interface to make good thermal contact between the LED module and the heat sink. The module is electrically connected to the collar through the PCB assembly on the collar.

The LED module is inserted into the locator slots of the collar and then connected via a twist and lock motion while pushing downwards.



Note:
Collars are supplied with and without leads attached.

LED Drivers

Infusion LED modules are designed to run from external LED drivers which provide constant current output and that are SELV rated. Modules in the M1000, M1500, and NPM series require a 700mA signal. Modules in the M2000, M3000, and M4500 series require a 1.4A signal.

GE has reviewed a wide range of commercially available LED drivers that are compatible with Infusion modules. This range includes dimming drivers that operate on DALI, DMX, 0-10V, leading edge and trailing edge systems, as well as static drivers and drivers with auxiliary active cooling outputs. GE is continuing this approval process, and the approved driver list will be updated on a regular basis. Please contact your GE representative for details.

Approved GE Lightech drivers for Infusion LED modules

Product Code	Description	Wiring	Safety	Compatible Module Series	Input Voltage	Frequency	Current	Dimming	Max Wattage (W)	Vf
93861	D030MS701/4V2BD	Bottom Feed	Class 2	NPM, M1000, M1500, M2000	120-277V	50/60	700/1400	1-10V	30	3-43
93862	D030MS701/4V2SD	Side Lead	Class 2	NPM, M1000, M1500, M2000	120-277V	50/60	700/1400	1-10V	30	3-43
93860	GELD60DMV1400BF	Bottom Feed	Class 2	M2000, M3000, M4500	120-277V	50/60	1400	1-10V	60	15-44
60724	GELD60DMV1400PU	Side Lead	Class 2	M2000, M3000, M4500	120-277V	50/60	1400	1-10V	60	15-44

For a complete list of drivers approved for the Infusion Module, visit gelighting.com/infusion.

GE maintains an Approved Drivers List for use with the GE Infusion LED modules. This list is available on the Infusion website at www.gelighting.com/infusion. In order for the module warranty to be valid, a driver must appear on this list. In the event that a driver which you would like to use is not on the approved list, please contact your GE representative to discuss driver selection and testing for inclusion on the list.

Optical Design & Performance

Infusion™ LED modules are supplied without integrated optics, allowing flexibility for luminaire designers to design or use optics of their choice according to the application needs.

GE offers a range of optics which interface with the Infusion LED modules. These attach using a twist and lock mechanism via an optical interface feature on the modules. This facilitates tool-free replacement and assembly. A schematic illustration of the tool-free attachment method is shown below:

Parts

LED module and optic are supplied separately.

Insert Optic

The optic is placed in the groove on the module

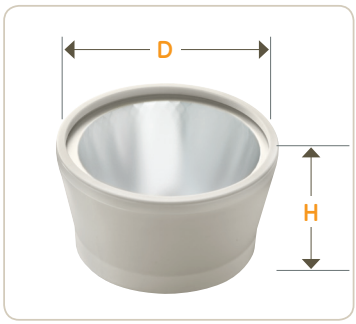
Twist and Lock

The optic connects to the module without use of tools.

Optical Accessories Available from GE

GE offers optical accessories that offer a range of beam angles in the categories spot (SP), flood (FL), wide flood (WFL) and very wide flood (VWFL). The following table summarizes the range that is available.

Beam Type	NSP 8-10°	NSP 11-12°	NSP 14°	FL 20-30°	WFL 30-40°	VWFL 50-60°
NPM	+	+	+			
M1000				+	+	+
M1500				+	+	+
M2000				+	+	+
M3000				+	+	+
M4500				+	+	+
Beam						
Dimensions (D x H, in)	3.94" x 2.80" (100mm x 71mm)	2.95" x 1.69" (75mm x 43mm)	3.94" x 2.76" (100mm x 70mm)	3.94" x 2.80" (100mm x 71mm) 2.95" x 1.69" (75mm x 43mm)	3.94" x 2.80" (100mm x 71mm) 2.95" x 1.69" (75mm x 43mm)	3.94" x 2.80" (100mm x 71mm) 2.95" x 1.69" (75mm x 43mm)



Note:
Dimensions above are for the optics only, not assembled system dimensions. Detailed product, assembled module and optic dimensions are available on individual product data sheets and CAD documentation. Beam patterns shown above are only visual approximations for illustrative purposes.

