

IMPLANTABLE SYSTEM FOR DETECTING ELECTRICAL SIGNALS OF A HUMAN HEART OR AN ANIMAL HEART

Description

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The present invention relates to an implantable system for detecting electrical signals of a human heart or an animal heart according to the preamble of claim 1, to a method for controlling the operation of such a system according to the preamble of claim 13, and to a computer program product according to the preamble of claim 14.

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The atrioventricular conduction time and the interventricular conduction time are two important characteristic variables from which the condition of a human heart or an animal heart can be inferred, and which must be taken into consideration during the operation of a cardiac pacemaker, so that the pulses emitted by the cardiac pacemaker result in effective stimulation of the treated heart.

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The atrioventricular conduction time is the time that passes between a stimulation or an intrinsic activity of the atrium and an immediately following ventricular activity. The interventricular conduction time indicates the temporal offset between a contraction of the right ventricle and the contraction of the left ventricle following immediately thereafter. In a healthy heart, the right ventricle and the left ventricle contract at the same time. In patients suffering from cardiological diseases, however, a temporal offset may occur. As a result, the heart's ability to pump properly declines, which is manifested in cardiac insufficiency and an enlarged heart. So as to achieve that both ventricles contract in a better synchronized manner in terms of time in such a case, it is necessary to determine the temporal offset between the contraction of the right ventricle and the contraction of the right ventricle with great precision. This typically takes place after the implantation of a pacemaker. The problem in this regard is that the interventricular conduction time can change, in particular during the initial time following the implantation of the pacemaker, but in principle also at a later time. It is then necessary to readjust the pacemaker so as to achieve good therapeutic effectiveness of the pacemaker. In the case of left ventricular leads having multiple stimulation poles, such as quadrupolar leads, a measurement of the interventricular

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conduction time between the right ventricle and each of the left ventricular stimulation poles can be carried out. The optimal stimulation pole is selected based on the measured times.

US 2010/0100148 A1 describes the option of determining the atrioventricular conduction time and the interventricular conduction time within the scope of a stimulation threshold test of a cardiac pacemaker. The problem with this determination method is that an extrinsic stimulation of the heart in question is carried out, which may overlap the intrinsic cardiac activity.

Aspects of the invention are defined in the independent claims. Some optional features of the invention are defined in the dependent claims.

An implantable system for detecting electrical signals of a human heart or an animal heart is disclosed. Such a system comprises a processor, a memory unit, a first detection unit, a second detection unit, and a third detection unit. The first detection unit is used to detect an atrial activity, that is, an activity in an atrium of the human or animal heart, and in particular in the right atrium. The second detection unit is used to detect a right ventricular activity, while the third detection unit is used to detect a left ventricular activity of a human heart or an animal heart.

Thus, it may be possible to provide an implantable medical product that also allows a simplified and reliable determination of the atrioventricular conduction time and/or of the interventricular conduction time after the medical device has been implanted.

The memory unit may include a computer-readable program, which prompts the processor to automatically carry out the steps described hereafter at regular intervals when the program is being executed on the processor.

According to a first variant, initially an intrinsic right atrial activity is detected by way of the first detection unit. Thereafter, an intrinsic right ventricular activity immediately following the previously detected right atrial activity is detected by way of the second detection unit. Afterwards, the time that has passed between the intrinsic right atrial activity and the intrinsic

right ventricular activity is determined. This is subsequently stored as the atrioventricular conduction time, for example in the memory unit.

As an alternative or in addition to the steps described above, the program can prompt the
5 processor to carry out the steps described hereafter.

According to this second variant, initially an intrinsic right ventricular activity is detected by way of the second detection unit. Thereafter, an intrinsic left ventricular activity immediately following the previously detected intrinsic right ventricular activity is detected by way of the
10 third detection unit. Afterwards, the time that has passed between the intrinsic right ventricular activity and the intrinsic left ventricular activity is determined. This is then stored as the interventricular conduction time, for example in the memory unit.

