Remote Control of Industrial Measurement and Test Automation Applications

Summary: This article explains the benefits of using remote BNC switch boxes or multiplexers in industrial or production line applications. A practical example with C pseudo code is included in this article.



This article is related to the following products:

- LinkBone 1-to-15 BNC switch
- LinkBone 1-to-15 Dual BNC switch
- LinkBone 1-to-15 XLR switch

Designing an automated electronic measurement system can be a complicated task. Modern hardware test stands or test environments require fast and reliable measurements at a high number of test points. Today's electronic prototype systems can have more than 100 inspection test points. Often designers make manual measurements in most critical system points, but this does not guarantee complete test coverage. Another approach is to use automated test systems where measurements are made via a remote PC executing a test script. The disadvantage of such systems is a need to allocate one measurement instrument to each test point resulting in an overall high system cost. To avoid such a situation remotely controlled BNC switch or BNC multiplexer box can be used. Figure 1 shows an example system. The primary measurement instrument is connected to the common output of the multiplexer switch. The Device Under Test (DUT) measurement points are connected to the inputs of the multiplexer. Control of the measurement instruments and switch is done via remote PC executing test procedure.

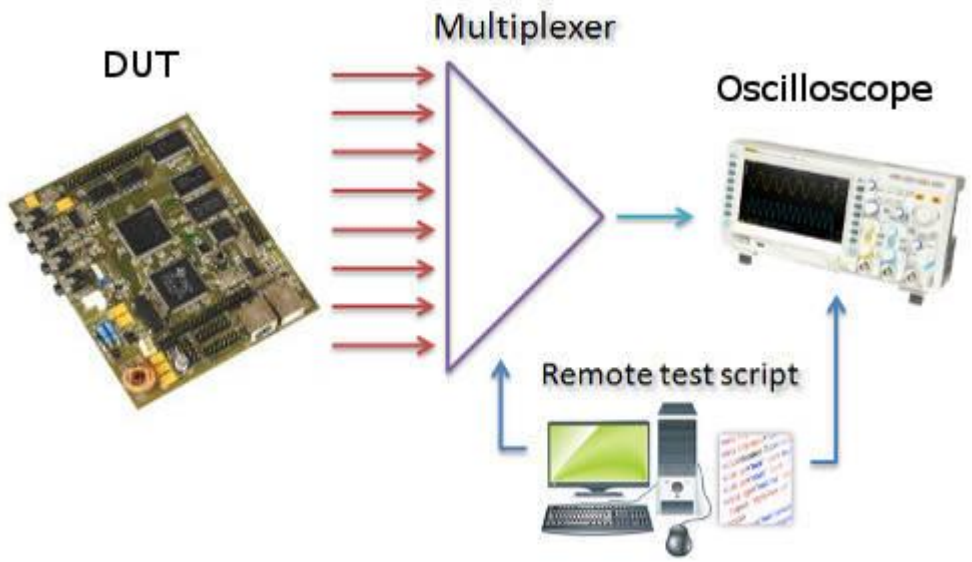


Figure 1: Analog multiplexer switch box routing test signals into an oscilloscope.

LinkBone 1-to-15 Remote BNC Switch/Multiplexer

A perfect example of an analogue BNC switch/multiplexer designed for routing digital and analogue signals is the **LinkBone 1-to-15 BNC Switch box**. Test signals are being routed from the common port to a set of fifteen ports. **Gold plating** of internal switching contacts ensures very low resistance and failure rate. To maximize contact life time all switching contacts are cut off from the external atmosphere to prevent corrosion and oxidation. The state of internal switches does not change after interruption or disconnection of power supply, limiting power consumption in standby mode to a minimum. LinkBone instruments' architecture provides high switching reliability for a wide range of input signals, voltage levels and current values.

