

Process and System for Regulating Millimeter Wave Power in a V Band TR Module

The invention relates to a process and a system for regulating the power of millimeter waves in a V band TR module according to the precharacterising part of Claim 1.

The output power, particularly that of mobile communication sets, should be as constant as possible, without dependence on the individual properties of the circuit elements and sets produced in large numbers. At frequencies <50 GHz, adjustable attenuating elements on MMICs are realised with PIN diodes or as MESFET switches. Other concepts of regulating the power at lower frequencies are also known as state of the art. A V band TR module with regulated output power is not known at the present time. Nor is an adjustable attenuating element for 60 GHz as MMIC at the present time available on the market.

Individual adjustment of the sets produced is very expensive and therefore it would be desirable to use an appropriate design in order to avoid the adjustment. At the same time, a minimum of additional components should be required, since the same have a spread of their features, on the one hand, and cause expenses, on the other.

A 50 - 60 GHz SPDT (= single pole double throw) switch for communication systems has been offered by the company United Monolithic Semiconductors S.A.S. of 91401 Orsay, Cedex France, under the designation CHS2190a, which to date has been used as a transmit-receive switch in transceiver modules. The goal of the invention is to obtain regulation of the power with the above-specified features, making use of this or a corresponding switch.

According to the invention, this is achieved by the features recited in the characterising part of Claim 1 and Claim 2.

By using the SPDT MMIC as an adjustable attenuating element, the desired transmission power can be obtained and the spread of chip features can be compensated. It forms the basic component for power adjustment (regulating element). Considerable savings are obtained from the double function of the chip.

The use of the second SPDT MMIC as power detector results in savings in view of the double function.

The regulation of the power for the entire TR module results in an overall increase in module yield by compensation of the spread of chip features and temperature effects. The multiple use of the SPDT MMICs as switch, attenuating element, and power detector provides the aforementioned advantages.

In accordance with an aspect of the present invention, there is provided a method to control the power of millimeter waves for a V-band TR module at a frequency in the range of 50GHz and higher, the method comprising the acts of, separating the transmitting and receiving path via two SPDT (single pole double throw) MMIC switches, for the transmission, using the first SPDT MMIC switch as a variable attenuator and the second SPDT MMIC switch as a detector for the output power, and by way of an electronic control circuit, the control of the output power, to a defined level is achieved.

In accordance with another aspect of the present invention, there is provided a device to control the power of millimeter waves for a V-band TR module at a frequency in the range of 50GHz and higher, comprising, two SPDT (single pole double throw) diode-based MMIC switches for separating the transmit and receive path, wherein for transmission, the first SPDT MMIC switch is used as a variable attenuator and the second SPDT MMIC switch is used as detector for the output power, and an electronic unit to control the output power.

In accordance with yet another aspect of the present invention, there is provided a device to control the power of millimeter waves for a V-band TR module at a frequency in the range of 50 GHz and higher comprising, two SPDT (single pole double throw) MMIC switches for separating transmit and receive path, wherein for transmission the first SPDT MMIC switch is used as a variable attenuator and the second SPDT MMIC switch is used as a detector for the output power, and an electronic unit to control the output power, wherein in the case of the SPDT MMIC having two switch arms, in switch mode, an input power at the IN port can optionally be switched to the O1 or O2 port, and wherein, in a mode as a variable attenuator, the O2 port is terminated in a reflection free manner and a variable attenuation can be set between the IN and O1 port by variation of the supply voltage.

In accordance with another aspect of the present invention, there is provided a device to control the power of millimeter waves for V-band TR module at a frequency in the range of 50 GHz and higher, comprising: two SPDT (single pole double throw) MMIC switches for separating the transmit and receive path, wherein for transmission, the first SPDT MMIC switch is used as a variable attenuator and the second SPDT MMIC switch is used as a detector for the output power, and an electronic unit to control the output power, wherein in the ease of the SPDT MMIC having two switch arms, on each switch arm, two parallel-connected diode pairs, respectively are connected between the HF line and ground, and wherein, in operation as a power detector, one arm is blocked and the second arm is switched via a bias voltage of 0 V to conducting, and further wherein the HF power flowing through the latter arm is rectified at the diodes, and the measurable rectified voltage is used as a measurement for the transmitted power.

Details of the invention will become obvious from the dependent claims and the description in which an embodiment is explained with reference to the drawings. There show:

Figure 1, a block diagram of the regulation of the transmission power in accordance with the invention;

Figure 2, the layout and the pad designation of the known SPDT MMIC;

Figure 3, the basic circuit diagram;

Figure 4, the external connections and the dc supply;

Figure 5, the attenuation in dependence upon the control voltage;

Figure 6, the use of the SPDT MMIC as a detector;

Figure 7, the maximum available and controlled transmission power.

According to the invention, the known MMIC can be operated either as a Schottky diode switch of the SPDT (single pole double throw) type or, by means of selecting other supply voltages, as an adjustable attenuating element. Figures 2 and 3 show the layout of the SPDT MMICs and a basic circuit diagram. In switching operation, the input power is switched at port IN either to port O1 or port O2. For operation as a variable attenuating element, gate O2 is closed in reflexion-free fashion and the switch path IN-O2 is open in the direction of flow. Between the gates IN and O1 a variable attenuation between 3.5 and 25 dB can be set via the dc supply voltage (see Figures 4 and 5).

