Application Note

Maximum Cable Fill Ratios in Cable Managers

Overview

Cable Fill Ratios in cabling pathways are defined in various Codes, Standards, and by industry best practices. The maximum allowable fill in these pathways is well-understood by most cabling professionals. Per the NEC (NFPA 70), ANSI/TIA-569-E, and EN50174:2 Section 4.4.2.2 rules for maximum cable fill ratio in pathways are these:

- For Conduits (where 3 or more cables are installed) the maximum cable fill ratio is 40%.
- For Cable Trays, the recommendation is to design for (and install) at no more than a 25% cable fill ratio (the cable tray at a 25% fill ratio will look half full).
- ***Note:*** *The EN50174:2 Standard cites no more than 40% initial fill for cable trays and a 50% maximum fill number. This Application Note will work with a 25% initial fill number. As will be shown, 40% is too great a fill number for cable manager applications.*
- Cable Tray fill standards allow for growth to a maximum 50% cable fill ratio (the cable tray at a 50% fill ratio will look completely full).

There are, however, **no industry standards for recommended maximum cable fill ratios for Cable Managers**. Because no standards exist for Cable Manager cable fill ratios, recommendations for Cable Trays (a similarly shaped cable pathway) are often suggested. The recommended 25% initial cable fill maximum is likely safe to claim for Cable Managers (the cable path within the manager would appear half full when a 25% cable fill ratio is employed). The Cable Tray maximum cable fill ratio of 50%, however, will not work for most Cable Manager applications.

Why can't we typically achieve a 50% cable fill ratio in these Cable Managers? In Conduits and Cable Trays, the installed cabling (generally) runs from one end of the pathway to the other, with little (or no) cable entry and exit from the pathway. In a Cable Manager, however, the whole purpose of the manager is to handle frequent cable entries and exits all along the length of the manager.

The bend radius of cables, patch cords, and cable bundles entering and leaving the cable manager, takes up space within the cable manager's cabling channel. Bundled cables take up more space than individual cables. The Velcro® brand ties used in cable bundling, also take up room within the cable pathway. Front-facing Horizontal Cable Managers (typically used for patch cord routing) have much of their cable pathway unavailable for use, due to patch cord bend radius requirements.

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Product Line:
Copper Cable Managers, Copper Cables, and Copper Patch Cords

Part Numbers Affected:
Most Copper Cable Managers, Copper Cables, and Copper Patch Cords

This Application Note will look at the typical usages of various Leviton Cable Managers with Leviton Cables and Patch Cords and introduce the concept of **recommended practical maximum cable fill ratios** for Cable Managers. The findings of our investigations into recommended practical maximum cable fill ratios are:

- For **rear-facing cable management components** (typically used for routing Horizontal cabling or Backbone cabling) the **recommended practical maximum cable fill ratio is 35%.**
- For **front-facing cable management components** (typically used for routing Patch Cords) the **recommended practical maximum fill ratio is 30%.**

Although this Application Note specifically addresses Leviton products, the concepts herein apply to most cable managers, data cables, and patch cords available on the market. All that is needed to determine Maximum Practical Cable Fill Ratio is the Cable Manager's cable pathway dimensions and the cable or patch cord outer dimension (O.D.).

This document covers the following subject matter:

- **Part 1 – Maximum Practical Cable Fill Ratio for Cable Managers, Cables, and Patch Cords for USA Products (dimensioned in inches)**
    - Definition of Cable Fill Ratio
    - Illustrations of Conduit and Cable Tray cable pathways
    - Discussion of cable fill ratio in Cable Managers
    - Information needed to calculate cable fill ratio
    - Example cable fill ratio calculation
    - Illustrations of 25% and 50% cable fill ratios
    - Understanding a <u>Practical</u> Maximum Cable Fill Ratio of Cabling in a Vertical Cable Manager
    - Cable pathway dimensions for Leviton Rear Cable Managers
    - Outer Diameters (O.D.s) for all common Leviton (Berk-Tek) cables
    - Cable Fill Ratio Table for all Leviton cable O.D.s in all Leviton Rear Cable Managers – (How many cables will fit into each cable manager?)
        - 25% initial recommended cable fill ratio
        - 35% recommended maximum <u>practical</u> cable fill ratio
    - Finger slots in rear cable managers/number of cables per slot
    - Cable pathway dimensions for Leviton Front Cable Managers
        - VERSI-DUCT™ and Ring-type managers
    - Outer Diameters (O.D.s) for all common Leviton Patch Cords
    - Illustration of the usable area of a "4-inch" cable management ring
    - Illustration of 50% cable fill ratio (Patch Cords in a Horizontal Cable Manager)
    - Illustrations of a practical usage of a Horizontal Cable Manager (plus discussion)
    - Cable Fill Ratio Tables for Leviton Patch Cord O.D.s in all Leviton Ring-type Front Cable Managers – (How many Patch Cords will fit into each Ring-type Manager?)
        - 25% initial recommended cable fill ratio
        - 30% recommended maximum <u>practical</u> cable fill ratio
        - 50% absolute maximum cable fill ratio (impractical for most applications)
    - Cable Fill Ratio Tables for VERSI-DUCT™ Horizontal Front Cable Managers
    - Cable Fill Ratio Tables for VERSI-DUCT™ Vertical Front Cable Managers
    - Cable Fill Ratio Tables for VERSI-DUCT™ Vertical Front Cable Manager Finger Slots and Front-to-Rear Through Holes
    - Illustrations of Finger Slots and Front-to-Rear Through Holes
    - Conclusions
- **Part 2 – Maximum Practical Cable Fill Ratio for Cable Managers, Cables, and Patch Cords for EMEA Products (dimensioned in millimeters)**
    - Content for Part 2 is the same as content for Part 1, except Cables and Patch Cords are Leviton-EMEA products.

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Part 1 – Maximum Practical Cable Fill Ratio for Cable Managers, Cables, and Patch Cords for USA Products (dimensioned in inches)

Definition of Cable Fill Ratio – Cable Fill Ratio is defined as the cross-sectional area of the cable pathway (conduit, tray, duct, channel, etc.) divided by the cross-sectional area of the cables running through the pathway.

Codes and Standards provide rules and guidelines for maximum Cable Fill Ratios in various pathways. For conduit, if 3 or more cables are running through the conduit, the maximum allowable cable fill ratio is 40% fill. For Cable Tray, industry best practice recommendations are to design for (and install) a maximum 25% cable fill ratio and allow for cable plant growth up to a maximum 50% cable fill ratio.
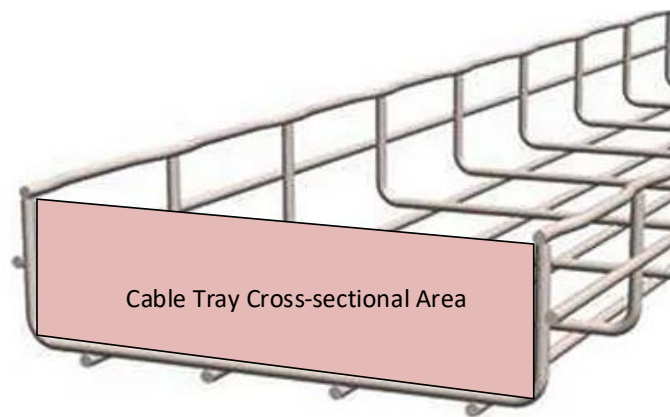
Conduit Cross-sectional Area

Cable Tray Cross-sectional Area

Cross-sectional Areas of Conduit and Cable Tray Pathways

Discussion of Cable Fill Ratio in Cable Managers – What do the industry standards give us to work with?

No industry standard exists for cable fill ratio in cable managers, so we start with the standard recommendations for a similar component, cable trays, which are:

- design for a 25% cable fill ratio
- allow for growth up to a 50% cable fill ratio.

What do we need to know in calculating the fill ratio?

