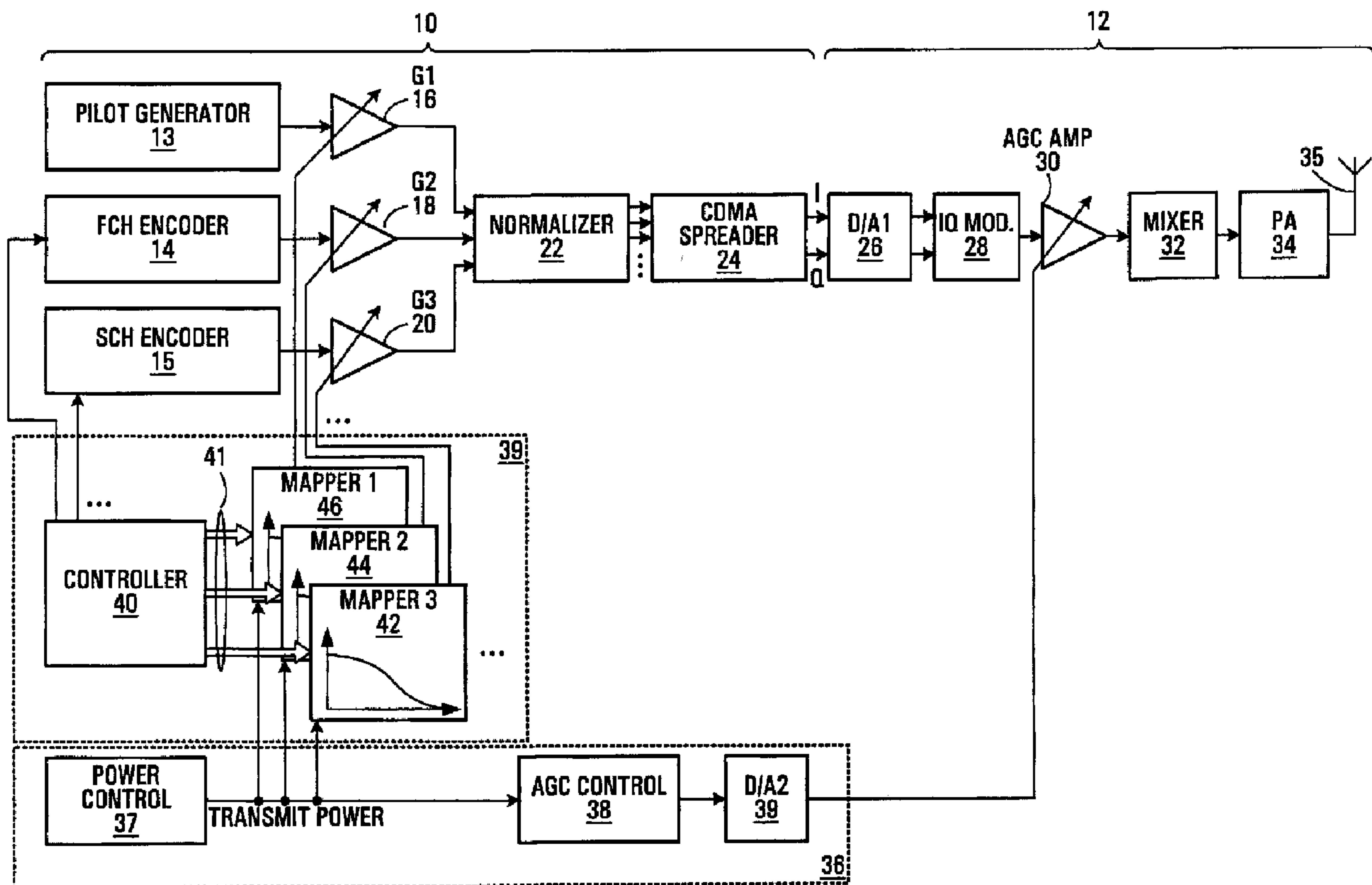




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(54) Titre : METHODE ET APPAREIL DE COMPENSATION DE PUISSANCE DE CANAL DE CODE DANS UN
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 (54) Title: METHOD AND APPARATUS FOR COMPENSATING CODE CHANNEL POWER IN A TRANSMITTER



(57) Abrégé/Abstract:

It has now been found that in some transmitter implementations which transmit multiple code channels, for example CDMA transmitters, the observed power for each code channel at the output relative to the other code channels is dependent upon the

(57) **Abrégé(suite)/Abstract(continued):**

total transmit power due to non-linearities in the transmitter. Methods and apparatus are provided which use pre-set digital gains or digital gain adjustments to compensate for the non-linearities as a function of total transmit power such that at the output, the desired relative powers are observed.

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Abstract

It has now been found that in some transmitter implementations which transmit multiple code channels, for example CDMA transmitters, the observed power for each code channel at the output relative to the other code channels is dependent upon the total transmit power due to non-linearities in the transmitter. Methods and apparatus are provided which use pre-set digital gains or digital gain adjustments to compensate for the non-linearities as a function of total transmit power such that at the output, the desired relative powers are observed.

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A few examples of other standards which include such requirements are 3GPP UMTS, 3GPP2 1xEVDO.

Conventional arrangements for implementing power control in such multiple code channel systems feature a controller which, in the digital domain, determines a gain for each of the channels which is to be active at a given time, subject to the relative code channel power requirement. These gains are then used to control digital gain elements. The outputs of the digital gain elements are combined, and normalized such that the sum of the channels has a more or less constant overall power. The output of the normalizer is then subject to further digital and RF processing before transmission. If the values of the individual digital gains provide a normalized total combined power, the digital portion of the transmitter does not need to include the normalizer.

Summary of the Invention

According to one broad aspect, the invention provides a method in a transmitter having an output comprising: determining a current total transmit power for the output; determining a set of digital gains in response to the current total transmit power; applying the set of digital gains to a corresponding set of code channels, the set of digital gains setting relative powers of the set of code channels and also compensating for non-linearities in the transmitter as a function of the current total transmit power such that a desired relationship between channel powers of the set of code channels after having been combined to produce the output is substantially achieved; combining the set of code channels to produce the output.

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In some embodiments, the desired relationship between channel powers comprises a specified relative power for each of the channels in the output.

In some embodiments, a method further comprises
5 for each at least one channel: maintaining a respective pre-set digital gain value for the channel for each of a plurality of states of the set of channels, and as a function of total transmit power; wherein the digital gain to be applied to the channel as part of said set of digital
10 gains comprises the pre-set digital gain for the current state of the set of channels, and for the current total transmit power.

In some embodiments, for each of said at least one channel, a respective pre-set digital gain is maintained for
15 each of the plurality of states of the set of channels and for a plurality of ranges of total transmit power.

In some embodiments, a method further comprises for each code channel: maintaining a respective pre-set digital gain value for the code channel for each of a
20 plurality of states of the set of code channels, and for each of a plurality of ranges of total transmit power; wherein the digital gain to be applied to the code channel as part of said set of digital gains comprises the pre-set digital gain for a current state of the set of code
25 channels, and for the range containing the current total transmit power.

In some embodiments, each state comprises a selection of a particular set of code channels from a set of possible code channels, and a selection of at least one of
30 an encoding format, a signal format, and a data rate for at least one of the set of particular code channels.

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In some embodiments, each state comprises at least one of: a selection of a particular set of code channels from an available set; a selection of a particular encoder format for at least one code channel; a selection of a particular signal format for at least one code channel; and a selection of a particular data rate for at least one code channel.

In some embodiments, a method comprises: for each state and for each code channel: maintaining the pre-set digital gains in a table mapping each range of transmit power to a respective pre-set digital gain.

