Department of Health and Human Services
Food and Drug Administration
Center for Devices and Radiological Health
Office of Device Evaluation

DATE: May 7, 2010

TO: File

CC: (b)(6) (consultant reviewer, clinical)

(b)(6) (consultant reviewer, software)

(b)(6) (consultant reviewer, electrical - batteries)

Mitchell Shein (Branch Chief)

FROM: (b)(6) (Lead Reviewer)

SUBJECT: P910023 / S226 / A001 & P030054 / S141 / A001 PMA Supplement Amendment

St. Jude Medical – Unify CRT-D family and Fortify DR / VR ICD Family

OVERALL RECOMMENDATION

Based on my review of the submission text, feedback from supporting reviewers, and interactive discussions with the sponsor, **I recommend approval of the submission**.

Signature	*Date*	*Signature*	*Date*
(b)(6)		Mitchell Shein	
Scientific Reviewer		Branch Chief	
(Lead Reviewer)		(Management Oversight)	

PURPOSE OF SUBMISSION

The sponsor would like to introduce two new families of pulse generators called Unify and Fortify. The enhanced sensing filter included within this submission was previously submitted as a pre-IDE (b)(6) which is discussed in more detail later in this review. The following table provides some basic information about these devices.

Model Number	Model Name	Device Type	Lead Connector Types	Brief Description
CD3231-40	Unify	Cardiac Resynchronization Therapy Defibrillator	IS-1 / DF-1	36 cc and 77-78 g, 40 J maximum delivered energy
CD3231-40Q	Unify	Cardiac Resynchronization Therapy Defibrillator	SJ4	36 cc and 77-78 g, 40 J maximum delivered energy
CD2231-40	Fortify DR	Dual-Chamber Defibrillator	IS-1 / DF-1	35 cc, and 75-76 g, 40 J maximum delivered energy
CD2231-40Q	Fortify DR	Dual-Chamber Defibrillator	SJ4	35 cc, and 75-76 g, 40 J maximum delivered energy
CD1231-40	Fortify VR	Single-Chamber Defibrillator	IS-1 / DF-1	35 cc, and 75-76 g, 40 J maximum delivered energy
CD1231-40Q	Fortify VR	Single-Chamber Defibrillator	SJ4	35 cc, and 75-76 g, 40 J maximum delivered energy

As described within the submission (from the Summary of Safety and Effectiveness), the following are the key new features and modifications of the devices:

- Low Frequency Attenuation Filter
- Extended ATP Programming (during and before HV charge in VF zone)
- Programmable % ventricular pacing device alert
- 40 Joules Delivered HV Therapy
- QHR Battery
- Enhanced memory capacity
- Device Security Enhancements

The Unify and Fortify families of devices are smaller in size (35cc) compared to the Current+/Current Accel and Promote +/Promote Accel families of pulse generators. Their internal mechanical package utilizes a new organic hybrid, new high voltage capacitor set, new battery with QHR chemistry, new feedthrus, a new vibratory patient notifier motor which is smaller than that used in previous devices, new output flexes to connect the feedthrus to the hybrid.

DEVICE DESCRIPTION

The following sections are excerpts from the submission. Discussion and proposed deficiencies follow each section of the submission. I personally reviewed all of the relevant sections of the text and received support from other reviewers for specific sections as identified below.

Overview of Changes

This PMA Supplement application proposes the introduction of the Unify and Fortify families of pulse generators, which are based on Promote+ CRT-D and Current+ DR/VR ICD devices. The Promote+ and Current+ platforms were previously reviewed and approved by FDA. The following new features and modifications are described within the submission.

- Low Frequency Attenuation Filter
- Extended ATP Programming (during and before HV charge in VF zone)
- Programmable % ventricular pacing device alert
- 40 Joules Delivered HV Therapy
- QHR Battery
- Enhanced memory capacity
- Device Security Enhancements

These features and other modifications are described and discussed in the following subsections.

Low Frequency Attenuation Filter

NOTE: This feature was the subject of pre-IDE I080745, which I reviewed prior to my review of this PMA supplement.

The following text was provided by the sponsor.

