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for Intelligent Completions Applications

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Abstract

The development work during this quarter was focused in the assembly of the downhole power generator hardware and its electronics module. The quarter was also spent in the development of the surface system electronics and software to extract the acoustic data transmitted from downhole to the surface from the noise generated by hydrocarbon flow in wells and to amplify very small acoustic signals to increase the distance between the downhole tool and the surface receiver.

The tasks accomplished during this report period were:
1. Assembly of the downhole power generator mandrel for generation of electrical power due to flow in the wellbore.
2. Test the piezoelectric wafers to assure that they are performing properly prior to integrating them to the mechanical power generator mandrel.
3. Coat the power generator wafers to prevent water from shorting the power generator wafers.
4. Test of the power generator using a water tower and an electric pump to create a water flow loop.
5. Test the power harvesting electronics module.
6. Upgrade the signal condition and amplification from downhole into the surface system.
7. Upgrade the surface processing system capability to process data faster.
8. Create a new filtering technique to extract the signal from noise after the data from downhole is received at the surface system.

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Figure 2 shows the downhole power generator storage module attached to the power generator and a current meter

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Introduction

The Downhole Power Generation and Wireless Communications for Intelligent Completions Application project progressed significantly well during the 4th quarter of 2003 report period. The goals for this period were to develop the software to process the acoustic data transmitted from downhole to the surface in real time using digital signal processing techniques to extract the data from flow noise. The assembly of the power generator was also a priority including the testing of the assembly in a water flow loop to simulate the wellbore production. The entire power generator mechanical and electrical as well as piezo components were received and assembled. The piezos were tested on a bench to verify that they were performing according to the specifications. The mechanical parts were inspected and assembled as part of the generator mandrel. The piezos were also coated to prevent the piezo wafers from electrically shorting when submerged in fluid. A bench prototype of the power harvesting electronics module was created and tested.

The development process continued to provide the digital signal processing required to extract the signal generated by the tool from noises from sources such as downhole and surface pumps, flow and gas injection. The DSP will be performed in real time and separate the signal from noise and amplify the signal after filtering. Support was provided for this task by the Rice University, Texas A&M University and British Petroleum Corporation. Multiple techniques were used to attempt to extract the downhole signal from the noise that was generated in the signal transmission band by the downhole flow. A tape of an acoustic signal from a tool deployed in Alaska was used as the data for the creation of the digital signal processing techniques.

A new surface system panel was also developed and assembled to provide the electronics hardware required to process the downhole data in real time using the new digital signal processing techniques.

Executive Summary

The power generation and wireless communications system progressed well during this report period. The company placed an emphasis on the development and testing of the downhole power generator prototype. A significant amount of time was devoted to surface digital signal processing development for detection and processing in real time of the acoustic signal transmitted from downhole.

The highlights of the accomplishments for this report period are listed below.

1. All parts for the integration of the downhole power generator has been received and tested.
2. Assembly of the downhole power generator mandrel for generation of electrical power due to flow in the wellbore was performed.
3. Tested the piezoelectric wafers to assure that they are performing properly prior to integrate them to the mechanical power generator mandrel.
4. Coated the power generator wafers to prevent water from shorting the power generator wafers.
5. Created a flow loop using a 20 ft high water tower, an electrical pump and PVC pipe used to simulate the fluid flow inside a well.
6. Tested the power generator by placing it in line with flow loop and pumping water from the water tower through the power generator.
7. Tested the power harvesting electronics module on the bench.
8. Upgrade the surface system signal condition and amplification for pre-processing the acoustic signals detected at the surface.
9. Upgrade the surface processing system capability to process data faster.
10. Assembled the new surface processing panel.
11. Two software programs were created to process the acoustic data. The first provides a post-processing capability for the PC to perform a high level DSP work to extract signal from noise where the signal to noise ratio

is less than 1. The second software package developed is for the real time processing of the acoustic signals at the surface using a less computational intensive algorithm.

12. The new real time algorithm was tested successfully using data recorded in a well in Alaska and processed in real time by the surface system.

Experimental

<u>Experimental Apparatus</u>-An experimental apparatus consisting of a 20 ft water tower, an electrical pump, a gasoline pump, PVC pipe and a downhole power generator module were assembled in series to create a flow loop required to simulate the flow of hydrocarbon in a wellbore.

A basic flow loop has been constructed at Tubel Tech's facility and flow tests were performed. Different piezo preloads have been tried ranging from 10 to 150 pounds (per piezo). The flow loop uses water as the working fluid. Although water does not reproduce well conditions with a high level of fidelity, it is very useful in evaluating the effectiveness of the power generator design. Also, 2 different pumps have been used. A 25 gallon per minute electric pump and a gasoline pump producing roughly 100 gallons per minute have been utilized.

The above described flow test indicated that the basic design of the piezo carrier is an appropriate device for mounting the piezos inside of an oil tool; however, without further refinement, the design does not effectively harvest enough useable electrical power at these flow rates. Although the design does generate some turbulence, the piezos are not cycled with enough force to adequately generate the required electricity.