Characteristics of LinkBone Remote BNC Switch box signal ports:

- **+/-24V** input/output voltage range
- Up to **1.5A** load per channel
- **DC** to **50Mhz** bandwidth
- **50Ω** channel impedance
- **Bidirectional** signal routing
- **BNC** and **XLR** switch port configuration

The block diagram illustrating the internal connection network of the BNC switch box is shown in figure 2. Each port marked with a letter from A to O includes individual signal switches allowing connection to common node P. Each switch state is set by the user independently. All lines can route electrical signals bidirectionally between ports. Meaning that port P can be connected to the signal source, and ports from A to O can be connected to receivers or vice versa. To prevent the accumulation of electrostatic charge, which might damage connected devices, each port is connected to the ground via a 5.1 MΩ resistor.

Due to the internal construction of signal ports, there are two LinkBone Switch types available:

- **Single 1-to-15**: each port contains only one line for routing electrical signals
- **Dual 1-to-15**: each port has two symmetrical lines for routing electrical signals with numbers 1 and 2 (e.g. for stereo audio or differential signals). The dual switch device variant allows switching up to thirty ports to two common connection points.

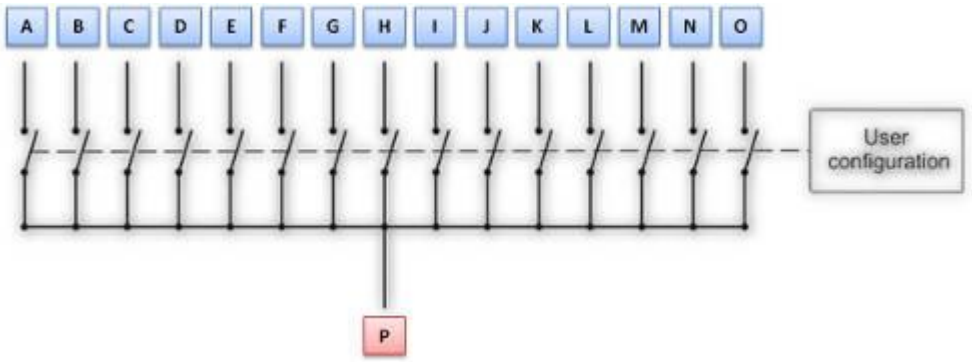


Figure 2: Schematic of internal connection network of 1-to-15 remote BNC switch box

The LinkBone BNC switch box can operate in two modes:

- **single** – only one out of A to O ports can be connected to common port P simultaneously. The BNC switch operates as a classic analogue multiplexer/demultiplexer in this configuration. All ports are disconnected before the switch state change to protect connected instruments from short circuits during switching.
- **multi** – there is no limit of ports connected to node P. Meaning that more than one port can be connected to port P simultaneously.

BNC Switch Box Remote Control Application

The example setup using the BNC multiplexer switch is shown in figure 3. The oscilloscope on the right side of the drawing monitors the system power supply, the system clock coming from the waveform generator and selected DUT test points. The measurement points are routed to the oscilloscope using the LinkBone switch in the BNC multiplexer configuration. The measurement sequence is controlled via a remote PC with a test script/program.