> *"Although there are means of programming ventricular channel sensing behavior to reduce the probability of oversensing T waves, the solutions force a compromise between avoidance of T wave detection and ability to detect true arrhythmias. The existing St. Jude Medical ICD device hardware design contains four narrow band filtering channels (filters). Currently only two of these filters (the Brady and Tachy filters) are used by the device. Each channel has four programmable band pass configurations (Figure 1). In legally marketed St. Jude Medical ICD devices, the Brady filter is used for atrial EGM sensing and the Tachy filter is used for ventricular EGM sensing.*
>
> *The Low Frequency Attenuation filter introduced in the Unify and Fortify devices is the combination of a high pass filter and the Brady filter. Both Low Frequency Attenuation and Brady filters share a similar center frequency. However, the Low Frequency Attenuation filter has a faster roll off slope below 20 Hz, allowing for additional attenuation of low frequency content. Compared with the existing Tachy filter, the Low Frequency Attenuation filter is able to increase R to T wave amplitude ratio by a factor of approximately two to three. An increased R to T wave ratio enhances sensing performance and makes it possible to reduce the possibility of oversensing T waves.*
>
> *The Low Frequency Attenuation filter increases the ratio of R wave amplitude to T wave amplitude, making the existing sensing system better able to avoid mis-classifying a T wave as an R wave because the T waves are smaller. The Low Frequency Attenuation Filter will use alternate nominal*

settings for the Threshold Start and Maximum Sensitivity values (50% and 0.5mV, respectively). The Low Frequency Attenuation Filter will be the default setting, but the clinician will be provided the option to choose between the Low Frequency Attenuation Filter and the current Tachy filter via the Merlin PCS programmer."

Discussion

The feature description and supporting data were reviewed. There were some questions regarding this feature, which the sponsor was able to resolve with information provided in the amendment as well as additional information provided during the interactive review process.

Extended ATP Programming (during and before HV charge in VF zone)

The following text was provided by the sponsor.

"St. Jude Medical CRMD ICD firmware in legally marketed devices supports the ability to categorize a ventricular tachyarrhythmia rate into VF, VT and VF or VT1, VT2 and VF. Current firmware capability also provides the option to deliver up to 15 bursts of ATP as the first and second therapies in the VT zones. The boundaries between the zones, should the user choose either VT and VF or VT1, VT2 and VF, are selectable by the user. The upper limit of the tachy interval for the VT zone next to the VF zone is 300 bpm. With these available settings, the clinician potentially could choose to deliver multiple bursts of ATP to tachycardia rates as high as 300 bpm. Multiple studies demonstrate the ability of ATP to convert ventricular tachycardias to sinus rhythm, but high tachy rates are not well tolerated and carry the risk of syncope due to decreased cardiac output. To minimize the likelihood the patient will experience an adverse event between the onset of a tachyarrhythmia and the delivery of HV therapy should ATP fail, clinicians usually will set the VT cutoff value below 300 bpm.

Extending the ATP programming allows the user to program the device to begin delivering a single sequence of ATP therapy while the device is charging for HV delivery in the VF zone. Subsequent to the delivery of ATP, the device will detect either sinus or continued tachyarrhythmia and will either abort or deliver the HV therapy as indicated. If the tachyarrhythmia rate detected in the VF zone exceeds a limit set by the clinician (up to 300 bpm), VF therapy will be delivered without ATP. The nominal value for this limit is 250 bpm. With the exception of the number of ATP therapies, the ATP parameters in the VF zone are the same as those for the "nearest-neighbor" VT zone. The clinician has the ability to choose one of three options: ATP prior to Charging, ATP while Charging, or Off."

Discussion

The feature description and supporting data were reviewed. There were some questions regarding this feature, which the sponsor was able to resolve with information provided in the amendment as well as additional information provided during the interactive review process.

Patient Alert for Percentage of Ventricular Pacing

The following text was provided by the sponsor.

"The devices provide a means of detecting a change in percent pacing across a clinician-defined threshold. The clinician also can specify the time window over which the pacing percentage is calculated. If the average percent pacing value crosses the threshold during the specified window, the system can notify the patient via the vibratory patient notifier and log an alert to be displayed at the next remote or in-clinic device interrogation. The clinician can set the threshold such that a change in pacing that crosses the threshold will trigger a patient notification and log an alert."