- The <u>interior</u> dimensions of the cable manager (used to calculate the cross-sectional area available for cables)
- The cross-sectional area of <u>one cable</u> (for this discussion we will assume that all cables intended to route in the wire manager, are the same size)

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Example Cable Fill Ratio Calculation:

- Example: 5-inch (nominal) Vertical Cable Manager (part numbers 4940L-VFx and 4980L-VFx) with LANMARK™-6 CMP Cable (calculation is for a single channel of the duct)
- Interior dimensions of duct channel:
  - 4.75" x 3.9" = 18.525 sq.in. or about 18.5 sq.in.
- Cross-sectional area of one LANMARK™-6 CMP cable: (Outer Diameter = 0.230", Radius = 0.115")
  - Area = πr^2 = 3.1416 x 0.115^2 = 3.1416 x 0.013225 = 0.0415 sq.in.
- 18.5/0.0415 = 445 cables (this would be a 100% fill ratio – which would be 100% cable, no air spaces)
  - 445 x 0.25 = **25% cable fill ratio = 111 cables** (duct looks half-full)
  - 445 x 0.50 = **50% cable fill ratio = 222 cables** (duct looks completely full)

What do 25% and 50% fill ratios look like?

Due to air spaces between round cables and additional air spaces caused by the random lay of cables:

5" duct with 111 LANMARK™-6 CMP cables (the calculated 25% cable fill ratio). The duct looks half-full.

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5" duct with 222 LANMARK™-6 CMP cables (the calculated 50% cable fill ratio). The duct looks completely full.

What cable fill ratio number is <u>practical</u> for a cable manager?

To illustrate the <u>practical</u> maximum fill ratio for a cable manager, we took the same cable manager and cables shown above and bundled the cables in groups of 12 (as one might do when routing cables to a patch panel). We then routed the cable bundles through the duct finger slots, and we can observe fill ratio vs. space for additional cables. The illustration below shows 12 bundles of 12 cables each (144 cables) routed in the cable manager.

144 LANMARK™-6 CMP cables in the 5" vertical cable manager constitute a 32.5% cable fill ratio.

From the example calculation (shown above) we can show the following:

445 x 0.325 = <u>32.5% fill ratio = 144 cables</u> (12 bundles of 12 cables)

From the close-up of the cable entry end of the cable manager shown below, we can see that the 12 cable bundles, added Velcro® brand wraps, and cable bundle bend radius (exiting the duct finger slots) come very close to filling the cable manager.

144 LANMARK™-6 CMP cables (in bundles of 12) create a 32.5% fill ratio in the 5" vertical duct. The duct appears to be very close to full.

There is still a little bit of room for a few more cables, so we could safely bump our <u>practical</u> maximum cable fill ratio up to 35%. Here is the calculation:

445 x 0.35 = <u>35% fill ratio = 155 cables</u>

<u>**Internal dimensions**</u> of cable manager channels (which likely house Horizontal or Backbone Cable)

Description	Part Number	Usable Size	Cross-sectional Area
8" (nominal) Vertical Duct (rear channel)	8980L-VFR	7.88" x 6.9"	54.3 sq.in.
5" (nominal) Vertical Duct (rear channel)	4980L-VFR, 4940L-VFR	4.75" X 3.9"	18.5 sq.in.
Rear Channel of 2RU Front/Rear Horizontal Duct	492RU-HFR	1.625" x 3.75"	6.1 sq.in.
Rear Channel of 1RU Front/Rear Horizontal Duct	491RU-HFR	1.125" x 3.75"	4.2 sq.in.

For the following Cables – O.D., r, r^2, and Area (πr^2) of a single cable:

Cable O.D.	Cable (or cables)	r (radius)	r^2	A=(πr^2) of 1 cable
0.290"	LANMARK™-10G FTP CMR	0.145	0.0210	0.0660 sq.in.
0.275"	SST CMR, LANMARK™-10G FTP CMP, LANMARK™-6 FTP CMP	0.1375	0.0189	0.0594 sq.in.
0.250"	SST CMP	0.125	0.0156	0.0490 sq.in.
0.245"	LM-RDT™ CMR	0.1225	0.0150	0.0471 sq.in.
0.240"	LANMARK™-IP 5e CMP	0.120	0.0144	0.0452 sq.in.
0.235"	LM-RDT™ I/O	0.1175	0.0138	0.0434 sq.in.
0.230"	LM-RDT™ CMP, LANMARK™-6 CMP, LANMARK™-1000 CMR	0.115	0.0132	0.0415 sq.in.
0.225"	LANMARK™-1000 CMP	0.1125	0.0127	0.0399 sq.in.
0.210"	Hyper Plus 5e CMP	0.105	0.0111	0.0349 sq.in.
0.205"	LANMARK™-6 CMR	0.1025	0.0105	0.0330 sq.in.
0.190"	Hyper Plus 5e CMR	0.0995	0.0099	0.0311 sq.in.

For cable with O.D. of:	For 8" Vertical Cable Manager (rear channel)		For 5" Vertical Cable Manager (rear channel)		2RU Front/Rear Horizontal Duct (rear channel)		1RU Front/Rear Horizontal Duct (rear channel)	
	25% fill	35% fill	25% fill	35% fill	25% fill	35% fill	25% fill	35% fill
0.290"	205	287	70	98	23	32	15	22
0.275"	228	319	77	109	25	35	17	24
0.250"	277	387	94	132	31	43	21	30
0.245"	288	403	98	137	32	45	22	31
0.240"	300	420	102	143	33	47	23	32
0.235"	312	437	106	149	35	49	24	33
0.230"	327	457	111	156	36	51	25	35
0.225"	340	476	115	162	38	53	26	36
0.210"	388	544	132	185	43	61	30	42
0.205"	411	575	140	196	46	64	31	44
0.190"	436	611	148	208	49	68	33	47

Fill ratios for various diameter Leviton Cables in Leviton Cable Managers – 25% fill is the suggested maximum fill ratio at installation and 35% is the suggested maximum practical fill ratio for a rear cable manager.

The 8" Vertical Managers also feature slots between the "fingers", which are used to route cords into and out of the manager.

8" Vertical Cable Manager – finger slots (8980L-VFO, -VFR). There are 22 finger slots on each side of each 40" section of the vertical manager; 44 slots along the entire 80" length.

Note: cable quantities stated are for each finger slot. Each slot provides 5.5 sq.in. of space for routing cables.

For larger cable bundles, there is a provision in the 8" Vertical cable manager product, where a finger may be removed, to provide a larger cable opening. This extra-wide finger slot is 2.75" x 5.5", or 15.1 sq.in. *Cable numbers provided in the table below are for a single extra-wide slot.*
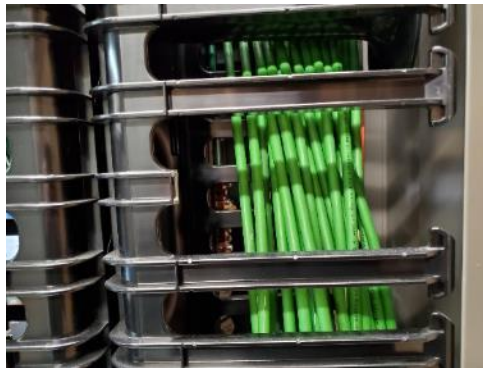
The 8" Vertical Cable Manager with a "finger" removed to create a wider cable slot which will accommodate a larger cable bundle.

The 5" Vertical Managers also feature slots between the "fingers", which are used to route cables into and out of the manager.

5" Vertical Cable Manager – finger slots (4940L-VFR, 4980L-VFR). There are 22 finger slots on each side of each 40" section of the vertical manager; 44 slots along the entire 80" length.

Note: cable quantities stated are for each finger slot. Each slot provides 3.0 sq.in. of space for routing cables.

