













**Fig. 15** Response time of digital ANFIS system.

**Table 2.** Comparison between ANN and ANFIS implementations.

	RNA (7-9-2)		ANFIS	
	$I_{sc}$	$V_{oc}$	$I_{sc}$	$V_{oc}$
MSE	2.0182E-07	10E-04	3.9939E-08	9.7904E-04
R	0.9998	0.9972	0.9999	0.9973
$t_{pd}$	1200 ns		75 ns	

## VI. CONCLUSIONS

In this work, we implemented an ANFIS architecture for emulating a photovoltaic panel that can operate in real time, this characteristic is very useful for analysis in the lab and in the field. We observed response times from 40 to 75 ns (the worst case) due to our parallel processing.

From results shown in table 2, we note that the photovoltaic panel emulator implemented with ANFIS and that realized with ANN, produce suitable values for short-circuit current ( $I_{sc}$ ) and open circuit voltage ( $V_{oc}$ ) so, with any implementation it is possible replicating the behavior that would have a commercial photovoltaic panel when excited with radiation and temperature.

The choice to employ ANN or ANFIS implementation will rely on the application speed needs, as ANFIS response time is significantly less, but with regards to error and utilized resources of the FPGA [1] we cannot conclude which one has the better performance.

## REFERENCES

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