GE Optics

OPTICS			Beam Angles						Optic Dimensions	
Product Code	Description	Body Color	M1000	M1500	M2000	M3000	M4500	NPM	Diameter	Height
97208	OP1000/1500/FL/W, OP3000/WFL/W	white	25	25		35	35		2.95" (75mm)	1.69" (43mm)
65294	OP1000/1500/FL/B, OP3000/WFL/B	black	25	25		35	35		2.95" (75mm)	1.69" (43mm)
97206	OP1000/1500/WFL/W	white	35	35					2.95" (75mm)	1.69" (43mm)
65295	OP1000/1500/WFL/B	black	35	35					2.95" (75mm)	1.69" (43mm)
97207	OP1000/1500/VWFL/W	white	55	55					2.95" (75mm)	1.69" (43mm)
65296	OP1000/1500/VWFL/B	black	55	55					2.95" (75mm)	1.69" (43mm)
64996	OP2000/3000/FL/W	white			25	25	25		2.95" (75mm)	1.69" (43mm)
65297	OP2000/3000/FL/B	black			25	25	25		2.95" (75mm)	1.69" (43mm)
64995	OP2000/WFL/W	white			35				2.95" (75mm)	1.69" (43mm)
65298	OP2000/WFL/B	black			35				2.95" (75mm)	1.69" (43mm)
64994	OP2000/3000/VWFL/W	white			55	55	55		2.95" (75mm)	1.69" (43mm)
65301	OP2000/3000/VWFL/B	black			55	55	55		2.95" (75mm)	1.69" (43mm)
98477	OP30/SP/75MM/W	white						12	2.95" (75mm)	1.69" (43mm)
98475	OP30/SP/75MM/B	black						12	2.95" (75mm)	1.69" (43mm)
94635	OP30/SP/75MM/G2/W	white						11	2.95" (75mm)	1.69" (43mm)
94636	OP30/SP/75MM/G2/B	black						11	2.95" (75mm)	1.69" (43mm)
98480	OP1000/1500/FL/100mm/W	white	25	25					3.94" (100mm)	2.76" (70mm)
98486	OP1000/1500/FL/100mm/B	black	25	25					3.94" (100mm)	2.76" (70mm)
98483	OP1000/1500/WFL/100mm/W	white	35	35					3.94" (100mm)	2.76" (70mm)
98489	OP1000/1500/WFL/100mm/B	black	35	35					3.94" (100mm)	2.76" (70mm)
98485	OP1000-4500/VWFL/100mm/W	white	55	55	55	55	55		3.94" (100mm)	2.76" (70mm)
98491	OP1000-4500/VWFL/100mm/B	black	55	55	55	55	55		3.94" (100mm)	2.76" (70mm)
98481	OP2000/FL/100mm/W	white			25				3.94" (100mm)	2.76" (70mm)
98487	OP2000/FL/100mm/B	black			25				3.94" (100mm)	2.76" (70mm)
98484	OP2000-4500/WFL/100mm/W	white			35	35	35		3.94" (100mm)	2.76" (70mm)
98490	OP2000-4500/WFL/100mm/B	black			35	35	35		3.94" (100mm)	2.76" (70mm)
98482	OP3000/4500/FL/100mm/W	white				25	25		3.94" (100mm)	2.76" (70mm)
98488	OP3000/4500/FL/100mm/B	black				25	25		3.94" (100mm)	2.76" (70mm)
98478	OP30/SP/100MM/W	white						10	3.94" (100mm)	2.76" (70mm)
98476	OP30/SP/100MM/B	black						10	3.94" (100mm)	2.76" (70mm)
94633	OP30/SP/100MM/G2/W	white						8	3.94" (100mm)	2.76" (70mm)
93634	OP30/SP/100MM/G2/B	black						8	3.94" (100mm)	2.76" (70mm)
99995	OP1000/1500/WFL/50MM/W	white	35	35					2.17" (55mm)	1.77" (45mm)
99996	OP1000/1500/WFL/50MM/B	black	35	35					2.17" (55mm)	1.77" (45mm)
94637	OP30/SP/50MM/W	white						14	2.17" (55mm)	1.77" (45mm)
94638	OP30/SP/50MM/B	black						14	2.17" (55mm)	1.77" (45mm)

Note:
Dimensions above are for the indivdual optics only, not assembed system dimensions. See CAD documentation for overall assembled system dimensions.

Optical Design & Performance

Beam Performances from Infusion™ Modules and GE Optics

NOTE: See previous page for assembled optic and module system heights.