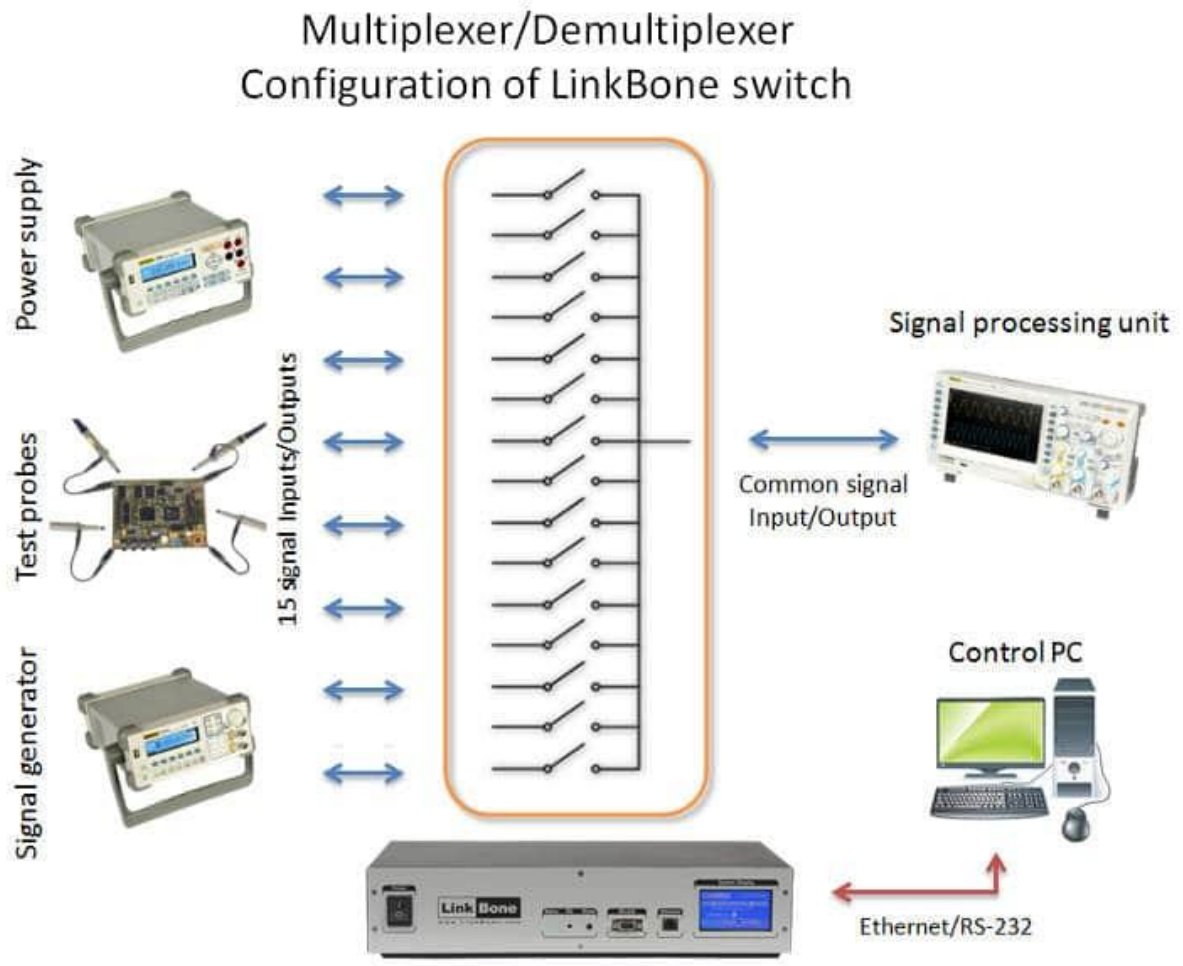


Figure 3: Multiplexer switch routing test signals into an oscilloscope.

The BNC switch box can be controlled remotely via Ethernet or RS-232 command line interface. The main commands used for remote switch configuration are:

- **off <port>** – disconnect selected port to common output
- **on <port>** – connects selected port to common output
- **reset** – disconnects all ports
- **mode <mode>** – sets the operation mode of the BNC switch box.

<mode> parameter can have two values:

single – only one of the A to O ports can be connected to the common port P. In this mode, the switch operates as a classic analogue multiplexer.

multi – more than one A to O port can be connected to port P. In this mode, the user should remember that ports in the On state are internally connected.

The measurement procedure executed on remote PC in pseudo C block code can be as follows:

```
int n, results[15];
```

```
connectToSwitch(SWITCH_ADR); // connect to the BNC switch box
connectToOscilloscope(OSCILLOSCOPE_ADR); // connect to the oscilloscope
sendToSwitch("mode single\n"); //set single mode (multiplexer) and reset
the device
sendToSwitch("reset\n");
for(n = 0 ; n < 15 ; n++ )
{
 char onCmd[] = {"on x\n"};
 onCmd[3]='a'+n; //update the "on x" command string with port letter
 sendToSwitch(onCmd); //change the state of the BNC switch box by "on"
command
 results[n] = oscilloscopeMeasure();
}
```

During the execution of the test code, fifteen measurements from ports A to P are made. The *results* array includes measurement values. The *oscilloscopeMesure()* function can return amplitude, frequency or other oscilloscope measurement functions.