For cable with O.D. of:	8" Vertical Cable Manager finger slot		8" Vertical Cable Mgr. extra-wide slot		5" Vertical Cable Manager finger slot	
	25% fill	35% fill	25% fill	35% fill	25% fill	35% fill
0.290"	20	29	57	80	11	15
0.275"	23	32	63	88	12	17
0.250"	28	39	77	107	15	21
0.245"	29	40	80	112	15	22
0.240"	30	42	83	116	16	23
0.235"	31	44	86	121	17	24
0.230"	33	46	90	127	18	25

Internal dimensions of front duct channels and rings (which likely house patch cords) of:

Description	Part Number	Usable Size	Cross-sectional Area
8" (nominal) Vertical Duct (front channel)	8980L-VFR, 8980L - VFO	7.88" x 6.9"	54.3 sq.in.
5" (nominal) Vertical Duct (front channel)	4980L-VFR, 4940L-VFR, 4980L-VFO, 4940L-VFO	4.75" X 3.9"	18.5 sq.in.
Front Channel of 2RU Front/Rear Horizontal Duct	492RU-HFR	2.75" x 3.00"	8.25 sq.in.
Front Channel of 1RU Front/Rear Horizontal Duct	491RU-HFR	1.125" x 2.75"	3.1sq.in.

Rings in all Horizontal Ring Managers

Description	Part Number	Usable area of rings	Cross-sectional Area
1RU, 4" (nominal) rings	49253-LPM	1.25" x 3.25"	4.0 sq.in.
1RU Angled, 2" (nominal) rings	49254-LPM	1.25" x 1.75"	2.2 sq.in.
2RU, 4" (nominal) rings	49253-BCM	2.75" x 3.250"	8.9 sq.in.
2RU, 2" (nominal) rings	49253-2CM	2.75" x 1.75"	4.8 sq.in.
2RU Angled, 2" (nominal) rings	49254-BCM	2.75" x 1.75"	4.8 sq.in.
4RU, 4" (nominal) rings	49253-4CM	(2.50" x 3.25") + (3.75" x 4.75")	24.3 sq.in.
1RU, 6" (nominal) rings	49253-6PM	1.25" x 5.25"	6.5 sq.in.
2RU, 6" (nominal) rings	49253-6MR	2.75" x 5.25"	14.4 sq.in.
1RU, recessed 3" (nom.) rings	49253-RCM	1.25" x 2.25"	2.8 sq.in.
feed-through dimensions		1.00" x 3.50"	3.5 sq.in.

For the following Patch Cords – O.D., r, r^2, and Area (πr^2) of a single cord:

Cord O.D.	Patch Cord Part Number	r (radius)	r^2	A=(πr^2) of 1 cord
0.240"	6AS10	0.120"	0.0144"	0.0452 sq.in.
0.185"	H6A10	0.0925"	0.0086"	0.0270 sq.in.
0.225"	6D460	0.1125"	0.0127"	0.0399 sq.in.
0.150"	6H460	0.075"	0.0056"	0.0176 sq.in.

Horizontal (ring type) Cable Managers

Number of Patch Cords which will fit into Front Cable Managers – The 30% Cable Fill Ratio column is the recommended Practical Maximum fill ratio for each Cable Manager
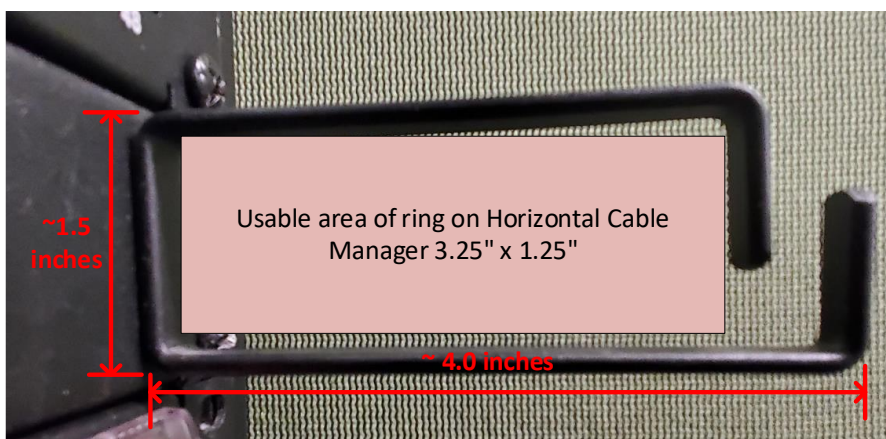
The following tables show 50%, 30%, and 25% cable fill ratio numbers for the most common Leviton Patch Cord part numbers in various Leviton cable managers where patch cords would normally be used:

Ring size: 4.0 sq.in. (**49253-LPM**)

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	44 cords	26 cords	22 cords
H6A10	74 cords	44 cords	37 cords
6D460	50 cords	30 cords	25 cords
6H460	113 cords	68 cords	56 cords

The usable area of a cable management ring in a 1RU Horizontal Cable Manager

In the 1RU 4-inch horizontal ring manager, the '4-inch' is a nominal size. The ring does extend 4 inches out the front of the manager, but the usable area of the ring for cables is 1.25" x 3.25".

An illustration from the calculations for cable fill ratio for the 49235-LPM

50% Fill Ratio of 6AS10 Patch Cords in 49253-LPM Ring-type Cable Manager (44 Cords). Even though 44 cords "fit" into the rings, this cord density is impractical for most horizontal cord manager applications.

Practical **use of 49253-LPM. 24 6AS10 Patch Cords per end. Cords route into Cable Manager from lower row of top Patch Panel and upper row of bottom Patch Panel 24 cords = 27.1% Fill Ratio for the 49253-LPM ring.**

A close-up view of the end ring of the 49253-LPM Cable Manager shows that, due to patch cord bend radius, about half of the ring is not available. The 24 patch cords almost completely fill the front part of the ring. The routing of the cords in this application is also important. Notice that the cords on the left side of the panel route to the left, while the cords on the right sides of the panels route to the right. If an attempt were made to route all 48 cords to one side, the maximum 50% cable fill ratio would be exceeded. Cord bend radius requirements limit the use of this cable manager. The calculated Cable Fill Ratio for the 24 patch cords in the cable management ring (shown above) is a 27.1% cable fill ratio. A few more cords could be placed, so the maximum practical fill ratio can be stated as 30%.

 In the example illustrated above, should it be necessary to route all 48 cords in one direction, several solutions could be evaluated to address the potential overloading of the 49253-LPM:

- Use a 2RU cable manager, such as 49253-BCM
- Use a 1RU cable manager with a deeper ring, such as 49253-6PM
- Use angled patch panels to eliminate the need for horizontal cable managers
- Use 28 AWG Patch Cords, such as H6A10

Ring size: 2.2 sq.in. (**49254-LPM**)

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	24 cords	14 cords	12 cords
H6A10	40 cords	24 cords	20 cords
6D460	27 cords	16 cords	13 cords
6H460	62 cords	37 cords	31 cords

Ring size: 8.9 sq.in. (**49253-BCM**)

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	98 cords	59 cords	49 cords
H6A10	165 cords	98 cords	82 cords
6D460	111 cords	66 cords	55 cords
6H460	253 cords	151 cords	126 cords

Ring size: 4.8 sq.in. (**49253-2CM, 49254-BCM**)

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	53 cords	31 cords	26 cords
H6A10	89 cords	53 cords	44 cords
6D460	60 cords	36 cords	30 cords
6H460	136 cords	81 cords	68 cords

Ring size: 6.5 sq.in. (**49253-6PM**)

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	71 cords	43 cords	35 cords
H6A10	120 cords	72 cords	60 cords
6D460	81 cords	48 cords	40 cords
6H460	184 cords	110 cords	92 cords

Ring size: 14.4 sq.in. (**49253-6MR**)

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	159 cords	95 cords	79 cords
H6A10	266 cords	160 cords	133 cords
6D460	180 cords	108 cords	90 cords
6H460	409 cords	245 cords	202 cords

Ring size: 2.8 sq.in. (**49253-RCM**)

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	30 cords	18 cords	15 cords
H6A10	51 cords	31 cords	25 cords
6D460	35 cords	21 cords	17 cords
6H460	79 cords	47 cords	39 cords

In addition to the rings, the 49253-RCM also features feed-through holes, which are used to route patch cords from front of rack to rear of rack:

Feed-through size: 3.5 sq.in (**49253-RCM**). Cord quantities stated are for <u>each</u> feed-through.

