Title: **Selecting MDBs for Your ACS Modular Power Wiring System**

Author: **Hal M. Mueller**

Introduction

There is often confusion regarding how to choose the most suitable Main Distribution Box (MDB) and Secondary Distribution Box (SDB) for an America Cable Systems modular power wiring system. Owners, specifiers, engineers, and designers all want to make sure that they have chosen "the best" or "the optimal" solution for their project. Although there are a generous, but limited number of standard MDBs, the flexibility of these components leaves one with numerous ways of creating a modular wiring solution. This note will attempt to give both general and technical guidelines to those who are selecting, specifying, and designing systems with these components.

The Big Picture

Before worrying over the type and number of MDBs, we should consider the overall use of the building to understand the power wiring needs. An owner-occupied space may be built around the company, like a tailored suit, and the modular wiring system may need to reflect that perfect fit. A tenant-occupied space may be required to change with each tenant and thus may benefit from a more off-the-rack approach to the modular wiring system. Some spaces like laboratories or call centers may require a dense power wiring system. The overall use of the building or space will set a direction for the modular power wiring system and the selection of the appropriate MDB.

Each building that needs power wiring already has some guidelines regarding the amount of power or number of voice and data ports that should be available as a minimum. The National Electric Code tells us that we must consider every duplex receptacle as needing at least 180 volt-amperes (VA). This will help us to set our minimum power budget once we decide how many duplex receptacles are needed for each of the individual points of use in the zone to be wired.

There is some overall information that should be at one's fingertips to make sense of the big picture. Knowing how many people will occupy the zone is absolutely necessary; if the number of occupants in the zone is large, more circuits will be needed than if there were fewer occupants.. Knowing the area (in square footage) and shape of the zone to be wired is vital. Knowing how many copiers and laser printers are in the zone will help to fill in the picture. Finally, knowing the plans for growth within the space will allow the designer to make the best use of the system.

Use of Space	Changing tenants may change use of space.
Number of occupants	More people, more circuits.
Area of the Zone	Larger zones call for MDB with many circuits.
Shape of the Zone	Chopped-up, odd shapes need smaller MDB.
Number of Copiers/Laser Printers	Both use lots of power, may be different voltage.
Plans for Growth	Any adds or major changes in the next 10-15 years?

Figure 1. Summary of Factors Affecting MDB Selection.

Assume for the moment that the power an occupant uses is the same whether they're in a huge zone in a large building or a small zone in a small building. If those occupants are in a large open zone, the modular wiring system will best distribute those circuits using many MDBs each with many circuits to geographically spread the power through the zone. If we take those many occupants and put them into many small isolated zones, we'll want to use fewer MDBs with many circuits each to distribute the power in those zones. If the zone is oddly shaped, we may be better off using fewer MDBs with few circuits each than if it were an open, square shaped zone where we could use MDBs with many circuits effectively. A summary of these factors is shown in Figure 1. An attempt to illustrate the effects of these factors and express guidelines for MDB selection is illustrated in Figure 2.

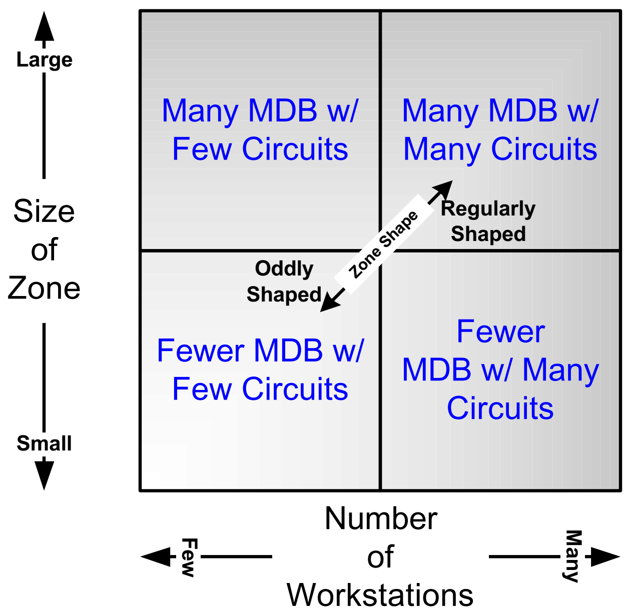


Figure 2. MDB Selection Matrix.

From Perfection to Saturation

I want you to get your mother to help you design your modular power wiring system.

To extend the tailored suit metaphor, one might be tempted to think that a modular wiring system that provides just the right amount of circuits is a perfect system. It's opposite, the modular wiring system that provides lots of extra circuits is like the pants that your mother bought you—there was lots of extra cloth bunching up all over in places you didn't need. She gave you room to grow into them and your folks didn't have to buy new pants every other month, saving significant money in the long run. You don't want perfection in your modular wiring system design! You want a system design that allows your company or tenant to grow and reorganize without cost or delays caused by the constraints of the wiring system. The ability to grow into your pants when best expressed in the modular wiring system is what I'll call *saturation wiring*.

Once we face a blank page, ready to design a modular power wiring system for our building or space, we need to decide where we'll land on the spectrum from perfection to saturation. With perfection, we'll get just enough circuits to fit the business. As we move in the direction of saturation, we'll get more spares in each space or zone to allow for changes. When we choose saturation, we'll have uniform distribution of circuits throughout the building, space or zone, meaning that we'll be able to handle any changes in the use of the space.

A Few Words About SDBs

The decision on whether to use SDBs or not in the modular power system comes down to determining the answer to a simple question: how many workstations will you place on each circuit. Once the number of workstations per circuit is determined, you can easily determine if an SDB is needed. Once the MDB is chosen, you know whether the circuits are split between the MDB ports. Then you simply select the appropriate SDB to divide the outputs from the MDB ports. The proper MDB and SDB will result in the selected number of workstations per circuit. Although we made our decision based on workstations per circuit, in essence, this SDB selection can allow you to spread the power distribution zone over a greater geographic area.

Custom or Standard?

Just like building a custom street rod, one can sink a lot of time and money into the design and fabrication of the MDBs that you choose for your modular wiring system. Like that street rod, it'll probably take longer to build than to buy a Chevy off the lot. Start thinking of the MDBs that you choose for your modular wiring system as off-the-shelf components and you'll save time and money in your modular wiring system. If you still need to have a custom design, it's always something that ACS can provide--for a lot less than a custom street rod.

Standard MDBs and Home Run Cables

ACS has a number of standard MDBs that can be used to design a modular wiring system. They range from those with many circuits to those with few circuits and allow one to find the MDB that best meets the factors discussed above. We'll need to cover some of the gritty details of the standard home run cables, the standard port configurations, and the standard number of ports per MDB before combining them into a standard system.

Standard Home Run Cables

There are four standard home run cables. Each cable contains a green equipment ground conductor and a green/yellow isolated ground conductor. The number and size of hot conductors, neutral conductors, and grounding conductors describe these cables as shown in the table below.

Home Run Cable	Hot Conductors	Neutral Conductors	Grounding Conductors
10/12 8/4 10/2	12 each #10 AWG	4 each #8 AWG	2 each #10 AWG
10/9 8/3 10/2	9 each #10 AWG	3 each #8 AWG	2 each #10 AWG
10/6 8/2 10/2	6 each #10 AWG	2 each #8 AWG	2 each #10 AWG
10/3 8/1 10/2	3 each #10 AWG	1 each #8 AWG	2 each #10 AWG

Figure 3. Standard Home Run Cables - Conductor Number and Size.

Standard MDB/SDB Ports

There are several standard port configurations used on ACS equipment. Each MDB will carry a number of standard ports; each port is the same. A port is a standard five-pole connector or two five-pole connectors configured to make a standard 10-pole connector. The standard 10-pole connector carries an isolated ground conductor.

In a standard configuration, these 5-pole and 10-pole connectors will not mate with each other. Additionally, the standard connectors will be made using different colors for the connectors. A standard five-pole connector will be made with a clear plastic connector insert. The standard outputs at a 5-pole port are described in the table below. MDBs with 5-pole connectors are oftentimes referred to as "single-port" MDBs.

Circuitry	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5
A (3-wire)		Hot #1	Equipment Ground	Neutral	
B (4-wire)	Hot #2	Hot #1	Equipment Ground	Neutral	
C (5-wire)	Hot #2	Hot #1	Equipment Ground	Neutral	Hot #3

Figure 4. Standard 5-Pole Port Connections.

