# ADAM™

# DBX

AIO-8 Port Cards

# Dual Bus Expander

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TELEX®

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### DBX Wiring and Communications

The DBX cards in all systems are wired such that if you could unplug the DBX cards with their port wiring intact and lay them out on the ground untangled, the DBX cards and the wiring connections would form a giant circle.

If all the links in a DBX system are up and running, it is possible for a DBX card to send a message out its PORT A, and receive the same message back on its PORT B after the message had passed through every other DBX card in the system (assuming that every card that received a message on one port then transmitted the message on its other port).

The purpose of this configuration is to allow any DBX card to have at least two paths to every other DBX card using coax only. A card can transmit out either of its ports to reach another card as long as all links are up. If a single link goes down (a link being a pair of coax cables for TX and RX), every card can still reach every other card using coax only by going out either its PORT A or its PORT B since a broken circle still has all the points connected by a single line.

Only when two or more links are broken is it possible to isolate one or more DBX cards from the other cards on the coax, but even in this case it is often possible to reach the isolated cards (which will be described later).

A DBX card can transmit and/or receive messages on either of its ports, as well as the control bus. However, a DBX card only transmits on the control bus to the destination card (the card who is the ultimate target of the message). All messages transmitted by a DBX card go out one of its ports, unless the target card is in the same frame as the DBX card, in which case the DBX card will use the control bus to make final delivery of the message.

This means that the “active” DBX card in the first frame can send a message to any DBX or AIO card in the system, as long as it has a coaxial path to the destination frame. If the “active” DBX card can reach the destination frame via coax hops, then the message can be delivered on the control bus by the DBX card in the destination frame.

This does NOT guarantee, however, that the destination card can send a message back to the “active” DBX card in the first frame. Each slave frame has an “active” DBX card who is responsible for polling the AIO cards and reporting status changes to the “active” DBX card in the first frame. All the AIO cards in a slave frame keep track of the “active” DBX card in their frame, and messages that need to go to the first frame are sent to the “active” DBX card in the slave frame for forwarding.

The asymmetry in message paths occurs because the DBX card in the slave frame, which delivered a message to the AIO card, may not be the “active” DBX card. The “active” DBX card may not have a coaxial path to the first frame, even though the “active” DBX card in the first frame does have a coaxial path to the destination frame. For this to occur, there has to be more than one link failure.

It might be possible to allow intermediary control bus hops in routing a message, however, the number of possible message routes becomes enormous, and it requires that every DBX card be aware of the link status of every other DBX card which becomes extremely difficult to do when you are trying to use link status to determine message routing, but you need to use message routing to pass link status back and forth.

An even worse consequence of allowing arbitrary message routing is that it becomes difficult to predict the order of arrival of transmitted message. In the case of crosspoint messages, the order is critical; suppose two messages are sent, one to turn a crosspoint on, the other to turn it off; now suppose the messages end up taking different routes because of a link status change, and the second message arrives first. The AIO card that receives the messages turns the crosspoint off (it already was off), and then turns it on, and the crosspoint is left in the wrong state!

### Failure Modes

In general, communications between two frames (called control) can occur when the "active" DBX card in the first frame has a coaxial path to the destination frame, AND the "active" DBX card in the destination frame has a coaxial path to the first frame.

Audio between frames will exist as long as there is a single valid link between the two frames. In redundant systems, there are two links between each frame, so losing either one will not affect audio (aside from a small glitch as the fault is recognized and corrected). In non-redundant systems, there is only one link between each frame, so if it goes down, the audio between the two frames is lost.

Control in a frame (i.e. the ability to talk to keypanels and act on keypresses) will exist as long as there is a coaxial path between the frame and the "active" DBX in the first frame, AND, there is a coaxial path between the "active" DBX in local frame and the first frame.

If a frame loses contact with the first frame, the crosspoints that have already been made will stay. If contact is restored before any critical messages need to be sent (such as crosspoints or key presses), the frame will resume normal operation. If a critical message needed to be sent but couldn't be delivered, the frame's panels will go to (****) and come back when contact is finally restored.

In a redundant system, it is possible to pull any one DBX card, or cut any one link (RX or TX or both), and the system will continue to operate normally (other than a small glitch in audio as faults are detected and the redundant resources kick in). It is even possible to pull other DBX cards, and/or cut other links without adversely affecting system operation, as long as there is at least one link between each frame (to provide audio), and as long as the "active" DBX cards in each slave frame have a valid coaxial path to the first frame, and the "active" DBX card in the first frame has a valid coaxial path to each slave frame (to allow for control operations).

