(54) Title: OPTOELECTRONIC TEST APPARATUS FOR COMMUNICATING WITH A RECEIVER

Test and measurement apparatus for testing a wristwatch pager (10) having an FM receiver (55) and a wristband antenna (14) coupled to the user's body. A monitor circuit (34) mounted on a watch-sized printed circuit board and its controller located remotely Therefrom provides a means to remotely control and monitor the operation of the watch circuits by way of a fiber-optic link (40, 41) between the controller (32) and the monitor circuit (34), thereby suppressing false antenna coupling and removing from the vicinity of the watch circuits all electromagnetic interference generated by the controller (32). An optoelectronic feedback circuit linearizes emissions from a light emitting diode transmitting analog data over the fiber-optic link.

* See back of page
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OPTOELECTRONIC TEST APPARATUS
FOR COMMUNICATING WITH A RECEIVER

Field of the Invention
This invention relates to electrical measurement, and more particularly to optically coupled apparatus for remotely monitoring the performance of radio receiver circuits.

Background of the Invention
Electronic test and measurement equipment connected to circuits under test by electrically conductive connecting means such as test probes can radiate signals from the connecting means that interfere with the normal operation of the tested circuits. For example, when a radio receiver circuit and its antenna are being tested, the electromagnetic characteristics of the interconnecting cables or leads can introduce radio frequency effects, which may perturb the operation of the circuit being tested, making it difficult to determine whether or not the tested circuit operates properly. The circuit under test may receive signals generated by the electronic test equipment that control the operation of the circuit; for example, signals to control a local oscillator in a receiver to generate a predetermined frequency at which the receiver is to operate. The problem of electromagnetic interference and false coupling from external sources is exacerbated in a
miniature radio receiver having a small antenna, as for
example in a wristwatch-receiver such as that used in
paging devices described in U.S. patent 4,713,808 to
Gaskill et al, and in a copending U.S. patent application
serial No. 07/121,139, filed November 16, 1987, which
application is assigned to the same assignee as the
instant invention. The small size and portable nature of
the wristband receiver dictates that the antenna be small
and unobtrusive, consequently the antenna is embedded in
the wristband of the device. The antenna, which is thus
necessarily proximate to the receiver, is likewise very
close to any probe or other electrically conductive
device that might be connected to or brought into contact
with the receiver circuits for testing purposes. A test
probe with connecting cable proximate to the wristband
antenna can itself act as an antenna, and thus electro-
magnetically coupled with the wristband antenna, can
cause the receiver to respond to unknown or unwanted
signals, or increase the amplitude of desirable signals,
making it impossible to evaluate the independent
operation of the receiver with its wristband antenna.
Optical coupling of electrical signals is well
known. Light generating devices such as strobotrons,
light-emitting diodes and lasers can be used to generate
and transmit electromagnetic radiation modulated with
data, and the radiation can be received by photosensors.
However, many light emitting devices are nonlinear, i.e.
there is a nonlinear relationship between the optical
output and the applied bias, and therefore not suitable
for transmitting highly linear analog signals without
conditioning.

It is therefore an object of the present invention
to provide improved apparatus for testing the operation
of a radio receiver circuit.

It is another object of the present invention to
provide improved apparatus for testing the operation of a
radio receiver circuit without causing electromagnetic
interference with the operation of the receiver, or false
coupling of desirable signals thereby creating an
anomalous indication of increased performance.

It is another object of the invention to provide
improved test and measurement apparatus for a radio
receiver, which operates remotely from the receiver by
way of an optical coupling.

Another object of the invention is to provide
improved optoelectronic test apparatus having a light
transmitting circuit using optical feedback, and having
power output which is linear in relation to the input
voltage.

**Summary of the Invention**

A remote test device coupled to a sensitive radio
receiver and its antenna provides a control signal for
testing the receiver using an optical link coupling the
test device and the receiver virtually eliminates false
antenna coupling and electromagnetic interference of the
receiver operation from the test device. In accordance
with one aspect of the invention an analog output signal
of the receiver responsive to the control signal input
from the test device is transmitted via the optical link
to the remote test device. An optical signal transmitter
includes optical feedback means for linearizing the
optical power output of the transmitter.

In accordance with another aspect of the invention
the remote test device generates a control signal that is
coupled by an optical fiber to an interface circuit
mounted on a radio receiver worn on a person's wrist, the
control signal, for example, tuning the receiver to a
predetermined frequency. The analog signal output from
the receiver is transmitted optically from the interface
circuit to the test device for measurement therein.