In some embodiments, for each of at least one of the code channels determining a digital gain of said set of digital gains comprises: determining a nominal digital gain for the code channel; determining a gain adjustment for the code channel in response to the current total transmit power; combining the nominal digital gain and the gain adjustment to produce the digital gain of said set of digital gains for the code channel.

In some embodiments, the gain adjustment is a multiplicative gain adjustment and wherein combining the nominal digital gain and the gain adjustment to produce the respective digital gains comprises multiplying the nominal digital gain by the gain adjustment.

In some embodiments, the gain adjustment is an additive gain adjustment and wherein combining the nominal digital gain and the gain adjustment to produce the respective digital gains comprises adding the nominal digital gain to the gain adjustment.

In some embodiments, a method comprises: for each state and for each code channel: maintaining the gain

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adjustments in a table mapping each range of transmit power to a respective gain adjustment.

In some embodiments, each gain adjustment is pre-determined to provide compensation over a range of nominal
5 digital gains.

In some embodiments, the code channels are CDMA code channels.

According to another broad aspect, the invention provides a transmitter having an output and a current
10 transmit power, the transmitter comprising: a plurality of code channel generators and/or code channel encoders; for each code channel generator and/or code channel encoder, a respective digital gain element; a compensation element adapted to apply a set of digital gains to the digital gain
15 elements, the set of digital gains compensating for non-linearities in the transmitter as a function of the current total transmit power such that a desired relationship between code channel powers of said set of code channels after having been combined to produce the output is
20 substantially achieved.

In some embodiments, the compensation element comprises: a memory containing for at least one code channel, a respective pre-set digital gain value for the code channel for each of a plurality of states of the set of
25 code channels, and for a plurality of ranges of total transmit power.

In some embodiments, the compensation element comprises a controller adapted to configure the transmitter to have a selected state of a plurality of states, each
30 state comprising at least one of: a) a selection of a particular set of code channels from a set of available code

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channels; b) a selection of a particular encoder format for at least one code channel; c) a selection of a particular signal format for at least one code channel; and d) a selection of a particular data rate for at least one code channel; a memory containing for each state, a pre-set digital gain value for each code channel for each of a plurality of ranges of transmit power; wherein for each code channel the controller is adapted to apply the appropriate pre-set digital gain value as a function of the state and total transmit power as one digital gain of said set of digital gains.

In some embodiments, the compensation element is further adapted to determine for at least one code channel a nominal digital gain for the code channel, and to combine a respective gain adjustment with each nominal digital gain value to determine the digital gains to be applied to the digital gain elements for the at least one code channel.

In some embodiments, the compensation element comprises a controller adapted to configure the transmitter to have a selected state of a plurality of states, each state comprising at least one of: a) a selection of a particular set of code channels from a set of available code channels; b) a selection of a particular encoder format for at least one code channel; c) a selection of a particular signal format for at least one code channel; and d) a selection of a particular data rate for at least one code channel; a memory containing for each state, the pre-set digital gain adjustment for each code channel for each of a plurality of ranges of transmit power; wherein for each code channel the controller is adapted to employ an appropriate pre-set digital gain adjustment as a function of the state and total transmit power as said respective gain adjustment.

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In some embodiments, a transmitter further comprises: a power control subsystem adapted to determine the total transmit power.

According to another broad aspect, the invention
5 provides a computer readable medium comprising computer
readable instructions for implementing a method comprising:
determining a current total transmit power for an output;
determining a set of digital gains in response to the
current total transmit power, the set of digital gains
10 setting relative powers of a set of code channels and also
compensating for non-linearities in a transmitter as a
function of the current total transmit power such that a
desired relationship between channel powers of the set of
code channels after having been combined to produce the
15 output is substantially achieved.

In some embodiments, the method further comprises
for each of at least one channel: maintaining a respective
pre-set digital gain value for the channel for each of a
plurality of states of the set of channels, and as a
20 function of total transmit power; wherein the digital gain
to be applied to the channel as part of said set of digital
gains comprises the pre-set digital gain for the current
state of the set of channels, and for the current total
transmit power.

25 In some embodiments, each state comprises a
selection of a particular set of code channels from a set of
possible code channels, and a selection of at least one of
an encoding format, a signal format, and a data rate for at
least one of the set of particular code channels.

30 In some embodiments, for each of at least one of
the code channels determining a digital gain of said set of

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digital gains comprises: determining a nominal digital gain for the code channel; determining a gain adjustment for the code channel in response to the current total transmit power; combining the nominal digital gain and the gain
5 adjustment to produce the digital gain of said set of digital gains for the code channel.

According to a further aspect of the present invention, there is provided a method in a transmitter having an output comprising: determining a transmit power
10 indicator; determining a set of digital gains as a function of the transmit power indicator; applying the set of digital gains to a corresponding set of code channels, the set of digital gains setting relative powers of the set of code channels and also compensating for non-linearities in the
15 transmitter as a function of the transmit power indicator such that a desired relationship between channel powers of said set of channels after having been combined to produce the output is achieved; combining the set of channels to produce the output.

20 According to another aspect of the present invention, there is provided a transmitter having an output and a transmit power indicator, the transmitter comprising: a plurality of code channel generators and/or code channel encoders; for each code channel generator and/or code
25 channel encoder, a respective digital gain element; a compensation element adapted to apply a set of digital gains to the digital gain elements, the set of digital gains compensating for non-linearities in the transmitter as a function of the transmit power indicator such that a desired
30 relationship between code channel powers of said set of code channels after having been combined to produce the output is achieved.

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According to still another aspect of the present invention, there is provided a computer readable medium having computer readable instructions stored thereon for implementation by a computer processor for implementing a
5 method comprising: determining a transmit power indicator; determining a set of digital gains as a function of the transmit power indicator; applying the set of digital gains to a corresponding set of code channels, the set of digital gains setting relative powers of a set of code channels and
10 also compensating for non-linearities in a transmitter as a function of the transmit power indicator such that a desired relationship between channel powers of said set of channels after having been combined to produce the output is achieved.

15 **Brief Description of the Drawings**

The invention will now be described in greater detail with reference to the accompanying diagrams, in which:

Figure 1 is a block diagram of a transmitter featuring code channel compensation, as provided by an embodiment of the invention;

Figure 2 is an example of a channel mapper table structure for use with the embodiment of Figure 1;

Figure 3 a block diagram of a compensation element for performing channel compensation, provided by another embodiment of the invention;

Figure 4 is a flowchart of an example method of determining pre-set digital gains;

Figure 5 is a block diagram of another transmitter featuring code channel compensation, as provided by another embodiment of the invention;

Figure 6 is a flowchart of an example method of determining gain adjustments; and

Figure 7 is another example of a channel mapper table structure.

Detailed Description of the Preferred Embodiments

Many impairments can result in the digital gains being applied to multiple code channels not achieving a desired relationship between the power of each of these channels in the output. One impairment of particular concern is non-linear distortions in the RF amplifier chain, in particular at the power amplifier (PA) stage. It has been conventionally thought that the relative code powers could be determined strictly by comparing the digital gains applied in the digital domain. However, it has now been found that in some implementations the observed power for

each code channel at the output relative to the other code channels is dependent upon the total transmit power. In particular, for example in a CDMA wireless handset, it has been observed that relative to other code channels, the FCH power changes with the total transmit power significantly when the SCH is turned on.

Referring now to Figure 1, shown is a block diagram of a CDMA transmitter featuring code channel power compensation, as provided by an embodiment of the invention. The transmitter includes a digital portion, generally indicated at 10 and an analog portion generally indicated at 12. The digital portion has a set of code channel generators and/or code channel encoders. In the illustrated example, those include a pilot generator 13, a FCH encoder 14, and an SCH encoder 15.

It is to be understood that these particular channels are indicated solely for the purpose of example. Additional or entirely different code channels could alternatively be employed. More generally any set of code channels can be employed that are to be combined such that a desired relationship between output channel powers is achieved.

