CREATING YOUR OWN RF SWITCHING SYSTEM

Abstract
The purpose of this Application Note is to introduce an alternative way of meeting switching needs by showing how to design your own RF switch solution using Dow-Key CANBus Switches together with a Dow-Key Switch Controller Kit. A bottom-to-top approach is taken to introduce the full integration solution.

Introduction
Dow-Key Microwave provides a flexible and creative solution to design and interface your own switching system using Dow-Key RF CANBus switches together with a Dow-Key Switch Controller Kit. It provides the means to create coaxial, CANBus RF switching systems controlled over Ethernet, GPIB, RS232, or RS422 interfaces. Our solution serves as an alternate way to meet design needs by putting together a switching system using Dow-Key building blocks.

Dow-Key Building Blocks
We present a building block approach to create a switching system on your own. This approach is easily achieved in four simple steps. First, select the appropriate RF switch with CANBus driver (Step 1). Second and third, integrate the switches using the patch panel (Step 2) and a GPIB or Ethernet translator board (Step 3). Lastly, write your own software using the provided commands (Step 4). Let us discuss these blocks in further details.

Step 1: CANBus Switch and Topology Integration
Dow-Key offers CANBus electromechanical switches in DPDT (transfer), SP3T, SP4T, SP6T, SP8T, SP10T, and SP12T configurations (see Figure 1). These switches have a CANBus driver board internally, which uses CANBus protocol to communicate either with the GPIB or the Ethernet translator board.

CANBus stands for Controller Area Network and it is a bus that transmits/receives data serially. Figure 1 shows the CANBus interface on the back of a Dow-Key switch. This interface features a high-speed communication rate of 10 Kbits/second, real-time control, fault confinement, and error detections and signaling. These attributes make the communication reliable in noise-critical environments such as switching systems. In addition, the serial bus provides a very easy way of cascading and interconnecting switches. Furthermore, the total switching speed of a CANBus switch is considered from the moment a command is given and to the moment the command has been executed. Knowing why CANBus controlled switches are used, let us take a closer look at the type of switches that are designed with this purpose.

Switch Topology Example
Figure 2 shows two possible switch configurations—(a) 4/10 configuration with individual switch topology and (b) a 10x10...
Table 1: Dow-Key CANBus Switches

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>431KL-420823N</td>
<td>Radial Switches with CAN Interface, Mechanical Indicator, 50 ohm Termination</td>
</tr>
<tr>
<td>441KL-420823N</td>
<td>SP4T, Latching Self Cut-Off, DC- 26.5 GHz, 12 Vdc, SMA</td>
</tr>
<tr>
<td>461KL-420823N</td>
<td>SP6T, Latching Self Cut-Off, DC- 26.5 GHz, 12 Vdc, SMA</td>
</tr>
<tr>
<td>581-420853N</td>
<td>SP8T, DC-18 GHz, Normally Open, 12 Vdc, SMA</td>
</tr>
<tr>
<td>5A1-520802N</td>
<td>SP10T, DC-18 GHz, Normally Open, 12 Vdc, SMA</td>
</tr>
<tr>
<td>5C1-420853N</td>
<td>SP12T, DC-18 GHz, Normally Open, 12 Vdc, SMA</td>
</tr>
</tbody>
</table>

Non-blocking crossbar switching matrix. A crossbar matrix means that any input can be connected to any output at one time. The figure illustrates how one can use SP10T switches, 5A1-520802N, to build up a matrix such that either each input goes to 10 outputs as shown in (a) or how ten inputs can be switched to all ten outputs, but only one at the time (b). The same idea can be applied to all other CANBus switches. Thus, each unique design may be using any of the available CANBus switches.

**Transfer Switch Topology**

Dow-Key’s CANBus transfer switch provides further design flexibility by allowing it to be used in four different ways; simple transfer, dual SPDT, externally terminated SPDT, or bypass transfer switch. Figure (3a) shows the simple transfer switch which allows two signals to be transferred (or switched) at the same time, if desired, as shown in (3b). It can also be used as a dual SPDT transfer switch by inserting signals at the opposite side of each ‘corner’ as shown graphically (3b). However, one has to be careful to allow enough time for the switch to latch before switching to the next position. Otherwise, the switch may switch one path and keep the previous path to the same output and hence cause a mismatch RF signal at the switched output. Furthermore, one of the input/outputs can be externally terminated and thus make the transfer switch to act as a SPDT switch.

