How to Circuit Lights in a Commercial Office Building

All commercial office buildings in North America are required to have adequate lighting by the local building department, National Electrical Code, Life Safety Code and common sense. This allows the businesses that are occupying the office to function smoothly.

The purpose of this article is to educate you on how an electrical engineer locates lighting, connects to the power source and then provides the controls for the lights. Using a real world example, I will go through industry standard practices and explain how everything works.

Contents at a Glance

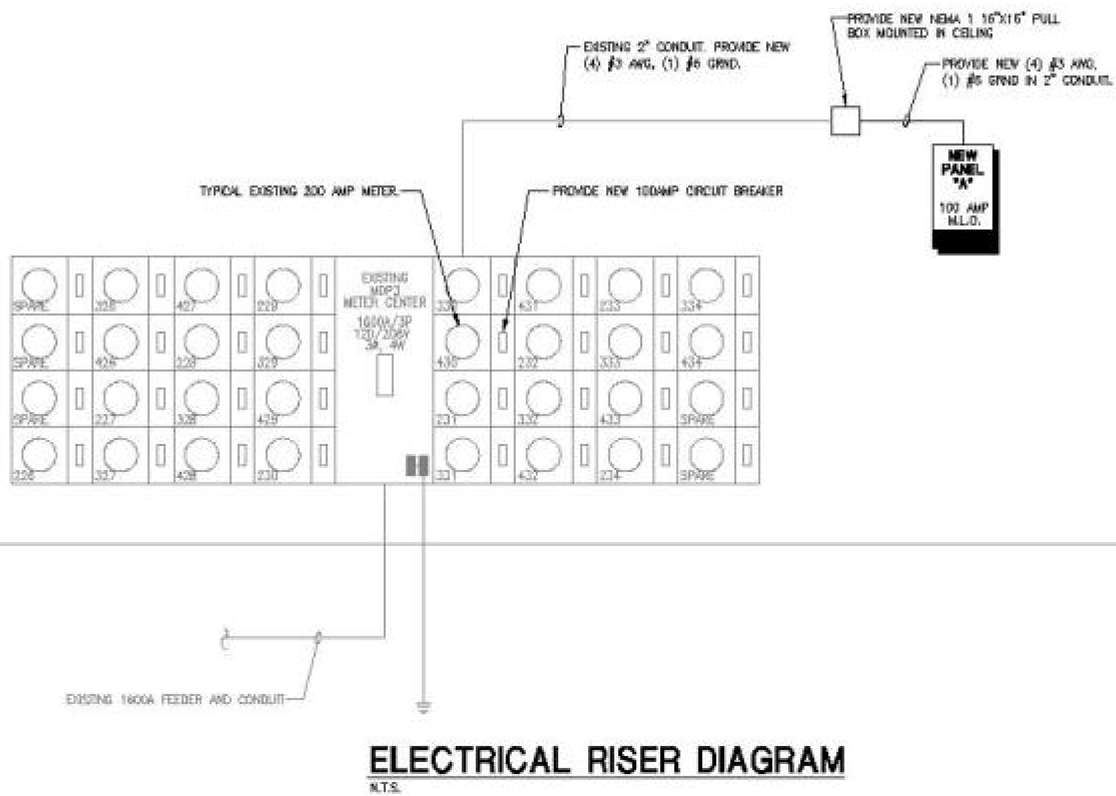
Given Information

This is what we know about the sample project

Lighting Fixture to be used:

2'x4' 18-cell parabolic fluorescent with three 32watt T8 lamps

Electrical Riser Diagram:



Electrical Panel Schedule:

PANEL A — RATING 100 AMP MLO; SERVICE 120 /208V 3ø, 4W; LUG LOCATION TOP; MOUNTING SURFACE; A.I.C. 22K; TYPE GENERAL ELECTRIC