Module Series	Module Product Code	Module CCT[K]	Optic Beam Category	Optic Product Code - White	Optic Product Code - Black	Peak Intensity*[cd]	Nominal Beam Angle** [°]	Nominal Diameter [mm]	Nominal Length [mm]
M1000	19192	827	FL	97208	65294	3800	25	75	43
	19193	830				4200	25	75	43
	19195	835				4200	25	75	43
	19196	930				3000	25	75	43
	19197	840				4200	25	75	43
	19192	827	FL	98480	98486	3200	25	100	71
	19193	830				3500	25	100	71
	19195	835				3500	25	100	71
	19196	930				2500	25	100	71
	19197	840				3500	25	100	71
	19192	827	WFL	99995	99996	2200	35	55	45
	19193	830				2400	35	55	45
	19195	835				2400	35	55	45
	19196	930				1700	35	55	45
	19197	840				2400	35	55	45
	19192	827	WFL	97206	65295	2400	35	75	43
	19193	830				2700	35	75	43
	19195	835				2700	35	75	43
	19196	930				1900	35	75	43
	19197	840				2700	35	75	43
	19192	827	WFL	98483	98489	2000	35	100	71
	19193	830				2200	35	100	71
	19195	835				2200	35	100	71
	19196	930				1600	35	100	71
	19197	840				2200	35	100	71
	19192	827	VWFL	97207	65296	1000	55	75	43
	19193	830				1100	55	75	43
	19195	835				1100	55	75	43
	19196	930				800	55	75	43
	19197	840				1100	55	75	43
	19192	827	VWFL	98485	98491	1100	55	100	71
	19193	830				1200	55	100	71
	19195	835				1200	55	100	71
	19196	930				900	55	100	71
	19197	840				1200	55	100	71
M1500	19198	827	FL	97208	65294	4600	25	75	43
	19200	830				4900	25	75	43
	19201	835				4900	25	75	43
	19202	930				3900	25	75	43
	19207	840				4900	25	75	43
	19198	827	FL	98480	98486	4300	25	100	71
	19200	830				4600	25	100	71
	19201	835				4600	25	100	71
	19202	930				3700	25	100	71
	19207	840				4600	25	100	71
	19198	827	WFL	99995	99996	2900	35	55	45
	19200	830				3100	35	55	45
	19201	835				3100	35	55	45
	19202	930				2400	35	55	45
	19207	840				3100	35	55	45
	19198	827	WFL	97206	65295	2800	35	75	43
	19200	830				3000	35	75	43
	19201	835				3000	35	75	43
	19202	930				2400	35	75	43
	19207	840				3000	35	75	43
	19198	827	WFL	98483	98489	2700	35	100	71
	19200	830				2900	35	100	71
	19201	835				2900	35	100	71
	19202	930				2300	35	100	71
	19207	840				2900	35	100	71
	19198	827	VWFL	97207	65296	1300	55	75	43
	19200	830				1400	55	75	43
	19201	835				1400	55	75	43
	19202	930				1100	55	75	43
	19207	840				1400	55	75	43
	19198	827	VWFL	98485	98491	1500	55	100	71
	19200	830				1600	55	100	71
	19201	835				1600	55	100	71
	19202	930				1300	55	100	71
	19207	840				1600	55	100	71
M2000	19209	827	FL	64996	65297	5700	25	75	43
	19210	830				6000	25	75	43
	19211	835				6200	25	75	43
	19214	930				4800	25	75	43
	19215	840				6200	25	75	43
	19209	827	FL	98481	98487	7200	25	100	71
	19210	830				7600	25	100	71
	19211	835				8000	25	100	71
	19214	930				6200	25	100	71
	19215	840				8000	25	100	71
	19209	827	WFL	64995	65298	3800	35	75	43
	19210	830				4000	35	75	43
	19211	835				4200	35	75	43
	19214	930				3200	35	75	43
	19215	840				4200	35	75	43
	19209	827	WFL	98484	98490	4200	35	100	71
	19210	830				4400	35	100	71
	19211	835				4600	35	100	71
	19214	930				3600	35	100	71
	19215	840				4500	35	100	71

* FL = Flood (25°); WF = Wide Flood (35°); VWF = Very Wide Flood (55°); NSP = Narrow Spot ** Full Width Half Maximum (FWHM)
Peak intensity values are for module driven at maximum rated drive currents. For values at lower drive currents contact your GE representative for details