The output of each code channel generator or code channel encoder is fed to a respective programmable digital gain element. In the illustrated example, the output of pilot generator 13 is passed to programmable digital gain element 16 having gain G_1 , the output of FCH encoder 14 is passed to programmable digital gain element 18 having gain G_2 , and the output of SCH encoder 15 is passed to programmable digital gain element 20 having gain G_3 . The outputs of the digital gain elements are input to a

normalizer 22. In embodiments in which the digital gains of the programmable digital gain elements are set to achieve a substantially normalized total combined power or in embodiments where a normalized total combined power is not required, the normalizer 22 would not be required. The output of the normalizer 22 is fed to a CDMA spreader 24 which has I and Q channel outputs fed to digital-to-analog converter 26. At this point the signals enter the analog domain from the digital domain. The analog portion 12 of the transmitter includes an IQ modulator 28, AGC (Automatic Gain Control) amplifier 30, mixer 32, power amplifier 34 and transmit antenna 35.

It is noted that the particular combination of elements in the digital portion 10 and the analog portion 12 are shown by way of example. A given implementation may include different functions in these two portions. For example, in a zero IF design, there would not be any requirement for a mixer.

The transmitter also has a power control subsystem generally indicated by 36. In the illustrated example, the power control subsystem includes a power control function 37 having an output fed to an AGC (Automatic Gain Control) control block 38 which in turn is connected to a digital-to-analog converter 39. The output of the digital-to-analog converter is used to control the gain of the AGC amplifier 30.

It is noted that a very specific example of a power control system is shown in the example. However, more generally any appropriate power control subsystem that produces the desired transmit power values can be employed. This might for example involve open-loop power control,

closed-loop power control or a combination of open loop and closed-loop power control.

Also shown is a compensation element 39. In the illustrated example, the compensation element 39 has a controller 40 which is responsible for configuring a current state of the various code channel generators and code channel encoders (elements 13, 14 and 15 in the illustrated examples). This control might for example, include selecting which channels are active, configuring various data rates, encoding formats and signal formats.

For each programmable digital gain element (more generally for at least one programmable digital gain element) there is a mapper which takes the current state and selects a new programmable digital gain value which takes into account the overall transmit power in such a manner to result in the ratios between code channel powers at the output of antenna 35 being substantially equal to the desired ratios notwithstanding non-linearity in the digital portion and/or the analogue portion. In the illustrated example, mapper 1 46 executes a mapping function for the first digital gain element 16, mapper 2 44 executes a second mapping function for the second digital gain element 18, and mapper 3 42 executes a third mapping function for the third digital gain element 20. These mappers 42, 44, 46 operate as a function of a signal generated by the power control subsystem 36 which is representative of the total transmit power. In the illustrated examples, this output is taken after the power control function 37. More generally, any transmit power indicator signal can be employed as an input to the mapping process. State information 41 from the controller is used to reconfigure the mappers each time there is a change in state, or the state can be used every

time a new code channel relative power is demanded by the controller and thus a new digital gain value is to be determined by the mappers.

In some embodiments, for any programmable digital gain elements which do not need to be compensated as a function of transmit power, the controller 90 uses a pre-calculated and static digital gain value for the current state of the channel encoders/generators.

The input to each mapper 42,44,46 is the total transmitted power as determined by the power control subsystem 36. The output of each of the mappers varies as a function of the total transmit power at a given current state. The output of each of the mappers controls one of the digital gain elements.

The mapping functions executed by the mappers 42,44,46 are typically non-linear, having been determined by calibration and/or characterization.

An example of a mapper structure is shown in Figure 2. A first table 60 is shown for the Ith channel and a Jth state for the set of channels, for example a particular selected active set, and/or a particular encoding and/or signal format and/or particular data rates. Additional tables are indicated at 62, 64, for the same channel for other states of the set of active channels. In one embodiment, the outputs 41 from the controller 40 are used to select the appropriate table to use at a given instance. Then, the mapping will simply be a direct mapping from the total transmit power indicated at 66 to the digital gain setting indicated at 68. For example, in table 60, shown are entries for total transmit powers for $P \leq P_1$, $P_1 < P \leq P_2$, ... $P_{N-1} < P \leq P_N$. Respective corresponding digital gain

settings 68 are indicated at DG_1 , DG_2 , ... DG_N . For a given current total transmit power, the pre-set value for the range containing that current total transmit power is selected.

5 In typical implementations, the channel state will not change frequently. A table can be loaded for each mapper for the current state, and this table does not need to be re-loaded until the state changes.

 In the above example, each state can be considered
10 to be a corresponding set of characteristics for which a different mapping function is required. Any characteristic or characteristics can be employed as a basis for different mapping tables. For example, in some embodiments the state may also include a particular set of values of the desired
15 ratios in power between the active code channels.

 The compensation element 39 of Figure 1 is a very specific example. More generally, any compensation element can be employed which is adapted to apply a set of digital gains to the digital gain elements, the set of digital gains
20 compensating for non-linearities in the transmitter as a function of the current total transmit power such that a desired relationship between channel powers of said set of channels after having been combined to produce the final output is substantially achieved.

25 More generally, another embodiment of the invention operates as illustrated in Figure 3. A compensation element is shown indicated generally at 70. This element 70 receives as input the total transmit power indicated at 72, state information indicated at 74, and
30 outputs digital gain values 76. In this embodiment, the state information 74 is any information necessary to enable

compensation element 70 to determine appropriate digital gains 76 as a function of the total transmit power 72 such that a desired relationship between channel powers after being combined to produce the transmitter output is

5 substantially achieved. In the above-described example, the operation performed was a table-look-up operation; the state information was an identification of one or more code channels, encoder information and/or a signal formatting information, and data rate information. The digital gain

10 values 76 are compensated digital gain values determined by the compensation element 70 such that the desired interrelationship between the output code channel power is achieved.

As discussed above, the compensation element can

15 perform a table-look-up in which there is a mapping for each channel and for each channel state from various ranges of channel total transmit power to a respective digital gain setting. This is the specific example discussed above with respect to Figure 2. In another example, each channel has a

20 respective table which maps ranges of total transmit power to digital gain setting for each of a plurality of states, with each state having a column in a table.

In another embodiment, a non-linear continuous function can be implemented in the compensation element 70.

25 Such a non-linear function might be identified by using curve-fitting operations. In other embodiments, the compensation element employs stored pre-set values and uses interpolation to reduce the number of values that need to be stored.

30 Referring now to Figure 4 shown is an example flow chart of a method for calibrating tables for use in the

embodiment of Figure 1. This calibration may be performed for each device manufactured during manufacturing, in the event that unit-to-unit variation is significant and cannot be ignored. In the event that a given batch of units do not
5 have significant unit-to-unit variation, calibration could be performed on a per batch level.

The method begins at step 4-1 with configuring the unit to transmit in each of the supported states. The method continues at step 4-2 with setting the transmit power
10 to each of an array of pre-selected values in a range of supported transmit power. This step is done for each state configured in step 4-1. Next, at step 4-3, for each state, and for each selected transmit power, while measuring the code channel powers at the transmitter output port, the
15 digital gains of all of the activated code channels are adjusted until the desired values are measured at the output port. Next, at step 4-4, the digital gain values thus obtained are saved. These values may be directly used to generate tables, or alternatively they can be processed for
20 example by interpolation or to generate appropriate ranges, with the output of the processing being used to fill the tables.

In the event that the unit to unit variation is negligible, a number of sample units can be calibrated as
25 above to find table values for each of the sample units, and an average of the table values thus obtained used in the batch of units.

In the example described above with reference to Figure 1 it has assumed that for a given set of channels and
30 configurations, the nominal relative code channel output powers desired are fixed or at least not changed often.