In a non-redundant system, the same rules for control apply, however every cut link causes the audio between the affected frames to be lost, and every pulled DBX card loses the audio between that frame and the two frames it was connected to. This is because every link in a non-redundant system carries audio.

If a frame was completely isolated because all its links were down, any crosspoints that already existed within the frame would stay made, but no new crosspoint changes could occur.

Lastly, every frame needs at least one DBX card to operate because the DBX cards provide the clock to the frame and, as with SBX systems, slave frames must have at least one link up that can trace its clock origin back to the first frame in order for the audio in that frame to be synched to the audio in other frames.

# ADAM Dual Bus Expander (DBX)

## Definitions

Here are some definitions and explanations, followed by system sizes.

**Redundancy:** We talk about DBX systems as being either "Redundant Audio", or "Non-Redundant Audio" where we've defined redundant audio as meaning that it is possible to cut any one DBX coaxial link without losing any audio between frames.

In order for redundant audio to exist, there must be two coaxial links between every pair of frames. In a three frame system, that means two links between frames 1 and 2, two links between frames 2 and 3, and two links between frames 1 and 3 (or six links in total). A non-redundant three frame system needs only one link between each pair of frames, (1-2, 2-3, and 1-3, or three links in total).

When there are two links between a pair of frames, only one link is required to pass audio (although both carry the audio between frames, the audio is only used from one link). So, if one link is cut, the other link can immediately be used to provide the same audio.

Because a DBX card can connect to two other frames, both ports on a DBX card are only needed when there are an odd number of frames. When there are an even number of frames, there will be one DBX card in each frame that has a port that is unused. However, since our message passing scheme requires that all the DBX cards be connected in a big loop, the unused ports on the DBX cards are connected to each other anyway which leads to "Partial Redundancy" of audio in systems with an even number of frames.

For instance, the 4 frame "Non-Redundant Audio" system (480x480) is actually "Partially Redundant" because there are two links between frames 1 and 2, and two links between frames 3 and 4. Similarly the 6 frame "Non-Redundant Audio" system (672x672) is also partially redundant because there are two links between frames 1 and 2, between frames 3 and 4, and between frames 5 and 6.

These configurations are partially redundant because you can cut a link between frames 1 and 2 (or frames 3 and 4, or frames 5 and 6) without losing any audio, but cutting a link between frames 2 and 3 (for instance) would cause a loss of audio between those frames.

**Link:** A connection between two DBX cards consisting of 2 coaxial cables (one for TX and one for RX).

**Path:** A way to get from one DBX card to another by travelling only on links (not on the control bus). A path consists of a series of connected DBX cards. A message travels along a path when it is received by a DBX on one port, and transmitted by the same DBX card on its other port. The DBX intercom wiring scheme creates one long circular path between all the DBX cards. This allows the circular path to be broken (by removing one link), and yet still allow a continuous path between all the DBX cards. This gives us fault tolerance for messaging, in that any ONE link can fail without preventing any messages from being delivered.

**Active DBX:** One DBX card in each frame is the Active DBX. The Active DBX card will be in either slot 8 or slot 9. In the first frame, the Active DBX card is in charge of the entire intercom. It handles crosspoints, volumes, and all intercom functionality. It is the only DBX card which originates messages to AIO cards. In a DBX system, the Active DBX card in the first frame plays the role normally played by the Active MC in a standard intercom. In a slave frame, the Active DBX is the contact point for AIO cards trying to send messages back to the Active DBX in the first frame.

**Control:** The ability of the Active DBX in the main frame to send messages to, AND receive messages from, AIO cards in slave frames. In order to send a message from one frame to another, a DBX card must have a continuous coaxial path from its frame to the destination frame. Note that because, in most cases, there are more than one DBX card per frame, it is possible for a message to be received by a DBX card in the destination frame and delivered to the target AIO card on the control bus even if that DBX card isn't the Active DBX card in that frame. A return message generated by the AIO card would be transmitted to the Active DBX card in its frame for delivery via a continuous coaxial path to a DBX card in the first frame who will then deliver the message to the Active DBX card in the first frame on the control bus (assuming that the DBX card in the first frame that received the message on one of its ports isn't already the Active DBX). This means that the message routing between an AIO card in a slave frame and the Active DBX card in the first frame is not symmetrical. Depending on which links are up or down, it may be possible for the Active DBX card to transmit to an AIO card, but impossible for the AIO card to send a return message (or vice-versa). So, in order for there to be "Control" between the first frame and a slave frame, there must be a valid continuous coaxial path between the Active DBX card in the first frame and any DBX card in the slave frame, AND, a return path between the Active DBX card in the slave frame, and any DBX card in the first frame.

