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Development of mini smart multipurpose vehicle for organic rice harvesting

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ABSTRACT

This research aimed to develop the mini smart multipurpose vehicle (MSMPv) innovative from the conventional agriculture tractor for three objectives. The novel automatic gear modified technique for the MSMPv is proposed, then an idea to enhance peripheral capability through a hitch system. The final purpose is to support the farmer's ability to follow organic agriculture regulations on the issue of contaminated tools and machinery, especially in the rules related to contamination of equipment or machines that cannot share with conventional agricultural production. The organic rice crop plot of Nong Bua Lamphu Province in Thailand has been set to the case study. Here, farmers faced problems; lack of labour, production under an organic system that does not permit chemicals, and limited harvesting. According to the existing technology, this research has developed a typical farm tractor used in the country by inventing a manual transmission engine to an automatic transmission and accessories such as remote control, GPS, camera, and sensors. Thus, the development of this organic rice harvesting prototype should be an approach that provides both the opportunity to raise the self-reliance concept and enhance the knowledge of the development of innovative tools for farmers simultaneously.

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1. INTRODUCTION

Nong Bua Lamphu province is the newly established province located in northeastern Thailand [1], as shown in Figure 1. The top agricultural productions are sugarcane and glutinous rice. Especially the sticky rice, which the native farmers have developed a breed called "Phua Long Sticky rice", is famous to consumers. The most suitable coordinates for planting at Ban Tho Sub-district, Non-Sang district, Nong Bua Lamphu province in Thailand. The farmers in the group faced rice production problems, such as the labour shortage in agriculture, chemical contamination on equipment and mechanic, and specific harvesting periods. Therefore, the farmer needs the agriculture machine to increase the post-harvest efficiency. But the agriculture machine that has high performance is much expensive and is beyond their power to pay.

Organic rice production must be careful of chemical contamination. Hence, they cannot use conventional agriculture equipment, tools, and machines [2], [3]. Besides, the harvesting time of Phua Long sticky rice is limited to 3-7 days to get the best aroma and flavour of rice. Farmers, therefore, need tools to help them harvest their rice crops in time. The general harvester cannot enter the rice planting area with small plots and uneven terrain. It is made the farmers have to work in small and narrow spaces. Eventually, farmers encounter difficulty accessing capital sources for modern technology, equipment and machinery [4]. All the problems mentioned above are significant obstacles to both quality and quantity production potential. As well as limited farmers' expertise in agricultural machinery and new technology opposite the campaign "Kitchen of the World".

Therefore, if we can develop agricultural machinery with modern technology like the development of powerful engines and the ability to interface with a semi-automatic control system [5], [6] as the organic rice grower needs. This mini multi-purpose vehicle develops from a conventional Thai tractor called the E-Tak. Finally, the research team expected that addressed the labour shortages problem, the limited technology access, comply with organic farming regulations, and increase the convenience of farming. These will be laid the basis and inspire the development of modern technology for the new generation of farmers in Thailand. The researcher teams explored the problem [7]-[9] with the farmer of the Non-Song district, attending a meeting the opinions from them. Then ask questions about farmers' needs in fieldwork. The village community leaders led the research team to meet and discuss the initial problems. Then, present the solution to the problem of this research. In this research, the paper contents are as following; 1) the part of the introduction, 2) the research method, this part explains the theorem applying for this algorithm, 3) result and discussion, and 4) conclusion.

Figure 1. The boundary of Nong Bua Lamphu province and the study area inside

2. METHOD

The mini smart multipurpose vehicle (MSMPv) was developed based on "E-Tak", a small conventional agricultural tractor typical in Thailand. The E-Tak engine has a low horsepower, is heavyweight, and consumes fuel while driving and work in general. Along with the other disadvantages of this conventional tractor that the researcher considers to be improved, such as the reduction of the number of operators from two to one, the original restructuring to be strong-lighter to relieve the carrying burden, and the ability to consume 20-80 per cent of biodiesel content produced from the local palm production. Two main components were designed and developed for proposed agricultural utility vehicles presented at this time: the main engine and the control parts, a semi-automatic remote control.