Figure 1 shows the downhole power generator (dark module) in line with flow pipe
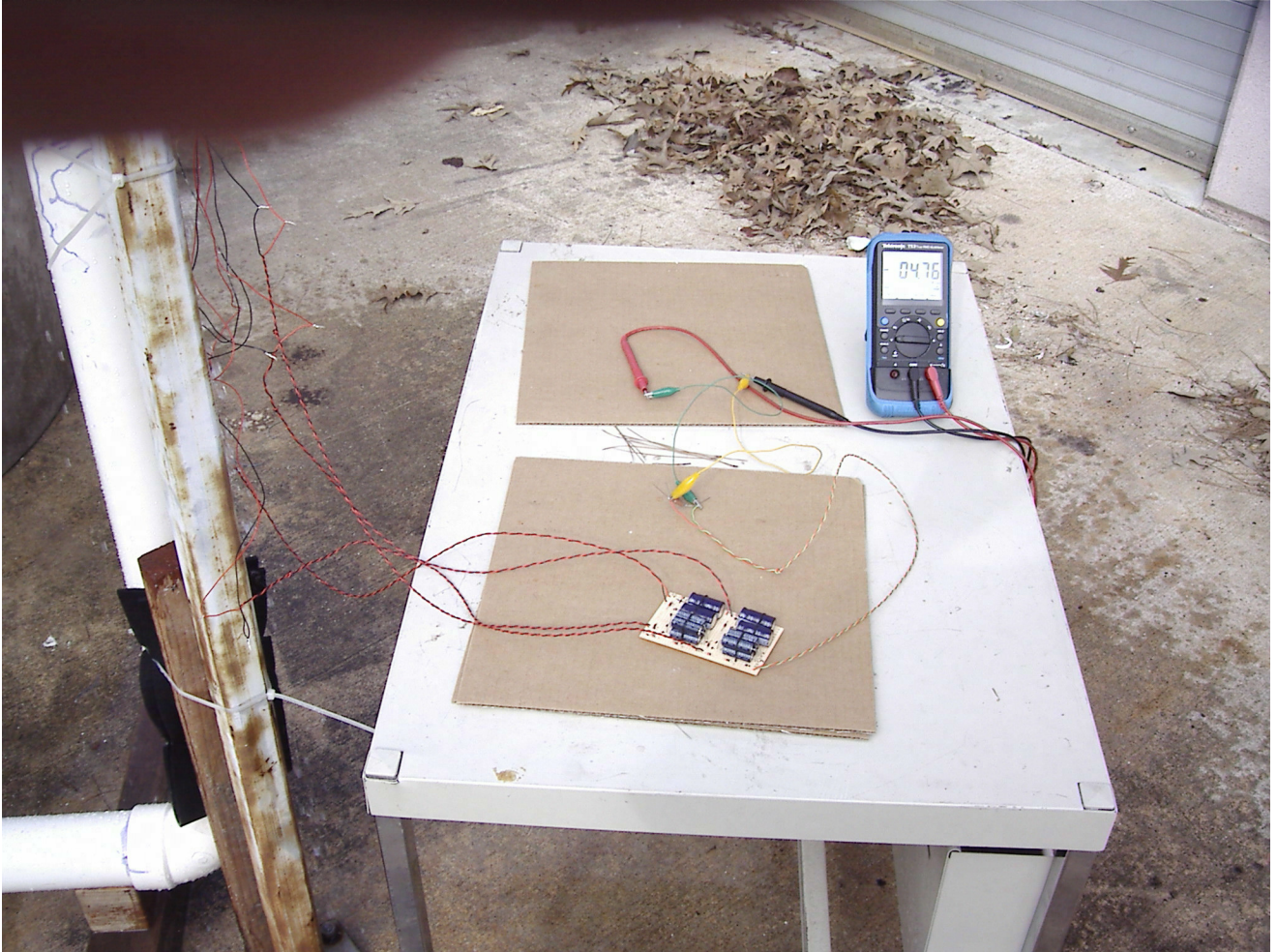
Figure 2 shows the downhole power generator storage module attached to the power generator and a current meter

The second test performed had the purpose of evaluating the real time processing capability of the surface system using the new processing software to extract the digital data from the flow noise. The system was composed of a analog recorder playing data obtained from a well in Alaska where the acoustic gauge had been deployed. A new surface panel with a digital signal processor pre-conditioned the signal and a PC performed the processing of the data for extraction of the data frame from the noise. The processed signal was next returned to the surface system for frame identification, and data calibration and processing for real time display and storage. The data was acquired and processed with 92% accuracy.