When there are at least two DBX cards per frame, we have "Redundant Control", in that any ONE DBX card can fail, and another DBX card will take over for the failed card. In systems with only one DBX card per frame, there is no redundant control.

**Audio Clock:** There is only one master clock used for audio in the entire intercom. This clock is provided by one of the cards in slot 8 or slot 9 in the first frame (usually a DBX card, although it could be an AIO card in slot 8 in systems that have only 1 DBX card per frame). In order for stable audio to be present in a frame, it must have access to the master audio clock. The audio clock is passed from the first frame to slave frames via the links. A slave frame with a valid direct link to the first frame from a DBX card in slot 8 or slot 9 will always have access to the audio clock. The audio clock can also be passed from one slave frame to another if the link between the slave frames has the proper link master/slave relationship, and the link slave card is in slot 8 or slot 9 of the second slave frame (the DBX cards will always try to create links with the proper orientation of the links).

**Audio:** There will be stable audio between frames if both frames have a valid audio clock, AND there is a valid link between the frames

If both of the frames also have "control" (i.e. round-trip communications with the Active DBX card in the first frame), then the audio between frames is "dynamic", meaning that crosspoints between the two frames can change dynamically when keypanel keys are pressed or other intercom events occur. If one frame has "control", but the other doesn't, then ports in the frame with "control" will be able to listen to ports in the other frame, but not talk to them. The frame without control will have "static" audio, meaning that only crosspoints that existed before control was lost will still exist, and that no new crosspoints can be made until control is restored.

If "control" between the first frame and a slave frame disappears for more than about 5-10 seconds, then the panels in the slave frame will "go to stars". This will happen sooner if there are any "important" messages that need to be sent between frames, but that cannot be delivered. "Important" messages are things like key presses or crosspoint closures. The panels are forced to stars when "important" messages are missed in order to ensure that all crosspoints are in the correct state when "control" is restored.

When there are two links between each frame we have "Redundant Audio", in that any ONE of the two links between two frames can fail and the audio between the frames can still be carried on the other link.

In a redundant audio system, it is possible to pull any one DBX card, or cut any one link, and the system will continue to operate normally (other than a small glitch in audio as faults are detected and the redundant resources kick in). It is even possible to pull other DBX cards, and/or cut other links without adversely affecting system operation, as long as there is at least one link between each frame (to provide audio), and as long as the Active DBX cards in each slave frame have a valid coaxial path to the first frame, and the Active DBX card in the first frame has a valid coaxial path to each slave frame (to allow for control operations).

In a non-redundant audio system, the same rules for control apply, however every cut link causes the audio between the affected frames to be lost, and every pulled DBX card loses the audio between that frame and the two frames it was connected to (because every link in a non-redundant system carries audio).

**Test Audio:** "Test Audio" is artificially generated audio by the SBX/DBX that it can produce, publish, forward, receive, and test. It is used by the SBX/DBX to ensure that the links are passing valid audio between frames. If the SBX/DBX detects that the link is up, but that the audio is corrupt (which does occur), the SBX/DBX tears down the link and builds it up again (which almost always solves the problem).

The need for Test Audio was discovered when the SBX was introduced. It was observed that it was possible to bring up the coax link with valid frame sync, but that no audio would be produced. The same situation occurs with the DBX cards. Test audio allows the SBX/DBX cards to detect when the link is not passing audio even when the frame sync is o.k.

The use of Test Audio is necessary to ensure that the coax links are properly passing audio, however, the use of Test Audio also can affect the number of available ports in some system configurations.

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An SBX/DBX link can forward 128 timeslots, but Test Audio requires 4 timeslots per link. In the 256x256 (2 frame SBX or DBX), and 384x384 (3 frame DBX) systems which have only 1 SBX/DBX card per frame, all timeslots per link are needed for real audio, but if Test Audio is enabled, the last 4 timeslots in each frame are not available, which means that only 124 timeslots of real audio can be passed between frames.

This means that the last four ports in each frame can listen to, but not talk to ports in other frames. Similarly, ports in other frames can talk to, but not listen to the last four ports in each frame. Within any frame, any port can talk or listen to any other port in that frame, the timeslots are only lost going between frames.

