

Guide to Downlight Mechanical Components



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INTRODUCTION

This guide describes the mechanical components of a downlight and is intended for manufacturers unfamiliar with this form factor. This guide focuses on the mechanical components required to produce a non-insulation contact (non-IC), UL-listed, general downlight for the North American market.

Downlights are constructed using the following basic mechanical parts. Requirements of the desired UL rating, the quantity of lumens the downlight produces, the amount of heat generated by the downlight and manufacturer options all have an impact on the construction of these parts.

- Ring
- Vertical-adjustment bracket
- Butterfly bracket
- Junction-box bracket
- Junction box/supply box/through-wire box
- Junction-box covers
- Bar hangers
- Self-heating insulation sensor (SHIS)

The most basic part of a downlight, regardless of the aperture size, is the frame assembly. The frame assembly provides the

flexibility that allows a downlight to be installed in a variety of ceiling constructions. Figure 1 shows how the parts listed above are connected to make the frame assembly.¹

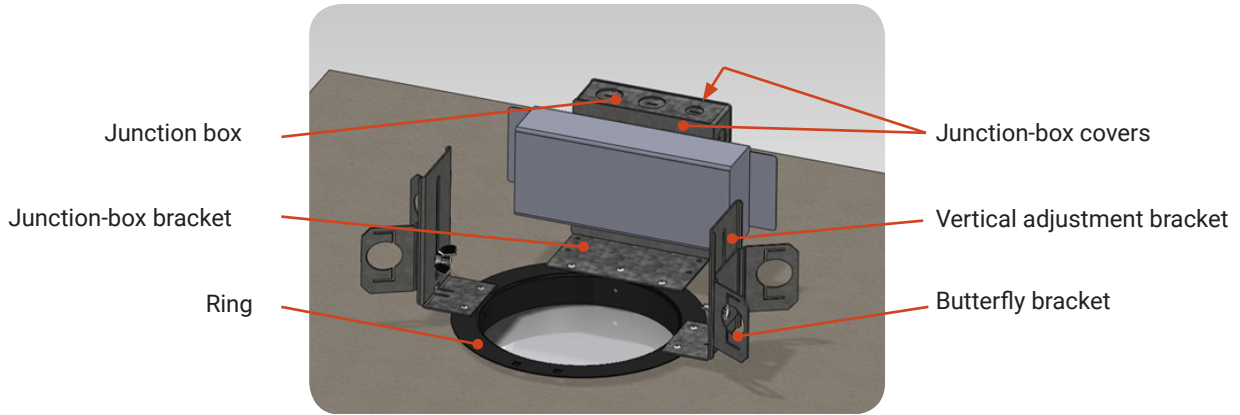


Figure 1: Downlight mechanical components - together, the frame assembly

Multiple forms of frame assembly are possible. A fully integrated, one-piece assembly has a high tooling cost but the assembly cost and time are low. A non-integrated assembly is comprised of many parts, with low tooling costs but high assembly cost and time. Both methods can produce a frame assembly that is very flexible and usable in multiple designs. This guide discusses the non-integrated assembly. This option allows the individual pieces to be used in multiple products, sourced from multiple places and offers a new luminaire manufacturer an array of design options.

All price estimates herein are based on information available at the time of writing and assume domestic US tooling and parts sourcing. Sourcing tooling and parts from Asia could result in a 25% to 50% price reduction that might be offset by the time in transit and shipping charges.

All luminaire designs are subject to review by Underwriters Laboratories (UL[®]), National Electrical Code[®] (NEC[®]) and Authorities Having Jurisdiction (AHJ). No regulatory approvals are implied by this document.

Bracket Materials

The vertical-adjustment brackets, butterfly brackets and junction-box bracket are made from galvanized steel. The highest quality luminaires have brackets of 16-gauge galvanized steel; the more cost-conscious luminaires use 18-gauge galvanized steel. Twenty-gauge galvanized steel can be used but gussets or other formed supports must be engineered into the parts to meet mechanical strength tests, i.e., the through-wire pull test from UL1598. The design and testing time involved in this engineering can defeat the cost savings of using a thinner gauge material.