Beam Performances from Infusion™ Modules and GE Optics (CONTINUED)

Module Series	Module Product Code	Module CCT[K]	Optic Beam Category	Optic Product Code - White	Optic Product Code - Black	Peak Intensity*[cd]	Nominal Beam Angle** [°]	Nominal Diameter [mm]	Nominal Length [mm]
M2000 (Continued)	19209	827	VWFL	64994	65301	2200	55	75	43
	19210	830				2300	55	75	43
	19211	835				2500	55	75	43
	19214	930				1900	55	75	43
	19215	840				2500	55	75	43
	19209	827	VWFL	98485	98491	2300	55	100	71
	19210	830				2400	55	100	71
	19211	835				2500	55	100	71
	19214	930				1900	55	100	71
	19215	840				2500	55	100	71
M3000	19216	827	FL	64996	65297	6500	25	75	43
	19218	830				7000	25	75	43
	19220	835				7000	25	75	43
	19224	930				5300	25	75	43
	19225	840				7200	25	75	43
	19216	827	FL	98482	98488	7900	25	100	71
	19218	830				8500	25	100	71
	19220	835				8500	25	100	71
	19224	930				6500	25	100	71
	19225	840				8700	25	100	71
	19216	827	WFL	97208	65294	6600	35	75	43
	19218	830				7000	35	75	43
	19220	835				7000	35	75	43
	19224	930				5400	35	75	43
	19225	840				7300	35	75	43
	19216	827	WFL	98484	98490	5300	35	100	71
	19218	830				5700	35	100	71
	19220	835				5700	35	100	71
	19224	930				4400	35	100	71
	19225	840				5900	35	100	71
	19216	827	VWFL	64994	65301	2700	55	75	43
	19218	830				2900	55	75	43
	19220	835				2900	55	75	43
	19224	930				2200	55	75	43
	19225	840				3000	55	75	43
	19216	827	VWFL	98485	98491	3000	55	100	71
	19218	830				3200	55	100	71
	19220	835				3200	55	100	71
	19224	930				2500	55	100	71
	19225	840				3300	55	100	71
M4500	19226	827	FL	98482	98488	8500	25	75	43
	19230	830				8900	25	75	43
	19231	835				9100	25	75	43
	19307	930				7100	25	75	43
	19337	840				9300	25	75	43
	19226	827	WFL	97208	65294	10600	25	100	71
	19230	830				11100	25	100	71
	19231	835				11300	25	100	71
	19307	930				8900	25	100	71
	19337	840				11600	25	100	71
	19226	827	WFL	98484	98490	7800	35	75	43
	19230	830				8100	35	75	43
	19231	835				8300	35	75	43
	19307	930				6500	35	75	43
	19337	840				8500	35	75	43
	19226	827	VWFL	64994	65301	7500	35	100	71
	19230	830				7800	35	100	71
	19231	835				8000	35	100	71
	19307	930				6300	35	100	71
	19337	840				8200	35	100	71
	19226	827	VWFL	98485	98491	3800	55	75	43
	19230	830				3900	55	75	43
	19231	835				4000	55	75	43
	19307	930				3100	55	75	43
	19337	840				4100	55	75	43
	19226	827	VWFL	98485	98491	4400	55	100	71
	19230	830				4600	55	100	71
	19231	835				4700	55	100	71
	19307	930				3600	55	100	71
	19337	840				4800	55	100	71
NPM	98471	827	NSP	94637	94638	11100	14	55	45
	98472	830				12000	14	55	45
	98473	930				9300	14	55	45
	98474	840				12600	14	55	45
	98471	827	NSP	98477	98475	18500	12	75	43
	98472	830				20000	12	75	43
	98473	930				15500	12	75	43
	98474	840				21000	12	75	43
	98471	827	NSP	94635	94636	22000	11	75	43
	98472	830				24000	11	75	43
	98473	930				18500	11	75	43
	98474	840				25000	11	75	43
	98471	827	NSP	98478	98476	27500	10	100	71
	98472	830				30000	10	100	71
	98473	930				23500	10	100	71
	98474	840				32000	10	100	71
	98471	827	NSP	94633	93634	33000	8	100	71
	98472	830				36000	8	100	71
	98473	930				28000	8	100	71
	98474	840				38500	8	100	71

* FL = Flood (25°); WF = Wide Flood (35°); VWF = Very Wide Flood (55°); NSP = Narrow Spot ** Full Width Half Maximum (FWHM)
Peak intensity values are for module driven at maximum rated drive currents. For values at lower drive currents contact your GE representative for details

Optical Design & Performance

Information for Optic Designers

Information is available from GE for customers who wish to design their own reflectors or other optics to interface with Infusion LED modules. Contact your GE representative for details. When designing an optic, there are several things to consider, including the mechanical attachment, diameter of the light emitting surface (LES) of the module, and the mating surface of the reflector, as shown in the diagram below.