In contrast to the medical devices known from the prior art, the disclosed implantable system
15 is aimed at exclusively detecting an intrinsic activity (action) of the individual chambers of a human heart or an animal heart. External stimuli, which are emitted, for example, by a stimulation unit of a cardiac pacemaker, are expressly not evaluated. Moreover, the implantable system is designed to automatically carry out the described method steps at regular intervals. In this way, it possible at all times to provide reliable data regarding the
20 atrioventricular conduction time and/or the interventricular conduction time. This data can then be used to set the parameters of a cardiac pacemaker or of another device for stimulating a human heart or an animal heart. It can also be used as starting data for subsequent diagnostic examinations. For example, a change in the condition of the heart can be ascertained from monitoring the chronological progression of the atrioventricular
25 conduction time or the interventricular conduction time. A physician can then decide on suitable counter-measures with respect to the observed change in the condition of the heart. Moreover, based on such data, a physician is also able to assess whether a device for stimulating the heart is functioning correctly and behaving as desired with respect to the cardiological condition of the patient.

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In one variant, it is not just the right ventricular activity and the left ventricular activity that are detected within the scope of the determination of the interventricular conduction time.

Rather, an intrinsic right atrial activity is also detected in this variant by way of the first detection unit. It is then possible to provide particularly reliable information that the detected ventricular activities were in fact triggered by an intrinsic atrial signal of the particular heart.

5 When the intrinsic right atrial activity is detected by way of the first detection device, the atrioventricular conduction time can additionally be determined in a further variant, so that both the atrioventricular conduction time and the interventricular conduction time are determined within one measuring cycle. This variant is consequently a combination of the two variants described above.

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In one variant, the program prompts the processor to carry out the above-described steps for the determination of the atrioventricular conduction time and/or the interventricular conduction time once within a time period of 3 hours to 48 hours, in particular of 6 hours to 36 hours, and in particular of 12 hours to 24 hours. For example, the program can prompt
15 the processor to carry out the described steps once a day. It is then possible to ascertain and store the atrioventricular conduction time and/or the interventricular conduction time particularly easily at a defined interval.

In one variant, the implantable system is not only suitable for detecting electrical signals of
20 a human heart or an animal heart, but also provided and configured to stimulate the same human or animal heart. The determined atrioventricular conduction time and/or the determined interventricular conduction time can then be used particularly easily for adapting parameters (for example, the AV delay or the VV delay) of the same device, which also carries out a stimulation of the heart if necessary.

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In one variant, the implantable system is a cardiac pacemaker, and in particular a device for cardiac resynchronization therapy (CRT device). The reason is that it is particularly relevant in the case of such cardiac pacemakers or CRT devices to precisely set the stimulation pulses to be delivered when needed to the physiological circumstances in the particular heart. As a
30 result of the ascertainment of the atrioventricular conduction time and/or of the interventricular conduction time, a particularly meaningful parameter setting can thus be implemented at the cardiac pacemaker or CRT device.

In one variant, the program prompts the processor to inhibit an atrial stimulation and a ventricular stimulation until the atrioventricular conduction time and/or the interventricular conduction time have been determined. In this way, it is ensured that no extrinsic stimulation signals can be detected, which can, in principle, be delivered by the implantable system, configured in this variant as a stimulation unit, to the human or animal heart in question, and which can overlap the intrinsic signals of the cardiac activity. Since it only takes very little time to carry out the above-described steps for determining the atrioventricular conduction time and/or the interventricular conduction time, inhibiting stimulation pulses during the required measuring time is not problematic for the safety of the device and/or the state of health of the patient.

In one variant, the program prompts the processor to carry out the above-described steps for the determination of the atrioventricular conduction time and/or the interventricular conduction time during a routine measurement of a signal of the intrinsic cardiac activity. As an alternative or in combination, said above-described steps can be carried out during a determination and/or an adaptation of a detection threshold of the implantable system.

The routine measurement of a signal of the intrinsic cardiac activity and the determination and/or adaptation of a detection threshold of the implantable system are typically carried out once a day. During this time, the delivery of stimulation pulses is generally suppressed anyhow. The method for ascertaining the atrioventricular conduction time and/or the interventricular conduction time carried out by the system can, in this variant, be carried out with any significant loss of time during the routine measurement of a signal of the intrinsic cardiac activity, or during the determination and/or adaptation of a detection threshold of the implantable system. In this way, it is additionally possible, when the implantable system is already being tested anyhow with respect to the response behavior thereof, to ascertain the atrioventricular conduction time and/or the interventricular conduction time, except without significant additional time expenditure. As a result, this variant in particular offers a particularly simple option for implementing the automatic regular ascertainment of the atrioventricular conduction time and/or of the interventricular conduction time.