¹ This and the other images in this guide are illustrative for reference only and do not imply a recommendation.

RING

Description

The ring determines the aperture size and some basic luminaire options and installation constraints. As depicted in Figure 2, the ring consists of a vertical portion, called the throat, and a horizontal portion, called the flange. The height of throat sets the maximum ceiling thickness that the luminaire can accommodate. It is common practice in commercial constructions to form a ceiling using two ½-in. sheets of drywall, so the depth of the throat should be at least 1 in. The throat can be round or square, as little as 1 in. and as large as 12 in. outside dimension. Twelve inches is deemed to be a practical limit for a commercial downlight, but the aperture can be any size. The throat usually has a few holes in it to accommodate clips, a ring extension and housing options. The flange has holes that accommodate mounting brackets, junction-box brackets or emergency-battery-pack brackets. The width of the flange affects the UL normal non-IC test box size and the versatility of the ring in other luminaire designs.

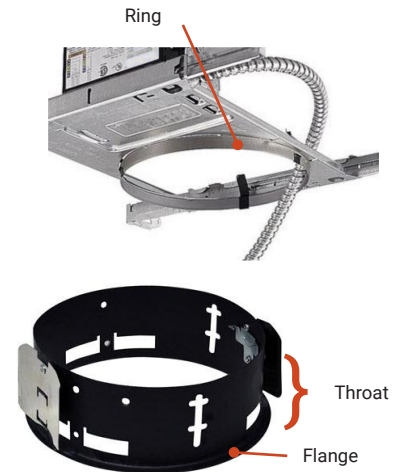


Figure 2: Example rings

Materials

The ring can be made from a variety of materials, including thin-gauge aluminum, ferrous materials, non-ferrous materials, hot-dipped galvanized steel and castings. An extrusion or an injection-molded plastic frame could be utilized but a plastic frame could have some regulatory challenges, such as with flame and burn tests. Such a frame presents some serious design challenges in order for the frame to have sufficient flame retardation and burn resistance properties. The target piece price and investment capital available will dictate the ring tooling, material and thickness. Generally 22- to 18-gauge galvanized sheet steel or 20- to 16-gauge aluminum is used. Any ferrous material that is not galvanized requires corrosion protection.

Tooling

Tooling is usually done through a spinning, stamping or deep draw process. Tooling is estimated to cost between \$1,500 and \$10,000.

Piece Price

The estimated piece price is \$1.00 to \$7.00, depending on the type of tooling utilized and the quantity purchased.

VERTICAL-ADJUSTMENT BRACKET

Description

Shown in Figure 3, the vertical-adjustment brackets mechanically attach to the ring and facilitate the frame assembly's use in various ceiling constructions. A minimum of two brackets are required. Vertical-adjustment brackets are usually sheet metal and are generally L-shaped. The butterfly brackets are mechanically attached to the vertical-adjustment brackets through a slot that runs nearly the length of the vertical bracket. The slot in the vertical-adjustment bracket allows up to 8 in of vertical adjustment flexibility. This flexibility allows the luminaire to be installed in ceiling structures (the parts that suspend the ceiling drywall or grid) of varying thickness.

Tooling

Vertical-adjustment brackets are usually die formed or progressive tooled. In short-run production, they can be handmade. Tooling is estimated to cost \$0 to \$50 (for the set-up charge and for laser-cut blanks) for handmade brackets to several thousand dollars for die-formed or stamped parts. Progressive tooling that utilizes a coil feed is estimated to cost \$10,000 to \$20,000 but would bring the piece price down significantly.

Piece Price

The estimated piece price is \$8 to \$15 for handmade brackets and \$0.05 to \$1.50 for die-formed brackets, depending on the type of tooling utilized and quantity purchased.