The last configuration is known as a bypass transfer switch. Although this can also be used as a SPDT switch, it is more often used to bypass an RF path as shown in (3c). This means that at position 1 (J1), the signal will go directly to the output (J3), while on the contrary at position 2, the RF path will be re-routed through an addition circuitry (not shown) connected between J2 and J4 and routed out to the output J3. Hence, the name bypass transfer switch.

![Diagram of Dow-Key SP10T CANBus Switches](image-url)
Note that since these switches communicate over CANBus protocol, each switch is recognized by a unique address. Hence, if a design contains more than one switch each switch needs to be configured to a unique address. It can either be done upfront by Dow-Key or through an Address Configuration Box (P/N 5060) which can be purchased separately to allow the user to configure each switch to a unique address. The CANBus driver supports up to 8-bit address which in turn allows up to 255 unique addresses.

Step 2: Patch Panel Integration

Now that various CANBus switches have been introduced and their usage explained, let us take a closer look at how the CANBus interface is integrated. The black board in Figure 4 is referred to as the Patch Panel. Its purpose is to plug in each CANBus switch via a RJ-11 cable into this board.

![Figure 4: Patch Panel CANBus Integration](image)

The patch panel needs to be powered up by +12 Vdc that will not only power up this board but also provide power to the switches and translator board as well. The power supply is not provided by Dow-Key and is not part of any kit. A 110-220 Vac power supply at a frequency of 50-60 Hz down converted to +12 Vdc is suggested. Also, it is strongly recommended to incorporate a power fuse protection in the design.

Step 3: Translator Board Integration

The brain of the integration lies in the translator board. It is a PCB board with a microcontroller that has the firmware that controls each CANBus switch via its unique designated 8-bit address. This board also allows the user to transmit/receive data via three different communication interfaces: Ethernet (TCP/IP) or GPIB (IEEE-488), RS-232, and RS-485. There are two different kits available, an Ethernet Translator Board (P/N 5188) and a GPIB Translator Board (P/N 5189).

Ethernet Translator Board Kit (P/N 5188)

The Ethernet interface transmits/receives data over TCP/IP protocol through 10base-T and 100base-T network (default setting) such as a LAN (Local Area Network) via a RJ-45 Ethernet cable.

Note that the supported maximum communication speed is 100Mbit/s at both half-duplex or full-duplex communication, and it does not support 1000base-T network.
A RJ-45 cable exists in two types: a “straight-through” cable or a “crossover” cable.

- To connect your Ethernet Translator Board to a LAN hub, a “straight-through” cable is required.
- To connect directly to a computer, a “crossover” cable is required.

A straight-through RJ-45 cable is provided in the Ethernet Kit. Figure 5 shows the actual Ethernet Translator Board with Ethernet, RS-232, and RS-485 connections.

The GPIB interface transfer data up to 1 Mbyte/s, which is slower compared to the Ethernet protocol, but this can be extended by using for instance the NI-GPIB-USB-B or NI-GPIB-USB-HS interfaces (provided by National Instruments) to 1.8 Mbyte/s or up to 7.2 Mbyte/s using HS-488 a.k.a. IEEE-488.1. Figure 7(a) shows the NI-GPIB-USB-B interface with a 24-pin connector on one end (needs to be attached to the GPIB ribbon cable) and with USB 2.0 connector on the other end (goes to the PC).

(a) GPIB Translator Board

(b) GPIB 24-pin Ribbon Cable

**GPIB Translator Board Kit (P/N 5189)**

The GPIB Translator Board communicates via a parallel General Purpose Interface Bus, also known as IEEE-488. The GPIB protocol allows for basic syntax and format convention as well as device-independent commands, data structures, and error protocol. Figure 6(a) shows the GPIB Translator Board with IEEE-488, RS-232, and RS-485 interfaces that are provided in the 5189 Kit. A GPIB ribbon cable with connectors is also supplied, which is shown in 6(b), but needs to be assembled by the user. It is required to attach the female-connector to the translator board and the male connector goes to a GPIB interface on the PC.