CKT. NO.	EQUIPMENT SERVED	KVA	CKT. BKR. POLE	CKT. BKR. TR.	BRANCH CIRCUIT #	NEUT	GND	COND.	Ø	CKT. NO.	EQUIPMENT SERVED	KVA	CKT. BKR. POLE	CKT. BKR. TR.	BRANCH CIRCUIT #	NEUT	GND	COND.
1	RECEPTACLES	0.90	1	20	12	12	12	1/2"	A	2	CU-1 *	1.98	2	20	10	--	10	3/4"
3	RECEPTACLES	0.36	1	20	12	12	12	1/2"	B	4	-----	1.98	--	--	10			
5	RECEPTACLES	0.28	1	20	12	12	12	1/2"	C	6	AHU-1 *	4.00	2	60	6	--	8	1"
7	RECEPTACLES	0.72	1	20	12	12	12	1/2"	A	8	-----	4.00	--	--	6			
9	RECEPTACLES	0.54	1	20	12	12	12	1/2"	B	10	SPACE							
11	SPARE		1	20	12	12	12	1/2"	C	12	SPACE							
13	SPARE		1	20					A	14	SPACE							
15	SPARE		1	20					B	16	SPACE							
17	SPARE		1	20					C	18	SPACE							
19	SPARE		1	20					A	20	SPACE							
21	SPARE		1	20					B	22	SPACE							
23	SPARE		1	20					C	24	SPACE							
25	SPARE		1	20					A	26	SPACE							
27	SPARE		1	20					B	28	SPACE							
29	SPARE		1	20					C	30	SPACE							
31	SPARE		1	20					A	32	SPACE							
33	SPARE		1	20					B	34	SPACE							
35	SPARE		1	20					C	36	SPACE							
37	SPARE		1	20					A	38	SPACE							
39	SPARE		1	20					B	40	SPACE							
41	SPARE		1	20					C	42	SPACE							

EQUIPMENT SERVED	CONN. LOAD	LF	DF	DESIGN LOAD (KVA)
RECEPTACLES	3.42		1.00	3.42
LIGHTING	2.60	1.25		3.25
HVAC	8.00		1.00	8.00
			TOTAL	14.67
* = AHU AND CU LOADS ARE NON-COINCIDENTAL			SPARE	

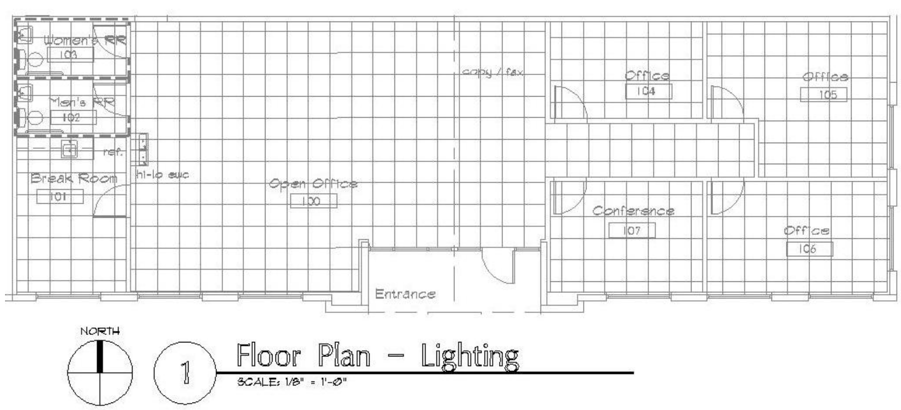
REMARKS:
- PROVIDE GRND BUS & NEUTRAL BUS
- PROVIDE TYPE WRITTEN DIRECTORY

42 CIRCUITS — 41 AMPS

Step 1

Set Up the Floor Plan

Download and set up the floor plan and reflected ceiling plan from the architect or interior designer. They're job is to prepare the space plan which shows the shape/layout of the office. Electrical engineers provide the power and lighting for that plan. This is the office with the ceiling grid:



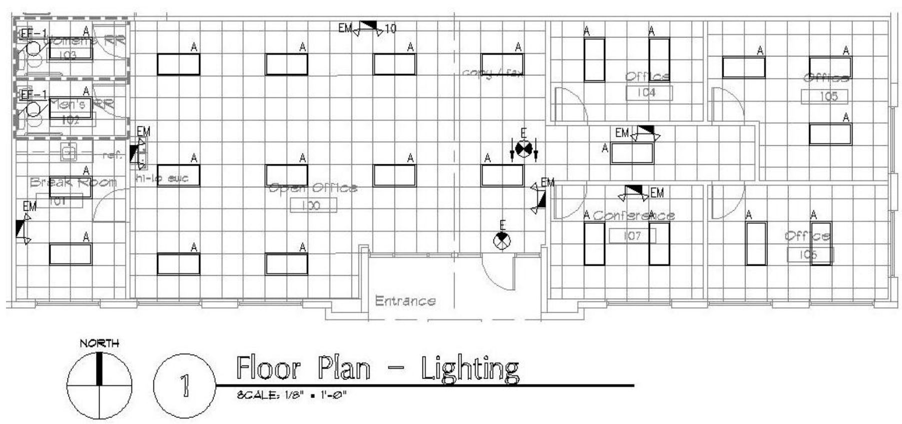
The architect has chosen to use a 2'x2' acoustical ceiling tile as the ceiling finish. Along with

2'x4' ACT, these are very common ceiling types in commercial buildings. They make locating lighting fixtures very easy.

Step 2

Layout the lighting fixtures.

First, let's start with the main lighting. As given earlier in this article, this suite will have 2'x4' parabolic fluorescent troffers with three 32w lamps. As a general rule of thumb, general office area requires 30-50 footcandles of lighting. This is adequate lighting for normal activities but is not too bright as to cause glare on computer monitors. So in the open office area, I will space the lights approximately 10' on center. Two lights in the enclosed offices will provide sufficient lighting for their dimensions (approx 10'x12'). And for sure, one 2'x4' fluorescent is sufficient for a single stall restroom. Let's look at the lighting layout:



As you can see, the 2'x4' lights fit best when they are spaced starting from the center of the room. This spreads the light evenly.

In addition to the 2'x4' lights, I have also located the exit signs and emergency lighting. The Life Saftey Code requires these in ALL commercial and industrial applications and the National Electrical Code defines the power requirements for these.

Locating exit signs requires some common sense. Their purpose is to direct people to the nearest exit in case of an emergency. The thought process behing this "means of eggress" is to direct someone who has never been in the office before towards the exit, even though most people in the establishment already know where the exits are. Per NEC 700.12(A),16,17 exit signs need to be connected to either an emeregency generator or be provided with a battery which last for 90 minutes.

Also in this example, we are using emergency battery wall packs which also have a 90 minute life per NEC 700.12(A). I have placed the emergency lights in the means of eggress (corridor and open office area) to provide "stumble" lighting or just enough lighting to get people to the nearest exit. This level of lighting would never be acceptable under normal working conditions but is satisfactory to "guide the way" out of the building during an emergency. You'll also notice there is an emergency light in both the Break Room and Conference Room. These rooms are required to have emergency lighting due to the fact that they are the type of areas where people gather and thus would be more vulnerable during an emergency.

Step 3

Assign a Circuit to each Lighting Fixture

Assign a circuit to each lighting fixture and document it on the electrical panel schedule. This step constitutes the main engineering involved in the process. There are two main concepts that you must know in order to circuit the lighting fixtures: wattage of the light fixture and voltage of the panel.

As discussed earlier, the lighting fixture chose to be used in this sample project has three 32w T8 lamps. This means that the light will use 3x 32watts or 96watts of power from the designated circuit breaker. I usually round this up to 100watts.

Also In the "Given Information" section, it was established that Panel A has a voltage of 120/208v. This means the general office lighting's voltage will be 120volts. Some warehouse lighting and most parking lot lighting is 208volts, but most office lighting is either 120volts or 277volts. It has already been established that 277/480v is not available on this project so 120volts is the only option.

One other item to note: Office lighting branch circuits' are connected to a 20amp circuit breaker. This is true for both 120volts and 277volts.

Taking the information that we now know, let's perform a calculation to determine the maximum wattage of lights on a circuit by multiplying the voltage by the circuit breaker amperage and then reducing this by the 125% continuous load factor:

$$\text{Volts} \times \text{Amps} = \text{Watts}$$

$$120\text{volts} \times 20\text{amps} = 2{,}400\text{watts}$$

$$\frac{2{,}400\text{w}}{1.25} = 1{,}920\text{w}$$

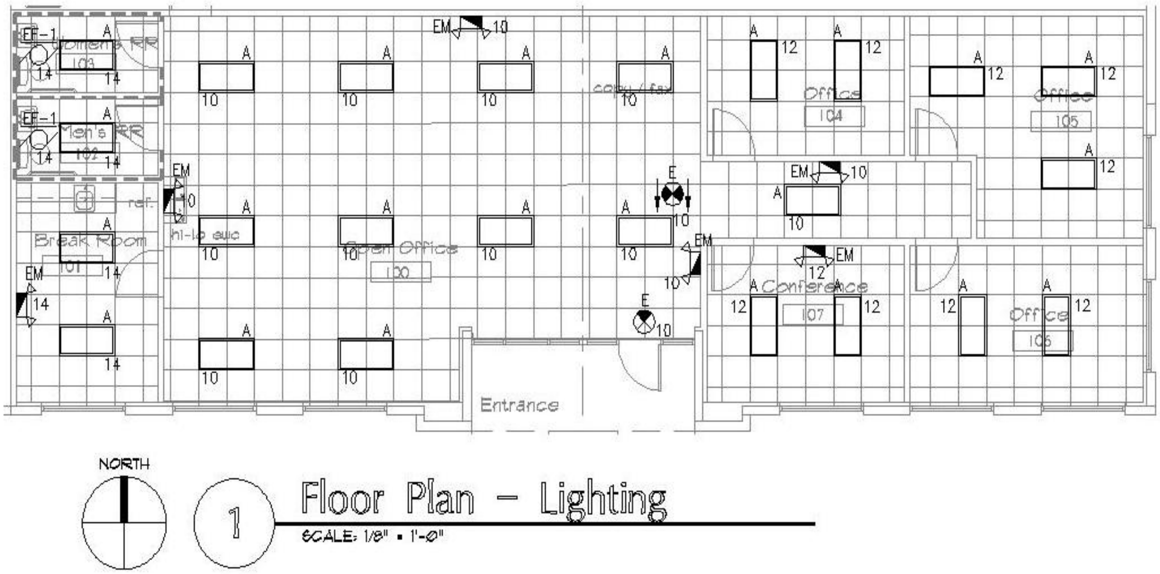
Even though the calculations show that the total load of lighting cannot exceed 1,920w, it is a good idea not to exceed 1,400w. Electrical engineering is about safety, safety and more safety. Figuring 1,400w for the maximum lighting load for your maximum lighting load allows for unbalanced loads, bad ballasts or lamps and the more common human error.

So, with all of this theory in mind, let's determine the maximum number of lighting fixtures that can be connected to one individual branch circuit:

$$\text{Maximum Load} \div \text{Load per Light} = \#\ \text{of Lights}$$

$$1{,}400\text{W} \div 100\text{W} = 14\ \text{Lights}$$

There you have it: We can begin circuiting the lighting fixtures knowing that the maximum number of lights on one circuit is 14. As you can see in the drawing below, I did not exceed 14 lights per circuit. I probably could have combined the lights connected to 14 on to circuit 12, but from my field experience I know that its common practice to not "stretch" a circuit all around a project. It is better to confine circuits to one area:



Note that I connected the exit signs and emergency battery packs to the closest lighting branch circuits. This is required by NEC 700.17. The wattage of these two devices are very minimal (+/- 5w) so they don't even get figured into the load calculation of the electrical panel. Here is what the electrical panel looks like now:

PANEL A

RATING 100 AMP M.L.O.
SERVICE 120 /208V, 3ø, 4W
LUG LOCATION TOP
MOUNTING SURFACE
A.I.C. 22K
TYPE GENERAL ELECTRIC

CKT NO	EQUIPMENT SERVED	KVA	CKT. BKR. POLE	CKT. BKR. TR	BRANCH CIRCUIT ø	NEUT	GND	COND	ø	CKT. NO.	EQUIPMENT SERVED	KVA	CKT. BKR. POLE	CKT. BKR. TR	BRANCH CIRCUIT ø	NEUT	GND	COND
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3	RECEPTACLES	0.90	1	20	12	12	12	1/2"	B	4	-----	1.96	--	--	10			
5	RECEPTACLES	0.36	1	20	12	12	12	1/2"	C	6	AHU-1 *	4.00	2	60	6	--	6	1"
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13	SPARE		1	20					A	14	LIGHTING	.60	1	20	12	12	12	1/2"
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17	SPARE		1	20					C	18	SPACE							
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21	SPARE		1	20					B	22	SPACE							
23	SPARE		1	20					C	24	SPACE							
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HVAC	8.00		1.00	8.00	– PROVIDE GRND BUS & NEUTRAL BUS – PROVIDE TYPE WRITTEN DIRECTORY
			TOTAL	14.67	
* = AHU AND CU LOADS ARE NON-COINCIDENTAL			SPARE		42 CIRCUITS 41 AMPS