Figure 3: Example vertical adjustment bracket

BUTTERFLY BRACKET

Description

A downlight requires a minimum of two butterfly brackets, one per vertical-adjustment bracket. As shown in Figure 4, a butterfly bracket is a sheet-metal bracket that accepts mounting bars. Through the mounting bars, butterfly brackets attach the luminaire to the ceiling structure or other mechanical elements. The better designed brackets accept mounting bars of 1½-in. C-channel, ½-in. trade conduit and ½-in. strap material. Butterfly brackets are die formed or progressive tooled. The complex shapes required for the various combinations of mounting bars usually preclude making brackets by hand; however, laser-cut blanks can be hand formed. Handmade parts can be utilized if the mounting options are minimized.

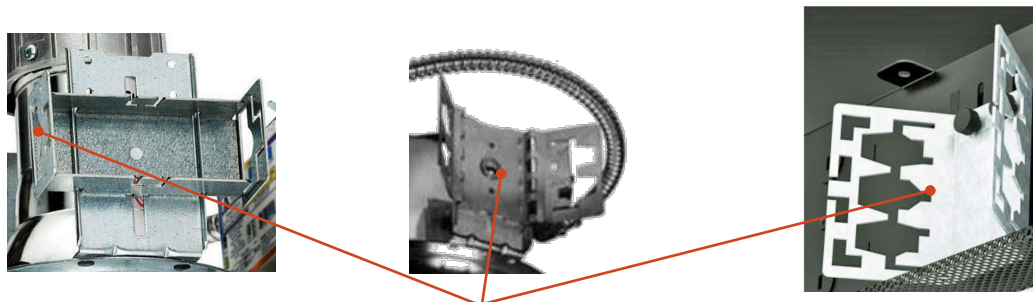


Figure 4: Example butterfly brackets

Tooling

Tooling is estimated to cost \$50 to \$100 (for the set-up charge and for laser-cut blanks) for handmade brackets to several thousand dollars for die-formed or stamped parts. Progressive tooling that utilizes a coil feed is estimated to cost \$10,000 to \$20,000 but would bring the piece price down significantly.

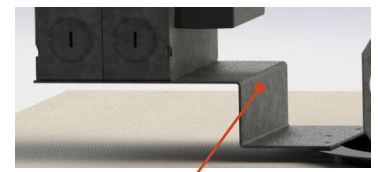
Piece Price

The estimated piece price is \$3 to \$10 for handmade brackets and \$0.50 to \$2.00 for die-formed brackets, depending on the type of tooling utilized and quantity purchased.

JUNCTION-BOX BRACKET

Description

A junction-box (J-box) bracket, shown in Figure 5, is used to secure the junction box to the ring and spaces the driver/ballast far enough away from the light source to keep the light source and the driver/ballast from overheating. The junction-box bracket is sheet metal and generally Z-shaped or flat. The shape of the bracket depends on the overall size of the luminaire frame. When assembled and installed in the center of a 2 ft. x 2 ft. ceiling tile, the junction-box bracket and junction box with the driver installed must not interfere with the T-bars in the ceiling. To prevent any interference, the junction-box bracket must be made to locate the junction box above the ceiling T-bars. The overall length of the bracket is heavily influenced by the aperture size of the luminaire and UL1598. Assuming a through-wire luminaire listing is required, the material used should be 18-gauge galvanized steel at a minimum. (More information on meeting through-wire requirements can be found in the "Junction Box/Supply Box/Through-Wire Box" section.)



Z-shaped bracket



Flat bracket

Figure 5: Example J-box brackets

Tooling

Tooling is estimated to cost \$50 to \$100 (for the set-up charge and for laser-cut blanks) for handmade brackets and several thousand dollars for die-formed or stamped parts. Progressive tooling that utilizes a coil feed is estimated to cost \$5,000 to \$15,000 but would bring the piece price down significantly.

Piece Price

The estimated piece price is \$1 to \$15 for handmade brackets and \$0.10 to \$2.00 for die-formed brackets, depending on the type of tooling utilized and quantity purchased.