A standard 10-pole port consists of a standard 5-pole connector made with a clear plastic connector insert and a second 5-pole connector made with an orange plastic connector insert. The standard outputs at a 10-pole port are described in the table below. MDBs with 10-pole connectors are oftentimes referred to as "dual-port" MDBs.

A word about circuit nomenclature: the "G" in the "xG/x" convention refers to the isolated ground circuits. Therefore, an "AG/A" circuitry means that there is one isolated ground circuit and one general purpose circuit at each of the dual ports.

Circuitry	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Pin 10
AG/A		Hot #1	Equip-ment Ground	Neutral #1			Hot #2	Equip-ment Ground	Neutral #1	Isolated Ground
AG/B	Hot #2	Hot #1	Equip-ment Ground	Neutral #1			Hot #3	Equip-ment Ground	Neutral #1	Isolated Ground
AG/C	Hot #2	Hot #1	Equip-ment Ground	Neutral #1	Hot #3		Hot #4	Equip-ment Ground	Neutral #1	Isolated Ground
BG/A		Hot #1	Equip-ment Ground	Neutral #1			Hot #2	Equip-ment Ground	Neutral #2	Isolated Ground
BG/B	Hot #2	Hot #1	Equip-ment Ground	Neutral #1		Hot #4	Hot #3	Equip-ment Ground	Neutral #2	Isolated Ground
BG/C	Hot #2	Hot #1	Equip-ment Ground	Neutral #1	Hot #3	Hot #5	Hot #4	Equip-ment Ground	Neutral #2	Isolated Ground

Figure 5. Standard 10-Pole Port Connections.

UPS or Generator Power

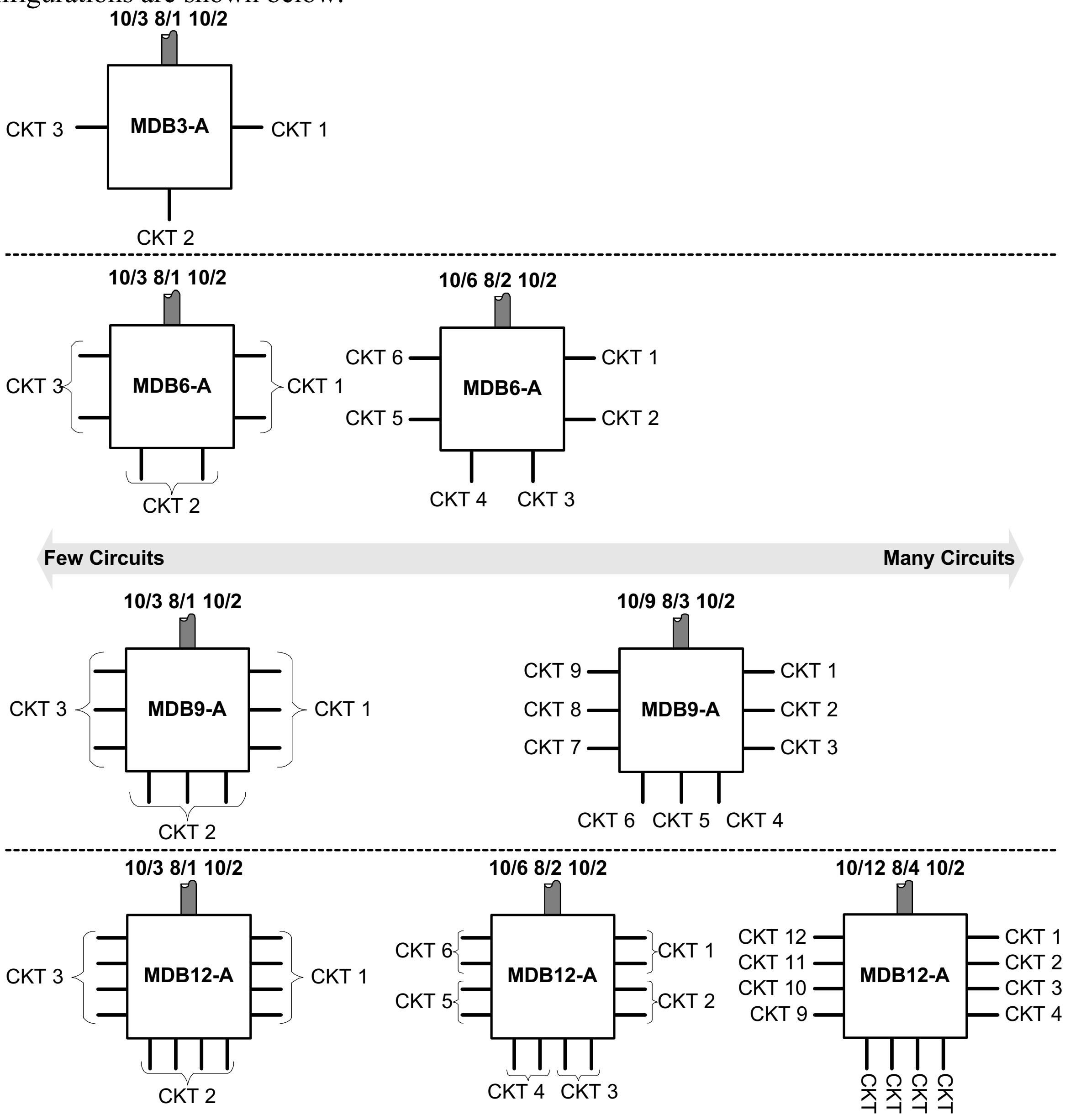
When your design calls for UPS or generator power supplied from a separate panel, the standard 10-pole port will meet this requirement. Although this paper doesn't specifically show configurations for UPS or generator power, the standard dual-port MDBs and SDBs would be used for these two modular power systems.

Standard Single-Port MDBs

There are four standard single-port MDBs: three-port MDBs, six-port MDBs, nine-port MDBs, and twelve-port MDBs. Each connects the standard home run cables with the ports of the MDB to yield various standard outputs for distribution throughout the zone. The standard outputs at each port of the standard single-port MDBs are described in the following sections.

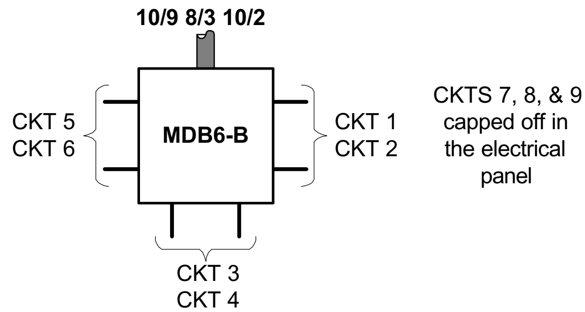
"A" Circuitry

The most basic and easiest to understand, the standard single-port MDBs in "A" circuitry configurations are shown below.