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	38 cords	23 cords	19 cords
H6A10	64 cords	38 cords	32 cords
6D460	43 cords	26 cords	21 cords
6H460	99 cords	59 cords	49 cords

Ring size: 24.3 sq.in. 50% fill ratio (**49253-4CM**)

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	268 cords	161 cords	134 cords
H6A10	450 cords	270 cords	225 cords
6D460	304 cords	182 cords	152 cords
6H460	690 cords	414 cords	345 cords

VERSI-DUCT™ Horizontal Cable Managers Front Channel Capacities

1RU Horizontal Cable Manager <u>3.1 sq.in.</u> (**491RU-HFR, -HFO**)

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	34 cords	20 cords	17 cords
H6A10	57 cords	34 cords	28 cords
6D460	38 cords	23 cords	19 cords
6H460	88 cords	52 cords	44 cords

2RU Horizontal Cable Manager <u>8.25 sq.in.</u> (**492RU-HFR, -HFO**)

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	91 cords	54 cords	45 cords
H6A10	152 cords	91 cords	76 cords
6D460	103 cords	62 cords	51 cords
6H460	234 cords	140 cords	117 cords

VERSI-DUCT™ Vertical Cable Managers Front Channel Capacities

5" Vertical Cable Manager – front channel 18.5 sq.in. (**4940L-VFO, -VFR, 4980L-VFO, -VFR**)

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	202 cords	122 cords	101 cords
H6A10	342 cords	205 cords	171 cords
6D460	231 cords	139 cords	115 cords
6H460	525 cords	317 cords	262 cords

The 5" Vertical Managers also feature slots between the "fingers", which are used to route cords into and out of the manager, as well as front-to-rear through holes, which are used to route patch cords from front of rack to rear of rack:

5" Vertical Cable Manager – finger slots (**4940L-VFO, -VFR, 4980L-VFO, -VFR**). There are 22 finger slots on each side of each 40" section of vertical manager. *Note that the cord quantities stated are for each finger slot. Each finger slot provides 3.0 sq.in. of space for routing cords.*

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	33 cords	19 cords	16 cords
H6A10	55 cords	33 cords	27 cords
6D460	37 cords	22 cords	18 cords
6H460	85 cords	51 cords	42 cords

5" Vertical Duct Finger Slots and Through Holes

5" Vertical Cable Manager – front-to-rear through holes (**4940L-VFO, -VFR, 4980L-VFO, -VFR**). There are eight front-to-rear through holes in each 40" section of vertical manager; 16 through holes in the

entire 80" length. *Note that the cord quantities stated are for <u>each</u> through hole. Each through hole provides <u>3.25 sq.in.</u> of space for routing cords.*

Note: Use of through holes decreases usable space in the vertical cable manager channels.

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	35 cords	21 cords	17 cords
H6A10	60 cords	36 cords	30 cords
6D460	40 cords	24 cords	20 cords
6H460	92 cords	55 cords	46 cords

8" Vertical Cable Manager – front channel <u>54.3 sq.in.</u> (**8980L-VFO, -VFR**)

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	600 cords	360 cords	300 cords
H6A10	1005 cords	603 cords	502 cords
6D460	680 cords	408 cords	340 cords
6H460	1542 cords	925 cords	771 cords

The 8" Vertical Managers also feature slots between the "fingers", which are used to route cords into and out of the manager, as well as round and oval-shaped front-to-rear through holes, which are used to route patch cords from front of rack to rear of rack:
8" Vertical Cable Manager – <u>finger slots</u> (**8980L-VFO, -VFR**). There are 22 finger slots on each side of each 40" section of the vertical manager; 44 slots along the entire 80" length. *Note that the cord quantities stated are for <u>each</u> finger slot. Each finger slot provides <u>5.5 sq.in.</u> of space for routing cords.*

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	60 cords	36 cords	30 cords
H6A10	101 cords	61 cords	50 cords
6D460	68 cords	41 cords	34 cords
6H460	156 cords	93 cords	78 cords

8" Vertical Front/Rear Duct – Finger Slots

8" Vertical Cable Manager – <u>front-to-rear round through holes</u> (**8980L-VFO, -VFR**). There are two front-to-rear round through holes in each 40" section of the vertical manager; four round through holes along the entire 80" length. *Note that the cord quantities stated are for <u>each</u> round through hole. Each round through hole provides <u>7.0 sq.in.</u> of space for routing cords.*

Note: Use of through holes decreases usable space in the vertical cable manager channels.

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	77 cords	46 cords	38 cords
H6A10	129 cords	77 cords	64 cords
6D460	87 cords	52 cords	43 cords
6H460	198 cords	119 cords	99 cords
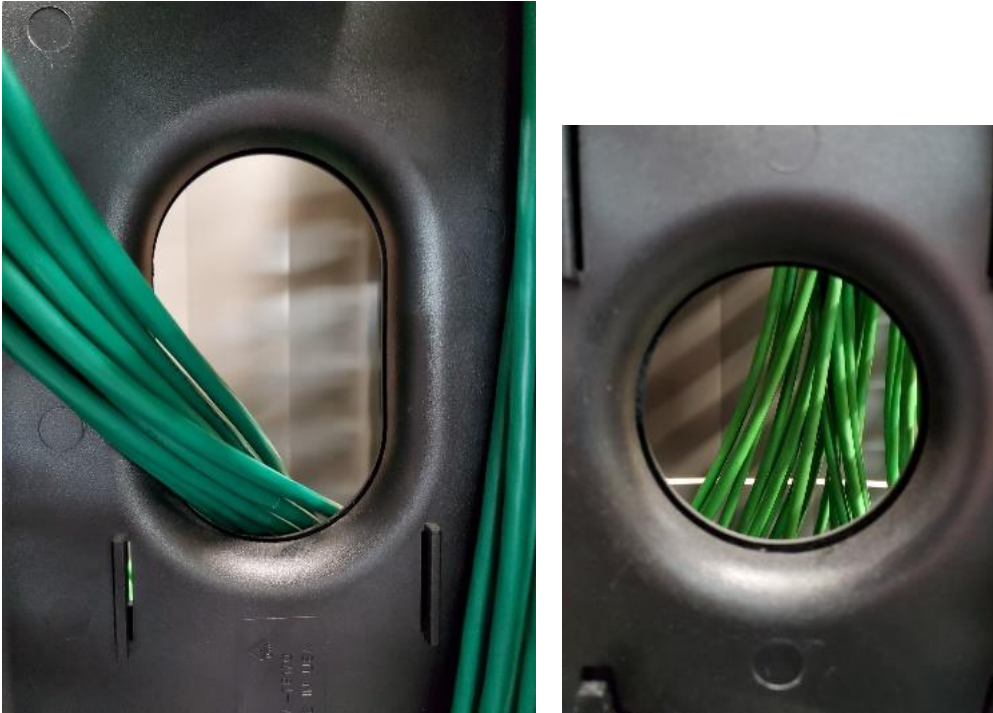
8" Vertical Duct – Oval-shaped and Round Through Holes

8" Vertical Cable Manager – <u>front-to-rear oval-shaped through holes</u> (**8980L-VFO, -VFR**). There are two front-to-rear oval-shaped through holes in each 40" section of vertical manager; four oval-shaped through hole along the entire 80" length. *Note that the cord quantities stated are for <u>each</u> oval-shaped through hole. Each oval-shaped through hole provides <u>12.25 sq.in.</u> of space for routing cords.*

Note: Use of through holes decreases usable space in the vertical cable manager channels.

Patch Cord Part Number	50% fill ratio	30% fill ratio	25% fill ratio
6AS10	135 cords	81 cords	67 cords
H6A10	251 cords	136 cords	125 cords
6D460	153 cords	92 cords	76 cords
6H460	348 cords	208 cords	174 cords

Conclusions

The material presented here illustrates the concept of **Maximum Practical Cable Fill Ratios in Cable Managers**. Specific maximum Cable and Patch Cord quantities are given for each Leviton Cable Manager when filled with commonly used Leviton Cables or Patch Cords.