Discussion

The feature description and supporting data were reviewed. There were some questions regarding this feature. As a result, the sponsor elected to lock out this feature from the final device.

40 Joule Maximum Delivered Energy Delivery

The following text was provided by the sponsor.

> *"The St. Jude Medical Unify and Fortify devices provide a means of delivering a safety shock of 40 Joules -10/+5% Joules, or 36 to 42 Joules. The system will prevent the clinician from programming 40 Joules as the first HV therapy in any of the tachyarrhythmia zones. Availability of the 40 Joule shock is restricted, in that at least one previous HV therapy at either 30 or 36 Joules must be delivered without successfully terminating the arrhythmia before the 40 Joule therapy becomes available.*
>
> *The maximum delivered energy in previous, FDA approved St. Jude Medical CRMD ICD devices is 38.2 Joules ±10%, or 34.4 to 42 Joules."*

Discussion

The feature description and supporting data were reviewed. There were some questions regarding this feature, which the sponsor was able to resolve with information provided in the amendment.

QHR Battery

The following text was provided by the sponsor.

> *"Fortify and Unify devices use the Greatbatch Model 2850 battery, which is a Q High Rate (QHR) battery. The QHR battery is a blend of SVO (silver vanadium oxide) and CFx (carbon monofluoride) chemistries. It uses Lithium on the anode and SVO and CFx on the cathode. The SVO provides power and the CFx provides increased longevity in comparison to pure SVO cathodes. This battery has the ability to supply higher current than a traditional battery, yet has the discharge characteristics that allow for accurate detection of ERI (elective replacement indicator). The QHR battery chemistry is intended to provide greater device longevity and enable faster charge times when used in conjunction with a new, larger transformer on the device hybrid. Connection to the hybrid is made in the same fashion as in Current +/Promote +, by plugging gold-plated battery posts into spring connectors."*

Discussion

The feature description and supporting data were reviewed. There were some questions regarding this feature, which the sponsor was able to resolve with information provided in the amendment.

Enhanced Memory Capacity (RAM-ROM Stitching)

The following text was provided by the sponsor.

> *"In order to support future firmware development yielding firmware greater than our current internal RAM size of 512KB, a modification of where and how the firmware operates was made. The*

modification is to shift the primary mode of execution from the internal RAM to the 512KB ROM. In order to retain the capability to provide field upgrades in the future by downloading new RAM code into existing devices or to expand beyond 512KB, the ROM was re-worked so that it is capable of supporting downloaded "patches" of code changes executed from the internal RAM. In general, this involves removing static references in the code in favor of dynamic references so that we can redirect to RAM as necessary. By doing so, the firmware is able to make use of both the ROM and internal RAM."

Discussion

The feature description and supporting data were reviewed. There were no questions regarding this feature. However, there were some general questions regarding the software, which the sponsor was able to resolve with information provided in the amendment.

Firmware change to facilitate the display of trended diagnostic data

The following text was provided by the sponsor.

"There currently are several diagnostics (AT/AF, Heart Rate, activity, and % pacing) collected by the device in a format presentable in a histogram on either the Merlin PCS programmer or on the Merlin.net remote care system. A firmware change was made in order to enable this data to be captured in the device firmware for the Unity and Fortify devices. The ability to capture and report trended data is being developed as a device firmware function as opposed to being an external device software function. For existing devices, Merlin.net compiles this data by reading from device histograms twice a day via Merlin@home. All currently existing diagnostic data are being maintained in their original format and location in the firmware. The new diagnostic data will be stored, with appropriate time stamps, in a memory location separate from that used for existing histogram data. To eliminate potential discrepancies in the display of diagnostics, both sets of data will be updated concurrently."

Discussion

The feature description and supporting data were reviewed. There were no questions regarding this feature. However, there were some general questions regarding the software, which the sponsor was able to resolve with information provided in the amendment.

Standardized Quick Retrieval Diagnostics Data

The following text was provided by the sponsor.