Two measurements can be done simultaneously when using the Dual BNC switch box version and dual channel oscilloscope. This also allows extending the measurement count up to thirty points. The following block code illustrates the measurement procedure with a Dual BNC switch box:

```
int n, resultsChannel1[15], resultsChannel2[15];
connectToSwitch(SWITCH_ADR); // connect to the BNC switch box
connectToOscilloscope(OSCILLOSCOPE_ADR); // connect to the oscilloscope
sendToSwitch("mode single\n"); //set single mode (multiplexer) and reset
the device
sendToSwitch("reset\n");
for(n = 0 ; n < 15 ; n++ )
{
 char onCmd[] = {"on x\n"};
 onCmd[3]='a'+n; //update the "on x" command string with port letter
 sendToSwitch(onCmd); //change the state of the BNC switch box by "on"
command
 resultsChannel1[n] = oscilloscopeMeasureCannel1();
 resultsChannel2[n] = oscilloscopeMeasureCannel2();
}
```

After executing the code *resultsChannel1* and *resultsChannel2* arrays include measurement values.

The yellow waveform plot in figure 4 shows a 10MHz system clock signal going from the signal generator through the LinkBone BNC switch box to the oscilloscope. The second blue waveform shows the original 10Mhz signal connected directly to the oscilloscope. The lower picture shows the rising and falling clock edges are visible. Directly connected signal has 9.8ns edge rise/fall time. Signal routed over the LinkBone BNC switch box has 10.20ns

rise/fall edge times. This example illustrates a low impact on the fast digital and analogue signals routed through LinkBone BNC switches.

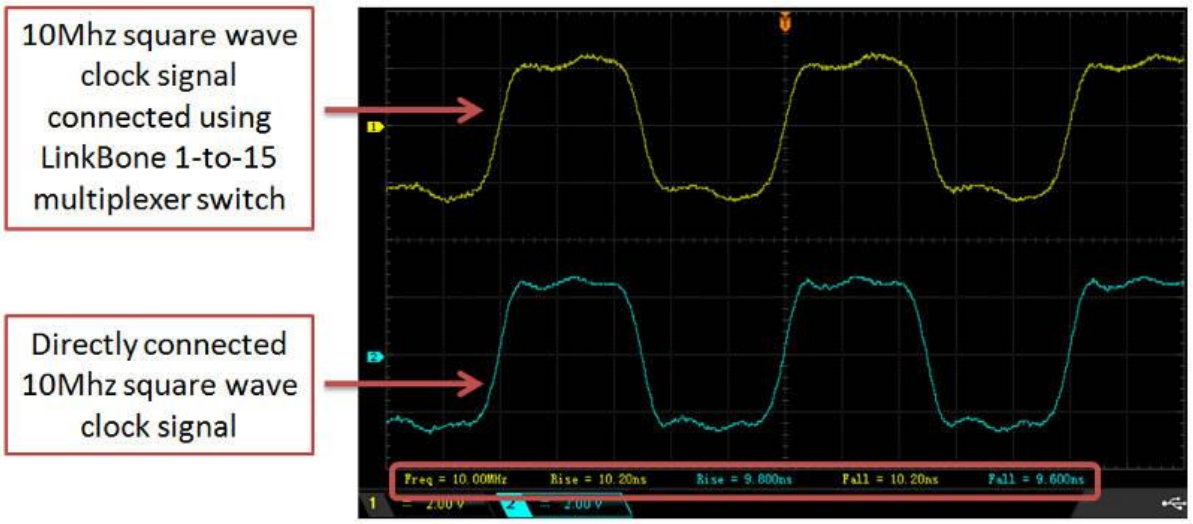


Figure 4: Multiplexer switch box routing test signals into an oscilloscope.

Test automation of measurements using LinkBone remote BNC switch boxes can be used in production lines and R&D facilities. The measurements are faster and more reliable than manual tests. The test automation in systems running over a long time and at various temperatures can help to identify the product's weak points and potential failures in the future.