#### Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

**Submission Title:** [WNG Higher speed wireless body area networks are required for implantable brainmachine interfaces]

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Re: []

**Abstract:** [A important use case of dependable body area network(WBAN) for implanted devices is introduced to perform reliable and massive data for implantable brain machine interface to require amendment for IEEE802.15.6 wireless medical body area network.]

Purpose: [information]

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## Higher speed wireless body area networks are required for implantable brain-machine interfaces

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## **Brain Machine Interfaces**



### **Medical potential of implantable BMIs**



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#### Fundamental basis of brain decoding: Brain functions are localized.



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#### **Brain signals used for BMIs**

		Measured physiological phenomena	Spatial coverage	Spatial resolution	Temporal resolution	Time delay	Invasive- ness	term recording stability	Portability
	fMRI	CBF	whole brain	<b>O</b> 3-5mm	<b>X</b> 4-5s	<b>X</b> 4-55	0	0	×
	NIRS	CBF	cortex	🗙 2cm	× 4-5s	<b>X</b> 4-5S	$\bigcirc$	0	0
	EEG	Neural activities	whole brain	<b>X</b> <sup>3-4cm</sup>	O 1ms	0	Ô	0	0
	MEG	Neural activities	cortex	<b>∆</b> 5-10mm	© <sup>0.1 ms</sup>	© 0	Ô	0	×
	EC <sub>0</sub> G	Neural activities	100cm²	O2-3mm	<b>O</b> 0.1 ms	0	$\bigtriangleup$	0	0
	LFP	Neural activities	$1\mathrm{cm}^2$	O 1mm	©<01ms	0	×	Δ	0
	spike	Neuronal activities	1 cm <sup>2</sup>	<b>O</b> 0.2mm	©< 0.1 ms	0	×	×	0

# High frequency brain activity better reflects functional localization than low frequency activity



High frequency brain activity (80-150Hz) offer highest decoding accuracy



#### ECoG-based real time BMI system (wired)





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#### Trends in neurosurgical treatments using implantable devices



#### **Deep brain stimulation (DBS) for Parkinson disease**

Present representative implantable device for clinical use Electrical stimulation to the deep brain improves Parkinson symptoms





#### DBS for Parkinson disease

Stimulation is independent of brain activity Data transfer is limited to setting stimulation condition.

#### Vagus nerve stimulation for intractable epilepsy

Electrical stimulation to the vagus nerve reduces the frequency of seizure attack.



Stimulation is independent of epileptic activity Data transfer is limited to setting stimulation condition.

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#### **Closed loop deep brain stimulation (DBS)**

Closed loop DBS stimulates the brain based on recorded brain activity



Stimulation depends on brain activity Data transfer includes a few channels of brain activity.

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#### **Responsive neurostimulator (RNS) for intractable epilepsy**

RNS stimulates epilepsy focus when brain recording detects seizure attack.



Stimulation depends on epileptic activity Data transfer includes a few channels of brain activity.

Present 400M Hz analog data transfer satisfies the data transfer demand.

#### Implantable brain machine interface (BMI)

Implantable BMIs control robotic arms and communication devices based on recording and decoding of multi-channel brain activity.



How fast do implantable BMIs require for wireless data transfer?

Submission

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High frequency brain activity (80-150Hz) offer highest decoding accuracy



#### 1000 Hz sampling rate is required for recording.

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#### ECoG ranges from 1 µV to 5 mV



# No. of recording channels depends on inter-electrode spacing and recording areas to be covered.



Submission

#### **Requirement for data transfer speed of implantable BMI**

#### 1st generation:

Dynamic range:1µV~10mV Sampling rate: 1000Hz Channel number: 100ch (Interelectrode spacing: 3mm, coverage 3cm<sup>2</sup>)

Data transfer speed:14 bit x 1000 Hz x 100 ch = 1.6 Mbps

#### 2nd generation:

Dynamic range:1µV~10mV Sampling rate: 1000Hz Channel number: 4000ch

(Interelectrode spacing: 1mm, coverage 3cm<sup>2</sup> X 4)

Data transfer speed:14bit x 1000 Hz x 4000 ch = 64 Mbps

![](_page_19_Picture_10.jpeg)

![](_page_19_Figure_11.jpeg)

#### Trends in neurosurgical treatments using implantable devices

![](_page_20_Figure_3.jpeg)

## Summary

Potential medical market of implantable BMIs is promising.

Implantable BMIs require higher speed  $(=10^2Mbps)$  and secure wireless communication.

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## Thank you for your attention