Because of this, the controller 40 does not generate digital gain values, but rather simply selects an appropriate one of the tables to be used in generating each of the digital gain values. In another embodiment, the desired code channel powers relative to each other are also required to be variable during transmission for at least one of the channels. An example of a method/apparatus of performing non-linear compensation in such a context will now be described with reference to Figure 5. This figure is the same as Figure 1 with the exception of the fact that the compensation element 39 is different. In this embodiment, the controller 40 generates an output to select an appropriate mapping table, as indicated at 41. This is substantially the same function as was performed by Figure 1. However, in this embodiment, the controller also generates variable nominal gains 80 for at least one of the channels, and in the illustrated example for all of the channels. The variable gain value is then combined with an output of the appropriate mapping function to provide an actual gain which is then fed to the appropriate digital gain element. The mapping functions output gain adjustments in this embodiment. In the illustrated example, it is assumed that the variable digital gains are logarithmic, and the values output by the mapping functions are also logarithmic offsets, and as such the two values can simply be added with adders 81, 82 and 83 to get the desired digital gains. In this case, it would be of course assumed that the digital gain blocks accept logarithmic inputs.

If the digital gain blocks accept inputs in the form of linear values, the adders 81, 82 and 83 are replaced with multipliers, and two linear values produced by the controller 40 and the mapping tables 42, 44, 46 are

multiplied together to produce gain values to be input to the digital gain elements.

An example of a method of calibrating the arrangement of Figure 5 is now described with reference
5 flowchart of Figure 6. The method begins at step 6-1 with configuring the unit to transmit at each of the states the unit is capable of operating in. At step 6-2, for each state selected in step 6-1, the transmit power is set to an array of selected values. In step 6-3, for each transmit
10 power and for each state, the digital gains are adjusted until the values measured reach each of an array of predetermined values within the range supported by the given product. This equates to working through the various ranges of nominal gain that could potentially be output by the
15 controller 40 in the example of Figure 5. At step 6-4, the difference between the actual digital gain after adjustment in accordance with step 6-3, and the controller produced gain is measured and averaged over the multiple adjustments conducted in step 6-3. This average value is then saved at
20 6-5 and is the value used in generating an appropriate offset for use in the non-linear operation.

Once again, the calibration can be performed on a per unit basis if unit-to-unit variation is significant or for batches if average results are acceptable.

25 A specific example of performing compensation in the context of variable nominal gains has been described with reference to Figure 5. It is to be understood that any method/apparatus which compensates for non-linearities as a function of total transmit power can be employed. For
30 example, in another embodiment, for each state, and for each range of total transmit power, a separate mapping table is

provided, and a mapping between nominal non-compensated digital gain to compensated digital gain is provided. This increases the number of tables that would be required since there would be a table for each state and each transmit
5 power range. An example of such a table is shown in Figure 7. This example shows that there is a given table for each state, and for each range of transmit power. The illustrated table is for channel mapper I, state number J and for $P_0 < P \leq P_1$. The nominal gain 80 is mapped to a
10 compensated gain 82.

It is noted that in the above examples, it is assumed that the power in all of the coded channels varies significantly over transmit power. More generally, in some embodiments it may be that one or more of code channels have
15 a power which does not varies significantly from transmit power, and as such it will not be necessary to perform an adjustment of the digital gain being applied for that channel.

Another embodiment of the invention provides a
20 computer readable medium having instructions thereon for implementation by a computer, a computer being any appropriate combination of processing hardware. The instructions are for implementing any of the code channel compensation methods described herein.

25 What has been described is merely illustrative of the application of the principles of the invention. Other arrangements and methods can be implemented by those skilled in the art without departing from the spirit and scope of the present invention.

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CLAIMS:

1. A method in a transmitter having an output comprising:

5 determining a current total transmit power for the output;

determining a set of digital gains in response to the current total transmit power;

10 applying the set of digital gains to a corresponding set of code channels, the set of digital gains setting relative powers of the set of code channels and also compensating for non-linearities in the transmitter as a function of the current total transmit power such that a desired relationship between channel powers of the set of code channels after having been combined to produce the
15 output is achieved;

combining the set of code channels to produce the output.

2. A method according to claim 1 wherein the desired relationship between channel powers comprises a specified
20 relative power for each of the channels in the output.

3. A method according to claim 1 or 2 further comprising for each at least one channel:

25 maintaining a respective pre-set digital gain value for the channel for each of a plurality of states of the set of channels, and as a function of total transmit power;

wherein the digital gain to be applied to the channel as part of said set of digital gains comprises the

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pre-set digital gain for the current state of the set of channels, and for the current total transmit power.

4. A method according to claim 3 wherein for each of said at least one channel, a respective pre-set digital gain is maintained for each of the plurality of states of the set of channels and for a plurality of ranges of total transmit power.

5. A method according to claim 4 further comprising for each code channel:

10 maintaining a respective pre-set digital gain value for the code channel for each of a plurality of states of the set of code channels, and for each of a plurality of ranges of total transmit power;

15 wherein the digital gain to be applied to the code channel as part of said set of digital gains comprises the pre-set digital gain for a current state of the set of code channels, and for the range containing the current total transmit power.

20 6. A method according to any one of claims 3 to 5 wherein each state comprises a selection of a particular set of code channels from a set of possible code channels, and a selection of at least one of an encoding format, a signal format, and a data rate for at least one of the set of particular code channels.

25 7. A method according to any one of claims 3 to 6 wherein each state comprises at least one of:

a selection of a particular set of code channels from an available set;

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a selection of a particular encoder format for at least one code channel;

a selection of a particular signal format for at least one code channel; and

5 a selection of a particular data rate for at least one code channel.

8. A method according to any one of claims 4 to 7 comprising:

for each state and for each code channel:

10 maintaining the pre-set digital gains in a table mapping each range of transmit power to a respective pre-set digital gain.

9. A method according to any one of claims 1 to 8 wherein, for each of at least one of the code channels
15 determining a digital gain of said set of digital gains comprises:

determining a nominal digital gain for the code channel;

determining a gain adjustment for the code channel
20 in response to the current total transmit power;

combining the nominal digital gain and the gain adjustment to produce the digital gain of said set of digital gains for the code channel.

10. A method according to claim 9 wherein the gain
25 adjustment is a multiplicative gain adjustment and wherein combining the nominal digital gain and the gain adjustment to produce the respective digital gains comprises multiplying the nominal digital gain by the gain adjustment.

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11. A method according to claim 9 wherein the gain adjustment is an additive gain adjustment and wherein combining the nominal digital gain and the gain adjustment to produce the respective digital gains comprises adding the
5 nominal digital gain to the gain adjustment.

12. A method according to any one of claims 9 to 11 comprising:

for each state and for each code channel:

maintaining the gain adjustments in a table
10 mapping each range of transmit power to a respective gain adjustment.

13. A method according to any one of claims 9 to 12 wherein each gain adjustment is pre-determined to provide compensation over a range of nominal digital gains.

15 14. A method according to any one of claims 1 to 13 wherein the code channels are CDMA code channels.

15. A transmitter having an output and a current transmit power, the transmitter comprising:

a plurality of code channel generators and/or code
20 channel encoders;

for each code channel generator and/or code channel encoder, a respective digital gain element;

a compensation element adapted to apply a set of digital gains to the digital gain elements, the set of
25 digital gains compensating for non-linearities in the transmitter as a function of the current total transmit power such that a desired relationship between code channel powers of said set of code channels after having been combined to produce the output is substantially achieved.

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16. A transmitter according to claim 15 wherein the compensation element comprises:

a memory containing for at least one code channel, a respective pre-set digital gain value for the code channel
5 for each of a plurality of states of the set of code channels, and for a plurality of ranges of total transmit power.