Note that this GPIB interface cable is not provided by Dow-Key, but is recommended to use (see Figure 7b). More information on this can be found on National Instruments website.

**RS-232 and RS-485 (Optional Interfaces)**

These two interfaces are provided on both translator boards and are optional to use. Both RS-232 and RS-485 communicate in serial, but the difference between them lies in the following:

RS-232 is point-to-point serial interface. The transmitting data (Tx) is transmitted one way while the receiving data (Rx) is transmitted in the opposite direction. Since the Tx and Rx paths are separated, the interface can operate in a full duplex mode such that it supports concurrent data flow in both directions.

(a) GPIB Translator Board

(b) GPIB 24-pin Ribbon Cable

**Figure 6: GPIB Translator Board and GPIB 24-pin Ribbon Cable with connectors**
RS-485 on our translator boards is a 4-wire serial interface that allows the communication to be operated in full-duplex mode.

Both interfaces are supported by Hyper Terminal; the most common Telnet communication tool provided on computers with Windows operating system and therefore it is recommended to use. The Dow-Key default baud rate for both interfaces is 9.6 kbps.

The IP address, subnet mask, gateway address, and TCP port for the Ethernet connection can be set or modified through RS-232 or RS-485 interfaces.

**WARNING:** If multiple patch panels are used, straight-through RJ-11 cables (not provided) must be used between each patch panel.

**Ethernet Integration and Interconnection in Summary**

*Figure 8 (a top level view)* and *Figure 9* shows how the parts need to be integrated together in order to create a switching system. In few steps a complete system can easily be created:

1) Select the type of switches needed using *Table 1*.
2) Use RJ-11 crossover cables to connect each CANBus switch to the path panel.
3) Connect the Patch Panel via another RJ-11 crossover cable to the Ethernet translator board.
4) Use RJ-45 cable for Ethernet connection.
5) Power up the system by only connecting a +12 Vdc to the Patch Panel. See warning for using multiple patch panels.
6) Use provided Software Commands to communicate with the CANBus switches directly.

**Ethernet Kit - Part Number: 5188**

Let us take a closer look at the Ethernet Kit in terms what it contains and how it shall be used for integration.

**Kit Part Number: 5188**

1) Ethernet Translator Board (firmware included)
2) Patch Panel (can interface up to 11 CANBus switches). See warning for using multiple patch panels.
3) RJ-11 crossover cables.
4) Feet of a ‘straight-through’ RJ-45 cables.
5) Phoenix connector plug (used for connecting the +12 Vdc wire coming out of a power supply)

*Figure 9* shows the interconnections in more details. Use the photo as an guidance in assembling the kit.
GPIB Kit - Part Number: 5189

The GPIB Kit is assembled in similar way as the other kit, but it contains different cables and Translator Board.

Kit Part Number: 5189

1) GPIB Translator Board (firmware included)
2) Patch Panel (can interface up to 11 CANBus switches). See warning for using multiple patch panels.
3) RJ-11 crossover cables.
4) Feet of a GPIB ribbon cable.

Communication with each switch via a translator board is available using sets of software commands (SCPI). Two specific Software Configuration Application Notes have been created for each kit (ENET or GPIB remote communication interface). Please refer to respective Application Note for detail instructions on how to communicate with CANBus switches.

Conclusion

This Application Note has guided the user from selecting CANBus switches to integrating a complete switching system. The solution presented involves Dow-Key switches, Patch Panel, specific Translator Board, and sets of Dow-Key software commands. By purchasing either the ENET-KIT or the GPIB-KIT together with CANBus switches, one has the freedom and the flexibility to design any type of switching solution imposed by design requirements.

For technical support contact Dow-Key Microwave

Toll Free: (800) 266-3695 or Direct: (805) 650-0260

WARNING: If multiple patch panels are used, straight-through RJ-11 cables (not provided) must be used between each patch panel.

Figure 10: GPIB Switch System Integration Interconnections

(1) Phoenix connector plug (used for connecting the +12 Vdc wire coming out of a power supply)

Figure 10 shows the interconnections in more details. Use the photo as an guidance in how to assemble the kit.