"In order to allow for more efficient data retrieval by the Merlin@home transmitter, we have simplified the storage of device data from several locations in the device firmware into one "Quick Retrieval Data Block" for Unify and Fortify devices. Data includes diagnostics as well as existing alert-related data."

Discussion

The feature description and supporting data were reviewed. There were no questions regarding this feature. However, there were some general questions regarding the software, which the sponsor was able to resolve with information provided in the amendment.

Device Security Enhancements

The following text was provided by the sponsor.

"Communication Channel Authentication (CCA) - The intent of CCA is to provide enhanced security by ensuring the device is exchanging data with an authorized interrogator (SJM Automated Test Equipment, Merlin@home transmitter, Merlin PCS Programmer, etc.). The protocol used is an industry standard encryption method to ensure that unauthorized interrogators can't communicate with a Fortify or Unify device. The data moving between the interrogator and the device will not be encrypted. This scheme is based on the assumption all telemetry breaks will require re-authentication of the channel before communication can proceed.

Patient Data Encryption - Patient information stored in the device by the Merlin PCS programmer in current devices is in clear text. For the Unify and Fortify devices, to enhance security, the programmer will now encrypt patient data stored on the device using an industry standard encryption method."

Discussion

The feature description and supporting data were reviewed. There were no questions regarding this feature. However, there were some general questions regarding the software, which the sponsor was able to resolve with information provided in the amendment.

Additional Hardware Changes

The submission includes a number of other hardware changes.

Discussion

Further discussion about these hardware changes is provided in the Hardware Testing section below.

INDICATIONS FOR USE

There were no changes to the indications for use, which are provided below. The sponsor provided the following supporting statement, "The indications for use of the Unify™ CRT-D, Fortify™ DR, and Fortify™ VR are identical to the Current + DR/VR, and Promote + CRT-D families of pulse generators."

The Unify™, Fortify™ DR, and Fortify™ VR pulse generator are intended to provide ventricular antitachycardia pacing and ventricular defibrillation for automated treatment of life-threatening ventricular arrhythmias. AF Suppression™ pacing is indicated for suppression of paroxysmal or persistent atrial fibrillation in patients with the above ICD indication and sinus node dysfunction. In patients indicated for an ICD, the Unify pulse generators are also intended:

- *To provide a reduction of the symptoms of moderate to severe hear failure (NYHA Functional Class III or IV) in those patients who remain symptomatic despite stable, optimal medical therapy and have a left ventricular ejection fraction less than or equal to 35% and a prolonged QRS duration.*

- *To maintain synchrony of the left and right ventricles in patients who have undergone an AV nodal ablation for chronic (permanent) atrial fibrillation and have NYHA Class II or III heart failure.*

Discussion

There were no questions regarding this section.

HARDWARE TESTING

The Unify / Fortify pulse generators include a number of hardware changes relative to the Current+ / Promote+ pulse generators. These changes are summarized in the following table and also in more detail in the following sections.

Feature	Unify/ Fortify	Current+ / Promote+
Organic Electronic Hybrid	Yes	Yes
QHR Battery	Yes	No
HV Capacitor	Charge to 40J	Charge to 36 J
Vibratory Patient Notifier	Yes	Yes
Headers; IS-1, DF-1 & SJ4	Yes	Yes
RF Telemetry Module	Yes	Yes
Titanium Can	Yes	Yes
MEMS Accelerometer Sensor	Yes	No*

* MEMS accelerometer sensor approved 7/15/09: FDA file numbers P880086/S174 and P030035/S53

Discussion

The relevant sections of the submission were reviewed. Further discussion about the specific testing is included in the sections below.

Hybrid

The following text was provided by the sponsor.

"The Unify / Fortify family of devices use a new organic hybrid that is functionally identical to the organic hybrid used on the approved Current+ / Promote+ family of ICD devices. Mechanically, the primary differences between the new and the predecessor are the replacement of weld tabs by two (2) spring connectors designed to receive a plug-in patient notifier assembly, and a new organic hybrid substrate. This substrate is designed to support the (b)(4) (b)(4) *the* (b)(4) (b)(4)

revision and the (b)(4) (b)(4) (which replaces the (b)(4) (b)(4) (b)(4) and the upper (b)(4) (b)(4) of the output stage), the (b)(4) (b)(4) (b)(4), the high voltage transformer (b)(4)), and combines the telemetry and aux coils into a single package.