Light Emitting Surface (LES)

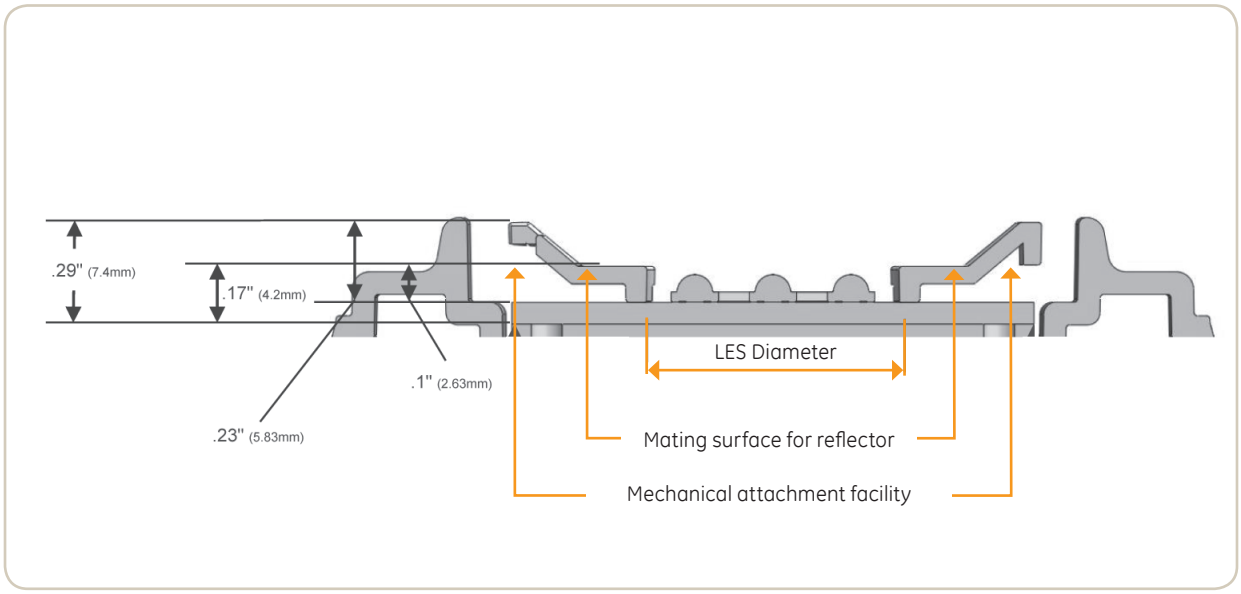
The light emitting surface is defined as the area of the module within which the LEDs are contained. There are three LES sizes depending on lumen package:

LES diameter for M1000 and M1500 series modules = 0.75" (19mm)

LES diameter for M2000, M3000 and M4500 series modules = 0.9" (23mm)

LES diameter for NMP module = 0.355" (9mm)

Care should be taken to keep the reflector clear of the LES in order to ensure compatibility of the optic design for future generations of the module.

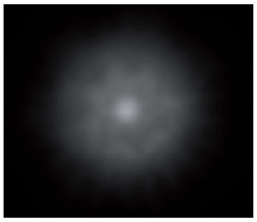


Mating Surface for Optic

The mating surface for the optic shown in the diagram is the optimal place to locate the bottom rim of the reflector. This allows optimal light collection, minimizing the escape of stray light outside the reflector. Ray files for the various versions of the Infusion LED module are available, as is CAD information which will provide detailed mechanical information regarding the optical interfaces.

Use of Diffusers

Because the light emitting surface of the Infusion LED module is comprised of an array of high intensity point sources, care must be taken in optical designs to avoid the appearance of visible structure in the beam, which is usually undesirable. Visible structure tends to be more of an issue with narrower beams, so in these cases, more diffusion will likely be needed to produce a smooth beam.



