A reconfigurable sensor monitoring system includes software tunable filters, each of which is programmable to condition one type of analog signal. A processor coupled to the software tunable filters receives each type of analog signal so-conditioned.

12 Claims, 3 Drawing Sheets
## References Cited

### U.S. PATENT DOCUMENTS

<table>
<thead>
<tr>
<th>Patent Number</th>
<th>Date</th>
<th>Inventor(s)</th>
<th>Classifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008/0150626</td>
<td>6/2008</td>
<td>DeAgro</td>
<td>H03H 7/0153</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>327/553</td>
</tr>
<tr>
<td>2008/0177436</td>
<td>7/2008</td>
<td>Fortson</td>
<td>G01D 5/2448</td>
</tr>
<tr>
<td>2009/0326859</td>
<td>12/2009</td>
<td>Hammerschmidt</td>
<td>702/151</td>
</tr>
<tr>
<td>2010/0057957</td>
<td>3/2010</td>
<td>Smilg</td>
<td>G05B 19/042</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>710/104</td>
</tr>
<tr>
<td>2014/0030987</td>
<td>1/2014</td>
<td>Malt</td>
<td>H04B 1/3838</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>455/77</td>
</tr>
<tr>
<td>2014/0040706</td>
<td>2/2014</td>
<td>Wu</td>
<td>H04L 10/041</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>714/776</td>
</tr>
<tr>
<td>2014/0287794</td>
<td>9/2014</td>
<td>Akhi</td>
<td>H04B 1/525</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>455/550.1</td>
</tr>
<tr>
<td>2015/0378954</td>
<td>12/2015</td>
<td>Field</td>
<td>G06F 13/4221</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>710/69</td>
</tr>
</tbody>
</table>

* cited by examiner
FIG. 1

PROCESSOR

SOFTWARE TUNABLE FILTER

SENSOR

SOFTWARE TUNABLE FILTER

SENSOR

FIG. 1
FIG. 2

Microcontroller

Variable Programmable Bridge

Analog Multiplexer

Variable Current Source

Variable Voltage Source

A/D Converter

SENSOR

SENSOR

VA
RECONFIGURABLE SENSOR MONITORING SYSTEM

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and by an employee of the United States Government and is subject to the provisions of Section 20135(b) of the National Aeronautics and Space Act, Public Law 111-314, §3 (124 Stat. 3330, 51 U.S.C. Chapter 201), and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefore.

BACKGROUND OF THE INVENTION

1. Field of the Invention
   This invention relates to sensor systems. More specifically, the invention is reconfigurable sensor monitoring system that is readily configured to filter sensor signals from a variety of sensor components prior to sensor signal sampling.

2. Description of the Related Art
   Spacecraft avionics typically utilize a sensor avionics box that contains all the sensors and digital interfaces necessary for a complete spacecraft. This sensor subsystem usually has numerous sensors on one card and thus requires dense connectors with multiple contacts. If the mission is complex, a sensor box can have several sensor cards with different configurations for each card. Each external sensor from all over the spacecraft is wired to these sensor box connectors. Recently, some avionics designers have started to miniaturize the sensor electronics.

A major disadvantage of the prior art is that the resulting sensor avionics box is a spacecraft-specific, highly-integrated complex unit that requires a set of support equipment that is usually larger than the avionics box itself. Designers must understand all of the avionics, sensors, and specific applications before they can finish the electronics design. The electronics design is typically matured through the process of preliminary and critical design review cycles that require an extensive amount of time and effort. It is usually incumbent upon the design engineers to write test procedures that verify the functionality of the electronics box. Developing and implementing the testing can be time consuming and very complex. Special test equipment for a sensor electronics box of this type can be as complicated as the avionics box itself. Additionally, the special test equipment requires a significant developing and manufacturing investment. The overall cost associated with a typical sensor avionics box can be well into the millions of dollars for a specific mission. Unfortunately, since each mission’s sensor avionics box is specially designed, this costly process gets repeated for every new spacecraft system at the expense of developer time, manpower and money.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a sensor monitoring system for use in spacecraft avionics.