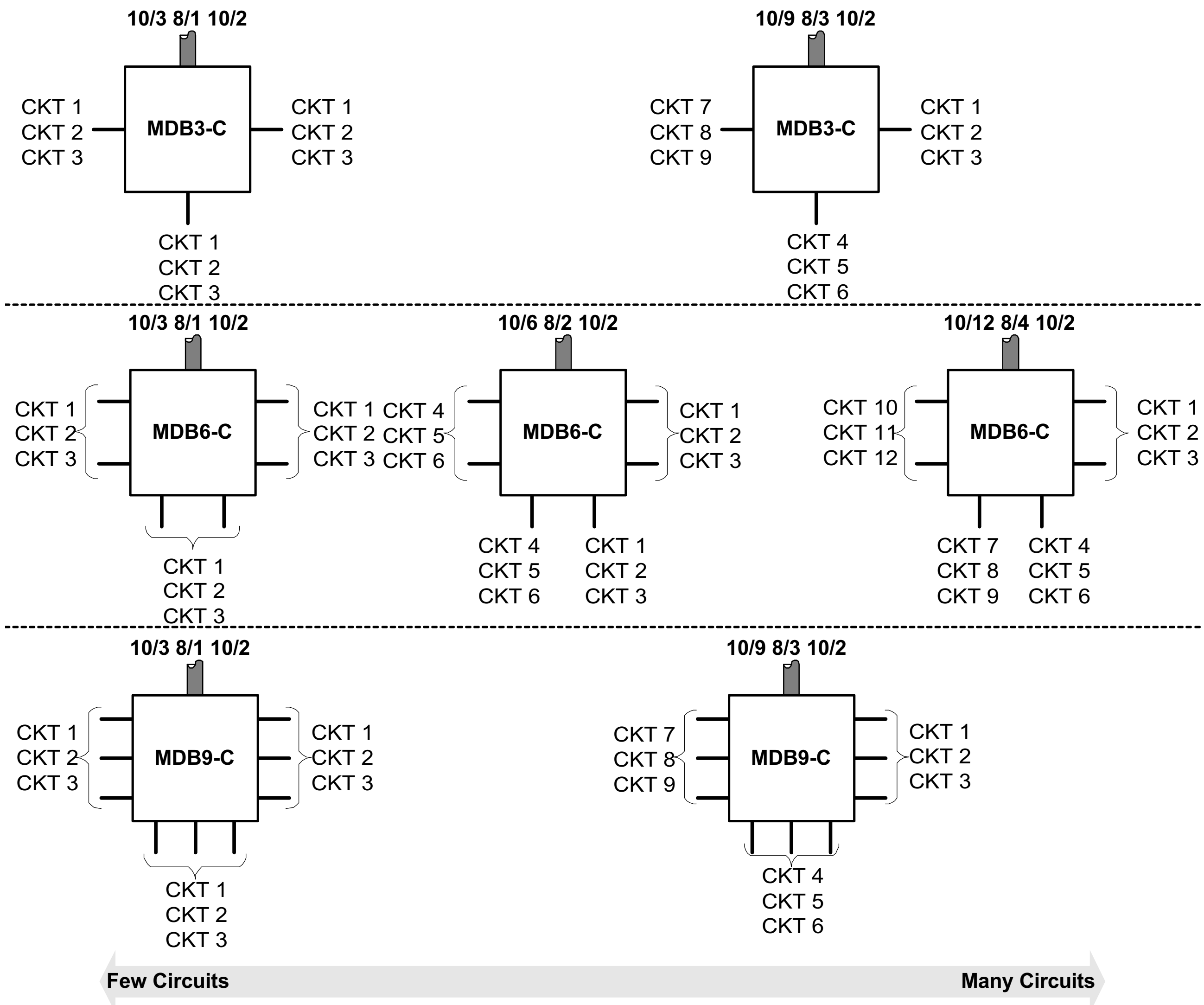
"B" Circuitry

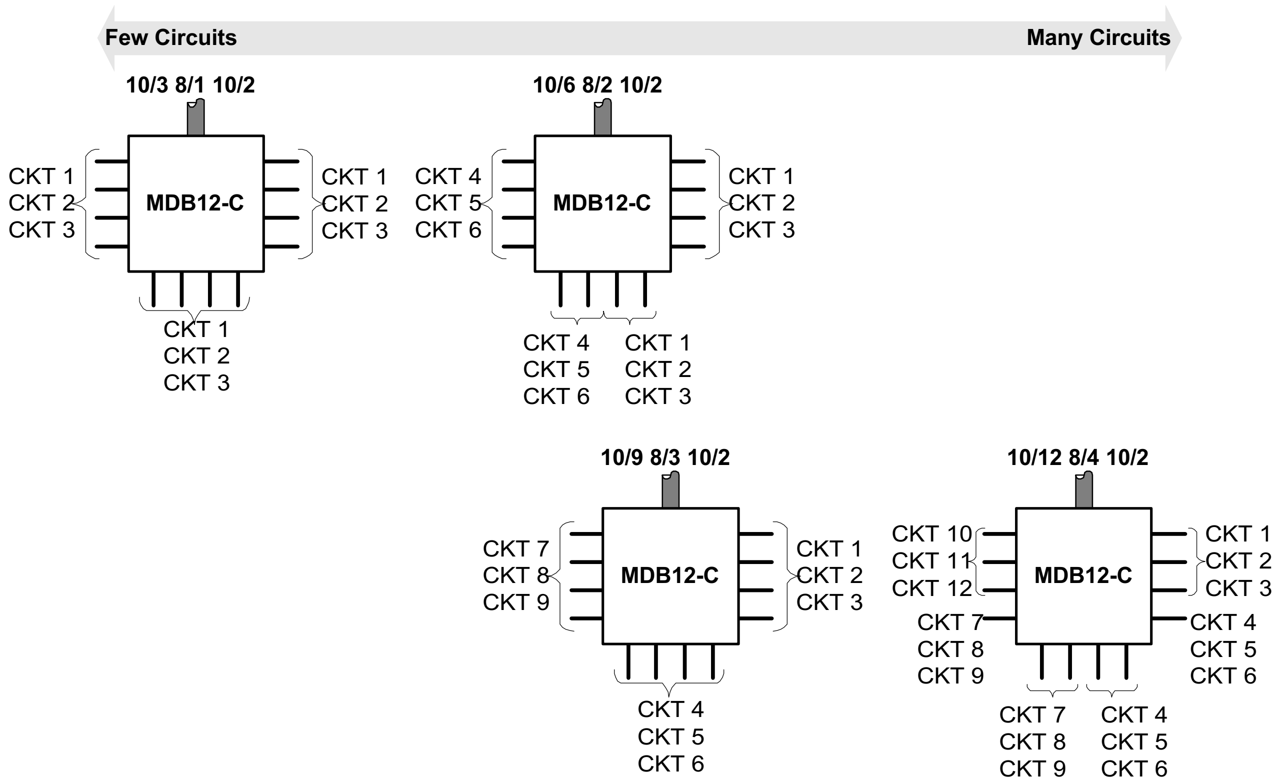
The standard single-port MDB in "B" circuitry configurations are shown below. Because of the nature of a three phase electrical system, the "B" systems are necessarily inefficient in the use of the neutral conductors. Each of the two hot conductors requires a neutral, even though the third hot conductor in the triplet goes unused. This requires a standard home run cable with its greater neutral count, leading to unused hot conductors that must be capped off in the electrical panel. In most cases, the "B" systems are readily replaced with a system using "C" circuitry, resulting in better use of the neutral conductors and fewer capped off hot conductors in the panel.



"C" Circuitry

The standard single-port MDB in "C" circuitry configurations are shown below. The "C" systems are the highest density single port MDBs in terms of circuits delivered to each port. Consequently, this requires a standard home run cable with a large hot conductor count or greater sharing of hot conductors between ports. The "C" circuitry efficiently uses the neutral conductors and results in all hot conductors in the home run cable being used.