Without diffuser

(structure in beam)

With diffuser

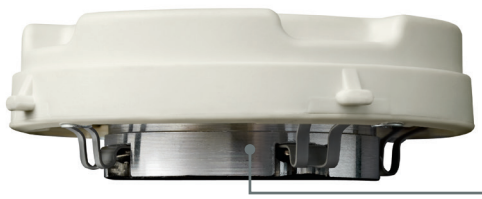
(smooth beam)

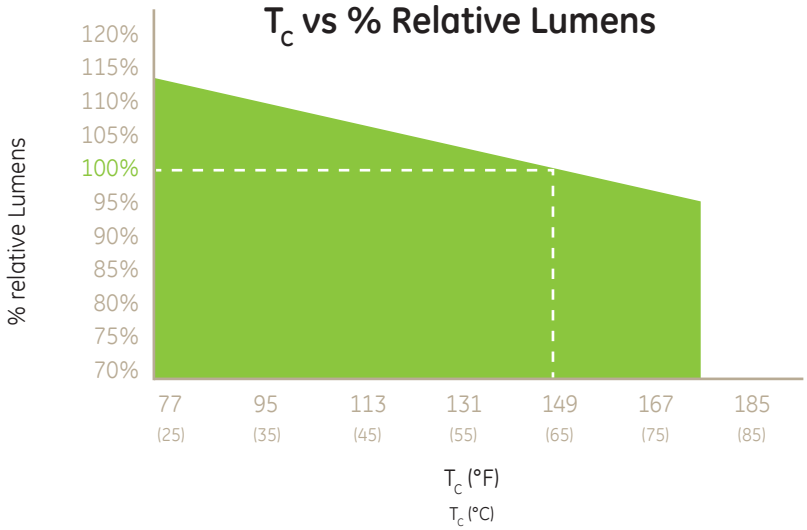
General

In order for a GE Infusion™ LED module to function optimally, it must be attached to a heat dissipation system. This section provides information about heat sink design as well as considerations when designing a heat dissipation system. The Infusion LED module transfers most of its heat through conduction. Using a heat sink will allow convection to dissipate the heat into surrounding air. For optimal performance, LEDs must operate within the specified temperature limits. Poor thermal management will accelerate LED chip degradation and affect lifetime and lumen output of the module.

Critical Measurement Points

The performance of an LED is temperature sensitive. The temperature at a measuring point on the module, **T_c** (see photograph), is correlated to the junction temperature of the LED chip. In order to meet life claims, and for product warranties to be valid, the temperature measured at **T_c** should not exceed 176°F (80°C) in the environment in which the module will operate.





Note:
The graph above is based on limited test data. This graph has been included for illustrative purposes to show the approximate correlation between the module Tc and output lumens as well as the importance of keeping the module at the performance temperature of Tc = 65ºC. It should not be interpreted as a representation of exact module performance.

To accurately measure **T_c**, use a pre-welded thermocouple. It is important that the tip of the thermocouple is pressed against the surface of the module. Any material or space between the surface and thermocouple tip will decrease the accuracy of the reading. A thermal epoxy can be used to glue the thermocouple tip to the surface. The temperature reading should be taken after the system has reached steady state.

The operating temperature of the module is also correlated to the lumen output. The claimed lumens for each version of the module assume a steady-state **T_c** reading of 149°F (65°C). Modules operating cooler than this will have higher lumen output, whereas modules operating at a higher temperature will experience a reduction in lumens. The following graph shows the relationship between **T_c** and relative lumen outputs.