The concepts presented here may be applied to any cable managers, data cables and patch cords on the market. To make the calculations, one needs the cross-sectional dimensions of the cable manager's cabling pathway, and the outer diameter (O.D.) of the cable or patch cord under consideration. Using this data, a 100% fill ratio number can be established, and then the appropriate multiplier may be applied to derive a cable or patch cord count for Maximum Practical Cable Fill Ratio (0.35 for cable, 0.30 for patch cords).

The often quoted 50% cable fill ratio number (from cable fill ratio rules for cable trays, called out in standards) has been shown here to be generally impractical for most cable manager applications.

A 25% fill ratio number remains a good guideline for Cable Manager design and initial installation. It is always good practice to save some room for future cable plant growth.

Based on our analysis:

- **The Maximum Practical Cable Fill Ratio for Cables in Rear Cable Managers is 35%.**
- **The Maximum Practical Cable Fill Ratio for Patch Cords in Front Cable Managers is 30%.**

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Part 2 – Maximum Practical Cable Fill Ratio for Cable Managers, Cables, and Patch Cord for EMEA Products (dimensioned in millimeters)

Definition of Cable Fill Ratio – Cable Fill Ratio is defined as the cross-sectional area of the cable pathway (conduit, tray, duct, channel, etc.) divided by the cross-sectional area of the cables running through the pathway.

Regulations and Standards provide rules and guidelines for maximum Cable Fill Ratios in various pathways. For conduit, if 3 or more cables are running through the conduit, the maximum allowable cable fill ratio is 40% fill. For Cable Tray, industry best practice recommendations are to design for (and install) a **maximum 40%*** cable fill ratio and allow for cable plant growth up to a maximum 50% cable fill ratio.

> **(* It will be shown that the 40% fill ratio for tray is too much cable fill for any Cable Manager, so the discussion below will use a 25% maximum initial cable fill ratio).**
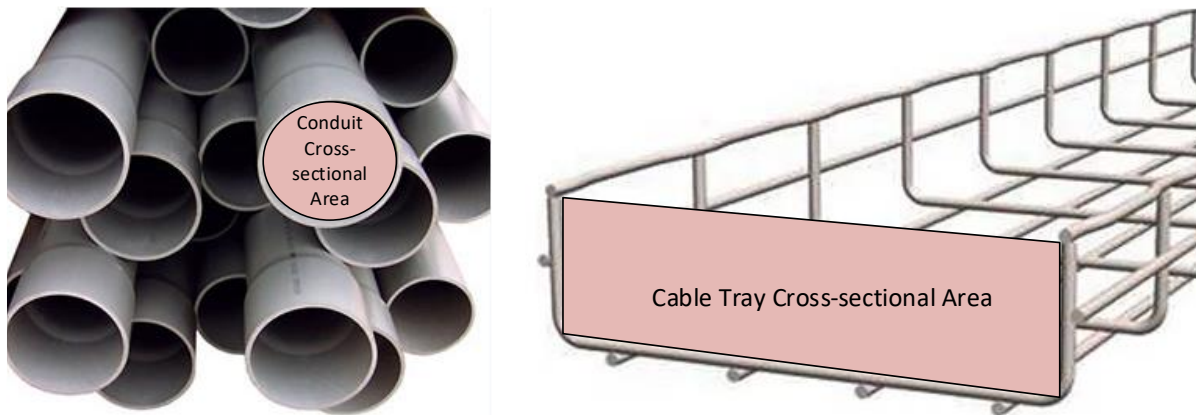
Cross-sectional Areas of Conduit and Cable Tray Pathways

Discussion of Cable Fill Ratio in Cable Managers – What do the industry standards give us to work with?

No industry standard exists for cable fill ratio in cable managers, so we start with the standard recommendations for a similar component, cable trays, which are:

- design for a 40% cable fill ratio
- *Note: The EN50174:2 Standard cites no more than 40% initial fill for cable trays and a 50% maximum fill number. <u>This Application Note will work with a 25% initial fill number</u>. As will be shown, 40% is too great a fill number for cable manager applications.*
- allow for growth up to a 50% cable fill ratio.

What do we need to know in calculating the fill ratio?

- The <u>interior</u> dimensions of the cable manager (used to calculate the cross-sectional area available for cables)
- The cross-sectional area of <u>one cable</u> (for this discussion we will assume that all cables intended to route in the wire manager, are the same size)

Example Cable Fill Ratio Calculation:

- <u>Example:</u> 5-inch (127 mm) Vertical Cable Manager (part numbers 4940L-VFx and 4980L-VFx) with a Category 6 Cable with 5.84 mm outside diameter (calculation is for a single channel of the duct).
- Interior dimensions of duct channel:
  - 120 mm x 99 mm = <u>11880 mm^2</u>
- Cross-sectional area of <u>one Category 6 CMP cable:</u>   (Outer Diameter = 5.84 mm, radius = 2.92 mm)
  - Area = πr^2 = 3.1416 x 2.92^2 = 3.1416 x 8.5 mm = <u>26.7 mm^2</u>
- 11880/26.7 = <u>445 cables</u> (this would be a 100% fill ratio – which would be 100% cable, no air spaces)
  - 445 x 0.25 = **25% cable fill ratio = 111 cables** (duct looks half-full)
  - 445 x 0.50 = **50% cable fill ratio = 222 cables** (duct looks completely full)

What do 25% and 50% fill ratios look like?

Due to air spaces between round cables and additional air spaces caused by the random lay of cables:

5-inch (127 mm) duct with 111 Category 6 cables (the calculated 25% cable fill ratio). The duct looks half-full. (Cable O.D. = 5.84 mm).

5-inch (127 mm) duct with 222 Category 6 cables (the calculated 50% cable fill ratio). The duct looks completely full. (Cable O.D. = 5.84 mm).

What cable fill ratio number is <u>practical</u> for a cable manager?

To illustrate the <u>practical</u> maximum fill ratio for a cable manager, we took the same cable manager and cables shown above and bundled the cables in groups of 12 (as one might do when routing cables to a patch panel). We then routed the cable bundles through the duct finger slots, and we can observe fill ratio vs. space for additional cables. The illustration below shows 12 bundles of 12 cables each (144 cables) routed in the cable manager.

144 Category 6 cables in the 5-inch vertical cable manager constitute a 32.5% cable fill ratio. (Cable O.D. = 5.84 mm).

From the example calculation (shown above) we can show the following:

445 x 0.325 = <u>32.5% fill ratio = 144 cables</u> (12 bundles of 12 cables)

From the close-up of the cable entry end of the cable manager shown below, we can see that the 12 cable bundles, added Velcro® brand wraps, and cable bundle bend radius (exiting the duct finger slots) come very close to filling the cable manager.

144 Category 6 cables (in bundles of 12) create a 32.5% fill ratio in the 5-inch vertical duct. The duct appears to be very close to full. (Cable O.D. = 5.84 mm).