The (b)(4) (b)(4) is our high voltage controller with updated drivers to turn on the SCRs as well as improve the functionality for high voltage protection, simplify SOSD detection and reduce potential for false SOSD.

The updated (b)(4) (b)(4) is the analog pacing / sensing / IM chip which provides better ESD protection and trimming ability to improve manufacturability and yields, and makes the hardware less sensitive to a reset in the presence of external defibrillations/electrocautery. More nodes are supported for impedance measurement for PLI.

The (b)(4) (b)(4), which replaces the (b)(4) (b)(4) is a high voltage / high current switch used to connect the "patient" to "high voltage positive" during defibrillation therapy. The (b)(4) (b)(4) save space and reduce cost compared to (b)(4) (b)(4) as previously used in the upper part of the (b)(4) (b)(4) design.

The (b)(4) (b)(4) accelerometer activity sensor replaces the (b)(4) (b)(4) acceleration sensor. This (b)(4) (b)(4) can provide the same AC (changing acceleration) response as the (b)(4) (b)(4) for rate adaptive pacing as well as a DC (static acceleration) response for future expandability. The (b)(4) (b)(4) accelerometer is used in the legally marketed (b)(4) (b)(4) and (b)(4) (b)(4) devices.

In addition, new output flex designs, capacitor boots, battery/device boots, and tapes were created to fit the configuration of the electronics. (b)(4) (b)(4) is used to insulate most of the electronic components in the same way as in previous ICDs."

Discussion

The relevant sections of the submission were reviewed. There were some questions regarding the wire bond strength, which the sponsor was able to resolve with information provided in the amendment.

QHR Batteries

The following bullets outline the testing included within the submission and summarized in greater detail within his memo. He concluded, "The sponsor has provided appropriate and acceptable documentation of the qualification testing of the new Wilson Greatbatch Model 2850 QHR battery, with the exception of accelerated life testing of the battery."

- Battery Component Testing
  - Cell Construction and Burn-In Testing
  - Accelerated Pulse Test
  - Low Pressure / Altitude Simulation
  - Temperature Shock / Thermal Test
  - Vibration and Shock

  - Short Circuit
  - Impact
  - Forced Discharge
  - Low Temperature Exposure
  - High Temperature Exposure
  - External Pressure
  - Vacuum
  - Mechanical Vibration
  - Mechanical Shock
  - Thermal Shock followed by Accelerated Pulse Testing
  - Accelerated Pulse Test to EOL
  - Mechanical Vibration to EOL
  - Mechanical Shock to EOL
  - Varying Orientation Discharge
  - 3-Month Accelerated Discharge
- Battery Device Testing
  - Single Therapy Test
  - Single Commanded Shock Test
  - Single High Voltage Capacitor Maintenance
  - Device Charge Time for Multiple Pulses Test
- Longevity Testing

Discussion

The relevant sections of the submission were reviewed. There were some questions regarding the qualification testing of the new battery, which the sponsor was able to resolve with information provided in the amendment.

High Voltage Capacitor

The following text was provided by the sponsor.

"The external case and connection design of the HV capacitor in Unify and Fortify is very similar to that of the Current+ / Promote+ HV capacitor, utilizing a similar clip and pin assembly for connection to the hybrid. The capacitor body is tailored to fit the Unify/Fortify can. The capacitor will have a nominal operating voltage of 845 volts and have the capability of charging to 890 volts so that it may deliver a 40J "Safety Shock" in the ICD. The capacitor has approximately a 15% increase in active surface area over previous 36J capacitor designs which allow us to deliver the 40J shock."

Discussion

The relevant sections of the submission were reviewed. There were some questions regarding the high voltage capacitors, which the sponsor was able to resolve with information provided in the amendment.

Patient Notifier

The following text was provided by the sponsor.

"The Unify / Fortify devices utilize a slightly thinner vibratory motor than has previously been used in SJM ICDs. It is a commercially available pancake motor that is assembled to a plastic housing and connected to gold-plated pins. In the device, the pins are plugged into receptacles on the hybrid which contain leaf springs."

