

# A TRACTOR DATA ACQUISITION SYSTEM FOR FIELD POWER AND ENERGY DEMAND MAPPING



## GENERAL

Management decisions related to agricultural machinery can affect plantation profits in many ways. Fuel, interest, labour and timeliness are the pertinent factors that contributed to the tractor's productivity and efficiency. To improve productivity and efficiency, it is necessary to have comprehensive information on all aspects of the tractor and implement performance in the plantation.

This exclusive Massey Ferguson 3060 agricultural tractor is equipped on-board

with an instrumentation monitoring and acquisition system capable of providing the information :

- \* Engine speed
- \* PTO speed,
- \* Forward travel speed,
- \* Drive wheel slippage,
- \* Acres worked,
- \* Fuel consumption per hour,
- \* Fuel consumption per hectare,
- \* Acres per hour,
- \* Cost factor,
- \* Fuel consumed,

- \* Fuel remaining,
- \* Distance travel,
- \* Drawbar pul force,
- \* PTO shaft torque,
- \* Drive wheel torque,
- \* Vertical and horizontal forces at the 3 point hitches

Such a system permits research on the development of an agricultural database, especially on the aspects of power and energy requirements for the agricultural field operations in Malaysia.

## DATARONIC INSTRUMENTATION SYSTEM

The system is already built in the tractor and is capable of providing information on engine speed, PTO speed, forward travel speed, drive wheel slippage, acres worked, fuel consumption per hour, fuel consumption per hectare, acres per hour, cost factor, fuel consumed, fuel remaining, and distance travelled of the tractor. It utilises a commercial type radar sensor to measure ground speed, a magnetic pickup sensor to measure rear wheel axle rotation and a flow meter in the engine flow line to measure fuel flow into the engine. The system digital readout is situated in the right pillar of the tractor cab. The unit is provided with a rotating knob and three touch sensitive keys for monitoring the measured performance parameters. The slip control key enables the operator to set the permissible slippage range limit for the tractor rear drive wheels during field operations.

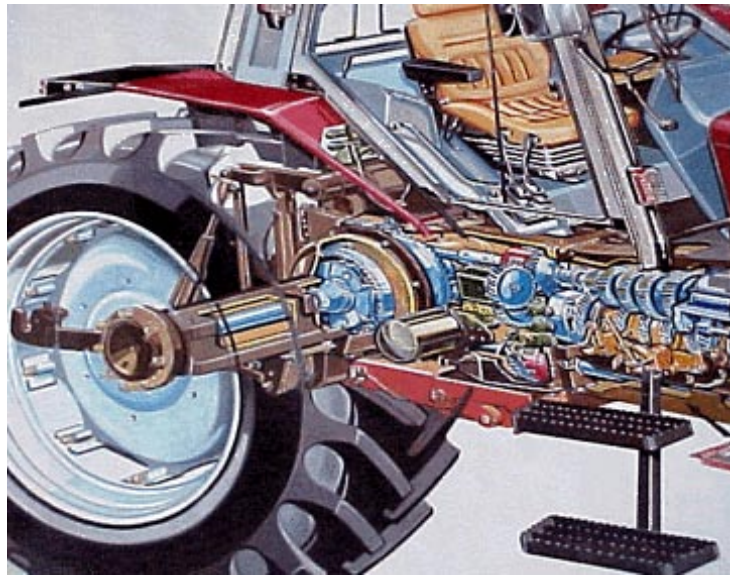


## DATATAKER ACQUISITION SYSTEM

The system is developed onto the tractor and is capable of recording information on drawbar pull force, PTO shaft torque, drive wheel torque, and both vertical and horizontal forces at the 3 point hitches of the tractor-implement. The data acquisition system is made up of the Datataker 605 datalogger, Compaq Contura 3/25C, Datatake 605 channel expansion module, 512K memory card, and Datataker 605 memory card reader. It utilises a locally designed drawbar pull transducer to measure horizontal pull at tractor drawbar point, wheel torque transducers to measure the torque at both tractor rear wheels, PTO shaft torque transducer to measure the torque at tractor PTO output, and a 3-point autohitch dynamometer to measure the horizontal and vertical forces on the implement behind the tractor. The Compaq Contura 3/25C notebook with the Decipher Plus software package and is used to program the datalogger for the data acquisition and recording processes.