There is still a little bit of room for a few more cables, so we could safely bump our <u>practical</u> maximum cable fill ratio up to 35%. Here is the calculation:

445 x 0.35 = <u>35% fill ratio = 155 cables</u>

<u>Internal dimensions</u> of cable manager channels (which likely house Horizontal or Backbone Cable) for:

Description	Part Number	Usable Size	Cross-sectional Area
8" (203 mm) Vertical Duct (rear channel)	8980L-VFR	200 mm x 175 mm	35000 mm^2
5" (127 mm) Vertical Duct (rear channel)	4980L-VFR, 4940L-VFR	120 mm X 99 mm	11880 mm^2
Rear Channel of 2RU Front/Rear Horizontal Duct	492RU-HFR	120 mm X 99 mm	3895 mm^2
Rear Channel of 1RU Front/Rear Horizontal Duct	491RU-HFR	28 mm x 95 mm	2660 mm^2

For the following Cables – O.D., r, r^2, and Area (πr^2) of a single cable:

Cable O.D.	Cable (or cables)	r (radius)	r^2	A=(πr^2) of 1 cable
7.2 mm	UM12-Dca-500BU (Cat 7A), UM10-Cca-500GN (Cat 7), AC6S/FTP-Cca-500GN (Cat 6A S/FTP)	3.6 mm	12.96 mm	40.7 mm^2
7.1 mm	AC6F/FTP-Cca-D500GN (Cat 6A F/FTP), C6F/UTP-Dca-500BU (Cat6 F/UTP)	3.55 mm	12.60 mm	39.5 mm^2
7.0 mm	C6S/FTP-Cca-500GN (Cat 6 S/FTP), C6F/FTP-Cca-500GN (Cat 6 F/FTP)	3.5 mm	12.25 mm	38.4 mm^2
6.9 mm	SST-Cca-305GN (Cat 6A SST)	3.45 mm	11.90 mm	37.3 mm^2
6.7 mm	AC6U/FTP-Cca-500GN (Cat 6A U/FTP), C6F/UTP-Dca-Rlx-305BU (Cat6 U/FTP)	3.35 mm	11.22 mm	35.2 mm^2
6.15 mm	C6U/FTP-Cca-Rlx-305GN (Cat 6 U/UTP)	3.075 mm	9.45 mm	29.6 mm^2
5.8 mm	C6U-Cca-500GN4 (Cat6 U/UTP 24AWG)	2.9 mm	8.41 mm	26.4 mm^2
5.7 mm	AC6-DCZ-Cca-Rlx-305GN (Cat 6A Zone)	2.85 mm	8.12 mm	25.5 mm^2

For cable with O.D. of:	For 8-inch (203 mm) Vertical Cable Manager (rear channel)		For 5-inch (127 mm) Vertical Cable Manager (rear channel)		2RU Front/Rear Horizontal Duct (rear channel)		1RU Front/Rear Horizontal Duct (rear channel)	
	25% fill	35% fill	25% fill	35% fill	25% fill	35% fill	25% fill	35% fill
7.2 mm	214	300	72	101	23	33	16	22
7.1 mm	221	310	75	105	24	34	16	23
7.0 mm	227	318	77	108	25	35	17	24
6.9 mm	234	328	79	111	26	36	17	24
6.7 mm	248	347	84	117	27	38	18	26
6.15 mm	295	413	100	140	32	45	22	31
5.8 mm	331	463	112	157	36	51	25	35
5.7 mm	343	480	116	162	38	53	26	36

Fill ratios for various diameter Leviton Cables in Leviton Cable Managers – 25% fill is the suggested maximum fill ratio at installation and 35% is the suggested maximum practical fill ratio for a rear cable manager.

The 8-inch (203 mm) Vertical Managers also feature slots between the "fingers", which are used to route cords into and out of the manager.

8-inch Vertical Cable Manager – finger slots (8980L-VFO, -VFR). There are 22 finger slots on each side of each 40-inch (~101.5 cm) section of the vertical manager; 44 slots along the entire 80-inch (~203 cm) length.

Note that the cable quantities stated are for each finger slot. Each finger slot provides 3548 mm^2 of space for routing cables.

For larger cable bundles, there is a provision in the 8-inch (203 mm) Vertical cable manager product, where a finger may be removed, to provide a larger cable opening. This extra-wide finger slot is 69 mm x 140 mm, or 9660 mm^2. *Cable numbers provided in the table below are for a single extra-wide slot.*

The 8-inch (203 mm) Vertical Cable Manager with a "finger" removed to create a wider cable slot which will accommodate a larger cable bundle.

The 5-inch (127 mm) Vertical Managers also feature slots between the "fingers", which are used to route cables into and out of the manager.

5-inch (127 mm) Vertical Cable Manager – finger slots (4940L-VFR, 4980L-VFR). There are 22 finger slots on each side of each 40-inch (~101.5 cm) section of the vertical manager; 44 slots along each side of the entire 80-inch (~203 cm) length.

Note that cable quantities stated are for each finger slot. Each finger slot provides 1935 mm^2 of space for routing cables.

For cable with O.D. of:	8-inch (203 mm) Vertical Cable Manager finger slot		8-inch (203 mm) Vertical Cable Mgr. extra-wide slot		5-inch (127 mm) Vertical Cable Manager finger slot	
	25% fill	35% fill	25% fill	35% fill	25% fill	35% fill
7.2mm	21	30	59	82	11	16
7.1mm	22	31	61	85	12	16
7.0mm	23	32	62	87	12	17
6.9mm	23	33	64	90	12	17
6.7mm	25	35	68	95	13	18
6.15mm	29	41	81	114	16	22
5.8mm	33	46	91	127	18	25
5.7mm	34	48	94	132	18	26

Internal dimensions of front duct channels and rings (which likely house patch cords) of:

Description	Part Number	Usable Size	Cross-sectional Area
8" (203 mm) Vertical Duct (front channel)	8980L-VFR, 8980L - VFO	200 mm x 175 mm	35000 mm^2
5" (127 mm) Vertical Duct (front channel)	4980L-VFR, 4940L-VFR, 4980L-VFO, 4940L-VFO	120 mm X 99 mm	11880 mm^2
Front Channel of 2RU Front/Rear Horizontal Duct	492RU-HFR	69 mm x 76 mm	5244 mm^2
Front Channel of 1RU Front/Rear Horizontal Duct	491RU-HFR	28 mm x 69 mm	1932 mm^2

Rings in all Horizontal Ring Managers

Description	Part Number	Usable area of rings	Cross-sectional Area
1RU, 4" (nominal) rings	49253-LPM	31 mm x 82 mm	2542 mm^2
1RU Angled, 2" (nominal) rings	49254-LPM	31 mm x 44 mm	1364 mm^2
2RU, 4" (nominal) rings	49253-BCM	69 mm x 82 mm	5658 mm^2
2RU, 2" (nominal) rings	49253-2CM	69 mm x 44 mm	3036 mm^2
2RU Angled, 2" (nominal) rings	49254-BCM	69 mm x 44 mm	3036 mm^2
4RU, 4" (nominal) rings	49253-4CM	(63 mm x 82 mm) + (95 mm x 120 mm	16566 mm^2
1RU, 6" (nominal) rings	49253-6PM	31 mm x 133 mm	4123 mm^2
2RU, 6" (nominal) rings	49253-6MR	69 mm x 133 mm	9177 mm^2
1RU, recessed 3" (nom.) rings	49253-RCM	31 mm x 57 mm	1767 mm^2
feed-through dimensions		25 mm x 88 mm	2200 mm^2

For the following Patch Cords – O.D., r, r^2, and Area (πr^2) of a single cord:

Cord O.D.	Patch Cord Part Number	r (radius)	r^2	A=(πr^2) of 1 cord
6.0 mm	(AC6PCG) Cat 6A Stranded (C6CPCS) Cat 6 Shielded	3.0 mm	9.00 mm	28.3 mm^2
5.8 mm	(C6CPCU) Cat 6 U/UTP, (C6CPCUxxx-488HSD) Cat 6 solid conductor	2.9 mm	8.41 mm	26.4 mm^2
5.6 mm	(AC6PCGxxx-588HBSC) Cat 6A Shielded solid conductor	2.8 mm	7.84 mm	24.4 mm^2
4.7 mm	(H6A10) Cat 6A High Flex	2.35 mm	5.52 mm	17.3 mm^2
3.8 mm	(6H460) Cat 6 High Flex	1.9 mm	3.61 mm	11.3 mm^2

Horizontal (ring type) Cable Managers

Horizontal Managers service the panels directly above and/or below its Rack Unit position, typically 24-48 ports.