Discussion

The relevant sections of the submission were reviewed. There were no questions regarding the patient notifier.

Headers

The following text was provided by the sponsor.

"The headers are cast in place of (b)(4) over pre-assembled connector bores. The pre-assembled connector bores eliminate the need for reaming and tapping of the bores during manufacture of the header. There are a total of (b)(4) header designs. (b)(4) are VR, DR, and HF containing standard IS-1 and DF-1 connector assemblies. The other (b)(4) are VR, DR, and HF containing (b)(4) connector assemblies. The DF-1 connector assembly was designed as part of the Unity DD program; the IS-1 and SJ4 connector assemblies have been used in previous device designs. All Unity DD headers contain RF antennas of (b)(4) which are embedded in the (b)(4) of the header."

Discussion

The relevant sections of the submission were reviewed. There were no questions regarding the headers.

RF Telemetry Module

The following text was provided by the sponsor.

"Radio frequency telemetry provides wireless communication between the device and programmer. The system provides wireless communication within two meters, which allows for interrogation and programming of the device from outside the sterile field during implantation. RF telemetry uses the

(b)(4) (b)(4) *frequency band* (b)(4) (b)(4) *. This is the same telemetry specifications used for the previously approved high voltage Current+ RF and Promote+ RF devices. The RF communication link will be used to download data to the implant from the external programmer unit and upload data to the external programmer unit from the implant. The RF communication link is intended to be used during implantation of an RF enabled implant and during in-clinic follow-ups*

The RF module is identical to previous RF modules with the exception of the flex which was customized to fit the Unify / Fortify electronics."

Discussion

The relevant sections of the submission were reviewed. There were no questions regarding the RF telemetry module.

Feedthru

The following text was provided by the sponsor.

"The Unity DD devices utilize the same six lead and eight lead feedthru designs used in previous devices; however, they are rated to a higher voltage in support of the Safety Shock feature. To meet the higher voltage rating no design changes are necessary."

Discussion

The relevant sections of the submission were reviewed. There were no questions regarding the feedthru.

Titanium Can

The following text was provided by the sponsor.

"The Unity DD device utilizes grade (b)(4) (b)(4) material. The footprint of the can is smaller than that of previous devices and the thickness is the same as that of previous 36 J devices."

Discussion

The relevant sections of the submission were reviewed. There were no questions regarding the titanium can.

SOFTWARE VERIFICATION AND VALIDATION

The devices include new supporting device firmware and programmer software.

Discussion

The relevant sections of the submission were reviewed. There were some questions regarding the software development and validation process, which the sponsor was able to address in the amendment.

BIOCOMPATIBILITY

There are no changes that would affect the biocompatibility of the device.

CLINICAL

This section is not applicable to this submission. No clinical studies were conducted with these devices.

STATISTICAL

This section is not applicable to this submission.

ANIMAL TESTING

The sponsor completed a chronic animal study. The study included (b)(4) followed for 6 weeks and was conducted in accordance with GLP guidelines. The goal of the study was to evaluate the operation of the system. The study evaluated the following:

- Pacing, sensing, and therapy functionality
- Electrical measurements, including P- and R-wave amplitudes, applicable pacing lead impedances, and applicable pacing thresholds
- High voltage device performance, including high voltage lead impedance, inductions, charging, defibrillation therapy, and capacitor maintenance

Discussion

The relevant sections of the submission were reviewed. There were some questions regarding the animal testing documentation, which the sponsor was able to address in the amendment.

PACKAGING, STERILIZATION, AND SHELF-LIFE

There are no changes that would affect the packaging, sterilization, and shelf-life of the device.

LABELING

The sponsor modified the labeling in order to describe the characteristics and new features of the devices.

Discussion

The relevant sections of the submission were reviewed. There were some questions regarding the labeling, which the sponsor was able to address in the amendment.

MANUFACTURING

The sponsor included some basic information about the manufacturing process.

Discussion

The relevant sections of the submission were reviewed. There were some questions regarding the manufacturing documentation, which the sponsor was able to address in the amendment.

POST-MARKET REQUIREMENTS

This section is not applicable to this submission.