(For more sample electrical panel schedules, click here)

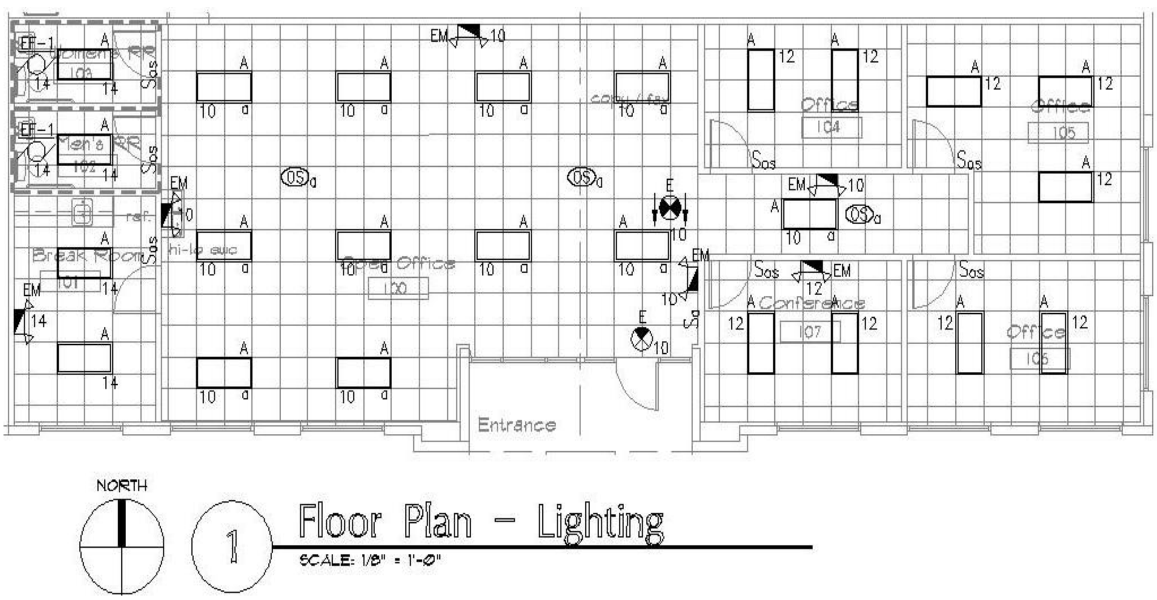
Step 4

Lighting Controls

In this sample project, as in most offices, there is required to be lighting switches and occupnacy sensors to control when the lights turn on and off.

Before I explain this concept I would like to point out that regulation for lighting controls varies widely across the United States right now. For example, I live in Central Florida. So far this articel has discussed code requirements from the National Electrical Code but the Florida Building Code has stricter energy efficiency standards. Chapter 13 of the 2007 FBC reuiqres that lights automatically shut off after 30 minutes. I realize that other areas of the country don't have this requirement but I'm sure they will one day. Energy efficiency is no longer a good idea. It is and will be the code.

With that being said, let's place the light switches and occupancy sensors.



I have provided a light switch with an integral occupancy sensor for each enclosed offices, restrooms and break rooms. After 30 minutes of no motion or heat detected, the lights in these rooms will turn off. 95% of the office buildings in the country have a single light switch that controls the lights for each individual office but the integral occupancy sensors are becoming more common. And in the open office area and corridor, there are ceiling mounted occupancy sensors with the override switch by the south exterior door. You'll notice that there are lowercase "a's" by that switch and the lights it is controlling. This is simply to add clarification to which lights are being controlled by that switch. Nothing more, nothing less.

Conclusion

The principles shown in this article apply to office buildings large and small alike. There are a lot of dynamics to light fixture technology and circuit theory but as in the example shown here, it's best to keep it simple. For more about electrical design principles, click here.