Number of Patch Cords which will fit into Front Cable Managers – The 30% Cable Fill Ratio column is the recommended Practical Maximum fill ratio for each Cable Manager

The following tables show 50%, 30%, and 25% cable fill ratio numbers for the most common Leviton Patch Cord part numbers in various Leviton cable managers where patch cords would normally be used:

Ring size: 2542 mm^2 (**49253-LPM**)

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	44 cords	26 cords	22 cords
C6CPCU (5.8 mm)	48 cords	28 cords	24 cords
AC6PCGxxx-588HBSC (5.6 mm)	52 cords	31 cords	26 cords
H6A10 (4.7 mm)	73 cords	43 cords	36 cords
6H460 (3.8 mm)	112 cords	67 cords	56 cords

The usable area of a cable management ring in a 1 RU Horizontal Cable Manager

In the 1RU 4-inch horizontal ring manager, the '4-inch' is a nominal size. The ring does extend 4 inches (101 mm) out the front of the manager, but the usable area of the ring for cables is 82 mm 31 mm (2542 mm^2).

Usable area of ring on Horizontal Cable Manager 82 mm x 31 mm = 2542 mm^2

~1.5 inches (~38 mm)

~ 4.0 inches (~101 mm)

An illustration from the calculations for cable fill ratio for the 49235-LPM

50% Fill Ratio of 6.0mm Patch Cords in 49253-LPM Ring-type Cable Manager (44 Cords). Even though 44 cords "fit" into the rings, this cord density is impractical for most horizontal cord manager applications.

Practical use of 49253-LPM. 24 Patch Cords (6.0mm O.D.) per end. Cords route into Cable Manager from lower row of top Patch Panel and upper row of bottom Patch Panel
24 cords = 27.1% Fill Ratio for the 49253-LPM ring.

A close-up view of the end ring of the 49253-LPM Cable Manager shows that, due to patch cord bend radius, about half of the ring is not available. The 24 patch cords almost completely fill the front part of the ring. The routing of the cords in this application is also important. Notice that the cords on the left side of the panel route to the left, while the cords on the right sides of the panels route to the right. If an attempt were made to route all 48 cords to one side, the maximum 50% cable fill ratio would be exceeded. Cord bend radius requirements limit the use of this cable manager. The calculated Cable Fill Ratio for the 24 patch cords in the cable management ring (shown above) is a 27.1% cable fill ratio. A few more cords could be placed, so the maximum practical fill ratio can be stated as 30%.

In the example illustrated above, should it be necessary to route all 48 cords in one direction, several solutions could be evaluated to address the potential overloading of the 49253-LPM:

- Use a 2RU cable manager, such as 49253-BCM
- Use a 1RU cable manager with a deeper ring, such as 49253-6PM
- Use angled patch panels to eliminate the need for horizontal cable managers
- Use High-Flex (smaller diameter) Patch Cords, such as H6A10 (Cat 6A) or 6H460 (Cat 6) cords

Ring size: 1364 mm^2 (**49254-LPM**)

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	24 cords	14 cords	12 cords
C6CPCU (5.8 mm)	25 cords	15 cords	12 cords
AC6PCGxxx-588HBSC (5.6 mm)	27 cords	16 cords	13 cords
H6A10 (4.7 mm)	39 cords	23 cords	19 cords
6H460 (3.8 mm)	60 cords	36 cords	30 cords

Ring size: <u>5658 mm^2</u> (**49253-BCM**)

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	99 cords	59 cords	48 cords
C6CPCU (5.8 mm)	107 cords	64 cords	53 cords
AC6PCGxxx-588HBSC (5.6 mm)	115 cords	69 cords	57 cords
H6A10 (4.7 mm)	163 cords	98 cords	81 cords
6H460 (3.8 mm)	250 cords	150 cords	125 cords

Ring size: <u>3036 mm^2</u> (**49253-2CM, 49254-BCM**)

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	53 cords	32 cords	26 cords
C6CPCU (5.8 mm)	57 cords	34 cords	28 cords
AC6PCGxxx-588HBSC (5.6 mm)	62 cords	37 cords	31 cords
H6A10 (4.7 mm)	87 cords	52 cords	43 cords
6H460 (3.8 mm)	134 cords	80 cords	67 cords

Ring size: <u>4123 mm^2</u> (**49253-6PM**)

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	72 cords	43 cords	36 cords
C6CPCU (5.8 mm)	78 cords	46 cords	39 cords
AC6PCGxxx-588HBSC (5.6 mm)	84 cords	50 cords	42 cords
H6A10 (4.7 mm)	119 cords	71 cords	59 cords
6H460 (3.8 mm)	182 cords	109 cords	91 cords

Ring size: <u>9177 mm^2</u> (**49253-6MR**)

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	162 cords	97 cords	81 cords
C6CPCU (5.8 mm)	104 cords	104 cords	86 cords
AC6PCGxxx-588HBSC (5.6 mm)	112 cords	112 cords	94 cords
H6A10 (4.7 mm)	265 cords	159 cords	132 cords
6H460 (3.8 mm)	406 cords	243 cords	203 cords

Ring size: <u>1767 mm²</u> (**49253-RCM**)

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	31 cords	18 cords	15 cords
C6CPCU (5.8 mm)	33 cords	19 cords	16 cords
AC6PCGxxx-588HBSC (5.6 mm)	36 cords	21 cords	18 cords
H6A10 (4.7 mm)	51 cords	30 cords	25 cords
6H460 (3.8 mm)	78 cords	46 cords	39 cords

In addition to the rings, the 49253-RCM also features feed-through holes, which are used to route patch cords from front of rack to rear of rack:

Feed-through size: <u>2200 mm²</u> (**49253-RCM**). Cord quantities stated are for <u>each</u> feed-through.

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	38 cords	23 cords	19 cords
C6CPCU (5.8 mm)	41 cords	24 cords	20 cords
AC6PCGxxx-588HBSC (5.6 mm)	45 cords	27 cords	22 cords
H6A10 (4.7 mm)	63 cords	38 cords	31 cords
6H460 (3.8 mm)	97 cords	58 cords	48 cords

Ring size: <u>16566 mm²</u> 50% fill ratio (**49253-4CM**)

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	292 cords	175 cords	146 cords
C6CPCU (5.8 mm)	313 cords	188 cords	156 cords
AC6PCGxxx-588HBSC (5.6 mm)	339 cords	203 cords	169 cords
H6A10 (4.7 mm)	478 cords	287 cords	237 cords
6H460 (3.8 mm)	733 cords	439 cords	366 cords

VERSI-DUCT™ Horizontal Cable Managers Front Channel Capacities

1RU Horizontal Cable Manager <u>1932 mm²</u> (**491RU-HFR, -HFO**)

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	34 cords	20 cords	17 cords
C6CPCU (5.8 mm)	36 cords	21 cords	18 cords
AC6PCGxxx-588HBSC (5.6 mm)	39 cords	23 cords	19 cords
H6A10 (4.7 mm)	55 cords	33 cords	27 cords
6H460 (3.8 mm)	86 cords	51 cords	43 cords

2RU Horizontal Cable Manager 5244 mm^2 (**492RU-HFR, -HFO**)

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	92 cords	55 cords	46 cords
C6CPCU (5.8 mm)	99 cords	59 cords	49 cords
AC6PCGxxx-588HBSC (5.6 mm)	107 cords	64 cords	53 cords
H6A10 (4.7 mm)	151 cords	90 cords	73 cords
6H460 (3.8 mm)	232 cords	139 cords	116 cords

VERSI-DUCT™ Vertical Cable Managers Front Channel Capacities

5-inch (127 mm) Vertical Cable Manager – front channel 11880 mm^2 (**4940L-VFO, -VFR, 4980L-VFO, -VFR**)

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	209 cords	125 cords	104 cords
C6CPCU (5.8 mm)	225 cords	135 cords	112 cords
AC6PCGxxx-588HBSC (5.6 mm)	243 cords	145 cords	121 cords
H6A10 (4.7 mm)	343 cords	205 cords	171 cords
6H460 (3.8 mm)	525 cords	315 cords	262 cords