17. A transmitter according to any one of claims 15 to 16 wherein the compensation element comprises a
10 controller adapted to configure the transmitter to have a selected state of a plurality of states, each state comprising at least one of:

a) a selection of a particular set of code channels from a set of available code channels;

15 b) a selection of a particular encoder format for at least one code channel;

c) a selection of a particular signal format for at least one code channel; and

20 d) a selection of a particular data rate for at least one code channel;

a memory containing for each state, a pre-set digital gain value for each code channel for each of a plurality of ranges of transmit power;

25 wherein for each code channel the controller is adapted to apply the appropriate pre-set digital gain value as a function of the state and total transmit power as one digital gain of said set of digital gains.

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18. A transmitter according to any one of claims 15 to 17 wherein the compensation element is further adapted to determine for at least one code channel a nominal digital gain for the code channel, and to combine a respective gain adjustment with each nominal digital gain value to determine the digital gains to be applied to the digital gain elements for the at least one code channel.

19. A transmitter according to any one of claims 15 to 18 wherein the compensation element comprises a controller adapted to configure the transmitter to have a selected state of a plurality of states, each state comprising at least one of:

a) a selection of a particular set of code channels from a set of available code channels;

b) a selection of a particular encoder format for at least one code channel;

c) a selection of a particular signal format for at least one code channel; and

d) a selection of a particular data rate for at least one code channel;

a memory containing for each state, the pre-set digital gain adjustment for each code channel for each of a plurality of ranges of transmit power;

wherein for each code channel the controller is adapted to employ an appropriate pre-set digital gain adjustment as a function of the state and total transmit power as said respective gain adjustment.

20. A transmitter according to any one of claims 15 to 19 further comprising:

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a power control subsystem adapted to determine the total transmit power.

21. A computer readable medium comprising computer readable instructions for implementing a method comprising:

5 determining a current total transmit power for an output;

determining a set of digital gains in response to the current total transmit power, the set of digital gains setting relative powers of a set of code channels and also
10 compensating for non-linearities in a transmitter as a function of the current total transmit power such that a desired relationship between channel powers of the set of code channels after having been combined to produce the output is achieved.

15 22. A computer readable medium according to claim 21 wherein the method further comprises for each of at least one channel:

maintaining a respective pre-set digital gain value for the channel for each of a plurality of states of
20 the set of channels, and as a function of total transmit power;

wherein the digital gain to be applied to the channel as part of said set of digital gains comprises the pre-set digital gain for the current state of the set of
25 channels, and for the current total transmit power.

23. A computer readable medium according to claim 22 wherein each state comprises a selection of a particular set of code channels from a set of possible code channels, and a selection of at least one of an encoding format, a signal

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format, and a data rate for at least one of the set of particular code channels.

24. A computer readable medium according to claim 23 wherein, for each of at least one of the code channels
5 determining a digital gain of said set of digital gains comprises:

determining a nominal digital gain for the code channel;

determining a gain adjustment for the code channel
10 in response to the current total transmit power;

combining the nominal digital gain and the gain adjustment to produce the digital gain of said set of digital gains for the code channel.

25. A method in a transmitter having an output
15 comprising:

determining a transmit power indicator;

determining a set of digital gains as a function of the transmit power indicator;

applying the set of digital gains to a
20 corresponding set of code channels, the set of digital gains setting relative powers of the set of code channels and also compensating for non-linearities in the transmitter as a function of the transmit power indicator such that a desired relationship between channel powers of said set of channels
25 after having been combined to produce the output is achieved;

combining the set of channels to produce the output.

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26. The method according to claim 25 wherein determining the transmit power indicator comprises:

determining a signal representative of a total transmit power.

5 27. The method according to claim 25 wherein determining the transmit power indicator comprises:

determining a signal representative of a current total transmit power.

28. The method according to any one of claims 25 to 27
10 wherein the desired relationship between channel powers comprises a specified relative power for each of the channels in the output.

29. The method according to any one of claims 25 to 28
15 wherein determining a set of digital gains as a function of the transmit power indicator further comprises:

for each of at least one channel:

20 using a non-linear function that is a function of the transmit power indicator in generating a digital gain value for the current state and for the current transmit power of the respective channel.

30. The method according to claim 29 wherein using a non-linear function further comprises:

using a curve-fitting operation to provide the non-linear function.

25 31. The method according to any one of claims 25 to 30 wherein determining a set of digital gains as a function of the transmit power indicator further comprises:

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for each of at least one channel:

maintaining a respective pre-set digital gain value for the channel for each of a plurality of states of the set of channels, and as a function of the transmit power indicator;

determining and using a digital gain value for the current state and for the current transmit power of the at least one channel by interpolation of pre-set digital gain values.

32. The method according to any one of claims 29 to 31 wherein each state comprises a selection of a particular set of code channels from a set of possible code channels, and a selection of at least one of an encoding format, a signal format, and a data rate for at least one of the set of particular code channels.

33. The method according to any one of claims 29 to 32 wherein each state comprises at least one of:

a selection of a particular set of code channels from an available set;

a selection of a particular encoder format for at least one code channel;

a selection of a particular signal format for at least one code channel; and

a selection of a particular data rate for at least one code channel.

34. The method according to any one of claims 25 to 33 wherein, for each of at least one of the code channels determining a digital gain of said set of digital gains comprises:

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determining a nominal digital gain for the code channel;

determining a gain adjustment for the code channel as a function of the transmit power indicator;

5 combining the nominal digital gain and the gain adjustment to produce the digital gain of said set of digital gains for the code channel.

35. The method according to any one of claims 25 to 34 wherein the code channels are CDMA code channels.

10 36. A transmitter having an output and a transmit power indicator, the transmitter comprising:

a plurality of code channel generators and/or code channel encoders;

15 for each code channel generator and/or code channel encoder, a respective digital gain element;

20 a compensation element adapted to apply a set of digital gains to the digital gain elements, the set of digital gains compensating for non-linearities in the transmitter as a function of the transmit power indicator such that a desired relationship between code channel powers of said set of code channels after having been combined to produce the output is achieved.

37. The transmitter according to claim 36 wherein the compensation element comprises:

25 a digital gain determiner for determining a digital gain value for a current state and for a current transmit power of each channel, by using a non-linear function that is a function of the transmit power indicator.

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38. The transmitter according to claim 36 wherein the compensation element comprises:

a memory containing for at least one code channel, a respective pre-set digital gain value for the code channel
5 for each of a plurality of states of the set of code channels, and for at least one of: a plurality of discrete values of transmit power; and a plurality of ranges of transmit power;

a digital gain determiner for determining a
10 digital gain value for a current state and for a current transmit power using interpolation of pre-set digital gain values.

39. The transmitter according to any one of claims 36 to 38 further comprising:

15 a power control subsystem adapted to determine the transmit power.

40. A computer readable medium having computer readable instructions stored thereon for implementation by a computer processor for implementing a method comprising:

20 determining a transmit power indicator;

determining a set of digital gains as a function of the transmit power indicator;

applying the set of digital gains to a corresponding set of code channels, the set of digital gains
25 setting relative powers of a set of code channels and also compensating for non-linearities in a transmitter as a function of the transmit power indicator such that a desired relationship between channel powers of said set of channels

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after having been combined to produce the output is achieved.

41. The computer readable medium according to claim 40 wherein the method step of determining a set of digital gains as a function of the transmit power indicator further comprises:

for each of at least one channel:

using a non-linear function that is a function of the transmit power indicator in generating a digital gain value for the current state and for the current transmit power of the respective channel.

42. The computer readable medium according to claim 41 wherein the method further comprises:

using a curve-fitting operation to provide the non-linear function.

43. The computer readable medium according to any one of claims 40 to 42 wherein the method step of determining a set of digital gains as a function of the transmit power indicator further comprises:

for each of at least one channel:

maintaining a respective pre-set digital gain value for the channel for each of a plurality of states of the set of channels, and as a function of the transmit power indicator;

determining and using a digital gain value for the current state and for the current transmit power of the at least one channel by interpolation of pre-set digital gain values.