2.1. The MSMPv engine designing and developing

The research team intends to develop an agricultural vehicle prototype using the power of a diesel engine, an automatic transmission gear system, and a universal joint (Sections 1-3 in Figure 2) as conventional. At the same time, additional new differentials will develop called Modified Gearbox (Section 5 in Figure 2), which relies on the direction shifting gear (Section 4 in Figure 2) to change the direction of power transmission from the main shaft to the Modified Gearbox. The engineer developed MSMPv prototype main engine based on an 85 hp diesel engine. Details and characteristics of the Modified Gearbox arrangement are shown in Figure 3.

The MSMPv was developed based on diesel engine power at a maximum power of 85-59 HP or equal to 64-66 kW at an engine speed of 4200 rpm. The full force of the forwarding gear train ratio is 3.928, resulting in the highest power will be 259 kW (66×3.928 kW) by calculation. Nonetheless, and design for safety about 20% more additional, therefore the gear train ratio must take the total capacity of the gear train ratio into account is 300 kW.

The invention developed by this research to be driven to both rear wheels via an automatic transmission gear system [10] is the modified transmission gearbox measuring 840 mm in height, 340 mm in width and 570 mm in length. The centre thickness of the primary driven gear is 10 mm, while the drive gear is 0.5 mm. This gearbox is responsible for receiving power from the engine through the automatic gear and then sending power to the differential. Significantly, the gear is newly milled to have 113 teeth, as the details illustrated in Figure 4.

Modified Gearbox's operation starts when the power sends to spur gear (No. 1). The power is transmitted through the driver shaft No. 2 to the first gear (No. 3) with 20 teeth, then forwarded to power gear having a gear tooth of 113 teeth (No. 4), where this gear is boosted power at a gear ratio of 5.56:1. It is then transmitted through the bridge shaft (No. 5) to transfer power to both sides of the second gear with 23 teeth (No. 6L and 6R) before being passed to the right side gear 82 teeth (No. 7) and the left side gear (No.9). The power will be increased again at a gear train ratio of 3.56:1, so the whole gear set will have a total gear train ratio of 9.12:1 and then pass through shaft left and shaft right (No. 8 and 10) to the wheels.

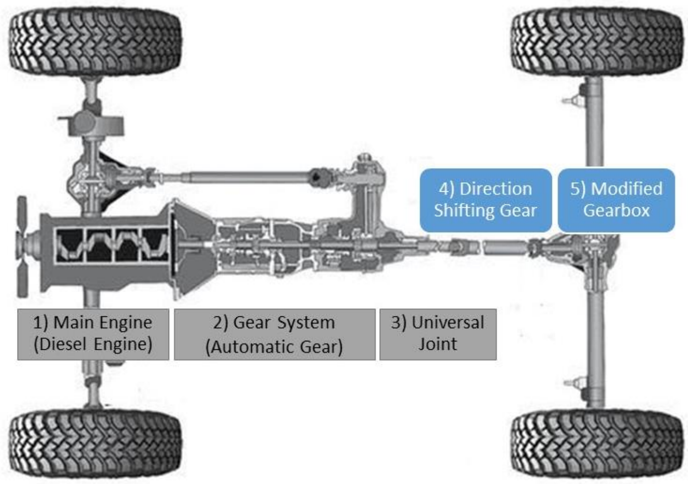
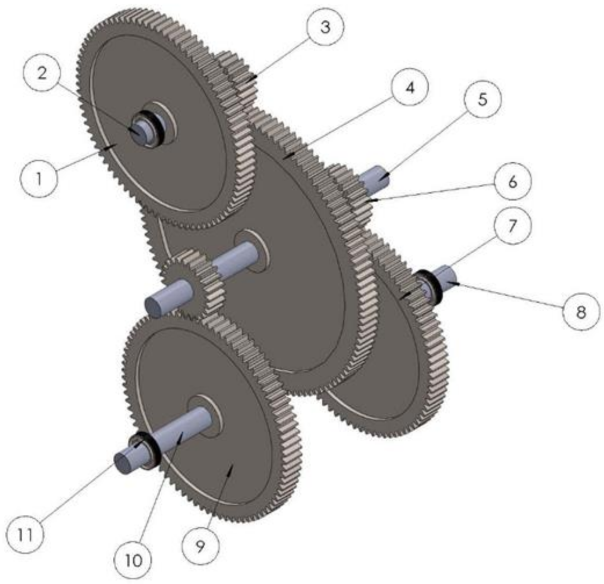