Results and Discussion

The results obtained by the downhole power generator tests indicated that a small amount of electrical power was generated but quite a bit less than on a previous test where the piezos were able to vibrate freely as the water flow hit directly at the piezos. The mandrel assembly prevented the full impact of the water flow from reaching the piezos reducing the vibration and reducing the power generation. The mechanical assembly is going to be modified to allow for the proper vibration of the piezo assembly in the mandrel and re-direct of the flow path to allow a better coupling between the flow and the power generator. The flow loop will also be modified to provide a larger flow into the generator to better simulate the downhole environment. The power harvest hardware was also tested and the results were very good and the power was acquired and stored in capacitors. The power harvest circuit diagram is shown below.
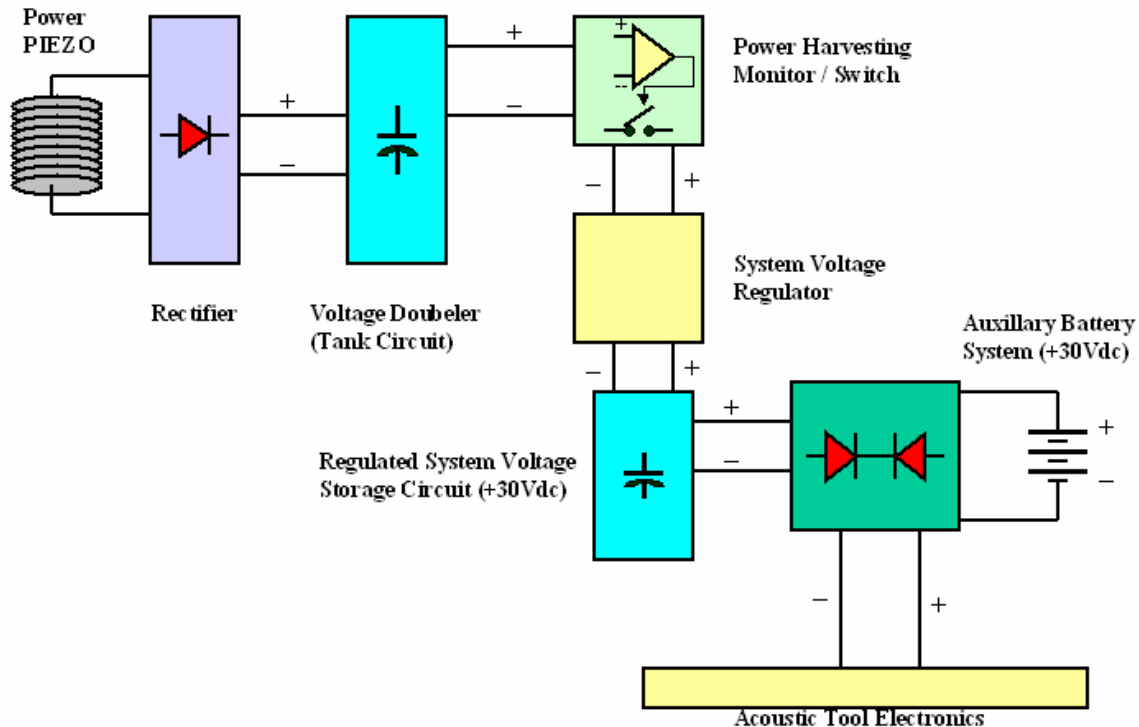

Figure 3 – Power harvesting module

The DSP work has shown to be working properly for a single well in the Alaska North Slope. Additional work is being performed to improve the algorithm used to extract the signal from the flow noise to better distinguish between noise in the acoustic signal band and the signal transmitted from downhole. The successful processing of the acoustic data in an extremely noisy environment with the wireless gauge located at 6,300 ft in a lateral well has shown that surface system has allowed new services and new capabilities for wireless system in downhole environments to be created. The tests also have shown that the processing power required to process the data even at fast data transmission rates can be achieved successfully with the algorithms developed to extract the data.

The DSP technique developed is a key component of this project allowing the data to be transmitted from deeper wells without repeaters while reducing the overall system costs and increasing reliability.

Conclusion

The conclusions for this quarter for this project are as following:

- A new surface system was created successfully to allow real time digital signal processing to be performed on the acoustic data transmitted from downhole to extract data from noisy environments created by flow from liquids in the wellbore.

- Real time data processing of acoustic data recorded in a well in the North Slope in Alaska was successful using the new digital signal processing software algorithm developed for this DoE program. This major milestone will allow wireless gauges to be deployed deeper in wellbores and provide a more reliable data acquisition and processing capabilities at the surface. The DSP work will also allow acoustic based communications systems to be deployed without having to add data repeaters in the well reducing costs and complexity in the wellbores.

- A downhole power generator was tested at a flow loop and the results indicated that some modifications were required to allow the piezo to operate properly to generate the necessary electricity in the downhole mandrel to power the downhole wireless gauge. The modifications are being performed now and additional flow tests will be performed during the next report period.

- The project is on schedule and should be fully assembled for well testing in early March of 2004. Halliburton will be approached in January to talk about allowing the system to be deployed in its test well in Carrollton, Texas.

References

There are no references related to this project and work performed over the past 3 months.

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List of Acronyms and Abbreviations

There are no acronyms or abbreviations in this report.

Appendices

No appendices.