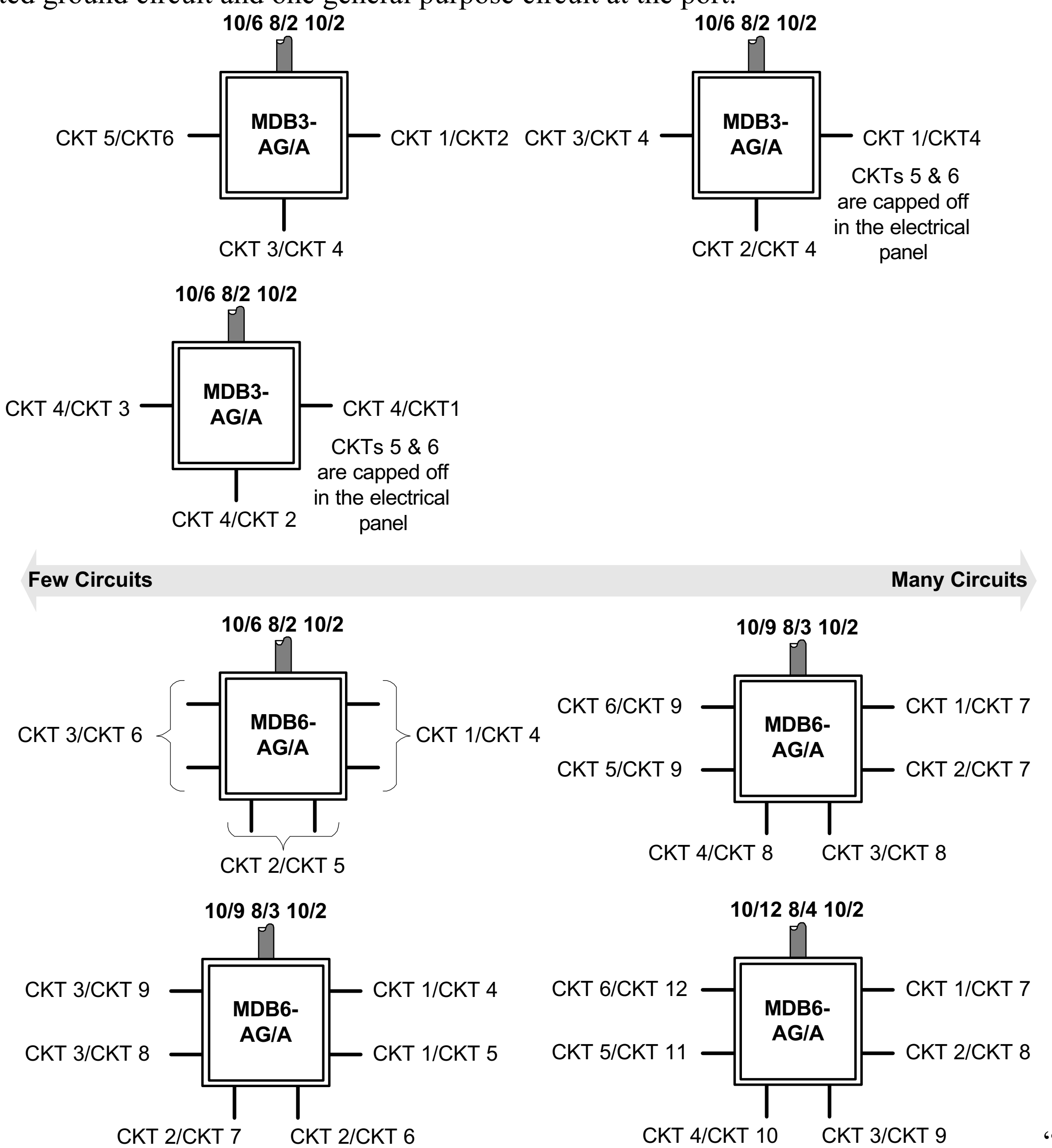

Few Circuits
Many Circuits
10/3 8/1 10/2
MDB12-C
CKT 1
CKT 2
CKT 3
CKT 1
CKT 2
CKT 3
CKT 1
CKT 2
CKT 3
10/6 8/2 10/2
MDB12-C
CKT 4
CKT 5
CKT 6
CKT 1
CKT 2
CKT 3
CKT 4
CKT 5
CKT 6
CKT 1
CKT 2
CKT 3
10/9 8/3 10/2
MDB12-C
CKT 7
CKT 8
CKT 9
CKT 1
CKT 2
CKT 3
CKT 4
CKT 5
CKT 6
10/12 8/4 10/2
MDB12-C
CKT 10
CKT 11
CKT 12
CKT 1
CKT 2
CKT 3
CKT 7
CKT 8
CKT 9
CKT 4
CKT 5
CKT 6
CKT 7
CKT 8
CKT 9
CKT 4
CKT 5
CKT 6

Standard Dual-Port MDBs

There are two standard dual-port MDBs: three-port MDBs and six-port. Each connects the standard home run cables with the two ports of the MDB to yield various standard outputs of general purpose and isolated ground power for distribution throughout the zone. The standard outputs at each port of the standard dual-port MDBs are described in the following sections.

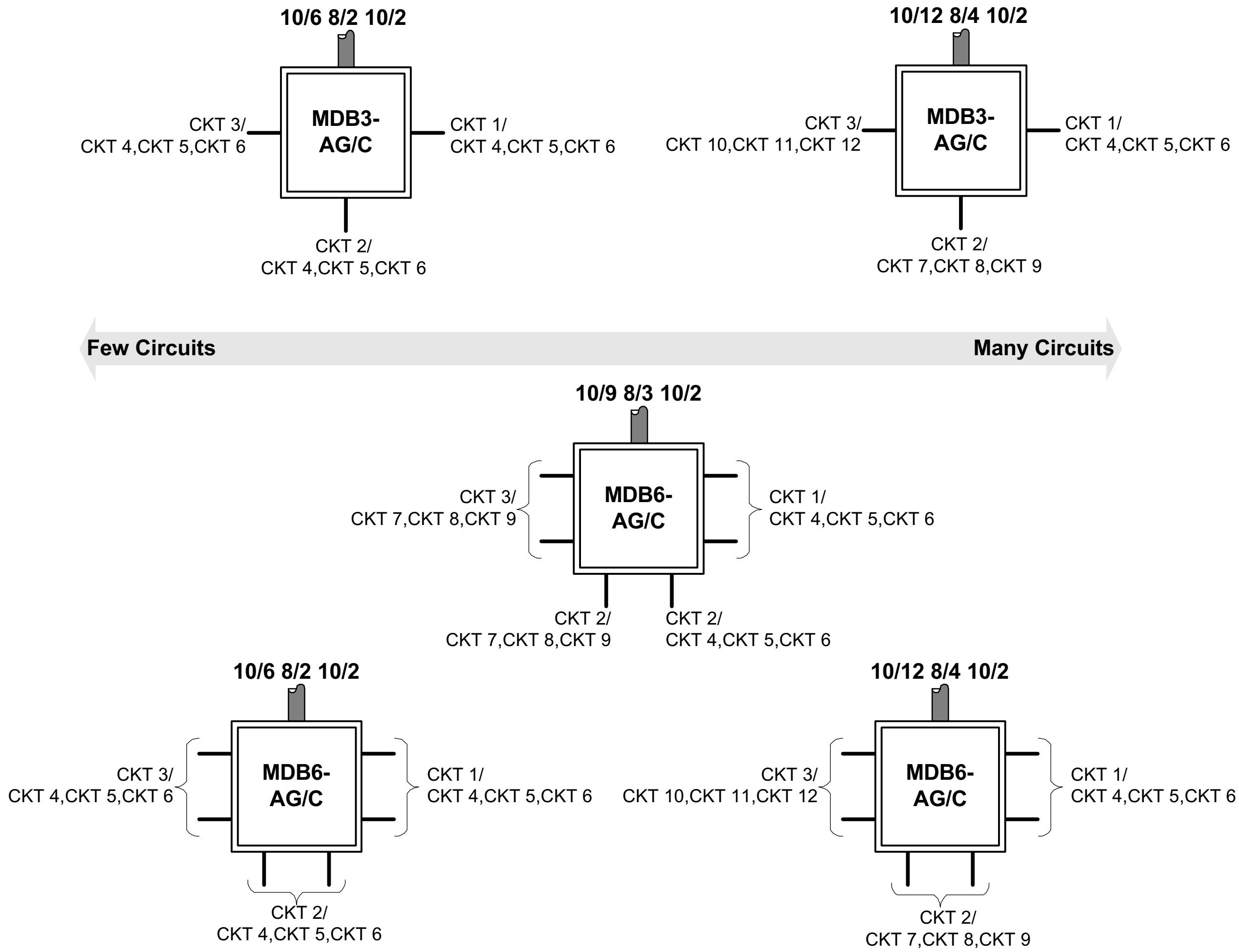
"AG/A" Circuitry

Again, the most basic and easiest to understand, the standard dual-port MDBs in "AG/A" circuitry configurations are shown below. Remember that the "G" in the "xG/x" convention refers to the isolated ground circuits. Therefore, an "AG/A" circuitry means that there is one isolated ground circuit and one general purpose circuit at the port.