According to one exemplary embodiment of the device, the measurement of a signal of the intrinsic cardiac activity encompasses the measurement and/or determination of at least one signal parameter of amplitude, pulse width, number of zero crossings, amplitude and/or phase frequency spectrum and/or energy of the signal, as well as the parameters

- 5 - of a model of the signal (such as autoregressive moving average (ARMA))
 and/or
- of a transformation of the signal (such as wavelet)
 and/or

amplitude, pulse width, number of zero crossings, amplitude and/or phase frequency
10 spectrum and/or energy of a time derivative of the signal.

In one variant, the program prompts the processor to store a plurality (two or more) of previously determined atrioventricular conduction times and/or interventricular conduction times. The storing can take place in the memory unit of the implantable system, for example.
15 Such storing of the previously determined conduction times allows a history of the conduction times already ascertained to be compiled. It is then possible, for example, to ascertain to what extent a newly determined conduction time differs from conduction times ascertained in the past. The two conduction time types (that is, the atrioventricular conduction times on the one hand, and the interventricular conduction times on the other
20 hand) are typically stored separately from one another in the process and compared to one or more conduction times of the same time as needed.

In one variant, the program prompts the processor to ascertain a chronological progression of the particular conduction time from the plurality of stored atrioventricular conduction
25 times and/or interventricular conduction times. For this purpose, the individual conduction times are stored together with a piece of time information with respect to the point in time of the determination thereof. It is then possible to ascertain a chronological progression of the corresponding conduction time particularly easily. A trend of one of the two conduction times, or of both conduction times, in a particular direction can be ascertained from this
30 chronological progression, which allows a change in the condition of the heart in question to be inferred. As an alternative or in addition, the data obtained in this way can also be used

to infer the interaction between the implantable system and the heart, of which the signals are detected.

5 In one variant, the program prompts the processor to transmit the atrioventricular conduction time and/or the interventricular conduction time to an external device or to an external data center. In this way, the obtained data can be evaluated particularly easily outside the implantable system. The data transmission to an external device can be useful, in particular, within the scope of individual examinations of a patient by a physician. In contrast, a data transmission to a data center allows continuous monitoring of the condition of the
10 implantable system that is sending the data, or of the patient in whom the system was implanted. In this way, results that allow improved patient care and/or enhanced device safety can be obtained within the scope of telemedicine. The data transmission to an external device or to a data center takes place, in particular, wirelessly in a radio-based way. For this purpose, the implantable system is, in this variant, equipped with a corresponding radio
15 module.

In one variant, the implantable system comprises a multipolar electrode. The first detection unit represents a first electrode pole of the multipolar electrode, while the second detection unit represents a second electrode pole of the multipolar electrode. The multipolar electrode
20 can comprise 2, 3, 4, 5, or 6 electrode poles, for example, wherein a larger number of electrode poles is, in principle, likewise conceivable. In this way, the implantable system can be configured with a floating electrode, for example, which detects both atrial cardiac signals and ventricular cardiac signals by way of the different electrode poles thereof.

25 In one variant, it is contemplated that the multipolar electrode not only comprises the first detection unit and the second detection unit, but additionally also the third detection unit.

In a further variant, the third detection unit itself is configured as a multipolar electrode. This means, in this variant, it has a plurality (two or more) of electrode poles. Each of these
30 electrode poles is used to detect an intrinsic left ventricular signal. In this variant, it is thus possible to ascertain different left ventricular signals and thus, with respect to a respective right ventricular signal detected immediately before, (slightly) different interventricular

conduction times. In one variant, it is possible to calculate a uniform interventricular conduction time from the previously ascertained individual interventricular conduction times, for example by finding a mean value. It is also conceivable to allocate a higher weight to isolated previously determined individual interventricular conduction times than others of the previously determined individual conduction times if this appears physiologically useful based on the arrangement of the individual electrode poles inside the heart of a patient.