Figure 2. The concept of an MSMPv engine designing and developing, 1-3 conventional set applying and 4-5 developing parts of proposed MSMPv



ITEM NO.	PART NUMBER	QTY.
1	Spur Gear 82 teeth	1
2	Diver Shaft	1
3	First Gear 20 teeth	1
4	Powergear 113 teeth	1
5	Bridge shaft	1
6	Second gear 23 teeth	2
7	Right gear 82 teeth	1
8	Shaft right	1
9	Left gear 82 teeth	1
10	Shaft left	1
11	Ball bearing 25mm.	3

Figure 3. The modified gear set arrangement

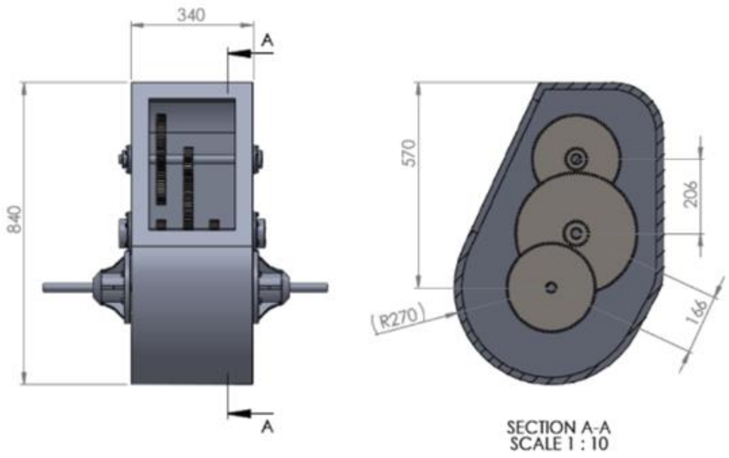


Figure 4. The modified gear set section design

2.2. The remote control for MSMPv

The remote operation called radiomaster TX16S consists of the HALL gimbals CNC sensor. The process inside multi-protocol is a full native TBS CrossFire (400K) protocol support and 16M memory dependent receiver and can be extended by micro SD card. Moreover, the researchers have been added the speech recognition system function using sound module recorder/playback for the voice commands instead of manual controls [11]. The navigation system function uses GPS with National Marine Electronics Association (NMEA) for checking the position of the ground control station compared to the vehicle's working position. This function is used for recording and navigating routes within the farm along the specified route in the automation. The research team have further developed the software of the RadioMaster TX16S remote system by updating the firmware from OpenTX within the Main ECU in the data interface from the original factory standard. The main idea shows the additional system connections according to the block diagram in Figure 5.

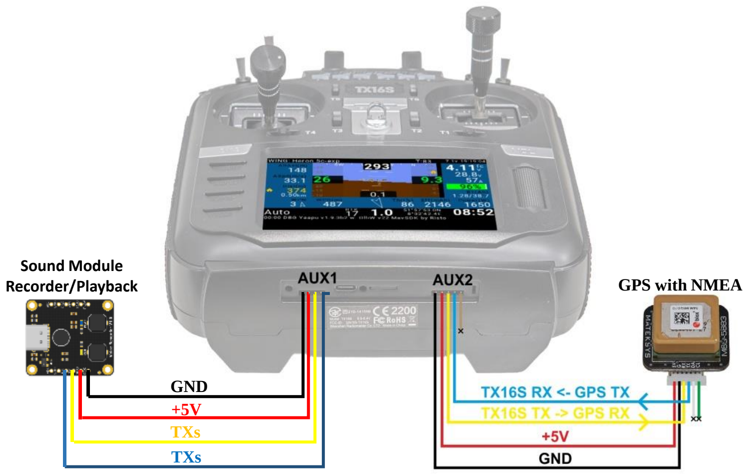


Figure 5. Connecting the remote control to the speech recognition system and navigation system

The connecting commands from a remote control using a GPS receiver model R12DS. The control channel uses pulse width modulation (PWM) which is a signalling technique that allows reading/writing analogue data with a digital signal. A digital signal (digital control) generates a square wave signal with different duty cycles and frequencies depending on the information of the command. Rev ch6 was used for speed control and forward-backwards control of the rear wheelset. It is working with automatic transmission systems by using the internal control of the gearbox with hydraulic oil. Rev ch7-8 for controlling the work of the front and rear ploughs by using the electric solenoid control unit, which has a magnetic coil appearance. It is a medium used in conjunction with electrical energy by releasing an electric current through the coil, a magnetic field is energized, resulting in closed-open work valve body flow. Rev ch9 for the feedback control system, the behaviour records and monitors the commanded behavior of the device according to the Rev ch1-8, then returns all the data to the ground control station for assembly. In analyzing the operating patterns of the system as well as evaluating the system fault values at the same time. The connection is shown in Figures 6 and 7.