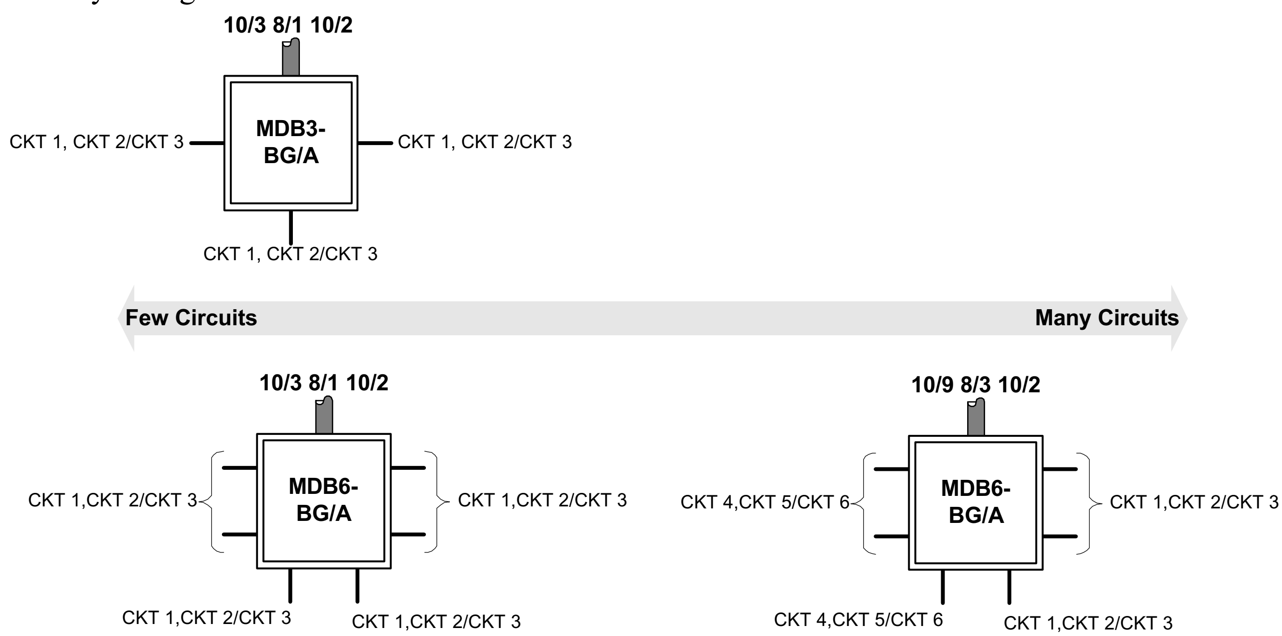
AG/C" Circuitry

Now we get to MDB configurations that those familiar with the modular furniture industry will recognize. The "AG/C" circuitry is the same as the "3+1" circuitry for modular furniture. The standard dual-port MDBs in "AG/C" circuitry configurations are shown below.



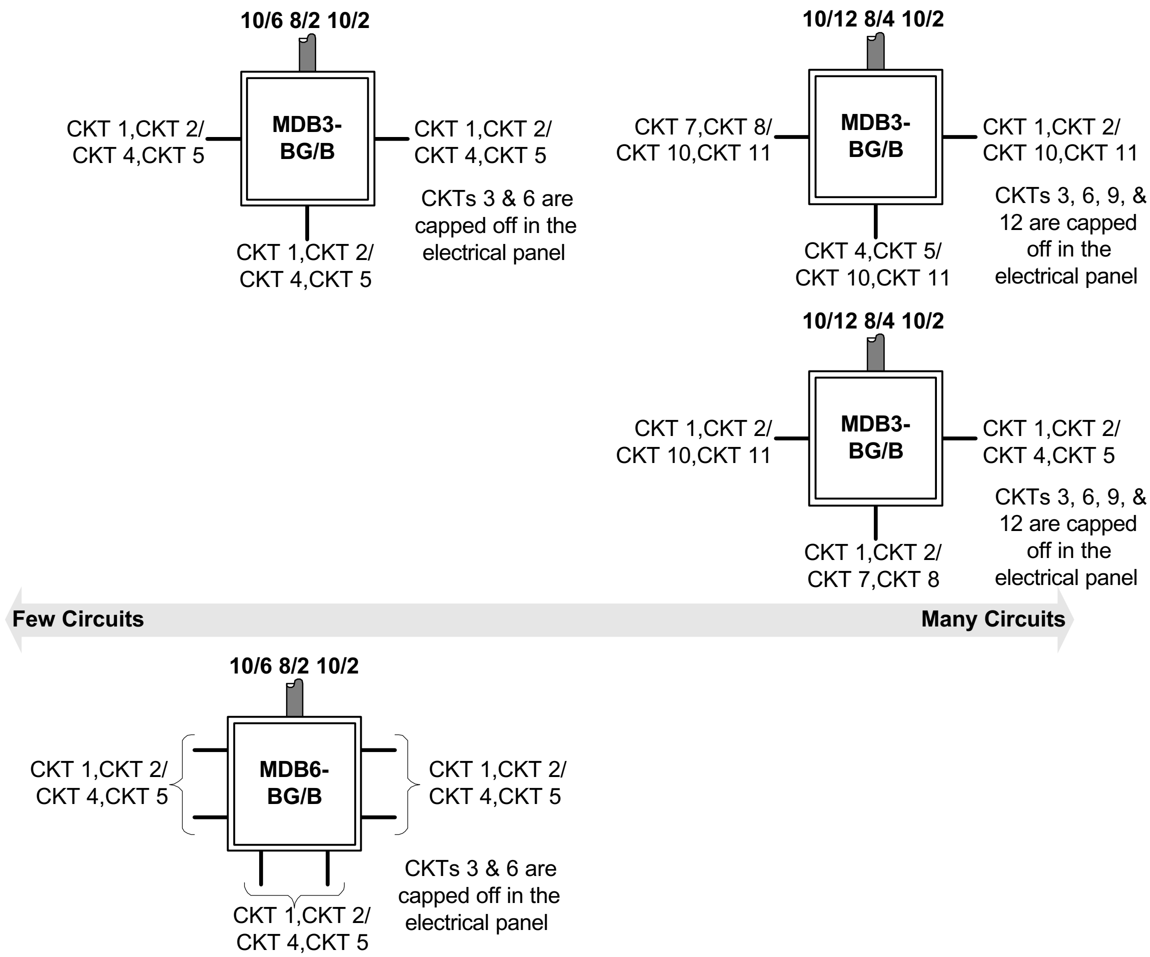
BG/A" Circuitry

Like all of the other "B"-type circuitry, the "BG/A" circuitry is unable to make the best use of the largest standard home run cables. It is only significant because the circuitry is the same as the "1+2" 5-wire circuitry used in modular furniture. The standard dual-port MDBs in "BG/A" circuitry configurations are shown below.