Brief Description of the Drawing
While the invention is set forth with particularity
in the appended claims, other objects, features, the
organization and method of operation of the invention
will become more apparent, and the invention will best be
understood by referring to the following detailed
description in conjunction with the accompanying drawing
in which:

FIG. 1 is a perspective view of a watch pager with
which the instant invention is utilized;
FIG. 2 is a plan view, partially cut away, of a watch monitor board in accordance with the present invention;

FIG. 3 is a schematic block diagram of a fiber optic watch monitor system according to the present invention;

FIG. 4 is a timing diagram useful in explaining the operation of the watch monitor system of the present invention;

FIG. 5 is a schematic diagram of the analog transmit circuit of FIG. 3; and

FIG. 6 is a schematic diagram of the analog receive circuit of FIG. 3.

Description of the Preferred Embodiment

Referring now to the various views of the drawing for a more detailed description of the components, materials, construction, function, operation and other features of the instant invention by characters of reference, FIGS. 1-3 show an electronic paging watch 10, which appears much like a conventional wristwatch. The watch 10 includes a wristband 12 having an antenna 14 embedded therein, and a body 16 or watchcase containing watch circuits 18 comprising an electronic clock and paging device, outputs of which are displayed on a face 20 of the watch. The watch face 20 includes an analog clock display 22 and, optionally, a calendar display 24, both of which are conventional. A paging data display 26 is provided on the watch face 20 for displaying various
message symbols including a telephone number output from the paging device. The watch 10 incorporates microcircuits mounted on watch-sized printed circuit boards (not shown) inside the watchcase 16.

Referring to FIG. 3 in conjunction with FIG. 2, a watch monitor system 30 for testing the watch circuits 18 comprises a watch monitor controller 32 located remotely from the watch 10 and a watch monitor 34 on a watch-sized printed circuit board (PCB) 36 mounted on the watch 10 and coupled to the watch circuits 18 by suitable electrically conductive connections 37 such as PCB edge connectors. A light transmission medium 38, which optically couples the controller 32 and the watch monitor 34, may be, for example, free space or an optical waveguide such as an optical fiber. The presently described embodiment of the invention utilizes a pair of fiber-optic cables 40, 41 mounted orthogonally with respect to the watch on the PCB 36 so that the cables extend up the arm of a person wearing the watch, see FIG. 2. The watch monitor 34 and its controller 32 provide a means to remotely control and monitor the operation of the watch circuits 18 by way of the fiber-optic cables 40, 41, which are suitably 90 meters in length. The light transmission medium allows testing of the watch circuits 18 without electromagnetic interference (EMI) generated by the controller 32 and signals which might otherwise be coupled to the antenna 14 by an electrically
conductive connection means between the controller 32 and
the watch 10.

The watch monitor controller 32 comprises a
microprocessor 42 and control means 44 providing input
signals thereto. The control means 44 is suitably a
plurality of switches set to define the operation of the
controller 32 and the watch 10 under test. Responsive to
a trigger signal, suitably from a panel switch 46 or
alternatively from an external trigger source 48, the
microprocessor 42 initiates a watch receive cycle,
addresses and reads the control means 44 by way of a bus
50, and controls a light emitting diode (LED) 52 by way
of a driver circuit 53 to transmit a pulse code modulated
(PCM) data stream to the watch monitor 34 by way of the
first fiber-optic cable 40. The PCM light signals
transmitted by the LED 52 are representative of digital
data, which stimulates a frequency agile, digitally
synthesized local oscillator 54 of an FM receiver 55 in
the watch circuits 18, as described below.

A standard RS-232 input/output port 56 provides an
alternative external command interface for the controller
32 through an I/O port connector 57, while an external
PCM input signal can be provided through an external
connector 58 on lead 59 to the LED driver circuit 53. An
indicator panel 60 displays LEDs responsive to the
microprocessor 42 showing status of the controller to an
operator, e.g., POWER ON, CONTROLLER TRANSMITTING,
LOCAL/REMOTE CONTROL. A digital sync pulse generated by
the microprocessor 42 on a BNC output connector 61 occurs a predetermined interval after the microprocessor 42 transmits control information to the watch monitor, thus providing a trigger pulse for external instrumentation. The delay interval, which is programmable by way of the control means 44 or through the I/O port 56, is set to accord with the test being performed, for example, the interval can be set relative to the watch power-up sequence. The microprocessor 42 is suitably a 63705V0C EPROM microcomputer manufactured by Hitachi.