Another object of the present invention is to provide a reconfigurable sensor monitoring system adaptable for use with a variety of spacecraft systems.

Other objects and advantages of the present invention will become more obvious hereinafter in the specification and drawings.

In accordance with the present invention, a reconfigurable sensor monitoring system includes a plurality of software tunable filters. Each software tunable filter is programmable to condition one type of analog signal such that a corresponding number of types of analog signals are adapted to be conditioned. A processor coupled to the software tunable filters receives each type of analog signal so-conditioned.

BRIEF DESCRIPTION OF THE DRAWING(S)

Referring now to the drawings and more particularly to FIG. 1, a block diagram of a reconfigurable sensor monitoring system in accordance with an embodiment of the present invention; FIG. 2 is a schematic diagram of a software tunable filter in accordance with an embodiment of the present invention; and FIG. 3 is a block diagram of a reconfigurable sensor monitoring system in accordance with another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Referring additionally now to FIG. 2, a single one of software tunable filters 12 is shown. In FIG. 2, dashed lines represent control signals used for programming of the filter, and solid lines represent the signals being passed through and conditioned by filter 12. In an embodiment of the present invention, multiples of filter 12 can be connected to an analog multiplexer 14 programmed to accept or pass a particular type/one of sensors 100. The passed analog signal is provided to a variable tunable bridge 121 (i.e., settable resistors and switches) that accepts the inputs in a bridge configuration. A microcontroller 128 changes the configuration of bridge 121 to balance the bridge’s input impedance with the rest of the bridge. A programmable and
variable current source 122 and a programmable and variable voltage source 123 are coupled to bridge 121 so that they can be used if required by the particular sensor signal being conditioned by filter 12. The analog signal output from bridge 121 is next provided to a series of amplifiers and filters that provide specific amplification and filtering needed for the particular type of analog signal. The particular ordering of these elements is generally not critical. A programmable instrumentation amplifier 124 provides precision amplification to the signal without adding extra noise. A programmable filter/gain stage 125 provides the desired filter type (e.g., low pass, high pass, band pass, multiple pole, etc.) in order to remove undesired elements in the sensor signal or satisfy sampling frequency requirements. Finally, a programmable level adjust amplifier 126 adjusts the analog signal supplied thereto to the proper level prior to digitization by an analog-to-digital (A/D) converter 127.

The programming of the above-described elements of filter 12 is provided by a microcontroller (or field programmable gate array) 128 whose programming control signals are indicated by dashed lines. Each conditioned and digitized signal from A/D converter 127 is placed on data bus 20 by microcontroller 128, and then the next analog signal sampled from sensor 100 is processed.

The reconfigurable sensor monitoring system of the present invention can include additional capabilities as illustrated in FIG. 3. For example, a temperature sensor 50 can be provided to monitor the temperature of the system. A heater 52 can be provided to generate heat for the components of the system when the system will be exposed to extremely cold environments (e.g., space). Sensor 50 and heater 52 can be coupled to one another (e.g., directly or indirectly through data bus 20) such that heater 52 is activated/deactivated predicated on the output of sensor 50. Processor 30 could be used to activate/deactivate heater 52 predicated on signals received from sensor 50. Programming for processor 30 could be provided off-line or in an on-line fashion. For on-line programming, one or more communication channels/ports 54 can be coupled to data bus 20. Communication channel 54 is representative of hardwired connections and/or wireless connections, either or both of which can be used without departing from the scope of the present invention.

The advantages of the present invention are numerous. The reconfigurable sensor monitoring system will eliminate the need to design spacecraft-specific sensor signal conditioning electronics. One or more of the sensor monitoring systems could be configured to support a wide variety of spacecraft systems. Configuration for a variety of spacecraft systems can be achieved by simply changing programming configurations of the software tunable filters’ microcontrollers.