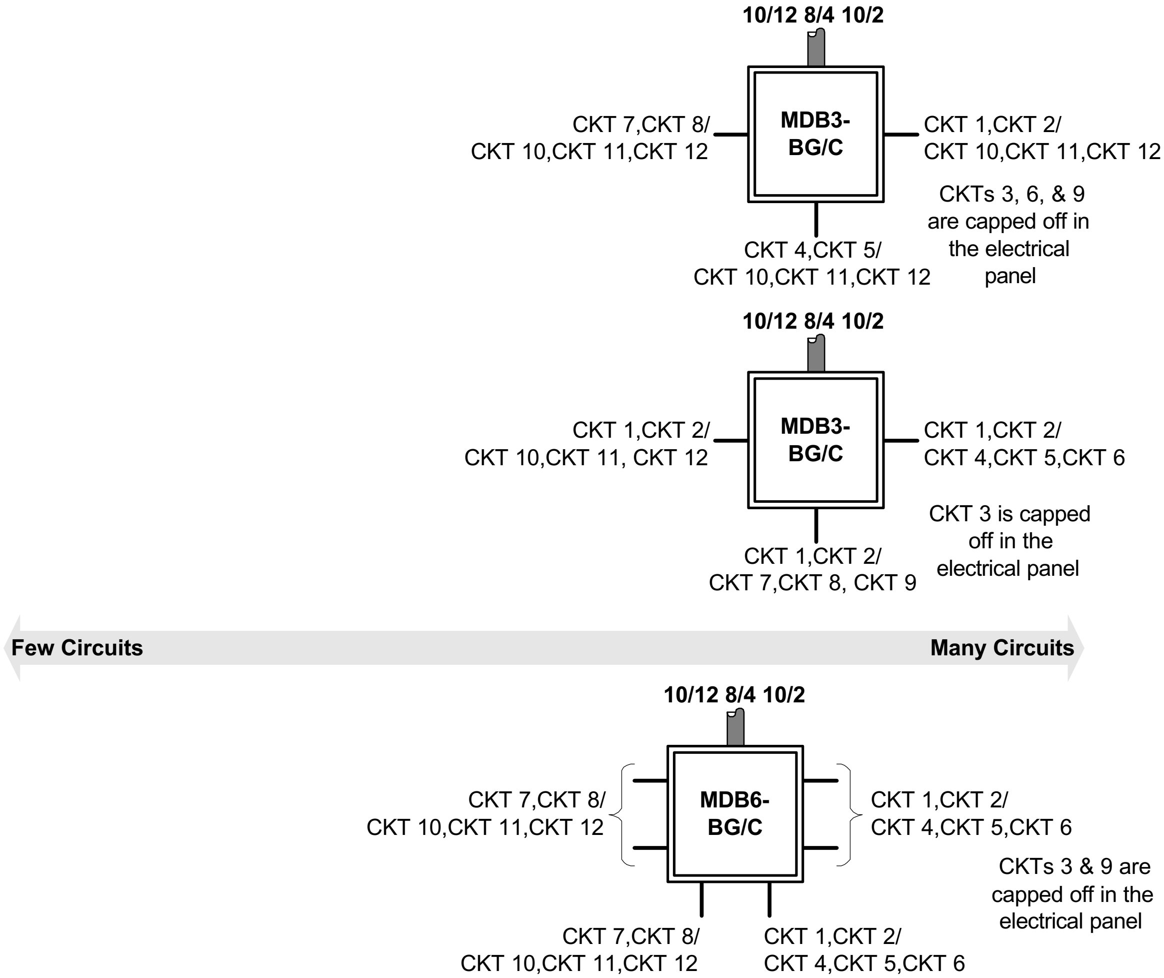
BG/B" Circuitry

Again, the "BG/B" circuitry doesn't allow the most efficient use of the hot conductors due to the need for neutral conductors. The "BG/B" circuitry provides two general purpose and two isolated ground circuits to each port. It is also the same as the "2+2" 8-wire circuitry used in modular furniture. The standard dual-port MDBs in "BG/B" circuitry configurations are shown below.



BG/C” Circuitry

The “BG/C” represents the maximum number of circuits possible in the standard 10-pole connector. Because of the “BG” circuits, there will be some circuits unused in the standard home run cables. The “BG/C” circuitry provides three general purpose and two isolated ground circuits to each port. It can thus supply the “3+1” or the “2+2” 8-wire circuitry used in modular furniture. The standard dual-port “BG/C” MDBs are shown below.

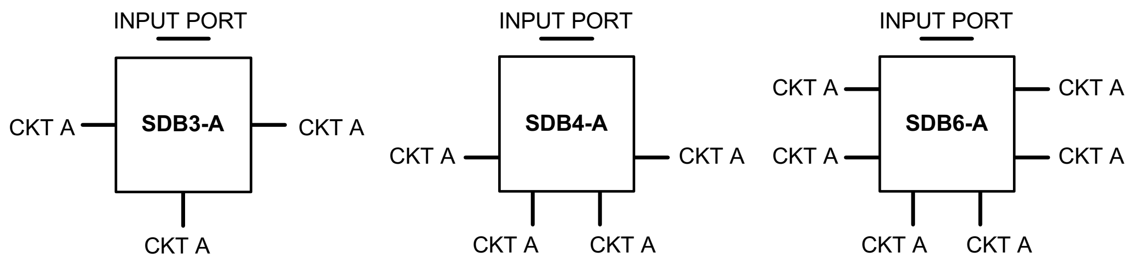


Standard Single-Port SDBs

There are three standard single-port SDBs: three-port SDBs, four-port SDBs, and six-port SDBs. Each connects the outputs of the standard MDB ports to split the circuits and distribute them throughout a greater geographic zone. The standard outputs at each port of the standard single-port SDBs are described in the following sections.

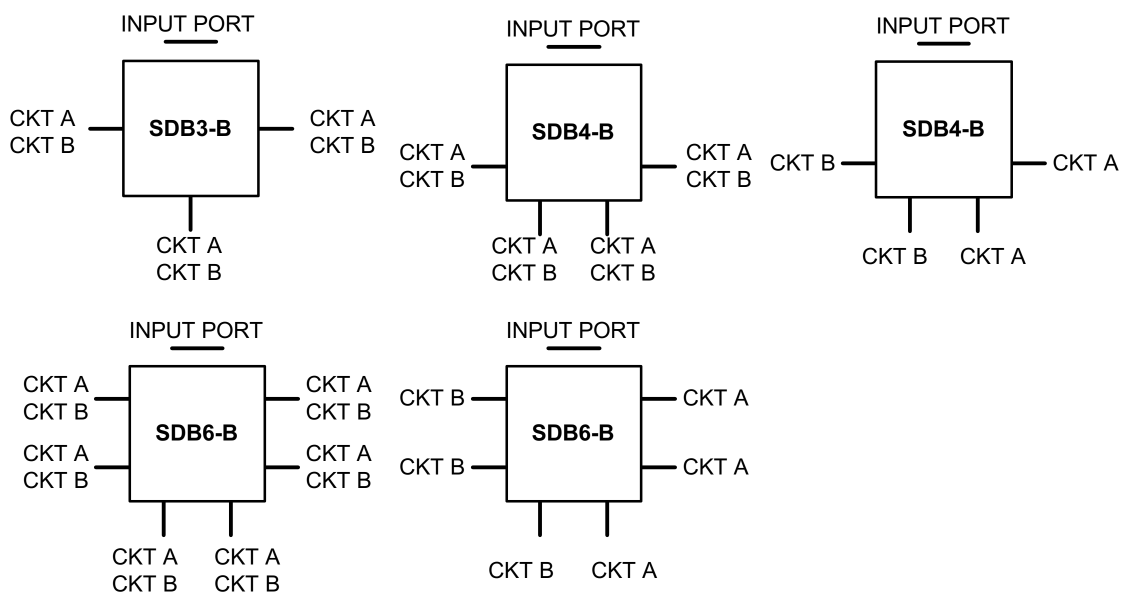
"A" Circuitry

As with the MDBs, the "A" circuitry SDBs are the most basic and easiest to understand. The standard single-port SDBs in "A" circuitry configurations are shown below.



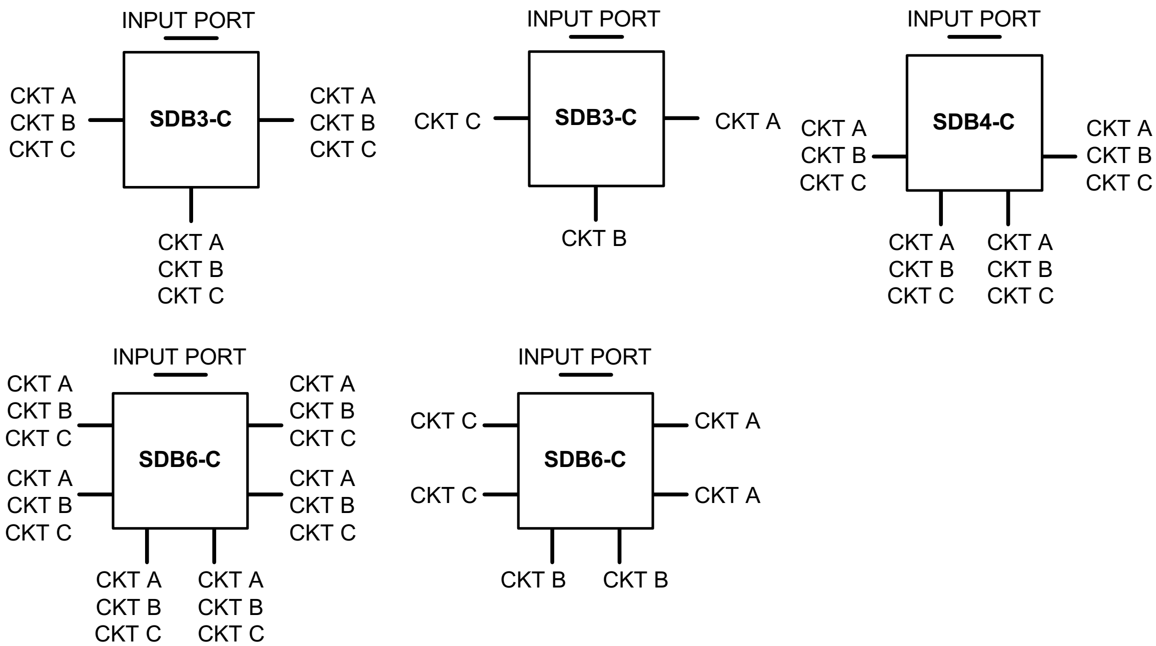
"B" Circuitry

The "B" circuitry SDBs are shown below.



"C" Circuitry

The standard single-port SDBs in "C" circuitry configurations are shown below. The "C" systems are the highest density in terms of circuits delivered to each MDB port. Consequently, this allows the SDB to split those circuits in various ways, offering a great variety of system configurations to the designer.