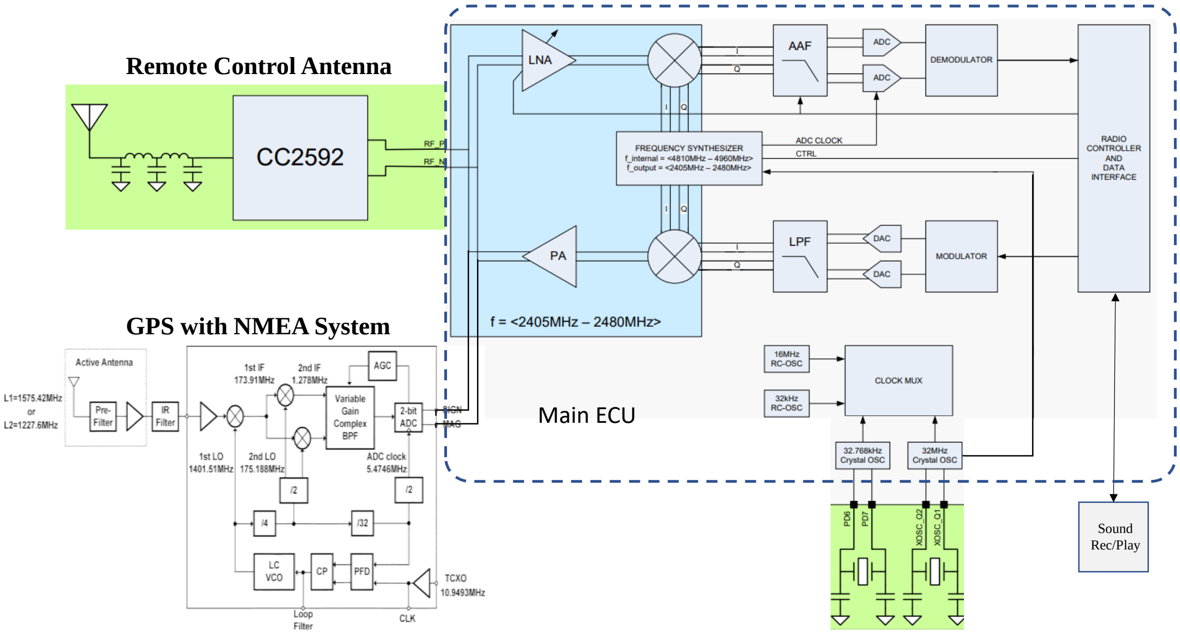


Figure 6. Block diagram for connecting the remote control to the speech recognition system and navigation system