Although the invention has been described relative to a specific embodiment thereof, there are numerous variations and modifications that will be readily apparent to those skilled in the art in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A reconfigurable sensor monitoring system, comprising:
   - an analog multiplexer adapted to receive a plurality of types of analog signals;
   - a plurality of software tunable filters, each of said software tunable filters coupled to said analog multiplexer,
   - each of said software tunable filters being programmable to condition one type of analog signal from said plurality of types of analog signals, each of said software tunable filters including
     - a variable current source,
     - a variable voltage source,
     - a reconfigurable bridge having an input coupled to said analog multiplexer and having an output, said reconfigurable bridge coupled to said variable current source and said variable voltage source, and
   - a controller coupled to said reconfigurable bridge, said variable current source, and said variable voltage source, said controller providing control signals to said reconfigurable bridge, said variable current source, and said variable voltage source for impedance balancing said reconfigurable bridge for said one type of analog signal; and
   - a processor coupled to said plurality of software tunable filters for receiving each said one type of analog signal so-conditioned.

2. A reconfigurable sensor monitoring system as in claim 1, wherein each of said software tunable filters further comprises:
   - a series of amplifiers and filters coupled to said output of said reconfigurable bridge for amplifying and filtering said one type of analog signal; and
   - an analog-to-digital converter coupled to said series of amplifiers and filters for digitizing said one type of analog signal amplified and filtered by said series of amplifiers and filters.

3. A reconfigurable sensor monitoring system as in claim 1, further comprising a temperature sensor coupled to said processor.

4. A reconfigurable sensor monitoring system as in claim 1, further comprising a heater coupled to said processor.

5. A reconfigurable sensor monitoring system as in claim 1, further comprising:
   - a temperature sensor for sensing ambient temperature; and
   - a heater coupled to said temperature sensor wherein operation of said heater is based on said ambient temperature.

6. A reconfigurable sensor monitoring system as in claim 1, further comprising at least one communications channel coupled to said processor.

7. A reconfigurable sensor monitoring system, comprising:
   - an analog multiplexer adapted to receive a plurality of types of analog signals;
   - a data bus;
   - a plurality of software tunable filters, each of said software tunable filters having an input coupled to said analog multiplexer and an output coupled to said data bus, each of said software tunable filters being programmable to condition one type of analog signal from said plurality of types of analog signals, each of said software tunable filters including
     - a variable current source,
     - a variable voltage source,
     - a reconfigurable bridge having an input coupled to said analog multiplexer and having an output, said reconfigurable bridge coupled to said variable current source and said variable voltage source, and
   - a controller coupled to said reconfigurable bridge, said variable current source, and said variable voltage source, said controller providing control signals to said reconfigurable bridge, said variable current source, and
said variable voltage source for impedance balancing
said reconfigurable bridge for said one type of analog
signal; and
a processor coupled to said data bus for receiving each
said one type of analog signal so-conditioned.

8. A reconfigurable sensor monitoring system as in claim
7, wherein each of said software tunable filters further
comprises:
a series of amplifiers and filters coupled to said output of
said reconfigurable bridge for amplifying and filtering
said one type of analog signal; and
an analog-to-digital converter coupled to said series of
amplifiers and filters for digitizing said one type of
analog signal amplified and filtered by said series of
amplifiers and filters.

9. A reconfigurable sensor monitoring system as in claim
7, further comprising a temperature sensor coupled to said
data bus.

10. A reconfigurable sensor monitoring system as in claim
7, further comprising a heater coupled to said data bus.

11. A reconfigurable sensor monitoring system as in claim
7, further comprising:
a temperature sensor coupled to said data bus for gener-
ating an ambient temperature measurement wherein
said ambient temperature measurement is available on
said data bus; and
a heater coupled to said data bus wherein operation of said
heater is based on said ambient temperature measure-
ment.

12. A reconfigurable sensor monitoring system as in claim
7, further comprising at least one communications channel
coupled to said data bus.

* * * * *