The 5-inch (127 mm) Vertical Managers also feature slots between the "fingers", which are used to route cords into and out of the manager, as well as front-to-rear through holes, which are used to route patch cords from front of rack to rear of rack:
5-inch (127 mm) Vertical Cable Manager – finger slots (**4940L-VFO, -VFR, 4980L-VFO, -VFR**). There are 22 finger slots on each side of each 40-inch (~101.5 cm) section of the vertical manager; 44 slots along each side of the entire 80-inch (~203 cm) length. *Note that the cord quantities stated are for each finger slot. Each finger slot provides 1935 mm^2 of space for routing cords.*

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	34 cords	20 cords	17 cords
C6CPCU (5.8 mm)	36 cords	21 cords	18 cords
AC6PCGxxx-588HBSC (5.6 mm)	39 cords	23 cords	19 cords
H6A10 (4.7 mm)	55 cords	33 cords	27 cords
6H460 (3.8 mm)	85 cords	51 cords	42 cords

5-inch (127 mm) Vertical Duct Finger Slots and Through Holes

5-inch (127 mm) Vertical Cable Manager – <u>front-to-rear through holes</u> (**4940L-VFO, -VFR, 4980L-VFO, -VFR**). There are eight front-to-rear through holes in each 40-inch (~101.5 cm) section of vertical manager; 16 through holes along the entire 80-inch (~203 cm) length. *Note that the cord quantities stated are for <u>each</u> through hole. Each through hole provides <u>2096 mm^2</u> of space for routing cords.*

Note: Use of through holes decreases usable space in the vertical cable manager channels.

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	37 cords	22 cords	18 cords
C6CPCU (5.8 mm)	39 cords	23 cords	19 cords
AC6PCGxxx-588HBSC (5.6 mm)	42 cords	25 cords	21 cords
H6A10 (4.7 mm)	60 cords	36 cords	30 cords
6H460 (3.8 mm)	92 cords	55 cords	46 cords

8-inch (203 mm) Vertical Cable Manager – front channel <u>35000 mm^2</u> (**8980L-VFO, -VFR**)

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	618 cords	370 cords	309 cords
C6CPCU (5.8 mm)	662 cords	397 cords	331 cords
AC6PCGxxx-588HBSC (5.6 mm)	717 cords	430 cords	358 cords
H6A10 (4.7 mm)	1011 cords	606 cords	505 cords
6H460 (3.8 mm)	1548 cords	929 cords	774 cords

The 8-inch (203 mm) Vertical Managers also feature slots between the "fingers", which are used to route cords into and out of the manager, as well as round and oval-shaped front-to-rear through holes, which are used to route patch cords from front of rack to rear of rack:

8-inch (203 mm) Vertical Cable Manager – finger slots (**8980L-VFO, -VFR**). There are 22 finger slots on each side of each 40-inch (~101.5 cm) section of vertical manager; 44 slots along the entire 80-inch (~203 cm) length. *Note that the cord quantities stated are for each finger slot. Each finger slot provides 3548 mm^2 of space for routing cords.*

| Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	62 cords	37 cords	31 cords
C6CPCU (5.8 mm)	67 cords	40 cords	33 cords
AC6PCGxxx-588HBSC (5.6 mm)	72 cords	43 cords	36 cords
H6A10 (4.7 mm)	102 cords	61 cords	51 cords
6H460 (3.8 mm)	156 cords	93 cords	78 cords

8-inch (203 mm) Vertical Front/Rear Duct – Finger Slots

8-inch (203 mm) Vertical Cable Manager – front-to-rear round through holes (**8980L-VFO, -VFR**). There are two front-to-rear round through holes in each 40-inch (~101.5 cm) section of vertical manager; four round through holes along the entire 80-inch (~203 cm) length. *Note that the cord quantities stated are for each round through hole. Each round through hole provides 4516 mm^2 of space for routing cords.*

Note: Use of through holes decreases usable space in the vertical cable manager channels.

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	79 cords	47 cords	39 cords
C6CPCU (5.8 mm)	85 cords	51 cords	42 cords
AC6PCGxxx-588HBSC (5.6 mm)	92 cords	55 cords	46 cords
H6A10 (4.7 mm)	130 cords	78 cords	65 cords
6H460 (3.8 mm)	199 cords	119 cords	99 cords
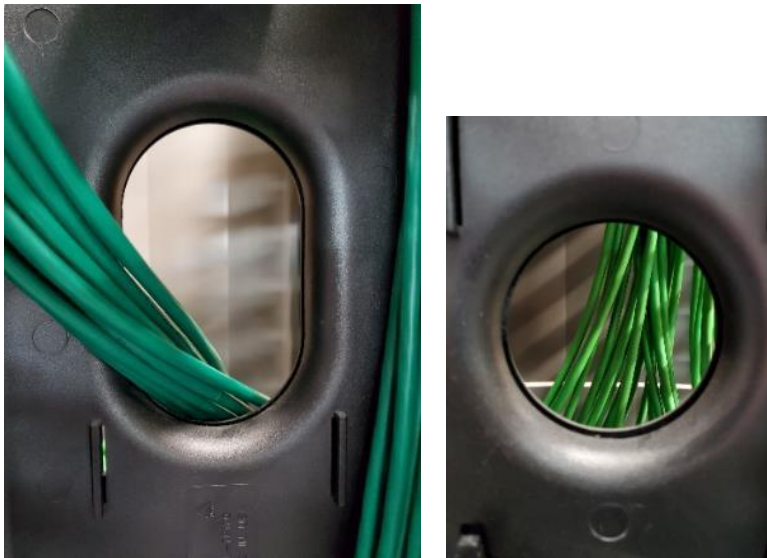
8-inch (203 mm) Vertical Duct – Oval-shaped and Round Through Holes
Note: Use of through holes decreases usable space in the vertical cable manager channels.

8-inch (203 mm) Vertical Cable Manager – front-to-rear oval-shaped through holes (**8980L-VFO, -VFR**). There are two front-to-rear oval-shaped through holes in each 40-inch (~101.5 cm) section of vertical manager; four oval-shaped through hole along the entire 80-inch (~203 cm) length. *Note that the cord quantities stated are for each oval-shaped through hole. Each oval-shaped through hole provides 7903 mm² of space for routing cords.*

Note: Use of through holes decreases usable space in the vertical cable manager channels.

Patch Cord and Outer Diameter (O.D.)	50% fill ratio	30% fill ratio	25% fill ratio
AC6PCG/C6CPCS (6.0 mm)	139 cords	83 cords	69 cords
C6CPCU (5.8 mm)	149 cords	89 cords	74 cords
AC6PCGxxx-588HBSC (5.6 mm)	161 cords	96 cords	80 cords
H6A10 (4.7 mm)	228 cords	136 cords	114 cords
6H460 (3.8 mm)	349 cords	209 cords	174 cords

Conclusions

The material presented here illustrates the concept of **Maximum <u>Practical</u> Cable Fill Ratios in Cable Managers**. Specific maximum Cable and Patch Cord quantities are given for each Leviton Cable Manager when filled with commonly used Leviton (EMEA) Cables or Patch Cords.

The concepts presented here may be applied to any cable managers, data cables and patch cords on the market. To make the calculations, one needs the cross-sectional dimensions of the cable manager's cabling pathway, and the outer diameter (O.D.) of the cable or patch cord under consideration. Using this data, a 100% fill ratio number can be established, and then the appropriate multiplier may be applied to derive a cable or patch cord count for Maximum Practical Cable Fill Ratio (0.35 for cable, 0.30 for patch cords).

The often quoted 40% and 50% cable fill ratio numbers (from cable fill ratio rules for cable trays, called out in standards) have been shown here to be generally impractical for most cable manager applications.

A 25% fill ratio number remains a good guideline for Cable Manager design and initial installation. It is always good practice to save some room for future cable plant growth.

Based on our analysis:

- **The Maximum Practical Cable Fill Ratio for Cables in Rear Cable Managers is 35%.**
- **The Maximum Practical Cable Fill Ratio for Patch Cords in Front Cable Managers is 30%.**