JUNCTION BOX/SUPPLY BOX/THROUGH-WIRE BOX

Description

A basic specification in commercial luminaires is that they are "Listed for Through Wire". A luminaire that meets this specification allows an electrician to run a separate circuit through the conduit and junction boxes of other installed luminaires. The most common

specification is "8 through wire listed, 4-in, 4-out". This standard allows one additional circuit to be in the luminaire junction boxes. UL requires a basic junction-box volume of 28 cubic in. or 4 in. x 4 in. x 1.75 in.

As shown in Figure 6, the junction box in a specification-grade commercial luminaire must have access and connection points for ½-in. trade conduit, ¾-in. trade conduit, the self-heating insulation sensor and the through-wire connections. Lower quality commercial luminaires have additional means for connecting Romex® wiring. Specifiers of higher-grade commercial luminaires and architects generally disapprove of Romex connections. Common access is two ½-in. conduit knockouts on each side, one ¾-in. knockout on each side and two additional ½-in. knockouts on the top. When a Romex connection is added, there are provisions for internal strain relief built into the junction box. Good planning and design should allow one junction box to be used in multiple products.

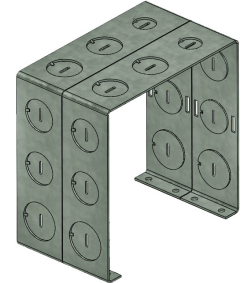


Figure 6: Example J-box

Many electricians have commented that junction boxes frequently have barely enough room for supply wires. Then, after adding through wire, ballast/driver supply connections, the insulation sensor and source connections, there can be 8-12 wire nuts and as much as 40 in. of wire in the luminaire junction box. In recent years, commercial luminaire manufacturers have listened to the installation and electrical contractor community and now make junction boxes that are more than the minimum required for through-wire testing and UL listing. Today's commercial luminaires have 6 in. x 4 in. x 2 in. junction boxes or combine two 4 in. x 4 in. x 1.75 in. boxes together to make a 4 in. x 4 in. x 3.5. in. box.

Lower-quality commercial luminaires have switch boxes or 2-, 3- or 4-gang boxes.

Materials

Twenty-gauge galvanized steel is difficult to use successfully in a junction box.

Tooling

Switch and gang boxes can be purchased and sometimes need to be modified to function as a junction box. There is no tooling for purchased parts. Non-purchased parts are die formed or progressive tooled. Tooling is estimated to be \$50 to \$100 (for the set-up charge and for laser-cut blanks) for handmade junction boxes to several thousand dollars for die formed or stamped parts. Progressive tooling that utilizes a coil feed is estimated to cost \$5,000 to \$15,000 but would bring the piece price down significantly.

Piece Price

The estimated piece price is \$2 to \$5 for handmade junction boxes and \$0.10 to \$0.75 for die-formed boxes.

JUNCTION-BOX COVERS

Description

Sheet-metal junction-box covers attach to the junction/supply box. As shown in Figure 7, junction-box covers have features that allow installation and removal without tools. These features usually include tabs, notches and various holes for mounting a driver/ballast and wire pass-through. Figure 8 shows a junction-box with a cover attached.

Various knockouts and holes can be added to a junction-box cover to increase its versatility. Good planning and design should allow one junction-box cover to be used in multiple products.

Materials

Like the various brackets, junction-box covers are 16- or 18-gauge galvanized steel. Some junction-box covers available in several big-box stores are 20-gauge galvanized steel.

Tooling

Tooling is estimated to cost \$50 to \$100 (for the set-up charge and for laser-cut blanks) for handmade covers to several thousand dollars for die-formed or stamped parts. Progressive tooling that utilizes a coil feed is estimated to cost \$5,000 to \$10,000 but would bring the piece price down significantly.

Piece Price

The estimated piece price is \$1 to \$5 for handmade covers and \$0.10 to \$1.00 for die-formed covers, depending on the type of tooling utilized and quantity purchased.