The third detection unit can, for example, be configured as a quadrupolar electrode, that is, comprise four electrode poles, which each detect a left ventricular signal. The cardiac signals that are indicative of a left ventricular activity are typically detected by an electrode that is anchored at the coronary sinus of a heart, since a direct insertion of the electrode into the left ventricle is generally not possible due to the pressure conditions present there.

There is also disclosed a method for controlling the operation of an implantable system for detecting electrical signals of a human heart or an animal heart. This control method refers, in particular, to the control of the operation of an implantable system according to the above descriptions. The method may comprise the steps described hereafter.

Initially, in a first variant, an intrinsic right atrial activity is detected by way of a first detection device. Afterwards, an intrinsic right ventricular activity, which immediately follows the previously detected right atrial activity, is detected by way of a second detection unit. Thereafter, the time that has passed between the intrinsic right atrial activity and the intrinsic right ventricular activity is ascertained. This time is then stored as the atrioventricular conduction time.

As an alternative or in addition to the above-described first variant, the second variant of the method described hereafter can be carried out. According to this variant, initially an intrinsic right ventricular activity is detected by way of a second detection unit. Furthermore, an intrinsic left ventricular activity immediately following the previously detected right ventricular activity is detected by way of a third detection unit. Afterwards, the time that has passed between the intrinsic right ventricular activity and the intrinsic left ventricular activity is determined. This time is then stored as the interventricular conduction time.

There is also disclosed a computer program product including computer-readable code, which prompts a processor to carry out the method steps described hereafter when the code is being executed on the processor.

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Initially, in a first variant, an intrinsic right atrial activity is detected by way of a first detection device. Afterwards, an intrinsic right ventricular activity, which immediately follows the previously detected right atrial activity, is detected by way of a second detection unit. Thereafter, the time that has passed between the intrinsic right atrial activity and the
10 intrinsic right ventricular activity is ascertained. This time is then stored as the atrioventricular delay.

As an alternative or in addition to the above-described first variant, the second variant of the method described hereafter can be carried out. According to this variant, initially an intrinsic
15 right ventricular activity is detected by way of a second detection unit. Furthermore, an intrinsic left ventricular activity immediately following the previously detected right ventricular activity is detected by way of a third detection unit. Afterwards, the time that has passed between the intrinsic right ventricular activity and the intrinsic left ventricular activity is determined. This time is then stored as the interventricular conduction time.

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There is also disclosed a method for treating a human patient or an animal patient in need of such treatment. This method is carried out by way of an implantable system for detecting electrical signals of the patient's heart, and in particular an implantable system according to the above description. The implantable system comprises a processor, a memory unit, and
25 three detection units. A first detection unit is used to detect an atrial activity. A second detection unit is used to detect a right ventricular activity. A third detection unit is used to detect a left ventricular activity. The method comprises the steps described hereafter.

According to a first variant, an intrinsic right atrial activity is detected by way of the first
30 detection device. Thereafter, an intrinsic right ventricular activity immediately following the previously detected intrinsic right atrial activity is detected by way of the second detection unit. Thereafter, the time that has passed between the intrinsic right atrial activity and the

intrinsic right ventricular activity is determined. This time is then stored as the atrioventricular conduction time.

As an alternative or in addition to the above-described first variant, it is also possible for the
5 second variant of the method described hereafter to be carried out. According to the second
variant, initially an intrinsic right ventricular activity is detected by way of the second
detection unit. Thereafter, an intrinsic left ventricular activity immediately following the
previously detected right ventricular activity is detected by way of the third detection unit.
Finally, the time that has passed between the intrinsic right ventricular activity and the
10 intrinsic left ventricular activity is determined. This time is then stored as the interventricular
conduction time.

Regardless of whether the first and/or second variants of the method are carried out, the
determined conduction times (that is, the atrioventricular conduction time and/or the
15 interventricular conduction time) are used thereafter to adapt the chronological sequence of
stimulation pulses that are delivered by a system suitable for delivering such stimulation
pulses. This delivery can be used to stimulate the heart of the patient as a substitute for absent
intrinsic cardiac pulses or activities, or else to support a weak or insufficient intrinsic cardiac
function. The system that is suitable for delivering stimulation pulses can be the same system
20 that is also used for detecting the cardiac signals. This means that a device, such as a cardiac
pacemaker or a CRT device, can be used both for the detection of cardiac signals or a cardiac
activity, and for the stimulation of the same heart.