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44. The computer readable medium according to any one of claims 41 to 43 wherein each state comprises a selection of a particular set of code channels from a set of possible code channels, and a selection of at least one of an
5 encoding format, a signal format, and a data rate for at least one of the set of particular code channels.

45. A computer readable medium according to claim 44 wherein, for each of at least one of the code channels determining a digital gain of said set of digital gains
10 comprises:

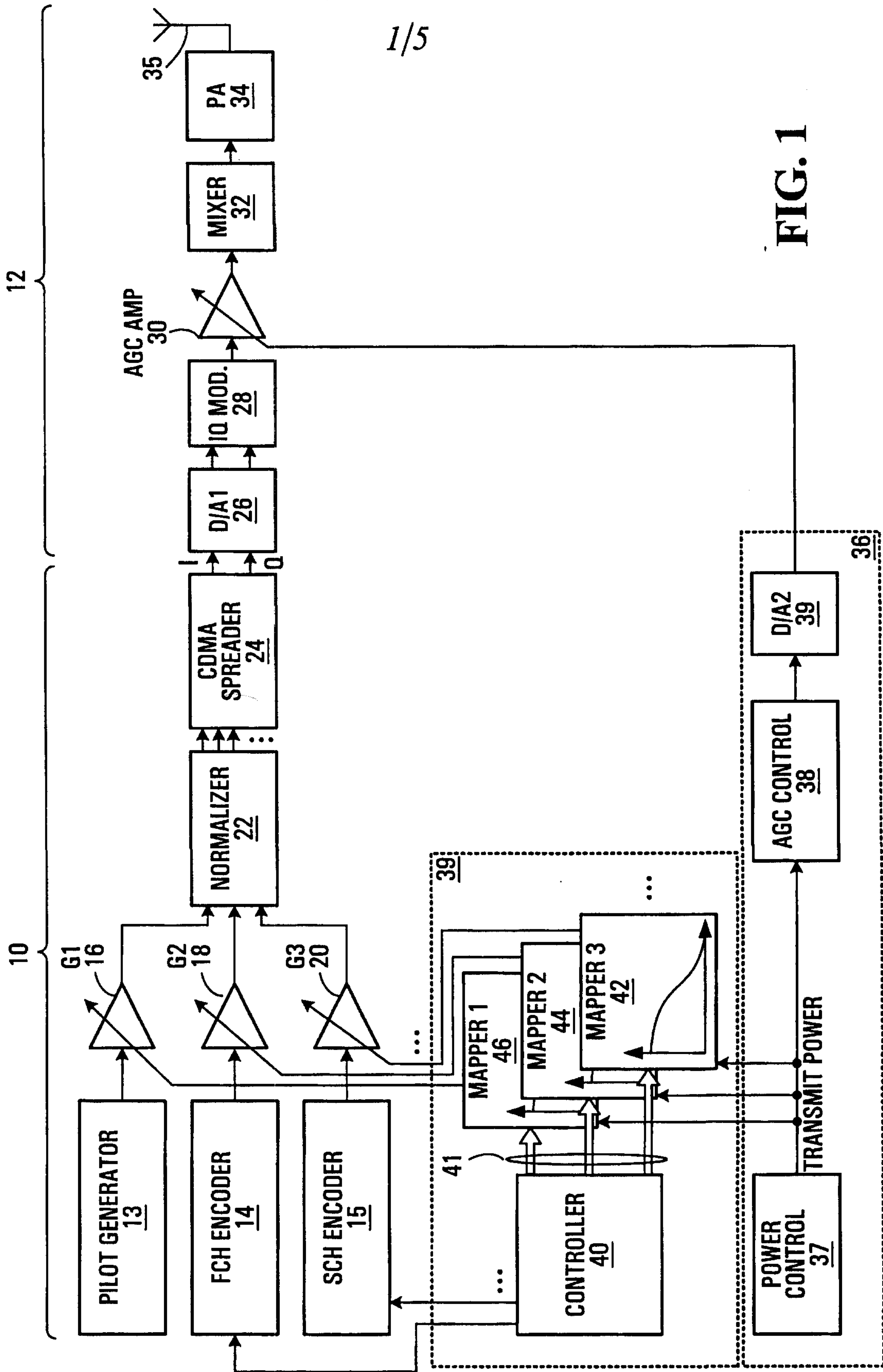
determining a nominal digital gain for the code channel;

determining a gain adjustment for the code channel in response to the transmit power indicator;

15 combining the nominal digital gain and the gain adjustment to produce the digital gain of said set of digital gains for the code channel.

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PATENT AGENTS



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FIG. 1

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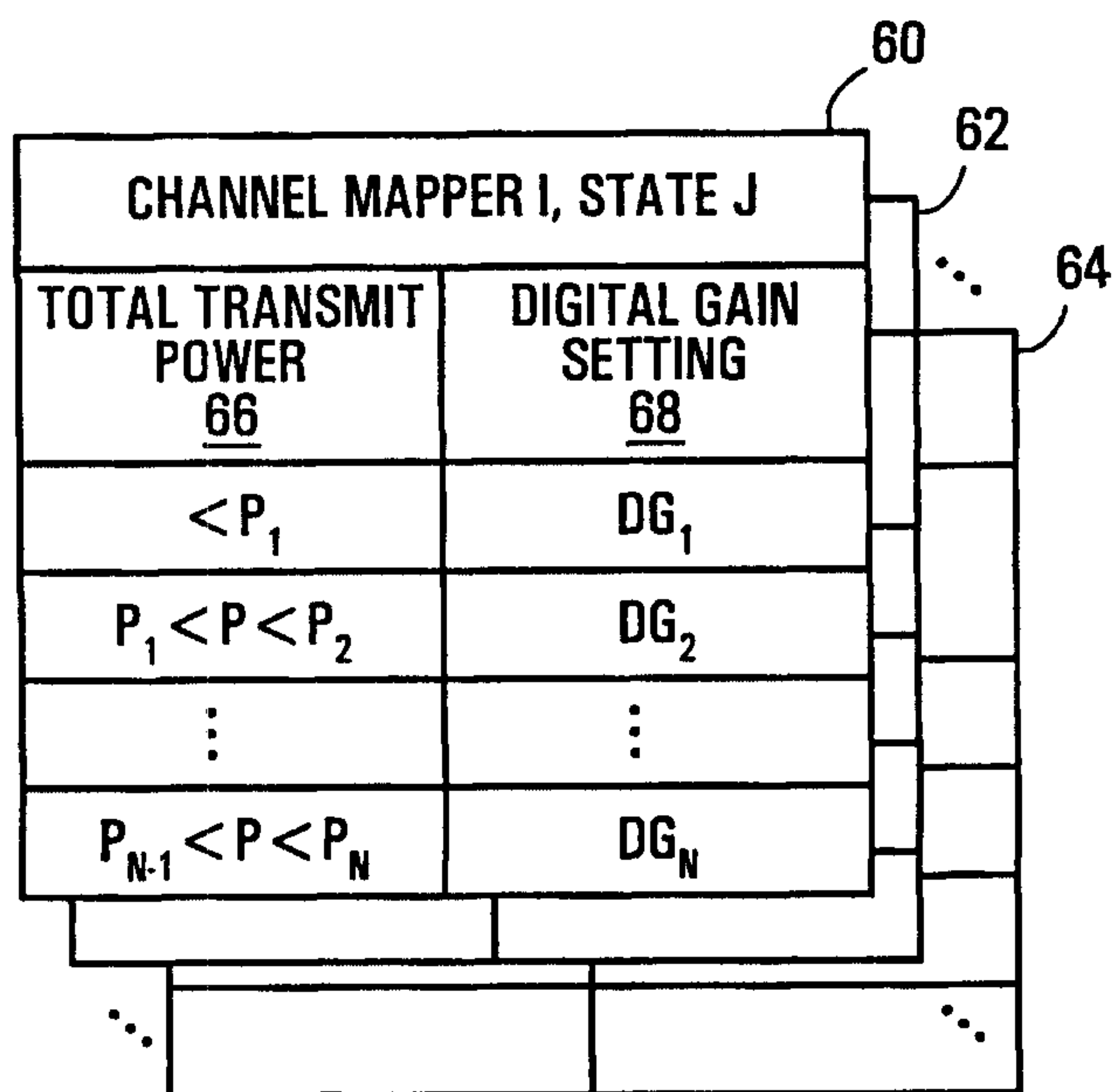