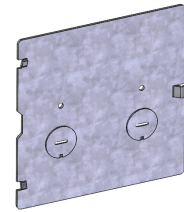


Figure 7: Example J-box cover



Figure 8: Example J-box with cover

BAR HANGERS

Description

Bar hangers are supplied as an option by commercial luminaire manufacturers. Residential luminaire manufacturers supply similar parts, often called nail bars, with the luminaire. Slightly longer than 24 in., bar hangers span the ceiling mechanicals and support the luminaire housing above the ceiling finish material. Properly formed butterfly brackets can accept bar hangers of job site scrap materials in the form of 1½-in. C-channels, ¾-in. conduit and ½-in. strap material.

Building codes require the luminaire to be secured to the ceiling mechanicals. Purchased bar hangers have built-in fasteners such as screws or clips that are an acceptable means of mechanical fastening. When job site scraps are used as bar hangers, the luminaire assembly must be wire-tied to the hangers to meet the mechanical mounting requirement.

Unique ceiling structures such as Alcan metal, wood, custom acoustics and some complex curve spaces can require bar hangers up to 60 in. long. Bar hangers of this length are almost exclusively 1½-in. C-channels.

Figure 9 shows several example bar hangers.



Figure 9: Example bar hangers

Materials

Bar hangers are made of 18- to 22-gauge sheet metal.

Tooling

Tooling is estimated to cost \$50 to \$100 (for the set-up charge and for laser-cut blanks) for handmade bar hangers to several thousand dollars for die-formed or stamped parts. Progressive roll tooling that utilizes a coil feed is estimated to cost \$5,000 to \$10,000 but would bring the piece price down significantly.

Piece Price

The cheapest residential versions cost pennies. The more complex and easier-to-use versions are estimated to cost \$2 to \$10 per pair.

SELF-HEATING INSULATION SENSOR

Description

A self-heating insulation sensor, shown in Figure 10, detects insulation close to a luminaire. UL does not require a luminaire to have an SHIS; passing several steps of UL testing has historically been enabled by the use of an SHIS. A luminaire manufacturer should contact their safety listing partner for clarification of this requirement.



Figure 10: Example of SHIS connected to J-box

The lack of a universal input-voltage option is the Achilles heel of a true universal-voltage luminaire. An SHIS is a voltage-specific device, so a luminaire that includes an SHIS becomes a dedicated-voltage product. This defeats the purpose of using a universal-voltage driver in the luminaire.

Tooling

There is a limited number of SHIS suppliers. Figure 11 shows parts made by two suppliers.



Leviton 9454 series



Sensata RP devices

Figure 11: 2 SHIS devices

Piece Price

The estimated piece price is \$2 to \$14 depending on the quantity purchased and the input voltage.

SUMMARY

This guide explains various aspects of the mechanical components of a downlight intended for the North American market and is intended as an aid to electronics manufacturers eager to provide LED- or LED-module-based downlights. Table 1 is a summary of the tooling and piece price estimates in this guide. There is obviously a very wide range of costs, depending on whether components are handmade or machine made.

Table 1: Summary estimated component tooling and piece price costs

Component	Tooling Estimate				Piece Price Estimate		
	Spinning, Stamped or Deep Draw	Handmade	Die Formed or Stamped	Progressive	Spinning, Stamped or Deep Draw	Handmade	Die Formed or Stamped
Ring	\$1,500-\$10,000				\$1-\$7		
Vertical-adjustment bracket		\$0-\$50	several \$K	\$10,000-\$20,000		\$8-\$15	\$.05-\$1.50
Butterfly bracket		\$50-\$100	several \$K	\$10,000-\$20,000		\$3-\$10	\$.50-\$2
Junction-box bracket		\$50-\$100	several \$K	\$5,000-\$10,000		\$1-\$5	\$.10-\$2
Junction box		\$50-\$100	several \$K	\$5,000-\$15,000		\$2-\$5	\$.10-\$1.75
Junction-box cover		\$1-\$5	several \$K	\$5,000-\$10,000		\$1-\$5	\$.10-\$1
Bar hangers		\$50-\$100	several \$K	\$5,000-\$10,000		pennies	\$2-\$10
SHIS							\$2-\$14

For technical information and support, please e-mail us at productsupport@cree.com.