Referring now to FIG. 3 in conjunction with FIG. 4, the watch monitor 34 receives the PCM data via the fiber-optic cable 40, the light signals being sensed by a photodiode 62 and light detect circuit 64. Upon receipt of the first data pulse, a PCM data detector circuit 66 generates a signal ENSYN, which is applied via an output level conversion circuit 68 to the frequency synthesizer 54 to enable reception of data signals therein. A PCMD detector-delay signal having a duration of 50 microseconds is also triggered by the leading edge of each data pulse, while the PCM data is supplied unmodified, except for level conversion in circuit 68, as a CTRAD signal to the frequency synthesizer 54. The trailing edge of the PCMD signal triggers a 2 microsecond clock pulse CTRCK, which strobes the data into a holding register in the synthesizer 54. When data transmission has ended, i.e., when no data pulses are received for a predetermined period, 300 microseconds in the presently
described embodiment of the invention, the ENSYN signal
is disabled and a PWR2 signal, which controls application
of power to the receiver and enables synthesizer
operation, is generated. See the aforementioned U.S
patent 4,713,808 for additional details of the operation
of the watch receiver not pertinent to the instant
invention.

During operation of the receiver 55 responsive to
the data supplied to the synthesizer 54 by the watch
monitor circuit 34, a base band composite signal BBCOMP
detected by the receiver 55 is supplied via a lead 70 to
an analog transmit circuit 72, which drives an output LED
74 coupled to the fiber-optic cable 41. Referring to
FIGS. 2 and 5, FIG. 2 shows a cutaway view of an optical
interface block 76 mounted on the watch monitor PCB 36.
The block 76 comprises a housing of opaque molded plastic
in which terminal ends 78, 80 of the fiber-optic cables
40, 41 are embedded and held aligned adjacent,
respectively, to photodiode 62 and output LED 74. The
photodiode 62 and LED 74 are optically isolated from each
other by the plastic material of the block 76. An
optical feedback photodiode 82, which is mounted in the
block 76 proximate to the LED 74 and juxtaposed at an
angle with the terminal end 80 of fiber-optic cable 41,
receives a portion of the light generated by the output
LED 74. Alternatively, a beam splitter can be
incorporated in the light transmission medium.
Referring to FIG. 5, the DC biased analog input signal BBCOMP is applied to an input node 84 of the analog transmit circuit 72 through a 1500 ohm resistor 85 in series with a 200 Kohm adjustable resistor 86 to the non-inverting input terminal of an operational amplifier 87. A 40 Kohm temperature compensating resistor 88 connected from a junction 89 to ground, with the resistor 85, forms a temperature compensating network at the input node 84 of the transmit circuit 72. The output of the amplifier 87 drives the base of a transistor 90, which in turn drives the output LED 74. A portion of the light generated by the LED 74 is detected by the feedback photodiode 82, which is connected to the input of the amplifier 87, thus providing a correction signal which results in a highly linear light output of the LED 74 coupled into the fiber-optic cable 41.

Referring to FIG. 6 in conjunction with FIGS. 2 and 3, the watch monitor controller 32 receives analog data transmitted by the watch monitor 34 via the fiber-optic cable 41 and input through a photodiode 92 to an analog receive circuit 93. The photodiode 92 is connected to the inverting input of an operational amplifier 94, which is configured as a current-to-voltage converter having an adjustable resistor 93 provided to set the current-to-voltage conversion ratio, while a resistor 96 provides temperature compensation. A variable capacitor 97 provides high frequency rolloff adjustment of the circuit 95. Output node 98 of the amplifier 94 is applied through
an output level potentiometer 99 to the non-inverting
input of an output amplifier 100, which provides an
analog output signal to a connector 102 on the controller
32. This output signal represents the DC coupled base
band composite signal detected by the watch receiver 55,
and then transmitted by the watch monitor analog transmit
circuit 72 over the fiber-optic link.

While the fiber-optic link is disclosed above
transmitting analog signal data, digital data output from
the watch circuits 18 can also be transmitted to the
watch monitor controller 32 by way of a demodulator 103
and digital transmit circuit 104. A digital receive
circuit 106 connected to the output node 98 of amplifier
94 regenerates digital data and clock signals in the
watch monitor controller 32.