FIG. 2

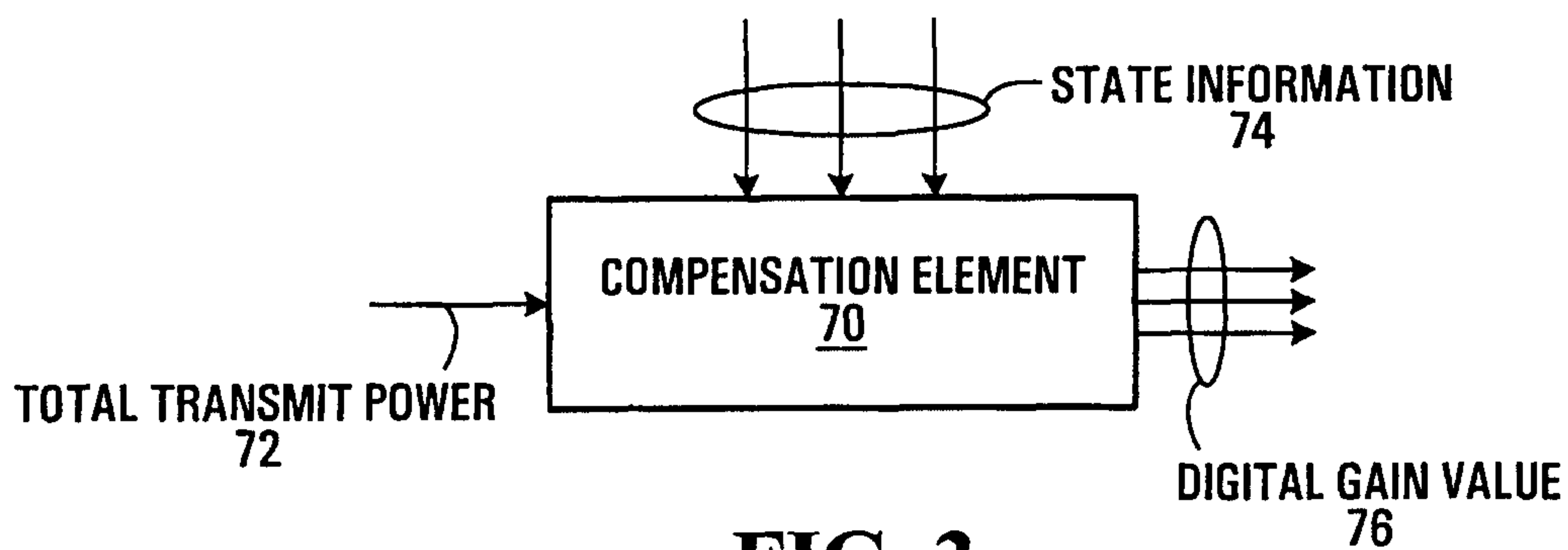


FIG. 3

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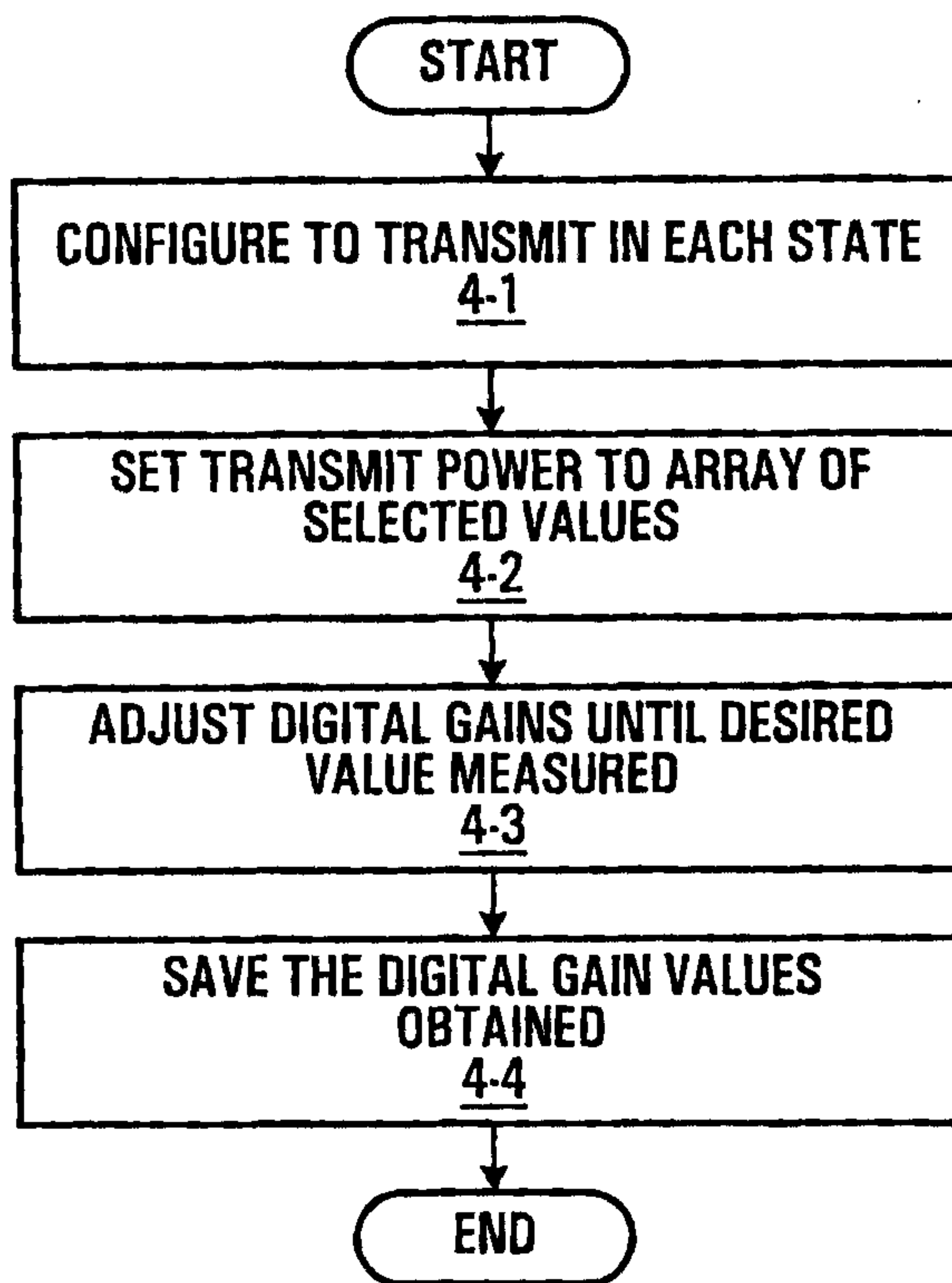