## DOPPLER RADAR

The doppler radar unit for the tractor ground speed measurement is mounted rearward facing at 35 degree and located about midway on the left side of the tractor. It uses the doppler radar effect from a 24 GHz microwave emission to generate a frequency signal that is proportional to ground speed. This factory calibrated radar unit could generate output signal at a frequency of 27.3 Hz per Km/hr within 3% tolerences.

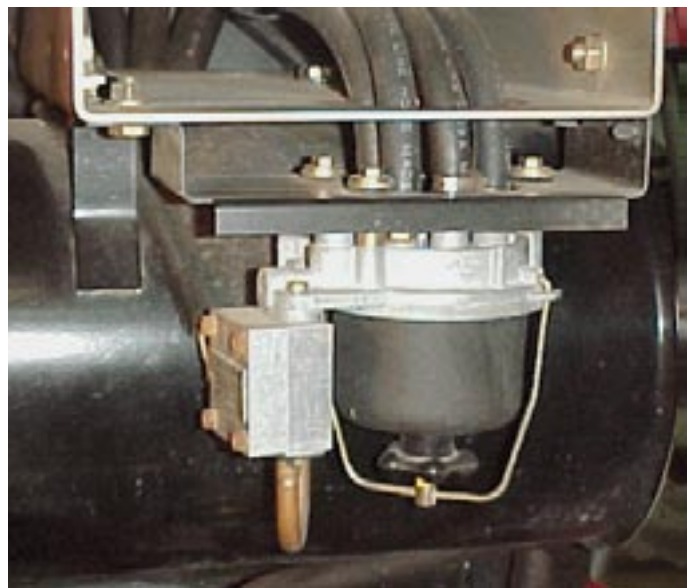


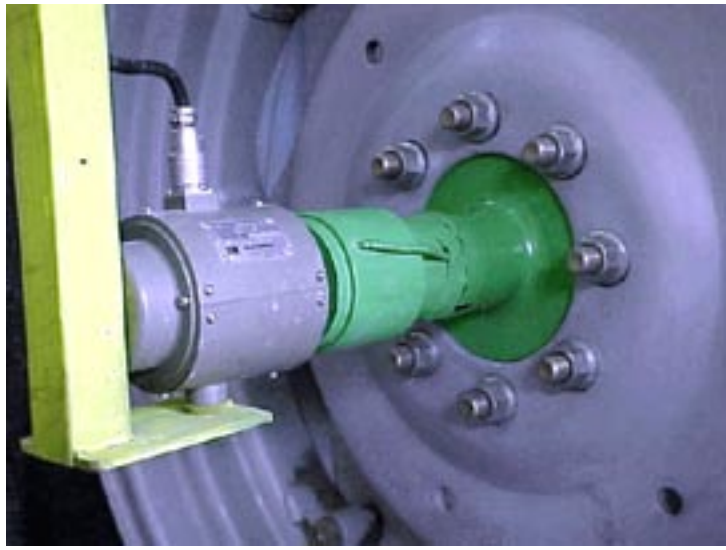
## RELUCTANCE MAGNETIC PICKUP

The conventional variable reluctance magnetic pickup for the tractor rear wheel shaft rotational speed measurement was installed near the crown wheel of the tractor rear axle differential unit. It measures frequency that is proportional to the average rotational speed of the tractor two rear wheels. This factory calibrated magnetic pickup unit could generate output signal in the range from 12 to 14 Hz per Km/hr, depending on the tires size fitted to the tractor.

## MICRO OVAL FLOW METER

The fuel flow rate is measured by a micro oval flow meter that is located in the fuel line between fuel filter and injection pump of the tractor. The device is an aluminum case with a measuring chamber having two oval wheels that rotates one on top the other. The top oval wheel actuates the reed switch as it rotates due to the magnetic field of the magnet on its body. The fuel flow meter output pulse as the results of the repeated opening and closing of the reed switch is proportional to the flow rate of fuel passing through the two oval wheels. This factory calibrated fuel flow meter could measure the flow rate in the range from 0.025 to 40 L/hr within +1% accuracy.