All variants and alternative embodiments described in connection with the implantable
25 system can be arbitrarily combined with one another and applied to the described methods
and the described computer program product. The described variants of the methods can
further be arbitrarily combined with one another and applied to the respective other methods
and to the computer program product and the system. Similarly, the described variants of the
computer program product can be arbitrarily combined with one another and applied to the
30 described methods and the described system.

Further details of aspects of the invention are described in greater detail hereafter in connection with an exemplary embodiment and a drawing. In the drawing:

FIG. 1 shows a schematic flow chart of a method for determining the atrioventricular conduction time and the interventricular conduction time by way of a cardiac pacemaker.

FIG. 1 shows a schematic flow chart of a program for determining the atrioventricular conduction time and the interventricular conduction time by way of a cardiac pacemaker. The individual lines indicate the chambers of the heart in which a signal can be detected or delivered by way of the cardiac pacemaker. RA denotes the right atrium, RV denotes the right ventricle, and LV denotes the left ventricle. Since the cardiac pacemaker in the exemplary embodiment of FIG. 1 comprises a quadrupolar left ventricular electrode, the left ventricular signals can be distinguished as a first left ventricular signal LV1, a second left ventricular signal LV2, a third left ventricular signal LV3, and a fourth left ventricular signal LV4.

In a first operating program 101 carried out by default, first stimulation pulses 102 can be delivered to the right atrium, second stimulation pulses 103 can be delivered to the right ventricle, and third stimulation pulses 104 can be delivered to the left ventricle.

In a measuring program 105, the actual or possible delivery of such stimulation pulses 102, 103, 104 is completely inhibited, which is illustrated by the dotted vertical lines in the temporal area of the measuring program 105. During the measuring program 105, consequently only an intrinsic activity of the heart of the patient wearing the cardiac pacemaker can be ascertained.

A right atrial signal detection 106 is carried out at regular intervals for detecting such an intrinsic cardiac activity. Likewise, a right ventricular signal detection 107 is carried out at regular intervals. A temporal offset between the detected right atrial signals 106 and the immediately following detected right ventricular signals 107 reflects the atrioventricular conduction time 108.

First left ventricular signals 109, second left ventricular signals 110, third left ventricular signals 111, and fourth left ventricular 112 can be detected by way of the different left ventricular channels. A detection of only one type of left ventricular signals is permitted at a given point in time. A detection of the other left ventricular signals, in contrast, is inhibited.
5 As a result, either only first left ventricular signals 109 or second left ventricular signals 110 or third left ventricular signals 111 or fourth left ventricular 112 can be detected at a point in time.

A first temporal offset between the detected right ventricular signals 107 and the detected
10 immediately following first left ventricular signals 109 represents a first interventricular conduction time 113.

A second temporal offset between the detected right ventricular signals 107 and the detected immediately following second left ventricular signals 110 represents a second
15 interventricular conduction time 114.

A third temporal offset between the detected right ventricular signals 107 and the immediately following third left ventricular signals 111 represents a third interventricular conduction time 115.
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Finally, a fourth temporal offset between the detected right ventricular signals 107 and the immediately following fourth left ventricular signals 112 represents a fourth interventricular conduction time 116.

25 The first interventricular conduction time 113, the second interventricular conduction time 114, the third interventricular conduction time 115, and the fourth interventricular conduction time 116 can be the same or different from one another, depending on how the individual electrodes that are used for detecting the different left ventricular signals are arranged within the heart, and depending on how the physiological stimuli conduction occurs
30 in the heart in question.

The measuring program 105 can be carried out in such a way that an interventricular conduction time is ascertained based on different detected cardiac signal groups (optionally immediately following one another), as is shown by way of example for the first interventricular conduction time 113. In this way, the first interventricular conduction time
5 113 is ascertained based on three signal groups, which are each composed of a right ventricular signal 107 and a first left ventricular signal 109.

Likewise, it is possible to evaluate only individual cardiac signals so as to ascertain a conduction time, as is shown by way of example for the second interventricular conduction
10 time 114, the third interventricular conduction time 115, and the fourth interventricular conduction time 116.