**Partial Redundancy:** (4 & 6 Frame Non-Redundant Systems only) Consider the 4-frame non-redundant system. Each frame requires 3 links - one to each of the other frames. That requires 2 DBX cards, which gives us 4 links, i.e. one spare link per frame. The wiring table is such that there will be 2 links between frames 1 & 2, and 2 links between frames 3 & 4; there is a single link between each other pair of frames.

Similarly, the same condition exists in the 6 frame non-redundant system. Looking at the wiring table it can be noticed there are 2 links between frames 1 & 2, 2 links between frames 3&4, and 2 links between frames 5&6 and single links between each other pair of frames.

The DBX system will handle these links automatically: if one link fails, the other link automatically provides the audio.

## System Sizes:

### 2 Frame Non-Redundant
- 256 x 256 with Test Audio disabled.
- 2 DBX cards total (1 per frame).
- 4 coax interconnections.
- this system actually has redundant audio on its two links,
- however, it does not have redundant control.
- Losing one link has no effect.
- Losing the slave DBX means losing frame 2.
- Losing the master DBX means losing the whole intercom.

### 2 Frame Redundant
- 240 x 240 with or without Test Audio.
- 4 DBX cards total (2 per frame).
- 8 coax interconnections.
- This system has both redundant control and redundant audio.
- Any one of the four links can carry all the audio.
- Losing one DBX in each frame has no effect.
- Losing up to three links has no effect,
  (as long as the Active DBX has at least one link up).

### 3 Frame Non-Redundant
- 384 x 384 with Test Audio disabled.
- 372 x 372 with Test Audio enabled *.
- (384 ports, but only 124 ports per frame have full connectivity).
- 3 DBX cards total (1 per frame).
- 6 coax interconnections.
- No redundant audio or control.
- Loosing a slave DBX card means losing a frame.
- Losing the master DBX card means losing the whole intercom.
- Losing a link means losing audio between two frames.

* The last 4 ports per frame are not available across frames for normal intercom use due to Test Audio enabled. These ports, however, may be used as monitor outputs only if desired.

For all systems that follow, the failure modes are described in the previous discussion of **Control** and **Audio**.

### 3 Frame Redundant
- 360 x 360 with or without Test Audio.
- 6 DBX cards total (2 per frame).
- 12 coax interconnections.
- redundant control and audio
- Loosing any single DBX card has no effect.
- Loosing any single link has no effect.
- Loosing either Master Controller in primary frame has no effect.
- If both Master Controllers in primary frame are lost the intercom will remain functional, however, the following peripheral devices will be dysfunctional:

| | |
|---|---|
| PAP(s) | Trunk Masters |
| UIO256s | ADAMedit |
| LCP(s) | Programming from keypads at panels |

In general, any keypanel which was operational prior to a failure such as this will retain its functionality within the intercom.

The above also applies to any multi-frame redundant system.

### 4 Frame Non-Redundant
- 480 x 480 with or without Test Audio.
- 8 DBX cards total (2 per frame).
- redundant control.
- partially redundant audio.
  (there are two links between frames 1 and 2, and also between frames 3 and 4).

### 4 Frame Redundant
- 448 x 448 with or without Test Audio.
- 12 DBX cards total (3 per frame).
- redundant control and audio.

### 5 Frame Non-Redundant
- 600 x 600 with or without Test Audio.
- 10 DBX cards total (2 per frame).
- redundant control.
- no redundant audio.

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### 5 Frame Redundant
- 520 x 520 with or without Test Audio.
- 20 DBX cards total (4 per frame).
- redundant control and audio.

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### 6 Frame Non-Redundant
- 672 x 672 with or without Test Audio.
- 18 DBX cards total (3 per frame).
- redundant control.
- partially redundant audio.
  (there are two links between frames 1 and 2, frames 3 and 4, and also frames 5 and 6).

### 7 Frame Non-Redundant
- 784 x 784 with or without Test Audio.
- 21 DBX cards total (3 per frame).
- redundant control.
- no redundant audio.

### 8 Frame Non-Redundant
- 832 x 832 with or without Test Audio.
- 32 DBX cards total (4 per frame).
- redundant control.
- partially redundant audio (not detailed yet).
- NOT CURRENTLY SUPPORTED IN DBX FIRMWARE.
- NO WIRING TABLE HAS BEEN GENERATED.

### 9 Frame Non-Redundant
- 936 x 936 with or without Test Audio.
- 36 DBX cards total (4 per frame).
- redundant control.
- no redundant audio.
- NOT CURRENTLY SUPPORTED IN DBX FIRMWARE.
- NO WIRING TABLE HAS BEEN GENERATED.

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