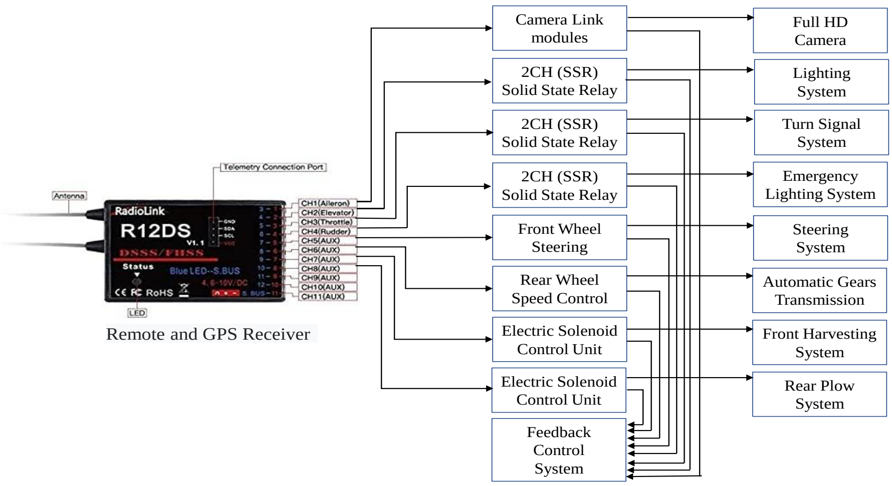


Figure 7. Connecting a GPS Receiver for controlling the tractor's control system

3. RESULTS AND DISCUSSION

This research presents an MSMPv prototype as shown in Figure 8 innovation for supporting farmers to harvest organic rice production. The MSMPv prototype will be a multi-purpose vehicle that can work via a remote control system connected with a smartphone or tablet application. Some testing results and specifications of this prototype shows in Table 1. The MSMPv might help the farmers under severe conditions [12]-[16], with the electronic-operating, connecting with several peripheral types of equipment covering various functions [17], [18] and allowing farmers to work more efficiently [19]-[22].

Moreover, they can share this vehicle in their group, separate from general equipment to serve the organic regulations. Therefore, new generation farmer has to understand how to learn the machine and technology applied in the mini-multipurpose vehicle. In the future, the researcher expects that they will provide excellent cooperation and also attempt to improve or extend this innovation to the non-profit organization in their area.

The MSMPv prototype can drive well with a maximum 65 km/hr. speed under a remote-control system. In standard work mode, the average speed is 45-50 km/hr. in the actual flat or undulating topography of Nong Bua Lumphu province. The modified differential is designed to be uncomplicated, conducive to the maintenance by farmers. The adjusting of the differential tooth and the radius allows for a higher torque output. Nevertheless, this MSMPv prototype still requires improvements in terms of the powertrain system. Especially, the modified differential part is easily damaged after bringing the vehicle to plough in the hard soil for a long time because the quality of the used materials and the tooth milling technology is quite limited. The MSMPv prototype installed a front-view camera and rear-view camera when farming without using people. The active bumper sensor will instruct the car to stop if the vehicle is overbound.

Figure 8. The mini smart multipurpose vehicle (MSMPv) prototype

Table 1. Shows the specification of the prototype of the mini smart multi-purpose vehicle

Specification	Description	Testing results
Horse Power	85 HP	pass
Type	4 strokes, water-cooled	pass
Combustion	IDI, naturally aspirated	pass
The number of the cylinder	4	pass
Bore x Stroke	92 x 92 mm	pass
Displacement	2.4L (2446 cc)	pass
Compression ratio	22.3 :1	pass
Nozzle type	Throttle	pass
Fuel type	Diesel/Bio diesel	pass
Cooling system	Pressurized circulation	pass
Gear system	Automatic transmission	pass
Total vehicle weight	1350 kg.	pass
Peripheral carrying weight (front)	500 kg.	pass
Peripheral carrying weight (back)	500 kg.	pass
Front wheel diameter	1.3 m.	1.3 m.
Back wheel diameter	1.43 m.	1.43 m.
Center distance of front wheel to the rear wheel	2.36 m.	2.36 m.
The height of the front wheel	615 cm.	615 cm.
The height of the back wheel	1.26 m.	1.26 m.
Length of the car	3.10 m.	3.10 m.
Centre of the vehicle car	2.37 m.	2.37 m.
Distance of remote control	1.5 km.	pass

The research team focus on Nong Bua Lumphu province as the case study area. Since the farmers in this province had the lowest average income per capita for many years, and now expect to extend the potential of organic production, for instance, vegetable and organic rice for domestic and worldwide markets [23]-[25]. Furthermore, this province topography is challenging terrain than the other province in the northeast region of Thailand.

4. CONCLUSION

This MSMPv can be controlled by a remote control system and install different equipment types at the crossbar or the attachment point. It will help farmers from traditional practices such as tillage, ploughing, or harvesting by manual labour move to new smart farming technologies the overall performance of the prototype from this study met 95% of the operational duties expectations. Nevertheless, the prototype still has not assessed the efficiency related to vehicle long runners, fuel consumption rate and harvesting efficiency of the harvester compared to manual labour. Moreover, there are still many improvements and developments required, especially in the additional gearbox parts, to make it more robust, more durable, and more efficient while being used in the field to increase the lifespan of the developed engine in the future.

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