In the exemplary embodiment of FIG. 1, the measuring program 105 is carried out when the corresponding cardiac pacemaker routinely carries out the measurement of a signal of the
15 intrinsic cardiac activity and the determination and/or adaptation of a detection threshold of the implantable system. Such an ascertainment typically takes place once a day. The atrioventricular conduction time 108 and the different interventricular conduction times 113, 114, 115, 116 are consequently also ascertained once a day. When the conduction times have been ascertained, and the routine measurement of a signal of the intrinsic cardiac activity
20 and the determination and/or adaptation of a detection threshold of the implantable system have been carried out, the cardiac pacemaker returns to the standard operating program 101, in which right atrial stimulation pulses 102 as well as right ventricular stimulation pulses 103 and left ventricular stimulation pulses 104 can be delivered. An inhibition of these stimulation pulses is thus only necessary during the measuring program 105 and provided to
25 detect in fact, at this point in time, only the intrinsic cardiac signals that reflect the intrinsic cardiac activity in the different compartments of the heart.

Claims

1. An implantable system for detecting electrical signals of a human heart or an animal heart, the implantable system comprising
 - 5 a processor, a memory unit, a first detection unit for detecting an atrial activity, a second detection unit for detecting a right ventricular activity, and a third detection unit for detecting a left ventricular activity,
 - said memory unit includes a computer-readable program, which prompts the processor to automatically carry out the following steps at regular intervals when the program is being executed on the processor:
 - a1) detecting an intrinsic right atrial activity (106) by way of the first detection unit;
 - 15 b1) detecting an intrinsic right ventricular activity (107) by way of the second detection unit;
 - c1) determining the time that has passed between the intrinsic right atrial activity and the intrinsic right ventricular activity, and storing this time as the atrioventricular conduction time (108);
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 - and/or
 - a2) detecting an intrinsic right ventricular activity (107) by way of the second
25 detection unit;
 - b2) detecting an intrinsic left ventricular activity (109, 110, 111, 112) by way of the third detection unit; and
 - 30 c2) determining the time that has passed between the intrinsic right ventricular activity and the intrinsic left ventricular activity, and storing this time as the interventricular conduction time (113, 114, 115, 116),

characterized in that

the program is configured to prompt the processor to carry out the described steps
5 during a determination and/or an adaptation of a detection threshold of the implantable
system.

2. The implantable system according to claim 1, **characterized in that**, in addition to
steps a2) and b2), the system is configured to carry out the step a1) prior to the step
10 c2).

3. The implantable system according to claim 1 or 2, **characterized in that** the program
is configured to prompt the processor to carry out the described steps once within a
time period of 3 hours to 48 hours.

4. An implantable system according to any one of the preceding claims, **characterized
in that** the implantable system is also provided and configured to stimulate the same
human heart or animal heart of which the activity can be detected by the implantable
system.

5. An implantable system according to any one of the preceding claims, **characterized
in that** the program is configured to prompt the processor to inhibit an atrial
stimulation (102) and a ventricular stimulation (103, 104) until the atrioventricular
conduction time (108) and/or the interventricular conduction time (113, 114, 115, 116)
25 have been determined.

6. An implantable system according to any one of the preceding claims, **characterized
in that** the program is configured to prompt the processor to carry out the described
steps during a routine measurement of a signal of the intrinsic cardiac activity of the
30 implantable system.