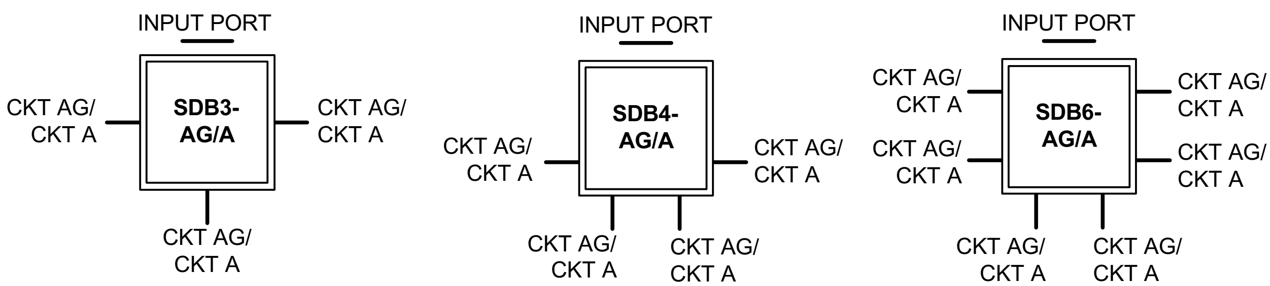


Standard Dual-Port SDBs

There are also three standard dual-port SDBs: three-port SDBs, four-port SDBs, and six-port SDBs. Although a little more complex than the single-port SDBs, each serves to connect the outputs of the standard MDB ports to split the circuits and distribute them throughout a greater geographic zone. The standard outputs at each port of the standard dual-port SDBs are described in the following sections.

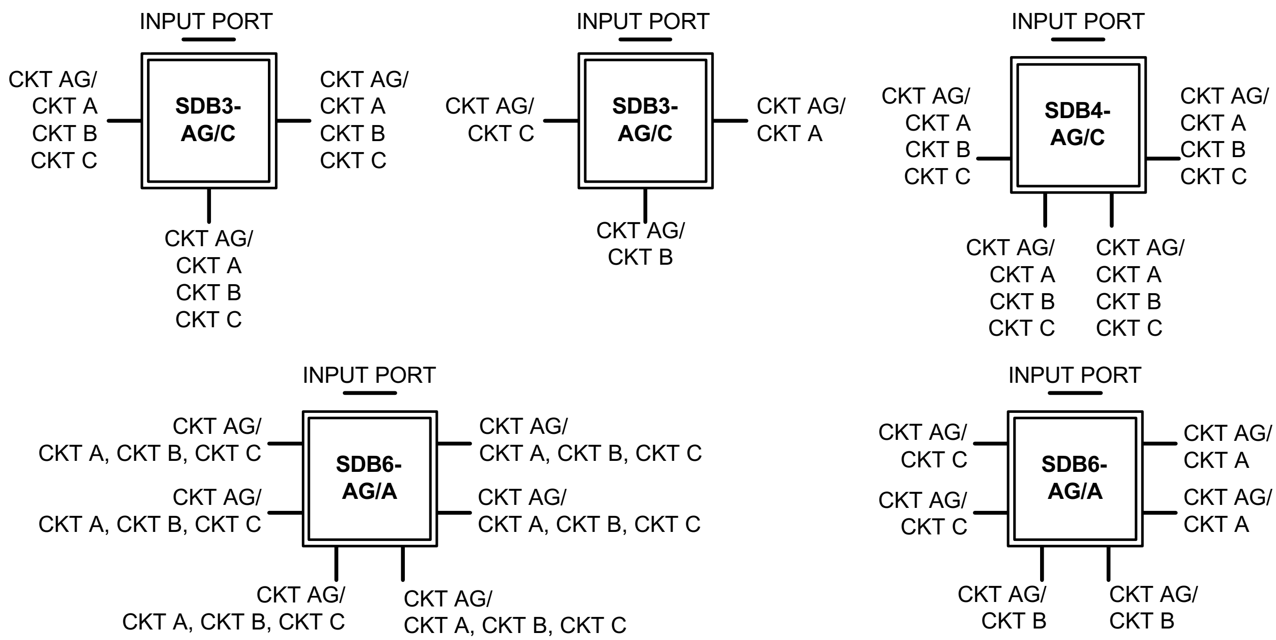
"AG/A" Circuitry

Again, the most basic and easiest dual-port circuitry to understand, the standard dual-port SDBs in "AG/A" circuitry configurations are shown below. Remember that the "G" in the "xG/x" convention refers to the isolated ground circuits. Therefore, an "AG/A" circuitry means that there is one isolated ground circuit and one general purpose circuit at the port.



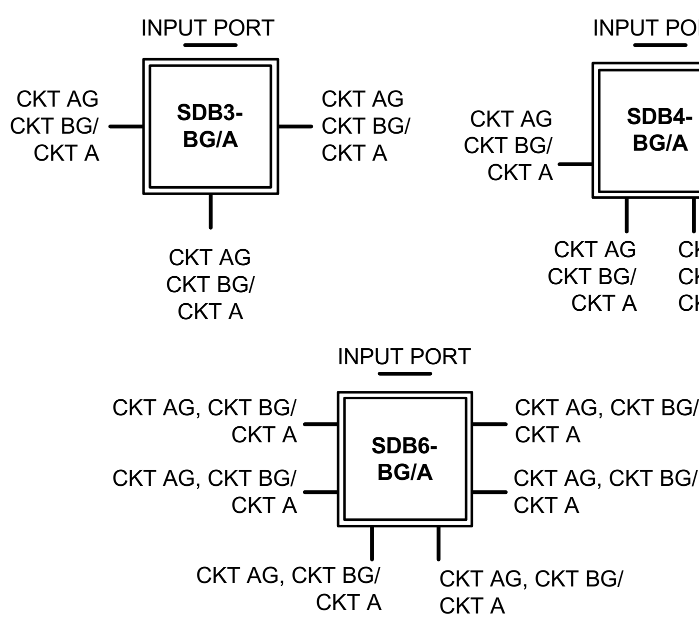
AG/C" Circuitry

The standard dual-port SDBs in "AG/C" circuitry configurations are shown below.



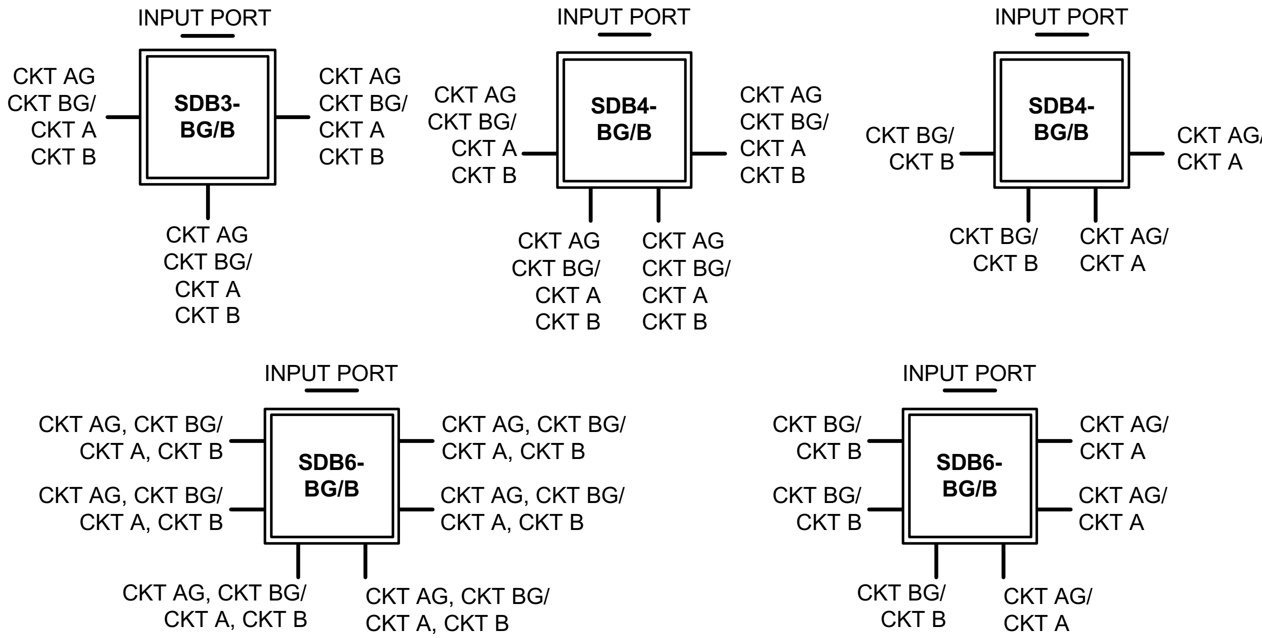
BG/A" Circuitry

The standard dual-port SDBs in "BG/A" circuitry configurations are shown below.