While the principles of the invention have now been
made clear in the foregoing illustrative embodiment,
there will be immediately obvious to those skilled in the
art many modifications of structure, arrangement,
proportions, the elements, material and components used
in the practice of the invention, and otherwise, which
are particularly adapted for
specific environments and operating requirements without
departing from those principles. The appended claims
are, therefore, intended to cover and embrace any such
modifications, within the limits only of the true spirit
and scope of the invention.
1. Apparatus for testing a radio receiver having an antenna, the apparatus comprising:

   test means located remotely from the radio receiver for generating a receiver control signal and including means for transmitting an optical signal representative of the control signal;

   optoelectronic means connected to the receiver for receiving the optical signal, the receiver being responsive to the control signal to perform a predetermined function; and

   means for optically coupling the optical signal between the test means and the optical signal receiving means, thereby suppressing false antenna coupling and electromagnetic radiation from the test means near the radio receiver and its antenna.

2. Apparatus according to claim 1 wherein the optical coupling means comprises an optical fiber.

3. Apparatus according to claim 1, further comprising:

   means in the optoelectronic means having an input node receiving an output signal of the receiver for transmitting a second optical signal representative of the receiver output signal, the receiver output signal being responsive to the control signal; and
means in the test means for receiving the second optical signal by way of the optical coupling means.

4. Apparatus according to claim 3 wherein the optical coupling means comprises an optical fiber.

5. Apparatus according to claim 3 wherein the second optical signal transmitting means includes means for feeding back a portion of the second optical signal to the input node for the purpose of linearizing the optical signal output of the transmitting means.

6. Apparatus according to claim 5 wherein the optical coupling means comprises an optical fiber.

7. Apparatus according to claim 3, wherein the second optical signal transmitting means comprises:
   an amplifier having the input node receiving the output signal of the receiver; and
   a light source driven by the amplifier, the light source generating the second optical signal.

8. Apparatus according to claim 7 wherein the light source comprises a light emitting diode optically coupled to the optical coupling means, and the second optical signal transmitting means further comprises a photodiode providing an input to the input node of the amplifier and
receiving a portion of the light output of the light emitting diode, thereby linearizing the optical signal output of the transmitting means.

9. In electrical test and measurement apparatus including means for receiving a signal to be tested from a remote analog signal source, means at the analog signal source for transmitting an optical signal representative of the analog signal, and optical means for coupling the transmitting means to the receiving means, the optical signal transmitting means comprising:

   an amplifier having an output node and an input node receiving the analog signal;

   a light source coupled to the optical coupling means;

   means connected to the output node of the amplifier for driving the light source; and

   a photodetector connected to the input node of the amplifier, the photodetector being optically coupled to the light source and receiving a portion of the light from the light source, the photodetector biasing the amplifier to linearize the optical power output of the transmitting means.

10. Apparatus according to claim 9 wherein the optical coupling means comprises an optical fiber.

11. Apparatus according to claim 9 wherein the light source comprises a light emitting diode.
12. A method of remotely testing a radio receiver worn on a person's wrist, the radio receiver having a wristband antenna, the method comprising the steps of:
   transmitting an optical signal representative of a receiver control signal from a remote test device to the receiver;
   converting the remotely transmitted optical signal into the receiver control signal at the receiver; and
   monitoring the operation of the receiver responsive to the converted control signal.

13. The method according to claim 12 wherein the monitoring step includes the steps of:
   converting an output signal of the receiver responsive to the control signal into an optical signal;
   transmitting the optical signal representative of the receiver output signal from the receiver to the remote test device;
   reconverting in the remote test device the optical signal transmitted from the receiver into the receiver output signal; and
   evaluating the reconverted receiver output signal in the remote test device.

14. The method according to claim 13 wherein the step
1 of transmitting the optical signal representative of the 
2 receiver output signal includes the step of linearizing 
3 the optical power output of the transmitting circuit. 

15. The method according to claim 14 wherein the 
linearizing step includes the steps of: 
splitting the optical signal output of the 
transmitting circuit with a beam-splitting means; and 
feeding back a portion of the transmitted 
optical signal from the beam-splitting means to a light 
sensing device connected to the input of the transmitting 
circuit.
### I. CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) or to both National Classification and IPC

**IPC(5):** H04B 10/00  
**US:** 455/607

### II. FIELDS SEARCHED

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### III. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US, A, 4,394, 691 (AMANO et al) 19 July 1983</td>
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### IV. CERTIFICATION

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International Searching Authority

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