Operation under Built-in Conditions

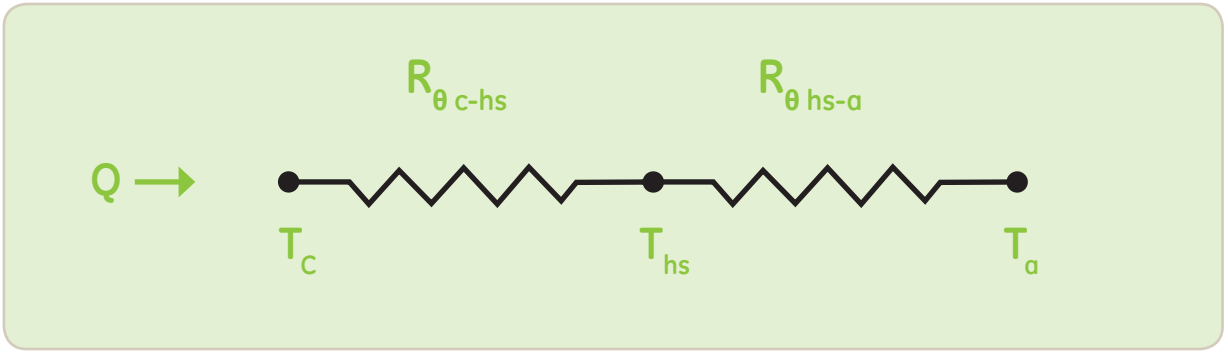
The heat produced by the module must be dissipated into the surrounding environment in order to meet the performance claims. To maximize the efficiency of the heat sink, the heat fins should be parallel to the direction of airflow. In general, density of air decreases when heated, causing it to flow upwards. Another factor to consider is the trade-off between heat fins and airflow – closely packed heat fins may result in higher surface area, but may also interfere with convection. If the heat dissipation system is in an enclosed area, a large surface area may not adequately dissipate heat due to a lack of airflow. Any obstacle in the airflow path will adversely affect thermal management.

Temperature and Performance

The ambient temperature must be taken into consideration when designing the heat sink. The application of the product, such as track lighting or a recessed fixture, will drive the thermal design of the system. The GE Infusion™ LED module will operate in the range of -4°F (-20°C) to 113°F (45°C) ambient temperature as long as a T_c of 176°F (80°C) is not exceeded.

Thermal Model

The primary mathematical tool used to model the impedance between various surfaces is thermal resistance. A simplified series thermal resistance circuit model for the LED heat system is shown below.



Q represents heat transfer through the circuit, T_a represents the ambient temperature, T_{hs} represents the temperature of the heat sink, and T_c represents the temperature measured on the module. $R\theta_{chs\text{-}a}$ is the thermal resistance from the T_c point to the heat sink. $R\theta_{hs\text{-}a}$ is the thermal resistance between the heat sink and ambient air and will be dependent on the conductivity of the heat sink and fin configuration. Some common $R\theta_{hs\text{-}a}$ values are shown in the table on the next page.

The heat transfer from the module to the heat sink (between T_c and T_{hs}) will occur mostly through conduction, while heat will be dissipated from the heat sink to ambient through convection and to a lesser degree, radiation. Radiation of smooth surfaces can be enhanced by anodizing or other techniques, such as painting. Do not paint the heat sink where it contacts the module's thermal interface.

Designing a Heat Sink

The necessary size of the heat sink will depend on the temperature difference between T_c and the ambient temperature, total input power, and material properties of the heat sink. To ensure that adequate heat is dissipated from the LED module, the heat sink design must take into consideration the input power to the module as well as effects from nearby heat sources.

There must be a clear path for heat transfer from the heat source to the environment. The heat from the LED module travels via conduction through the heat sink to the heat fins. Heat is then transferred from the heat fins to the ambient environment through convection (and to a lesser degree through radiation). Generally, more surface area will dissipate more heat to the environment.

It is important that there is good thermal conductivity along every point of the thermal path. Each interface in the system will add to the overall resistance of the system. If the heat sink is fabricated in multiple pieces, care must be taken to manage the impact of each interface. For example, applying a thin layer of thermal grease between the interfaces or applying significant pressure between components may improve thermal conductivity.

Assuming that the ambient temperature is 77°F (25°C), T_c is 149°F (65°C), the heat sink is in a free-air condition, and the module is run at nominal current (necessary to achieve the rated lumens) the minimum $R\theta_{hs-a}$ for the different module systems are in the table below. A smaller $R\theta_{hs-a}$ will improve thermal performance.

Module Lumen Value	$R\theta_{hs-a}$ (K/W)
NPM	1.7
1000	3.6
1500	2.4
2000	1.7
3000	0.8
4500	0.4

Notes:
$R\theta_{hs-a}$ can generally be reduced by adding heat fin surface area or introducing forced convection via active cooling methods.

Infusion™ heatsink

SKU	Description	Outer diameter [mm]	Height [mm]	Pack quantity	Manufacturing process	Surface finish	Material
95104	HS160-040 BLACK	160	40	20 pcs/box	Extrusion	Black anodized	AL 6063
95105	HS110-025 BLACK	110	25	48 pcs/box	Extrusion	Black anodized	AL 6063

Active Cooling as an Alternative to Passive Cooling

The above design guide is written relative to a 'passive cooling' scenario, where a static heat sink is used to dissipate most of the heat generated by the LED module. The higher the wattage rating of the LED module, the larger the heat sink required. Therefore it follows that higher wattage LED modules may require very large heat sinks to achieve the required level of heat management.