## REAR WHEEL TORQUE TRANSDUCER

The rear wheel torques are measured by a pair of special made transducers that are mounted on each side of the rear wheel axles of the. The design of the transducer is based on an extension shaft that is securely mounted between the rear wheel axle flange and tyre rim. A RBE-4A Kyowa slip ring and a special made adapter is fitted to the end of extension shaft. Two sets of KFG-5-120-D16-11-L1M-2S Kyowa, 90orosette, 120+0.8 Ohm, 2.1 gauge factor strain gauges are bonded at 45oshear planes on opposite sides of the extension shaft. The bonded strain gauges on extension shaft are connected in a full bridge configuration. A 2.5 mA constant current excitation source is supplied from the datalogger to each wheel torque transducers via their respective slip rings. Two L shaped steel conduits are mounted on each side of the tractor mudguards to carry the cables from the slip rings to the datalogger inside the tractor operator cab. Each torque transducers is designed for a torque range of 0 to 32 kNm and a sensitivity of 0.101 mV/V/Nm.

## PTO SHAFT TORQUE TRANSDUCER

The PTO torque is measured by a special made PTO shaft torque transducer that is located between the tractor PTO and the implement PTO input. The design of the transducer is based on the modification made on the standard commercial PTO tractor drive shaft. The free end of the female PTO drive shaft is provided with a raised collar, a screw bracket and a lock nut to position a 9E06-S1-3B NEC slip ring while the other end is welded to a universal joint. Two sets of KFG-5-120-D16-11-L1M-2S Kyowa, 90o rosette, 120+0.8 Ohm, 2.1 gauge factor strain gauges are bonded at 45 degree shear planes on opposite sides of the circumferential outside surface of the female PTO drive shaft. The bonded strain gauges on the female PTO drive shaft are connected in a full bridge configuration. A 2.5 mA constant current excitation source is supplied from the data logger to the shaft transducer via the slip ring. The shaft transducer is designed for a torque range of 0 to 937 Nm and sensitivity of 0.2852 mV/V/Nm.





## DRAW BAR PULL TRANSDUCER

The pull at the drawbar point is measured by a special made drawbar pull transducer. The thick proof ring part is made close to front pin of the drawbar pull transducer to reduce the effects of lateral and longitudinal moments on the transducer measurements. The drawbar transducer is mounted with four sets of KFG-5-120-C16-L1M-2R Kyowa, uniaxial,  $120+0.8$  Ohm, 2.1 gauge factor strain gauges at the nodes and 90° locations on the inner and outer circumference of the thick to the thick ring maximum strain nodes. The bonded strain gauges on drawbar transducer are connected in a full bridge configuration. A 2.5 mA constant current excitation source is supplied from the data logger to the drawbar pull transducer. The transducer is mounted to the exact position of the original tractor drawbar bar. The drawbar pull transducer is designed for a pull range of 0 to 50 kN and a sensitivity of 13.68 mV/V/kN

## 3 POINT AUTOHITCH DYNAMOMETER

The force sensing elements comprises of three steel extended octagonal transducers that are located between the frame and hook brackets. Each extended octagonal transducer is mounted with KFG-5-120-C16-L1M-2R, Kyowa strain gauges at strain angles nodes of 90° and 39.5° to monitor independently strains that are proportional to the vertical and horizontal forces about the center of the ring. Each transducer is designed for a maximum horizontal and vertical force of 25 and 12.5 kN, respectively. The complete dynamometer unit is about 870 mm wide and 820 mm height. The 3-point hitch location of the tractor has shifted rearwards by 230 mm and added 150 kg mass to the implement. The dynamometer is designed for a draft range of 0 to 75 kN.



## CALIBRATION AND DEMONSTRATION TESTS

Static calibration tests on the designed transducers showed excellent measurement linearity with correlation coefficients closed to 0.99.

Field demonstration tests showed that the instrumentation monitoring and acquisition system on-board the tractor was able to function successfully without giving much problems. All the developed transducers were able to scan and record by the data acquisition system under the harsh field environments. The stored data in the memory card of the Datalogger 605 from the field demonstration trials were able to be downloaded and retrievable from a host computer.



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