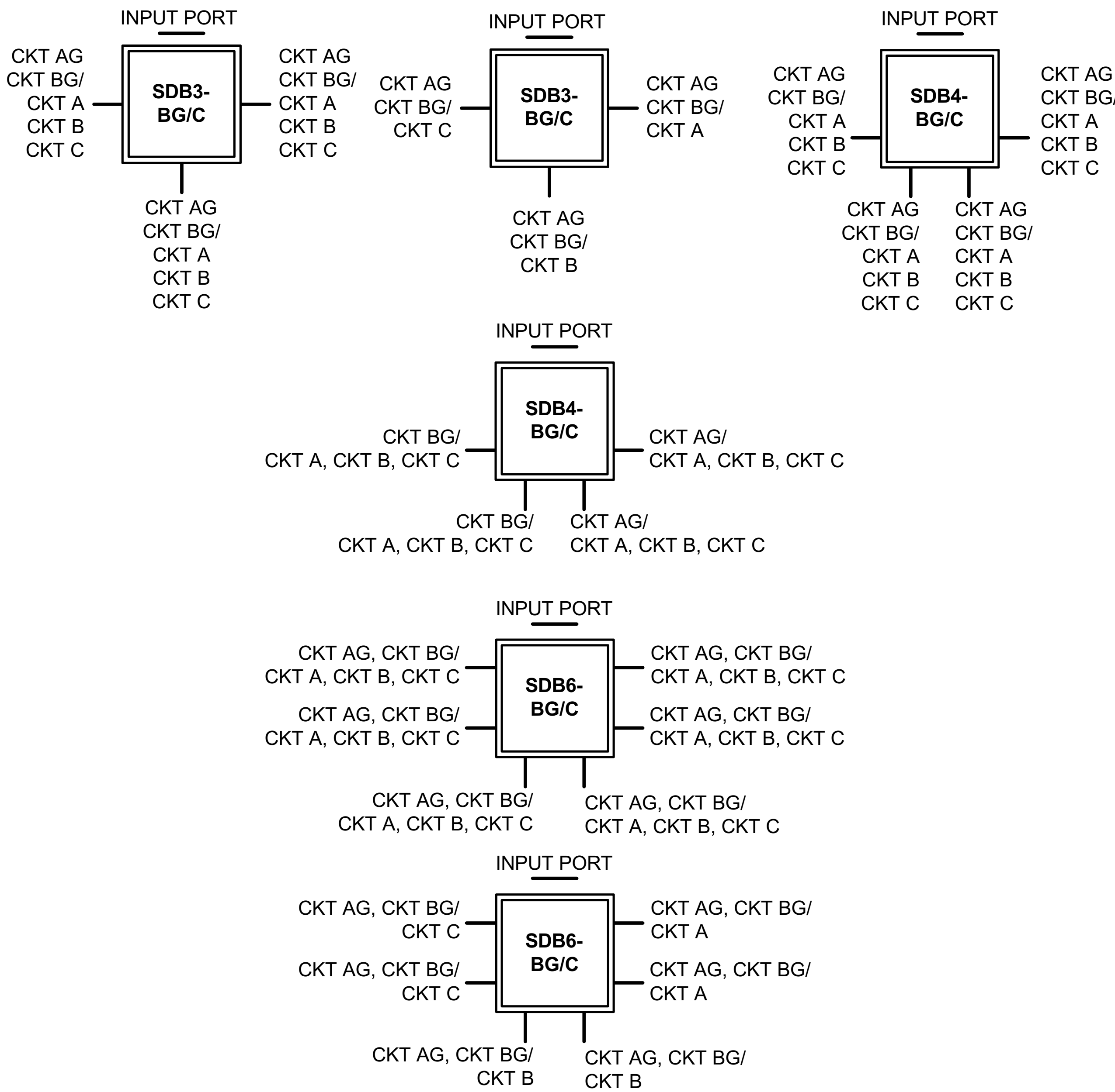
BG/B" Circuitry

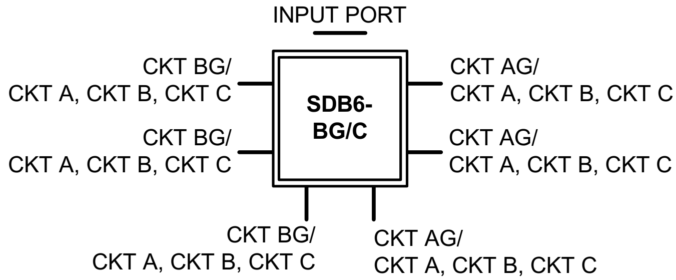
The "BG/B" circuitry is used with the "2+2" 8-wire circuitry used in modular furniture. The standard dual-port SDBs in "BG/B" circuitry configurations are shown below.

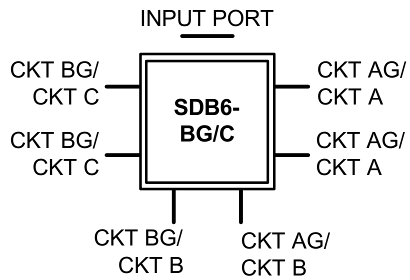


BG/C" Circuitry

The "BG/C" represents the maximum number of circuits possible in the standard 10-pole connector. This also allows a number of variations in the SDB circuitry. The standard dual-port "BG/C" MDBs are shown below.







Putting It All Together

Well, now! How does one pick out the *optimal* system from all of these choices? Don't fret: I believe that there are many possible ways of configuring an excellent wiring system from all of the MDBs and SDBs offered and none of those excellent systems is any more right than the others. Sometimes, it comes down to a matter of design style. When you look at a Frank Lloyd Wright building, you can tell it has a distinctive style. When you see an Apple computer, you can tell that it too has a distinctive style. Two different designers may look at a space and select from the MDBs and SDBs to configure two completely different modular wiring systems because they have developed different styles that work best with the particulars of their local conditions.

In the end, though, the optimal system may be determined based on the installed system cost. Even in the case of saturation wiring, consider these design tradeoffs that will affect the cost of the system.

Custom MDBs and SDBs

As we discussed before, it costs more and takes longer to get something that is customized just for your design. Stick to the standard systems and you'll keep your cost and schedule frustrations to a minimum.

Excess Home Run Cable Length

Although this is rarely a problem, be aware of the distance from the panel to the MDB. The standard home run cables carry #10 conductors and #8 neutrals and they can run quite a distance, but don't try to stretch them too far. Consider your panel placement to avoid a circuitous path to the panel that would cause excessively long home run cables or force the use of a non-standard home run cable.

Excess Spare Capacity

Although your mother bought you pants with room to grow, she probably didn't make you wear a pup tent cinched at your waist! So, don't design in too much spare capacity. A larger number of circuits per MDB may seem like a better distribution of the available power because it requires fewer MDBs and thus less labor to install the boxes in each zone. Nevertheless, an over-sized MDB may carry excess spare capacity. The more spare circuits that are included in each MDB, the more breakers and panels you'll need.

Watch out for the number of workstations per circuit. Don't let the circuits get overloaded by having too many workstations on each, but don't forget that office equipment is getting more and more efficient. A few years ago, computer power supplies were regularly sized to deliver 300W, but now they're usually half that and low-power flat panel displays are more common. Choose MDBs or use SDBs to split circuits between workstations where it makes sense.

Doggie Bag

Finally, allow me just offer a couple of tidbits to take home in your doggie bag. Designing an electrical system to use a modular wiring system isn't that different from designing to use a wiring system that would be manufactured on the construction site. Don't be intimidated by the abundance of choices; enjoy the possibilities. I encourage you to dive in, mix and match MDBs with SDBs, and practice configuring systems on spaces you've already designed and built. Try designing it into building projects one zone at a time. In time, you'll find your own style and standard MDBs and SDBs to help you achieve your design vision.

Questions? Did you find this article useful? For further information or to discuss the author's conclusions, please call Hal M. Mueller at 1-800-426-3170 or 508-985-4150
or send email to hal@acs-mail.com.