Where compact luminaires are required, additional heat dissipation can be achieved very effectively by the use of 'active cooling' methods. Active cooling aims to effectively move air over the cooling surfaces to increase the heat transfer coefficient, therefore enabling small, compact and lightweight cooling solutions.

There are two types of active cooling solutions available on the market – fans and synthetic jets. Synthetic jets use oscillating diaphragms to create high velocity pulses of air that can be precisely directed to the area requiring the most critical cooling.

Particular design considerations for active cooling are:

- Provisions in luminaire design for the inlet and outlet of cool and hot air, respectively, ensure smooth airflow from inlet to outlet and prevent restrictions in the flow path
- Avoidance of recirculation of hot air inside the luminaire, which leads to lower thermal performance
- Ensuring fan or synthetic jet noise is minimized, which can be done by avoiding unnecessary openings near the fan or synthetic jet in the luminaire housing

Suppliers of Cooling Solutions

The following companies supply both active and passive cooling solutions for Infusion™ LED modules. Details are provided in the table below:

Supplier	Contact	Email	Website	Heat Sinks	Fans	Synthetic Jets
AVC – EU AVC - NA	Jeff Huang	Jeff_huang@avccn.com.tw	www.avc.com.cn	X	X	
Nuventix – EU	Francois Jaegle	fjaegle@nuventix.com	www.nuventix.com	X		X
Nuventix - NA	Jeff Kelley	jkelley@nuventix.com	www.nuventix.com	X		X
Sunon – EU	Florian Delier	florian.delier@sunoneurope.com	www.sunoneurope.com	X	X	
Sunon - NA	Russell Lucia	russl@sunon.com	www.sunon.com	X	X	
Journee Lighting	Nate Quan	nate@jrne.com	www.journeelighting.com	X		

Evaluating the Thermal System

Evaluate the system in its intended application. Measure the temperature, $\mathbf{T_c}$, at the specified point to ensure that it is below the specified maximum temperature ($\mathbf{T_c}$ = 176 °F (80°C)), and to achieve rated lumens, at or below the specified performance temperature ($\mathbf{T_c}$ = 149 °F (65°C)). If the system does not meet criteria, improve heat sink or active cooling system performance. It is important to evaluate the LED module in the final application. The environment (recessed versus track, insulated versus non-insulated) will affect the heat sink requirements. An environment with a high ambient temperature and restricted airflow will require a more efficient thermal system.

Vibration and Shock

The LED Module and LED Module Collar will withstand 5G shock/vibration for one hour.

Dry Location Use

The Infusion module is only for use in dry locations.

End-of-Life Behavior

LEDs have passive failure modes. The light output will gradually diminish over usage and time.

GE Infusion System Disposal

The LED system must be disposed of according to local and national regulations that pertain to this system.

Troubleshooting FAQ

While problems with your Infusion module will be rare, should you have problems, the following tips will help.

PROBLEM: I have hooked up the wires from the module collar, inserted the module and turned on power, but the module does not light, flashes or is dim.

SOLUTION: Disconnect the power and check that all electrical connections are secure and that the polarity is correct. If the polarity was reversed, then the module would have entered a protection mode, which can be resolved by removing the power, correcting wire polarity and reapplying power. In addition, the problems described above can be caused by using a LED driver that does not have the correct voltage or current output for the module it is trying to power. Verify that the drive is from the Approved Drivers List and is matched correctly with the module. A copy of the Approved Drivers List is available on the website at www.gelighting.com/infusion

PROBLEM: My newly installed module has been working, but stops working after a little while. I removed power and turned it on again, but had the same result.

SOLUTION: If your module operates correctly for a period of time and then shuts off, this is an indication that the unit is getting too hot and going into thermal protection mode. Check your thermal system, the module and ambient temperatures to ensure operation within limits.

PROBLEM: I have installed a new low lumen module into a fixture that was previously used for a high lumen module, but it does not light up.

SOLUTION: Check to ensure you have the correct LED driver hooked up for a low lumen module. The driver for a high lumen module provide too much current to a low lumen module and activate a protection mode. Remove the incorrect driver, install a low lumen driver, and then recheck operation.

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