7. The implantable system according to claim 6, configured for the measurement of a signal of the intrinsic cardiac activity to encompass the measurement of at least one signal parameter of amplitude, pulse width, number of zero crossings, amplitude and/or phase frequency spectrum and/or energy of the signal, as well as the parameters
- 5 - of a model of the signal (such as ARMA)
 and/or
 - of a transformation of the signal (such as wavelet)
 and/or
 of amplitude, pulse width, number of zero crossings, amplitude and/or phase frequency spectrum and/or energy of a time derivative of the signal.
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8. An implantable system according to any one of the preceding claims, **characterized in that** the program is configured to prompt the processor to store a plurality of previously determined atrioventricular conduction times (108) and/or interventricular conduction times (113, 114, 115, 116).
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9. The implantable system according to claim 8, **characterized in that** the program is configured to prompt the processor to ascertain a chronological progression of the particular conduction time from the plurality of stored atrioventricular conduction times (108) and/or interventricular conduction times (113, 114, 115, 116).
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10. An implantable system according to any one of the preceding claims, **characterized in that** the program is configured to prompt the processor to transmit the atrioventricular conduction time (108) and/or the interventricular conduction time (113, 114, 115, 116) to an external device or to a data center.
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11. An implantable system according to any one of the preceding claims, **characterized in that** the implantable system comprises a multipolar electrode, the first detection unit being a first electrode pole of the multipolar electrode, and the second detection unit being a second electrode pole of the multipolar electrode.
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12. An implantable system according to any one of the preceding claims, **characterized in that** the third detection unit comprises a plurality of electrode poles, which are each provided for detecting an intrinsic left ventricular activity (109, 110, 111, 112).
- 5 13. A method for controlling the operation of an implantable system for detecting electrical signals of a human heart or an animal heart, in particular of an implantable system according to any one of the preceding claims, comprising the following steps:
- a1) detecting an intrinsic right atrial activity (106) by way of a first detection unit;
- 10 b1) detecting an intrinsic right ventricular activity (107) by way of a second detection unit;
- c1) determining the time that has passed between the intrinsic right atrial activity and the intrinsic right ventricular activity, and storing this time as the
- 15 atrioventricular conduction time (108);
- and/or
- a2) detecting an intrinsic right ventricular activity (107) by way of a second
- 20 detection unit;
- b2) detecting an intrinsic left ventricular activity (109, 110, 111, 112) by way of a third detection unit; and
- 25 c2) determining the time that has passed between the intrinsic right ventricular activity and the intrinsic left ventricular activity, and storing this time as the interventricular conduction time (113, 114, 115, 116),
- 30 characterized in that

the described steps are carried out during a determination and/or an adaptation of a detection threshold of the implantable system.

5 14. A computer program product including computer-readable code, which prompts a processor to carry out the following steps when the code is being executed on the processor:

a1) detecting an intrinsic right atrial activity (106) by way of a first detection unit;

10 b1) detecting an intrinsic right ventricular activity (107) by way of a second detection unit;

c1) determining the time that has passed between the intrinsic right atrial activity and the intrinsic right ventricular activity, and storing this time as the
15 atrioventricular conduction time (108);

and/or

a2) detecting an intrinsic right ventricular activity (107) by way of a second
20 detection unit;

b2) detecting an intrinsic left ventricular activity (109, 110, 111, 112) by way of a third detection unit; and

25 c2) determining the time that has passed between the intrinsic right ventricular activity and the intrinsic left ventricular activity, and storing this time as the interventricular conduction time (113, 114, 115, 116),

characterized in that

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the described steps are carried out during a determination and/or an adaptation of a detection threshold of the implantable system.

15. A method for treating a human patient or an animal patient requiring such treatment by way of an implantable system for detecting electrical signals of the heart of the patient, the implantable system comprising a processor, a memory unit, a first detection unit for detecting an atrial activity, a second detection unit for detecting a right ventricular activity, and a third detection unit for detecting a left ventricular activity, the method comprising the following steps:
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- a1) detecting an intrinsic right atrial activity (106) by way of the first detection unit;
 - 10 b1) detecting an intrinsic right ventricular activity (107) by way of the second detection unit;
 - c1) determining the time that has passed between the intrinsic right atrial activity and the intrinsic right ventricular activity, and storing this time as the atrioventricular conduction time (108);
 - 15
- and/or
- a2) detecting an intrinsic right ventricular activity (107) by way of the second detection unit;
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 - b2) detecting an intrinsic left ventricular activity (109, 110, 111, 112) by way of the third detection unit; and
 - c2) determining the time that has passed between the intrinsic right ventricular activity and the intrinsic left ventricular activity, and storing this time as the interventricular conduction time (113, 114, 115, 116),
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- the described steps a1) to c2) being carried out during a determination and/or an adaptation of a detection threshold of the implantable system,
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- and

- 5 d) using the determined atrioventricular conduction time and/or the determined interventricular conduction time for adapting the chronological sequence of stimulation pulses, which are delivered by a system suitable therefor for stimulating the heart of the patient as a substitute for intrinsic cardiac pulses or for supporting an intrinsic cardiac function.