FIG. 4

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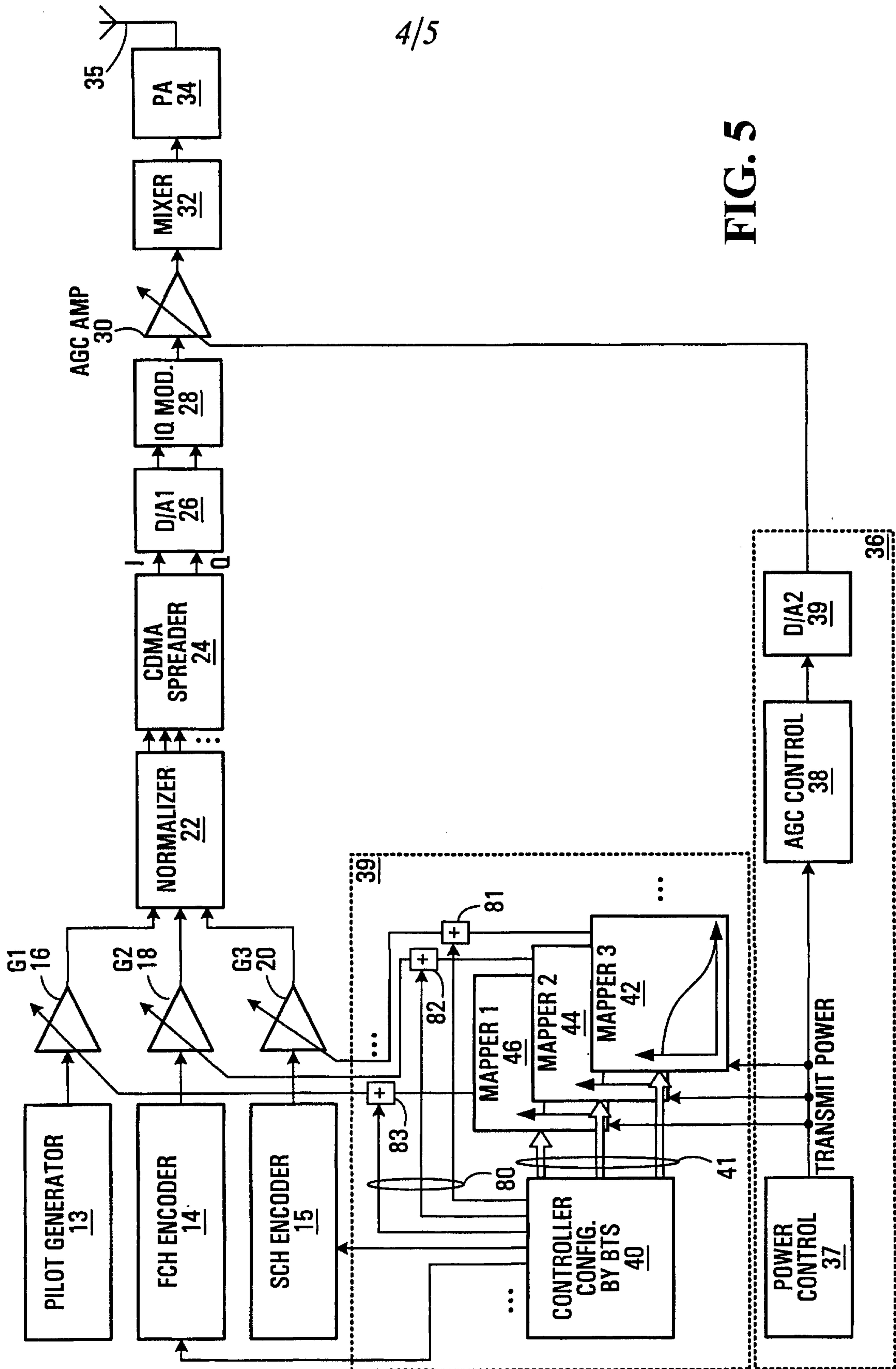


FIG. 5

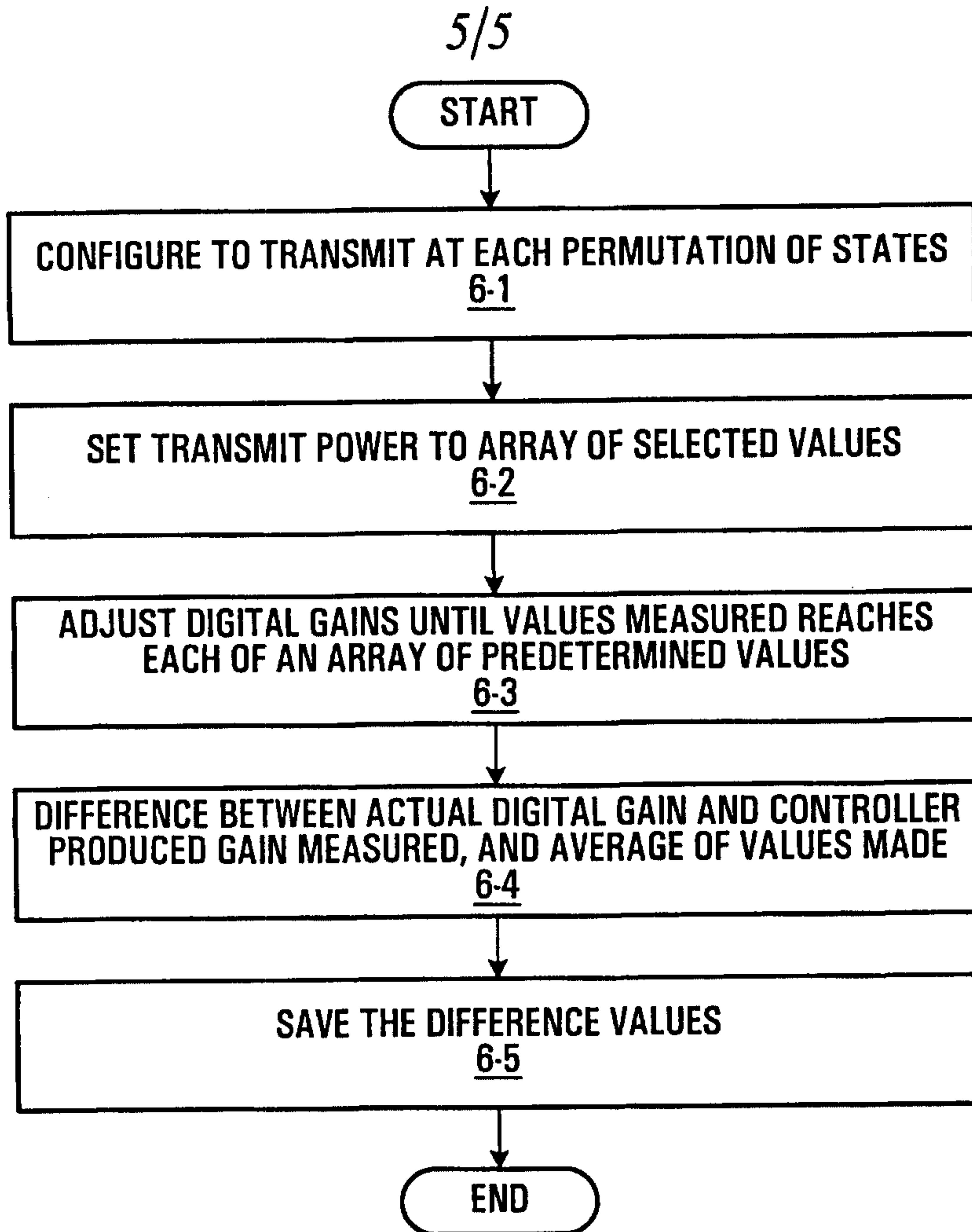


FIG. 6

CHANNEL MAPPER I, STATE J, $P_0 < P < -P_1$	
NOMINAL GAIN <u>80</u>	COMPENSATED GAIN <u>82</u>

FIG. 7