Figure 4 shows the external connections and the dc supply. The modes of operation are:

Switching operation:

Switch path IN-O1 in the ON state, switch path IN-O2 in the OFF state. Pads A1, A2: - 2.5 v; pads B1, B2: 12 mA.

OFF state: switching path blocked;

ON state: switching path allows flow.

The external voltage supply takes place via serial resistors of about 200 Ω connected in series with pads A1, A2, B1, B2.

Detector operation:

Switch path IN-O1 as detector, switch path IN-O2 in the OFF state. Pads A1, A2: 0 v (1 k Ω in series with the pads). Pads B1, B2: 0 - 12 mA (corresponds to 0 - 4 v after 250 Ω resistor in series).

Operation as a variable attenuating element:

Switch path IN-O1 in ON state (gate O1 closed in reflexion-free fashion), switch path IN-O2 in attenuating operation: Pads A1, A2: - 2.5 v. Pads B1, B2: 0 - 12 mA (corresponds to 0 - 4 v after 250 Ω resistor in series).

In each switch path on the SPDT MMIC there are two diode pairs 4/5, respectively, 6/7 connected between the hf line and ground. When the SPDT MMICs are operated as power detectors, one switch path is blocked (e.g., IN-O2), the second path is switched open with a bias voltage of 0 v. The hf power flowing through the ON path is rectified at the diodes connected in parallel. The voltage which can be measured at pads A1 and, respectively, A2 is a measure of the passing power, as shown in Figure 6. The voltage at pad A2 is used for measuring the power. Power can be detected at the SPDT MMIC in the range from 3 dBm to < 10 dBm..

Figure 5 shows the attenuation in dependence upon the control voltage. The following values apply:

dc connection and voltage supply:

Pads A1, A2: -2.5 v

Pads B1, B2: control voltage applied through 250 Ω resistor in series.

hf configuration:

Measurement with wafertester at 58 GHz.

Input power at gate IN, output power at gate O2, gate O1 was terminated with a 10 dB attenuating element.

Figure 6 shows the use of the SPDT MMIC as detector. The diagram shows the detector voltage in dependence upon the output power measured. The following applies:

dc connection and voltage supply:

Pads A1, A2: 0 v applied through 1 k Ω resistor in series.

Control voltage

Pads B1, B2: 12 mA.

hf configuration:

Measurement with wafertester at 58 GHz.

Input power at gate O1, output power at gate IN, gate O2 was terminated with a 10 dB attenuating element.

The adjustment of the transmission power in accordance with the invention was developed with the circuit components described for a transmitter/receiver module as shown in the block diagram of Figure 1. In reception, the two SPDT MMICs (1 and 2) are used as switch. LO power (pin_LO) and receiver power (pin_RX) are switched to the mixer. In transmission, SPDT MMIC 1 works as an adjustable attenuating element and SPDT MMIC 2, as a power detector. The power adjustment circuit is closed via analog electronic means. The desired output power level is adjusted at the electronic means via the nominal value. Figure 7 shows the output power measured at the spectrum analyser in the case without regulation (maximum available power) and in the case of control ($P_{out} = 5 \text{ dBm} = \text{const}$).

Claims

1. Method to control the power of millimeter waves for a V-band TR module at a frequency in the range of 50 GHz and higher, the method comprising the acts of:
 - separating the transmitting and receiving path via two SPDT (single pole double throw) MMIC switches;
 - for the transmission, using the first SPDT MMIC switch as a variable attenuator and the second SPDT MMIC switch as a detector for the output power; and by way of an electronic control circuit, the control of the output power to a defined level is achieved.
2. Device to control the power of millimeter waves for a V-band TR module at a frequency in the range of 50 GHz and higher, comprising:
 - two SPDT (single pole double throw) diode-based MMIC switches for separating the transmit and receive path;
 - wherein for transmission, the first SPDT MMIC switch is used as a variable attenuator and the second SPDT MMIC switch is used as a detector for the output power; and an electronic unit to control the output power.
3. Device to control the power of millimeter waves for a V-band TR module at a frequency in the range of 50 GHz and higher comprising:
 - two SPDT (single pole double throw) MMIC switches for separating transmit and receive path;
 - wherein for transmission the first SPDT MMIC switch is used as a variable attenuator and the second SPDT MMIC switch is used as a detector for the output power; and
 - an electronic unit to control the output power;
 - wherein in the case of the SPDT MMIC having two switch arms, in switch mode, an input power at the IN port can optionally be switched to the 01 or 02 port, and wherein, in a mode as a variable attenuator, the 02 port is terminated in a

reflection free manner and a variable attenuation can be set between the IN and O1 port by variation of the supply voltage.

4. Device to control the power of millimeter waves for a V-band TR module at a frequency in the range of 50 GHz and higher, comprising, two SPDT (single pole double throw) MMIC switches for separating the transmit and receive path; wherein for transmission, the first SPDT MMIC switch is used as a variable attenuator and the second SPDT MMIC switch is used as a detector for the output power; and an electronic unit to control the output power; wherein in the case of the SPDT MMIC having two switch arms, on each switch arm, two parallel-connected diode pairs, respectively are connected between the RF line and ground, and wherein, in operation as a power detector, one arm is blocked and the second arm is switched via a bias voltage of 0 V to conducting, and further wherein the RF power flowing through the latter arm is rectified at the diodes, and the measurable rectified voltage is used as a measurement for the transmitted power.